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MÉMO TECHNIQUE

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Préparé par : Nouveau Monde Graphite

Pour : Direction générale de l'évaluation environnementale et stratégique

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Sujet : Réponses aux questions QCM-14 et QCM-15 pour la demande de modification du décret 47-2021 du 20 janvier 2021 concernant le projet minier Matawinie sur le territoire de la municipalité de Saint-Michel-des-Saints par Nouveau Monde Graphite Inc.

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Pour fin de consultation au décret ministériel 47-2021

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1 CONTEXTE

Les réponses aux questions QCM-1 à QCM-18 en lien avec la modification de décret 47-2021 du projet Matawinie ont été transmises en juin 2025 par Nouveau Monde Graphite Inc. (NMG) (NMG, 2025). Les réponses QCM-14 et QCM-15 n'étaient pas incluses à ce mémo technique et sont présentées ci-dessous.

Ce livrable documente les réponses aux questions QCM-14 et QCM-15 et complète les réponses en lien avec la modification de décret 47-2021.

2 QUESTIONS ET RÉPONSES

2.1 Gestion des eaux usées

QCM 14 : Demande de modification du décret 47-2021

L'initiateur doit préciser l'impact anticipé de l'augmentation des taux de traitement journaliers au concentrateur sur le bilan des eaux et confirmer que la capacité du système de gestion des eaux, incluant les bassins d'eaux usées, sera suffisante pour gérer ce surplus d'eau.

RÉPONSE - 14

L'augmentation des taux de traitement journaliers au concentrateur a un impact sur le bilan des eaux. Le bilan des eaux a été actualisé en fonction de l'avancement de l'ingénierie détaillée et des études réalisées depuis le décret 47-2021, lesquelles soutiennent la gestion des eaux du site, incluant l'intégration des changements climatiques (condition 7 – Adaptation aux changements climatiques).

Le Tableau 1 présente les éléments à jour traitant de la gestion des eaux du site en comparaison avec les données utilisées dans l'Étude d'Impact Environnemental et Social (ÉIES) de SNC-Lavalin (2019).

Tableau 1 : Bilan des eaux du projet – Données de l'ÉIES et à jour

Élément	ÉIES (SNC-Lavalin, 2019)			Données à jour		
	Valeur	Commentaire	Source	Valeur	Commentaire	Source / Annexe
Demande moyenne pour le concentrateur (eau fraîche et eau de procédé)	435 m^3/j	Provient d'un puits de pompage d'eau souterraine	Section 4.7	5 616 m^3/j (234 m^3/h)	Provient directement de l'eau des bassins sans traitement (eau de procédé) ou des bassins après traitement (eau fraîche). Des puits de pompage d'eau souterraine seront disponibles afin de combler des besoins temporaires (backup).	Figure 3-1 de SRK (2025a) - Annexe A
	2 747 m^3/j	Provient du bassin de polissage (eau traitée)	Tableau 4-32			
Eau de procédé retournée au bassin	2 208 m^3/j (92 m^3/h)	Retourné au bassin de collecte pour traitement et recirculation.	Tableau 4-32	5 136 m^3/j (214 m^3/h)	Retourné au BC-2. L'eau du BC-2 peut-être recirculée sans traitement.	Figure 3-1 de SRK (2025a) - Annexe A
Demande en eau potable	19 m^3/j	-	Section 4.7	25 m^3/j	-	Section 4.2 de SRK (2025b) - Annexe B

Pluie printanière de récurrence 1:2000 ans de durée de 24 h	133,7 mm	-	Section 7.2.2	171 mm[1]	-	Tableau 2-8 de SRK (2025b) - Annexe B Tableau 7-4 de SRK (2025d) - Annexe D
Considération des changements climatiques sur la pluie de conception des bassins	10 %	Contingence appliquée sur la capacité de pompage	Section 4.8	6% à 25% selon le contexte [2]	Contingence appliquée sur la pluie de conception	Tableau 2-17 de SRK (2025b) - Annexe B

[1] Depuis l'émission du rapport en Annexe C (pluie printanière 1 : 2000 ans de 133,7 mm), des études ont été finalisées dont celle de SRK (2025d) de l'Annexe D et une pluie de récurrence 2000 ans de 171 mm a été utilisée pour valider la capacité des infrastructures. Les sections 5.4 du rapport de bilan des eaux et 2.8.2 du rapport de critères de conception de SRK (SRK 2025a,b) présentées respectivement à l'Annexe A et à l'Annexe B démontrent que le système de gestion des eaux est en mesure de gérer une crue de projet de la Directive 019 associée à une pluie printanière de 171 mm qui correspond à une récurrence de 2000 ans et à une durée de 24 heures.

[2] Les phases sont divisées : 2015-2040 (6 %) 2041-2071 (14 %) 2071-2100 : (25 %). Depuis l'émission du rapport en Annexe C où une majoration de 10% était considérée sur la pluie de conception pour l'intégration des changements climatiques, des études ont été finalisées dont celle de l'étude SRK (2025e) en Annexe E qui présente les facteurs de majoration des changements climatiques pour différentes projections. Les rapports de bilan des eaux (Annexe A) et de critères de conception (Annexe B) de SRK (SRK 2025a,b) considèrent ces facteurs de changements climatiques qui sont variables selon l'année du projet ou la durée de vie de l'infrastructure. Une vérification de la capacité du système de gestion des eaux a été est effectuée dans SRK (2025a) afin de valider que celui-ci est en mesure de gérer la crue de projet incluant la mise à jour des facteurs de majoration des changements climatiques.

						Tableaux 5-6 à 5-8 de SRK (2025e) - Annexe E
Considération de l'effet orographique	Pas considéré	-	-	14 %	-	Section 4.4 de SRK (2025c) - Annexe C Section 2.6 et 3 de SRK (2024) – Annexe F
Rejet annuel à l'effluent final	1 169 346 m^3	Moyenne annuelle durant les 10 dernières années d'exploitation	Tableau 4-32	1 384 000 m^3	Moyenne annuelle durant les 10 dernières années d'exploitation	Tableau 5-1 de SRK (2025a) - Annexe A
Capacité de traitement de l'usine de Traitement des eaux (UTE)	900 m^3/h	Maximale durant l'exploitation	Section 4.7.5	1 800 m^3/h	Maximale durant l'exploitation	Tableau 2-1 de SRK (2025b) - Annexe B

L'impact anticipé de l'augmentation des taux de traitement journaliers au concentrateur sur le bilan des eaux et la capacité du système de gestion des eaux, incluant les bassins d'eaux usées, sera suffisante pour gérer le surplus d'eau. Les paragraphes suivants décrivent ce qui a été mis à jour avec les références qui valident la capacité des ouvrages.

Les données du bilan d'eau ont été mises à jour avec l'agrandissement de la fosse et l'ingénierie détaillée. Les figures 5-2 et 5-3 de la section 5.4 du bilan des eaux de SRK (2025a) de l'Annexe A montrent que le système de gestion des eaux est en mesure de gérer l'évènement de conception de la Directive 019.

Les rapports de conception d'infrastructures de gestion des eaux (Annexe C), de bilan d'eau (Annexe A) et de la chaine de traitement de l'UTE de Mabarex (2024) de l'Annexe G présentent la capacité totale de traitement de l'UTE pour la phase A et la phase B, qui est respectivement de 900 et 1800 m^3/h. Le rapport de l'Annexe G présente la chaine de traitement de l'UTE à jour pour chacune des phases du projet.

La chaine de traitement des eaux dans l'ÉIES (SNC-Lavalin, 2019) comportait un bassin de polissage situé en aval de l'UTE. Celui-ci permettait d'agir comme un bassin pour décanter les matières en suspension (MES) résiduelles provenant de l'UTE et de fournir une réserve d'eau pour alimenter le procédé. Le rapport de AtkinsRéalis (2025a) en Annexe H se veut une revue technique de la nouvelle chaine de traitement qui inclut l'ajout d'un traitement tertiaire. Ce rapport propose de remplacer ce bassin par une étape de filtration tertiaire. Cette dernière assure une performance de traitement supérieure, tout en remplissant les fonctions initiales de clarification de l'eau. Bien que le retrait du bassin de polissage réduise la capacité de stockage d'eau dans la chaîne de traitement pour les besoins de recirculation au concentrateur (et non dans la capacité totale reliée à la Directive 019), cette modification n'a pas d'impact sur la gestion globale des eaux du site. Une réserve dédiée à l'eau traitée est prévue pour compenser cette réduction de capacité d'emmagasinement d'eau traitée et permettre la réutilisation de l'eau dans le procédé en tout temps si l'eau non traitée ne peut pas être recirculée.

Des objectifs environnementaux de rejet (OER) ont été établis en 2020 par le MELCCFP (2020). Avec les données à jour du bilan d'eau, ces OER ont été révisés de façon préliminaire en 2025 par AtkinsRéalis (2025b) (Annexe I) puisque les OER à respecter devront être évalués par le MELCCFP.

Le bilan des eaux prévue durant les opérations ainsi que la chaine de traitement de l'UTE présentés précédemment seront en mesure de respecter les OER préliminaires.

Le Tableau 2 compare les OER du décret 47-2021 avec ceux estimés par phase. La détermination des OER et des impacts est présenté en Annexe I.

Tableau 2 : Comparaison des OER de 2020 établis par le MELCCFP à ceux estimés en 2025

Contaminants	OER 2020	OER préliminaires 2025 (Phase A)	OER préliminaires 2025 (Phase B1)	OER préliminaires 2025 (Phase B2)
	Concentrations dans l'effluent (mg/L)			
Matières en suspension	Directive 019	Directive 019	Directive 019	Directive 019
Aluminium	1,4	2,2	1,5	1,5
Argent	0,00034	0,00056	0,00036	0,00037
Arsenic	0,074	0,12	0,077	0,079
Baryum	0,140	0,23	0,15	0,15
Béryllium	0,000027	0,0011	0,00068	0,00069
Cadmium	0,000187	0,00031	0,00020	0,00020
Chrome	0,038	0,062	0,040	0,041
Cobalt	0,35	0,57	0,37	0,38
Cuivre	0,0046	0,0073	0,0047	0,0049
Fer	4,3	7,0	4,5	4,6
Manganèse	1,0	1,7	1,1	1,1
Mercure	0,0000013	0,0000013	0,0000013	0,0000013

Nickel	0,029	0,048	0,031	0,032
Plomb	0,00065	0,0011	0,00068	0,00069
Zinc	0,066	0,11	0,071	0,073
Azote ammoniacal (hiver)	6,6	11	6,9	7,1
Azote ammoniacal (été)	4,2	6,8	4,4	4,5
Diésel	0,70	1,2	0,73	0,75
Fluorures	0,62	1,0	0,65	0,67
Nitrates	10,3	17	11	11
Nitrites	0,069	0,12	0,073	0,075
pH	6,0 à 9,5	6,0 à 9,5	6,0 à 9,5	6,0 à 9,5
Toxicité aigue	1,0	1,0	1,0	1,0
Toxicité chronique	3,5	5,7	3,7	3,8

En complément d'information, les rapports de GHD (2025a,b) se trouvant respectivement à l'Annexe J et à l'Annexe K présentent le concept de drainage de l'UTE vers l'effluent final. Une conduite en provenance de l'UTE se décharge dans un bassin de dissipation d'énergie avant de rejoindre le ruisseau à l'eau morte par un canal. Le rapport de AtkinsRéalis (2025c) de l'Annexe L présente une revue de la conception du bassin et du canal de dissipation en amont du ruisseau à l'eau morte. Cette revue propose une augmentation de la profondeur (1,5 à 2,0 m) et une diminution du calibre d'enrochement (600-1500 mm à 300-500 mm) nécessaires pour le bassin de dissipation. De plus, le canal de dissipation a été relocalisé plus en aval du ruisseau à l'eau morte et une marche ayant une hauteur de 600 mm a été ajoutée afin d'éviter que les poissons en provenance du ruisseau à l'eau morte ne remontent pas le canal et atteignent le bassin de dissipation. Le canal de dissipation proposé est moins large (2,0 à 1,5 m), moins profond (1,0 à 0,6 m) et possède une pente longitudinale et un calibre d'enrochement

supérieurs par rapport à GHD (2025a,b). C'est ce dernier concept proposé par AtkinsRéalis (2025c) qui est retenu comme drainage à la sortie de la conduite provenant de l'UTE jusqu'au ruisseau à l'eau morte.

La comparaison des données et la présentation des plus récents rapports préparés pour le projet minier Matawinie démontrent que :

- La localisation de l'UTE a été ramenée près de la plateforme industrielle étant donné que le bassin Sud n'est pas requis au début de la mine et que l'UTE permet de traiter au besoin l'eau à recirculer au concentrateur.
- Le rapport d'eau de procédé retournée au bassin d'alimentation du procédé par rapport à l'eau des bassins requise pour le procédé a augmenté d'environ 11%, ce qui signifie que le système de recirculation est plus efficace (plus grand pourcentage de réutilisation de l'eau).
- Le procédé demande une plus grande utilisation d'eau journalière.
- Pour la recirculation, le besoin en eau fraîche provenant de puits de pompage d'eau souterraine est diminué et variable en fonction de la disponibilité d'eau dans les bassins de collecte.
- Dans la mesure du possible, le prélèvement d'eau souterraine sera effectué que pour l'approvisionnement en eau potable seulement. Des puits distincts et à différents endroits sont prévus pour l'eau potable et l'eau fraîche, et les lithologies où ils se situent ont des capacités et propriétés différentes. Les puits en backup (s'il n'y a plus d'eau disponible dans les BC) pour les eaux fraiches requises au concentrateur sont des puits qui seront localisés dans le secteur de la fosse pour bénéficier simultanément au dénoyage de la fosse.
- Le rejet annuel moyen à l'effluent passe de 1 169 346 m^3 (phase B2 qui correspond aux 10 dernières années d'exploitation dans l'ÉIES, SNC-Lavalin, 2019) à 1 384 000 m^3 (calculé à partir

du Tableau 5-1 de SRK 2025a pour les 10 dernières années de la phase B2[3] qui s'échelonne sur 20 ans dans la planification actuelle du projet).

- La capacité maximale de traitement requise pour le projet passe de 900 à 1 800 m^3/h, c'est-à-dire que deux trains de traitement de 900 m^3/h (2e train requis à partir de l'année 5) sont maintenant requis au lieu d'un seul pour assurer une gestion d'eau sécuritaire du système global.
- La pluie de conception des bassins passe de 133,7 mm à 171 mm en raison de données climatiques mises à jour incluant l'intégration des changements climatiques (condition 7 décret 47-2021), ce qui justifie en partie l'augmentation de la capacité de traitement nécessaire et le volume rejeté à l'effluent final.
- L'effet orographique applicable au site qui est maintenant considéré pour la conception des infrastructures de gestion des eaux justifie en partie l'augmentation de la capacité de traitement nécessaire et le volume rejeté à l'effluent final.
- Les bassins de collecte permettant la gestion des eaux sont en mesure de respecter les exigences de la directive 019 concernant la crue de projet et la gestion des eaux globales du site. Une optimisation du système de gestion des eaux a été faite pour ne pas augmenter les impacts sur le milieu récepteur qui auraient pu être occasionnés par une plus grande empreinte des bassins. Pour cela, un deuxième train de traitement a été ajouté à l'UTE.
- La chaîne de traitement est en mesure de respecter les exigences des OER (calculés préliminairement).
- Le concept de l'effluent final permet à la conduite de l'UTE de se déverser sécuritairement dans un bassin de dissipation d'énergie avant d'atteindre le ruisseau à l'eau morte.

Ces éléments de réponse et les rapports présentés en annexes démontrent comment l'augmentation des taux de traitement journaliers au concentrateur a été intégrée au projet et plus particulièrement

[3] La phase B2 ne représente pas le même nombre d'année car l'ingénierie détaillée et le bilan des eaux révisés ont permis une optimisation des besoins et du séquencement de l'UTE. Les phases sont déterminées avec les besoins additionnels pour l'UTE, ou d'un bassin collecteur additionnel.

dans le bilan des eaux. Il a également été démontré que la capacité du système de gestion des eaux sera suffisante pour gérer le surplus d'eau résultant de la modification du décret (47-2021) et que le système intègre les plus récents développements en vue de l'exploitation du projet minier Matawinie.

QCM 15 : Demande de modification du décret 47-2021

L'initiateur doit préciser si des modifications seront apportées au réseau de drainage et aux bassins d'eaux usées dans la partie sud de la mine en raison de l'agrandissement de la fosse d'exploitation.

RÉPONSE - 15

Le dimensionnement et le positionnement des infrastructures de drainage ont été adaptés avec l'agrandissement de la fosse, l'avancement de l'ingénierie détaillée et le bilan d'eau. L'Annexe A et l'Annexe C présentent le système de gestion des eaux qui considère l'agrandissement de la fosse d'exploitation pour le projet minier Matawinie. La localisation des bassins et le réseau de drainage s'y rattachant sont montrés aux figures 2-1 et 2-2 du rapport de conception des infrastructures de gestion des eaux de l'Annexe C. Le bassin BC-Sud sera construit afin d'être opérationnel au début de la phase B, c'est-à-dire pour le début de l'année 5 d'exploitation. Ce dernier permet de capter les eaux du sud de la halde de co-disposition. Le système de traitement des eaux (Annexe G), le concept de l'émissaire (Annexe J et Annexe K), ainsi que la revue du concept de l'effluent (Annexe L) représentent le drainage acheminant l'eau de l'usine de traitement jusqu'au point de rejet de l'effluent final dans le ruisseau à l'eau morte. Un bassin de dissipation d'énergie se trouve à la sortie de la conduite de l'effluent provenant de l'usine de traitement afin de réduire les vitesses d'écoulement et de permettre une décharge sécuritaire dans le ruisseau à l'eau morte.

Le réseau de drainage et les ouvrages de gestion des eaux (bassins, localisation de l'usine, fossés) restent dans la même empreinte globale du projet Matawinie du décret 47-2021 et la localisation des infrastructures est montrée aussi à l'annexe A de la demande de modification de décret (NMG, 2024).

3 RÉFÉRENCES

AtkinsRéalis (2025a). Revue de la mise à jour de la chaine de traitement des eaux de contact. Préparé pour Nouveau Monde Graphite Inc. Révision 00. N/Réf. : 701617-0001-4KER-0001. Publié le 13 mai 2025. *Rapport présenté à l'annexe H.*

AtkinsRéalis (2025b). Détermination des OER et des impacts sur la qualité des eaux de surface. Modification du décret de NMG. Préparé pour Nouveau Monde Graphite Inc. Révision 00. N/Projet n° : 701617 N/Réf. : 701617-0001-4EER-0001-00. Publié le 5 septembre 2025. *Rapport présenté à l'annexe I.*

AtkinsRéalis (2025c). Rapport d'étude hydraulique - Révision de la conception du point de rejet de l'effluent. Préparé pour Nouveau Monde Graphite Inc. Révision 00. N/Projet n° : 701617 N/Réf. : 701617-0001-4HER-0001-00. Publié le 26 août 2025. *Rapport présenté à l'annexe L.*

GHD (2025a). Conception chemin et émissaire. Préparé pour Nouveau Monde Graphite Inc. Révision 0. N/Projet n° : 12646006 N/Réf. : 12646006-RPR-1-CI-0001-C01-Note technique chemin et émissaire.docx. Publié le 15 janvier 2025. *Rapport présenté à l'annexe J.*

GHD (2025b). Plans pour permis - Projet Matawinie - Chemin et Émissaire. Préparé pour Nouveau Monde Graphite Inc. Révision S. Publié le 15 janvier 2025. *Plans présentés à l'annexe K.*

Mabarex (2024). Performance du système de traitement des eaux - Projet minier de graphite Matawinie. Description de la filière de traitement. Révision 04. Décembre 2024. *Rapport présenté à l'annexe G.*

MELCCFP (2020). OBJECTIFS ENVIRONNEMENTAUX DE REJET POUR LE PROJET MINIER MATAWINIE À SAINT-MICHEL-DES-SAINTS. Publié le 12 novembre 2020.

NMG (2024). Demande de modification du décret 47-2021. Projet Matawinie. Préparé par Lamont Inc. Février 2024.

NMG (2025). Réponses aux questions et commentaires pour la demande de modification du décret 47-2021 du 20 janvier 2021 concernant le projet minier Matawinie sur le territoire de la municipalité

de Saint-Michel-des-Saints par Nouveau Monde Graphite Inc. N/Réf : NMG-ENV-030. Publié le 17 juin 2025.

SNC-Lavalin (2019). Projet Matawinie - Étude d'impact environnemental et social (ÉIES). Rapport. Ref. : 3211-16-019. Avril 2019.

SRK Consulting (2024). Precipitation parameters correction due to orographic effect Nouveau Monde Graphite. Juillet 2024. N/Réf. : CAPR003306. *Rapport présenté à l'annexe F.*

SRK Consulting (2025a). Goldsim Model Build : Water Balance Model. Matawinie Site - Nouveau Monde Graphite. 12 septembre 2025. N/Réf. : CAPR003306. Final 00. *Rapport présenté à l'annexe A.*

SRK Consulting (2025b). Goldsim Water Balance Design Basis Memorendum. Nouveau Monde Graphite. 12 septembre 2025. N/Réf. : CAPR003306. Final. *Rapport présenté à l'annexe B.*

SRK Consulting (2025c). Rapport d'ingénierie des ouvrages de gestion des eaux de surface du projet minier Matawinie. Nouveau Monde Graphite. Janvier 2025. N/Réf. : CAPR002717. *Rapport présenté à l'annexe C.*

SRK Consulting (2025d). Baseline Climate Analysis. Nouveau Monde Graphite. Avril 2025. N/Réf. : CAPR003306. *Rapport présenté à l'annexe D.*

SRK Consulting (2025e). Climate Change Analysis. Nouveau Monde Graphite. Avril 2025. N/Réf. : CAPR003306. *Rapport présenté à l'annexe E.*

Annexe A – SRK Consulting (2025a). GoldSim Model Build: Water Balance Model

Annexe B - SRK Consulting (2025b). GoldSim Water Balance Design Basis Memorandum

Annexe C : SRK Consulting (2025c). Rapport d'ingénierie des ouvrages de gestion des eaux de surface du projet minier Matawinie

Annexe D : SRK Consulting (2025d). Baseline Climate Analysis

Annexe E : SRK Consulting (2025e). Climate Change Analysis

Annexe F : SRK Consulting (2024). Precipitation parameters correction due to orographic effect

Annexe G : Mabarex (2024). Performance du système de traitement des eaux - Projet minier de graphite Matawinie

Annexe H : AtkinsRéalis (2025a). Revue de la mise à jour de la chaine de traitement des eaux de contact

Annexe I : AtkinsRéalis (2025b). Détermination des OER et des impacts sur la qualité des eaux de surface

Annexe J : GHD (2025a). Conception chemin et émissaire

Annexe K : GHD (2025b). Plans pour permis - Projet Matawinie - Chemin et Émissaire

Annexe L : AtkinsRéalis (2025c). Rapport d'étude hydraulique - Révision de la conception de l'effluent

FINAL 00

GoldSim Model Build: Water Balance Model

Matawinie Site, Saint-Michel-des-Saints, Québec,, Canada
Nouveau Monde Graphite

SRK Consulting (Canada) Inc. ▪ CAPR003306 ▪ September 12, 2025

srk consulting

FINAL 00

GoldSim Model Build: Water Balance Model

Matawinie Site, Saint-Michel-des-Saints, Québec, Canada

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A	TF	BS/COG	--	2025-06-27	All	Internal working document
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The opinions expressed in this document have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. While SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

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Useful Definitions

This list contains definitions of symbols, units, abbreviations, and terminology that may be unfamiliar to the reader.

BC	Stormwater management ponds (*Bassin Collecteur*)
CDF	Co-disposal facility
ESG	Environmental, social, and governance
MOWL	Maximum Operating Water Level
LOM	Life of Mine
OVB	Overburden
PFD	Process flow diagram
WBM	Water Balance Model
WTP	Water Treatment Plant

1 Introduction

1.1 Overview

SRK Consulting (Canada) Inc. (SRK) was retained by Nouveau Monde Graphite (NMG) to update and develop their water balance into an Operational Water Balance Model (WBM) in GoldSim for the Matawinie Project in Quebec, Canada. The content herein is intended to provide a Mine Plan Operational Update that will be included as part of NMG's proposal to the Quebec Regulatory Bodies to start this project.

1.2 Scope of Work

The objectives of this scope of work were to transition the Matawinie WBM from MS Excel to GoldSim and update the model to reflect the proposed Life of Mine (LOM) plan. After completing the model update, simulations will be performed to estimate the quantity of discharge expected to be released to the receiving environment. SRK understands that the results of these WBM simulations will assist in assessing whether the discharge volumes are likely to comply with applicable criteria and will support water management planning and optimization.

The current WBM simulates the exchange of water between water management facilities for the LOM, but does not include progressive reclamation, closure and post-closure phases at this time (this will be included in future updates). The model is designed to evaluate water management needs across the project site. The WBM was built to later incorporate geochemistry data and evaluate mass exchange throughout operations as a water and load balance (WLB) model at future stages of work.

2 Project Description

2.1 Overview

NMG aims to be a major contributor to the energy transition from fossil fuels and to be a leader in the mining industry by developing, operating, and restoring the Matawinie graphite mine project, in accordance with the highest environmental, social, and governance (ESG) standards.

NMG will operate a world-class graphite open pit mine. Ore will be concentrated at the Matawinie plant site before being transported to Bécancour, Québec for further processing, an approach that will result in a high purity graphite concentrate intended for use in the manufacturing of battery anode materials. The planned LOM for the Matawinie project is 28 years, including construction and pre-mining phases (BBA, 2022).

In addition to the open pit mine and industrial area, a co-disposal facility (CDF) for tailings and waste rock, surface water management infrastructure (i.e., ditches and collection ponds), and an overburden (OVB) stockpile will be constructed on the mine site (the site).

SRK was engaged by NMG in 2023 to review and update a previously developed MS Excel-based water balance tool to support the sizing of stormwater management ponds (referred to as “BC” for *Bassin collecteur* in French). One of SRK’s recommendations from that work was to transition the model into a GoldSim format to allow for improved forecasting and modelling scenarios to support surface water management planning.

2.2 Project Layout

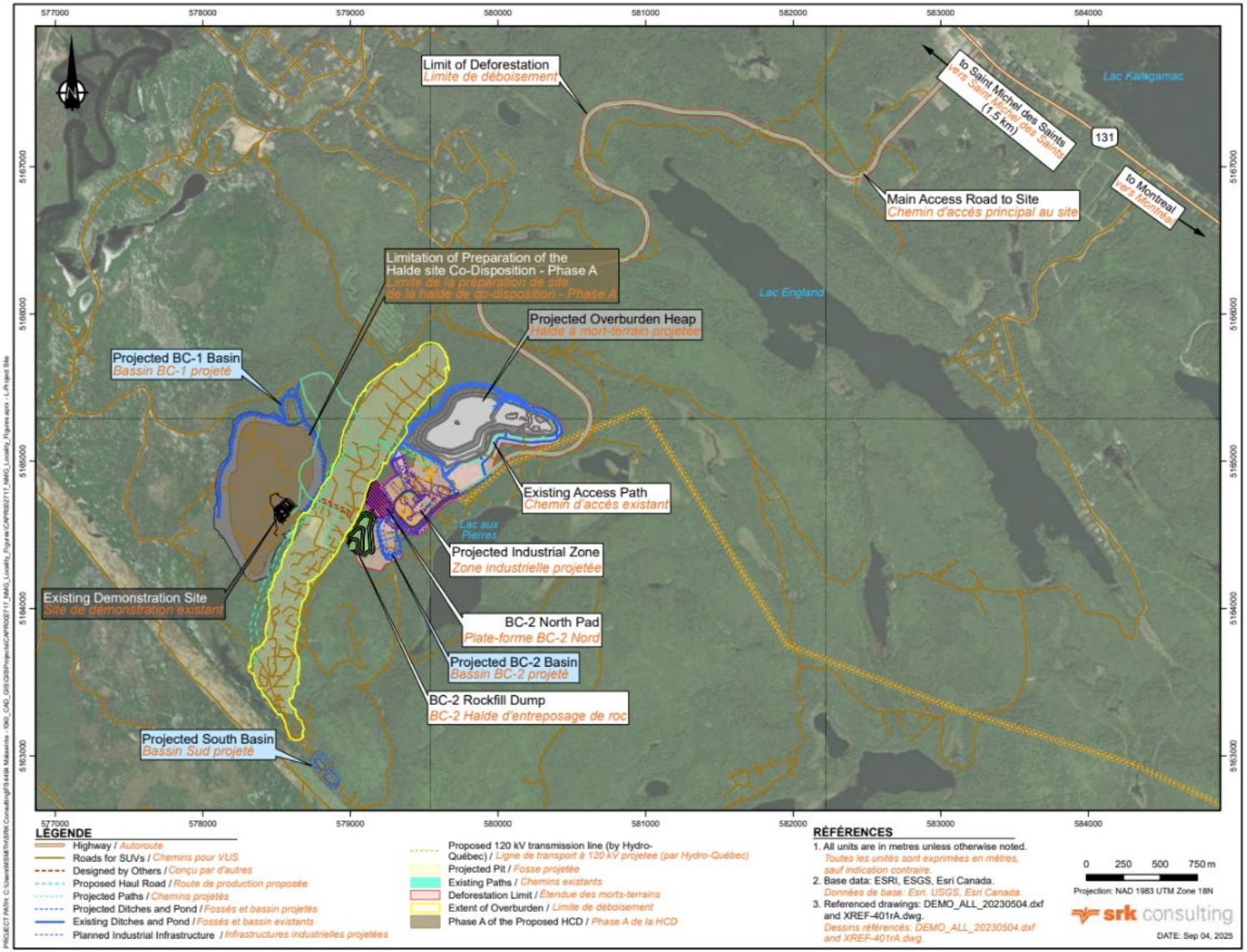
The project is located in the Lanaudière region of Quebec, approximately 5 km southwest of the municipality of Saint-Michel-des-Saints, and 400 m west of Lac aux Pierres (**Figure 2-1**). **Figure 2-2** illustrates a generate site layout of the planned mine facilities.

Planned mine facilities include:

- Pit
- Industrial area and concentrator
- Water Treatment Plant (WTP)
- CDF (Mine Waste and Dry Stack Tailings)
- OVB stockpile
- BC-1 pond
- BC-2 pond
- BC-Sud pond
- Ancillary facilities
- Discharge infrastructure

Figure 2-1: Matawinie Mining Project Location

Figure 2-2: Detailed Location Map



2.3 Water Management Objectives

The water management plan for the Matawinie mine is summarized as:

- Provide a continuous source of treated water for the concentrator to maintain production throughout the year.
- Respect the target operating water levels of the ponds while storing enough water to supply the concentrator through the winter months.
- Minimize the amount of supplemental groundwater required to meet concentrator water demand.
- Store and supply water to meet dust suppression requirements.
- Collect, treat, and discharge water to the receiving environment during the permitted discharge window.
- Respect applicable discharge criteria:
  - No discharge when streamflow in Ruisseau à l'Eau Morte is less than 182 L/s
  - Do not exceed a total annual discharge volume of 2,800,000 m^3.

3 Mine Plan

3.1 Overview

The following sections summarize SRK's understanding of mining activities associated with each stage of the proposed LOM plan. The proposed model scenario has been constructed to align with the staging described below.

A Process flow diagram (PFD) for the Matawinie operation is provided in **Figure 3-1**.

Project operational details and production schedule are included within the design basis (**Appendix B**).

3.1.1 Pond Narratives

Each of the three water management ponds at site has a critical role in the successful operation of the Matawinie mining facility. The narrative for each pond is described in the following sections.

BC-1

The primary objectives of the BC-1 pond are to collect surface water runoff from the north end of the CDF, receive pit water, and provide sufficient retention time for solids to settle. During winter months, BC-1 also serves as a supplemental head pond for BC-2, ensuring adequate supply for the concentrator. In addition, BC-1 will act as the main source of water for dust suppression across the site.

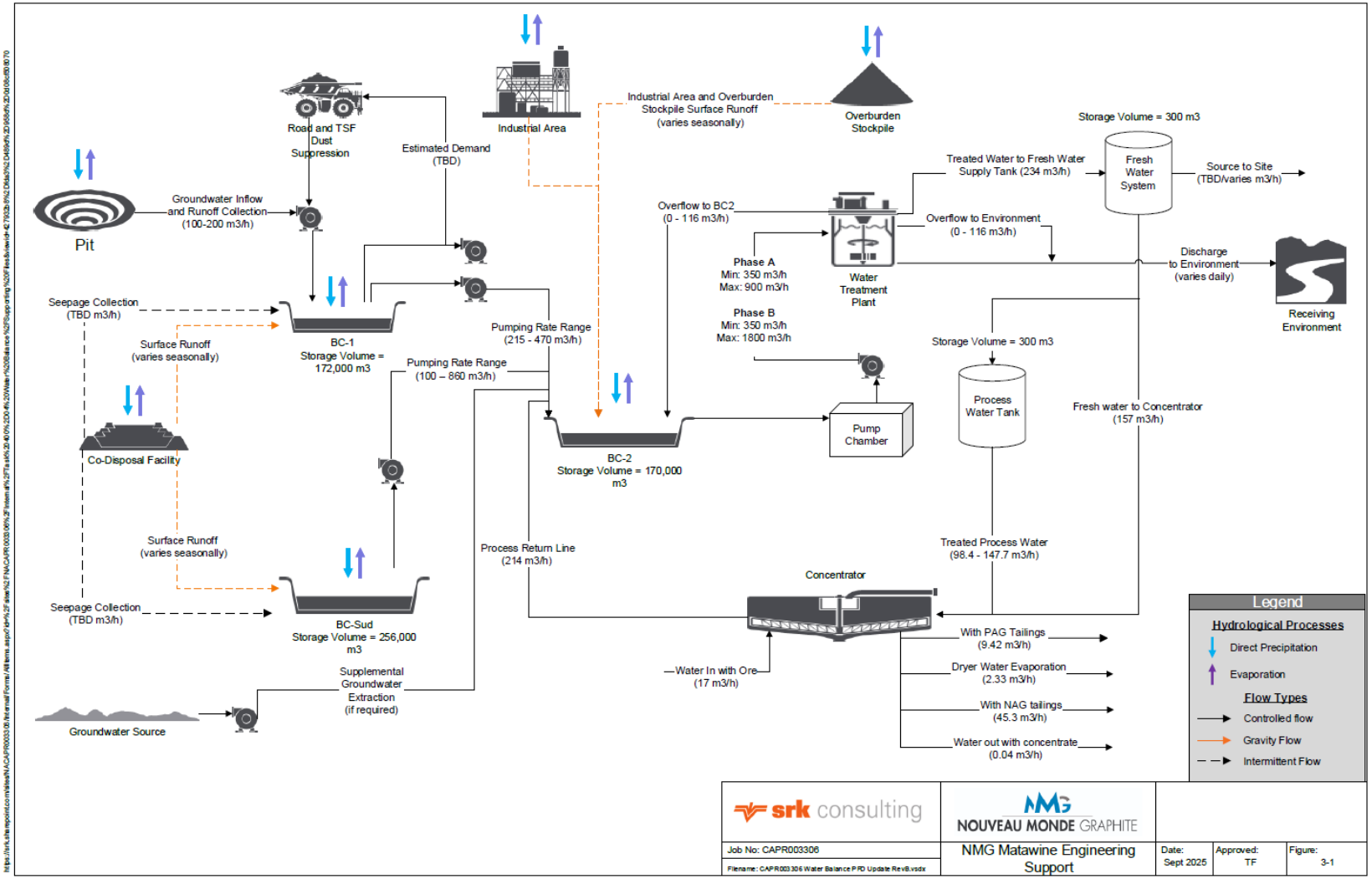
BC-2

The primary function of the BC-2 pond is to serve as the intake reservoir for the WTP. All site contact water will be routed through BC-2 for treatment and discharge to the receiving environment. Dust suppression water can be sourced from the water treatment plant return line, if treated water is required. Additionally, BC-2 will function as an emergency reservoir for fire suppression, maintaining a minimum operational volume of 10,000 m^3 at all times.

BC-Sud

The primary objectives of BC-Sud are to collect surface water runoff from the south end of the CDF and to serve as a supplemental head pond for BC-2, providing additional supply to the concentrator during the winter months.

Figure 3-1: Operational Water Balance Process Flow Diagram



3.2 Phase A

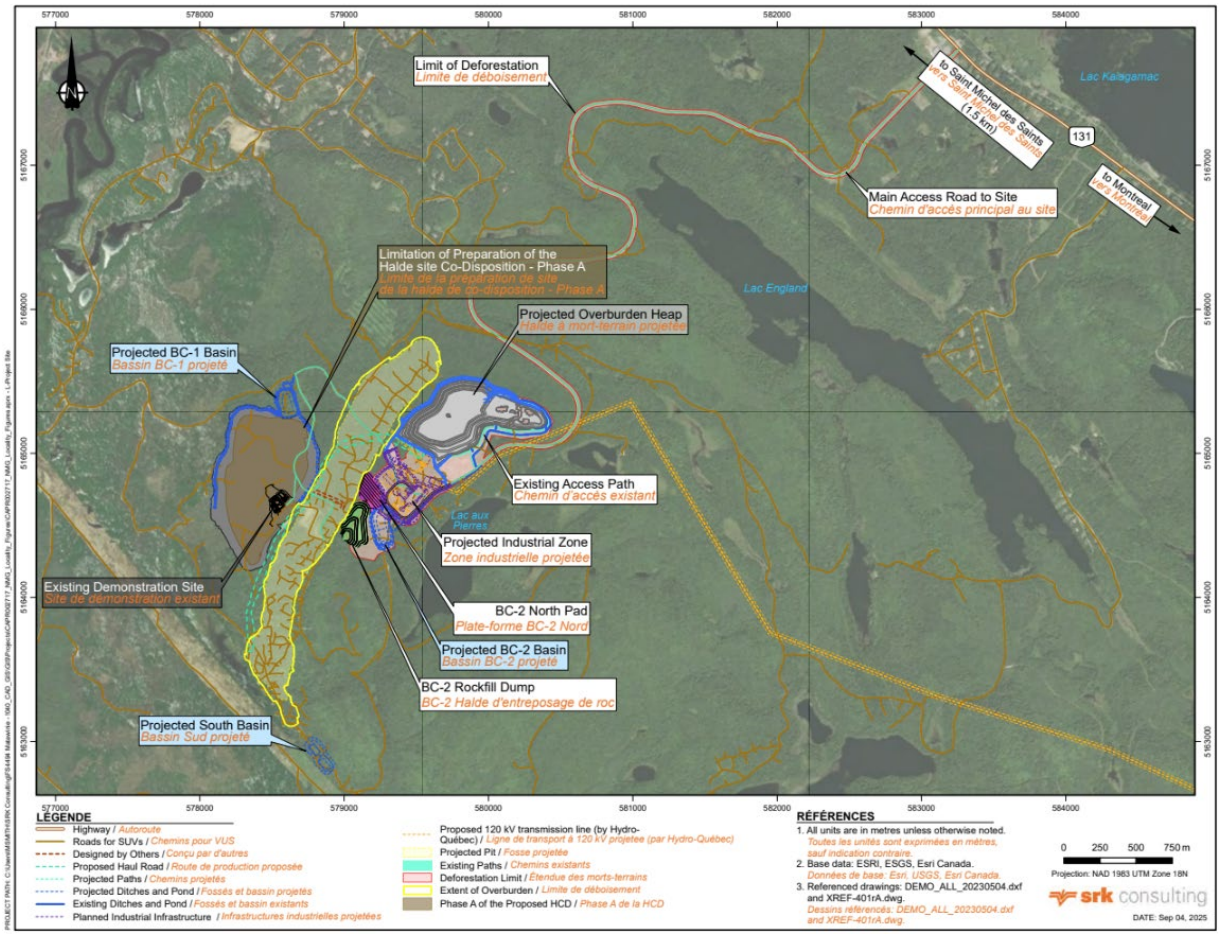
Phase A represents the first four years of operations between 2028 and 2032 (**Figure 3-2**).

The first stage of the Mine Plan involves the initial development of the pit and the CDF. Production from the pit is expected to ramp up in 2028 (Year 1) and planned to reach full production in 2029, remaining consistent until the end of operations.

During this stage, the following activities are proposed:

- Early stages of pit development and the CDF.
- WTP Phase A – Maximum treatment rate of 900 m^3/h.
- Water management activities include:
  - Contact water from the CDF, pit, OVB stockpile and the industrial areas will be collected and conveyed to BC-1 and BC-2 ponds.
  - BC-1 provides primary source of dust suppression water, which is assumed to be required daily between May to October. Secondary treated dust suppression water is sourced from BC-2 via water treatment plant return line, as required.
  - Contact water will be stored as much as possible to supply the concentrator. Discharge will be used to ensure ponds stay within Maximum Operating Water Levels (MOWLs).
  - Additional groundwater may be required to supplement BC-2 in meeting the concentrator's water needs.
  - Discharge to the environment is expected intermittently during freshet and immediately following larger rainfall events. For the remainder of the year, discharge is expected to be minimal.

Figure 3-2: Mining Phase A



3.3 Phase B1

The second stage of the Mine Plan is Phase B1, from 2033 to 2035.

During this second stage, the initial expansion of the CDF towards the south will increase the catchment areas for contact water collection and the pit will be fully developed in this phase. The following water management activities are planned for Phase B1:

- Expansion of the pit and of the CDF southwards and subsequent contact water collection system.
- BC-Sud Phase 1 will be operational and collecting contact water from the southern portion of the CDF. Water will be pumped to BC-2 for treatment. BC-Sud Phase 1 will accommodate 86,000 m^3 of inventory.
- The maximum rate of the WTP will be doubled to 1,800 m^3/h.

3.4 Phase B2

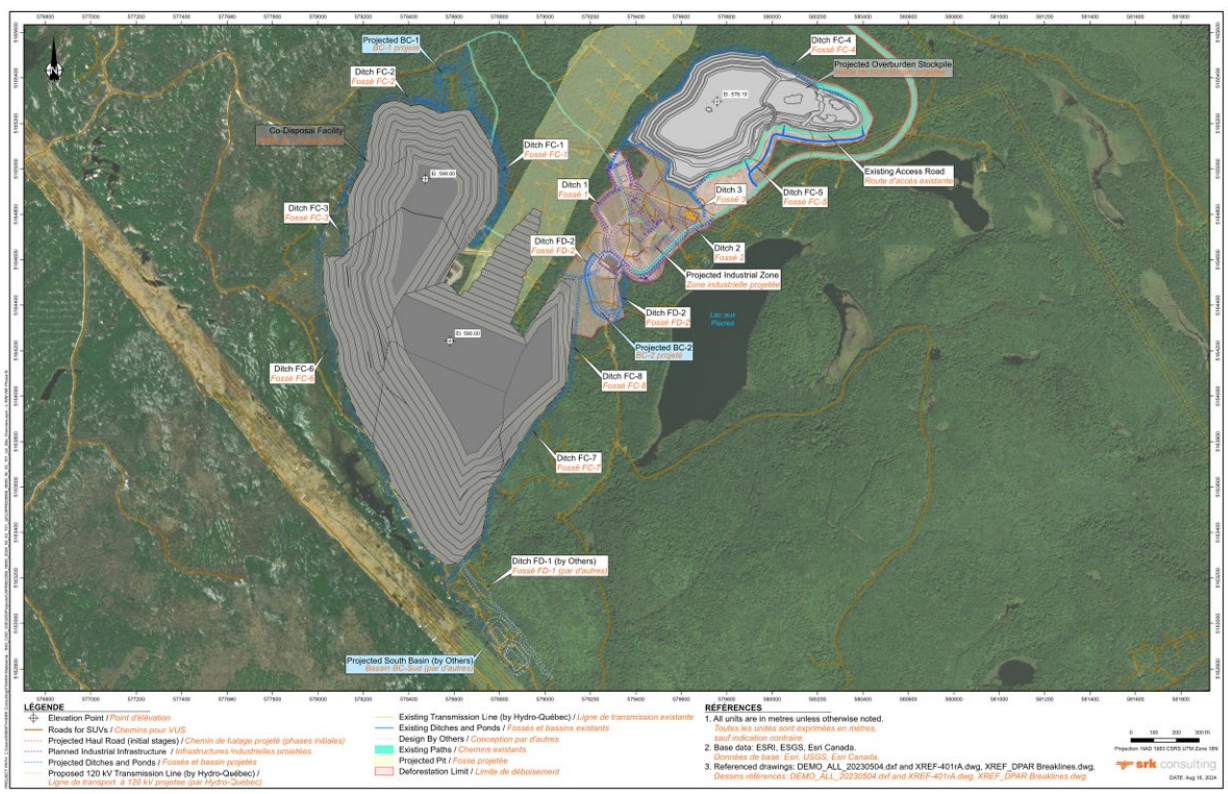
The last stage of the Mine Plan is Phase B2, from 2036 to 2056 (**Figure 3-3**).

During this stage, the CDF will reach full expansion towards the south, representing the fully operational state of the mine until closure.

The following water management activities are planned for Phase B2:

- At this point in time, the full operational mine catchment will be active and reporting runoff to the mine water collection ponds.
- BC-Sud will be expanded to Phase 2 and will have an ultimate water holding capacity of 256,000 m^3.
- The pit will be continually increase in depth over the LOM. As pit development progresses, more groundwater will require to be collected and treated.
- The CDF will be progressively reclaimed during operations. Details on reclamation schedule, placement, and impacts to hydrology and the water balance are not yet understood and were therefore not included in the model at this time.

Figure 3-3: Mining Phase B2



3.5 Closure and Post-Closure

SRK understands that NMG has progressive reclamation and closure plans in development. However, at the time of this report, these details were not included in the WBM.

Conceptual closure and post-closure plans are expected to be included in future iterations of modelling.

4 Modelling Objectives

Details pertaining to the structure, settings, updates, inputs, and assumptions applied by SRK to the Matawinie WBM are summarized in the model design basis (SRK, 2025a; Appendix B). The following sections are intended to provide a high-level summary of this information.

4.1 Objectives

The primary objectives of this Mine Plan Operational study were to:

- Determine if there is sufficient water available through storage, and if required, supplemental groundwater, to meet the concentrator demand throughout the year.
- Determine if discharge restrictions can be met (i.e., only sending discharge to the environment during the discharge window and complying with the annual discharge volume limit).
- Confirm that the ponds can be operated in a manner that consistently provides sufficient volume to meet the Directive 019 (D019) storm event and demonstrate that the system can manage the D019 storm event without spillage.

4.2 Model Framework

- Model simulations run time was from January 1, 2028, to December 31, 2056.
- Model simulations were performed on a daily timestep.

4.3 Climate

- Model climate simulations were performed by applying climate change rates of change (SRK, 2025b) to daily precipitation and daily mean temperature time series developed for the Matawinie Project (SRK, 2025c).

4.4 Project Model Simulations

The WBM was simulated under several scenarios to address the objectives of the study. All simulated scenarios include climate change adjustments over time. The scenarios are defined as:

- Scenario 1: “Baseline”: Baseline (Expected average conditions + Climate Change). This baseline was used as the foundation for the other scenarios.
- Scenario 2: “Wet”, Consecutive wet years:
  - Running back-to-back Wet100 years in 2030 and 2031, and in 2039 and 2040. These dates were selected to test the infrastructure at the end of Phase A and the Start of Phase B2.
  - Years 2030/2031 represent the latter end of Phase A to highlight early system sensitivity before expansion. Years 2039/2040 represent the first opportunity to show the full expanded mine site and system.

- Scenario 3: “Dry”, Consecutive dry years:
  - Running back-to-back Dry100 years in 2030 and 2031, and in 2039 and 2040. These dates were selected to test the infrastructure at the end of Phase A and the Start of Phase B2.
  - Years 2030/2031 represent the latter end of Phase A to highlight early system sensitivity before expansion. Years 2039/2040 represent the first opportunity to show the full expanded mine site and system.
- Scenarios 4 – 7: Sensitivity to groundwater inputs and dust suppression demand:
  - Scenario 4: Adjusting the forecasted dust suppression demand by +50%
  - Scenario 5: Adjusting the forecasted dust suppression demand by -50%
  - Scenario 6: Adjusting the estimated pit groundwater inflows by +50%
  - Scenario 7: Adjusting the estimated pit groundwater inflows by -50%
- Scenario 8: Directive 019 Design Storm:
  - Testing the D019 storm event (1:2000-year rain on 1:100-year snowpack) in years 2031 and 2040.

5 Model Results

5.1 Annual Discharge Compliance

Estimated annual discharge volumes for Scenarios 1-7 are summarized in **Table 5-1,** including the mean, minimum, and maximum volumes. The baseline scenario was compared relative to several alternative scenarios to illustrate a range of potential outcomes.

Across all evaluated scenarios, annual discharge volumes increase as the mine is developed—beginning at approximately 400,000 m³ in 2028 and increasing to over 1,600,000 m³ by 2056, under average conditions. This is primarily driven by the mine development, particularly notable in 2036 with the onset of Phase B2, and continues as both the pit and associated groundwater inflows increase.

Importantly, none of the scenarios suggest that the mine will exceed the annual discharge limit of 2,800,000 m³.

The mean annual discharge volumes align closely with those projected for Scenario 1 (Baseline). The minimum and maximum annual volumes correspond to Scenario 5 (Dust Suppression -50%) and Scenario 4 (Dust Suppression +50%), respectively, highlighting the sensitivity of the water balance to variations in dust suppression demand.

Table 5-1: Annual Discharge to Ruisseau à L'Eau Morte (m^3)

Year	Scenario 1 Baseline	Scenario 2 Wet	Scenario 3 Dry	Scenario 4 Dust +50%	Scenario 5 Dust -50%	Scenario 6 GW +50%	Scenario 7 GW -50%	Mean	Min	Max
2028	400,000	400,000	360,000	220,000	690,000	640,000	520,000	470,000	220,000	690,000
2029	410,000	410,000	270,000	340,000	500,000	420,000	370,000	390,000	270,000	500,000
2030	370,000	400,000	270,000	330,000	480,000	390,000	350,000	370,000	270,000	480,000
2031	350,000	510,000	190,000	300,000	450,000	360,000	320,000	350,000	190,000	500,000
2032	400,000	570,000	230,000	380,000	540,000	440,000	370,000	420,000	230,000	590,000
2033	880,000	880,000	700,000	810,000	1,110,000	890,000	840,000	850,000	700,000	1,110,000
2034	900,000	900,000	710,000	850,000	1,220,000	950,000	890,000	910,000	710,000	1,220,000
2035	920,000	920,000	730,000	860,000	1,210,000	960,000	920,000	920,000	730,000	1,210,000
2036	1,300,000	1,400,000	1,100,000	1,210,000	1,540,000	1,300,000	1,260,000	1,290,000	1,100,000	1,540,000
2037	1,230,000	1,850,000	960,000	1,190,000	1,570,000	1,300,000	1,210,000	1,300,000	960,000	1,660,000
2038	1,280,000	1,720,000	870,000	1,230,000	1,560,000	1,300,000	1,230,000	1,300,000	870,000	1,620,000
2039	1,300,000	1,300,000	1,000,000	1,240,000	1,560,000	1,300,000	1,280,000	1,280,000	1,000,000	1,560,000
2040	1,280,000	1,280,000	980,000	1,210,000	1,540,000	1,330,000	1,220,000	1,260,000	980,000	1,540,000
2041	1,300,000	1,260,000	1,060,000	1,210,000	1,540,000	1,340,000	1,230,000	1,280,000	1,060,000	1,540,000
2042	1,280,000	1,280,000	970,000	1,240,000	1,550,000	1,290,000	1,230,000	1,270,000	970,000	1,550,000
2043	1,270,000	1,290,000	980,000	1,200,000	1,540,000	1,340,000	1,230,000	1,260,000	980,000	1,540,000
2044	1,270,000	1,230,000	930,000	1,210,000	1,560,000	1,340,000	1,210,000	1,260,000	930,000	1,560,000
2045	1,280,000	1,220,000	990,000	1,220,000	1,530,000	1,390,000	1,260,000	1,280,000	990,000	1,530,000
2046	1,390,000	1,280,000	950,000	1,270,000	1,630,000	1,390,000	1,310,000	1,310,000	950,000	1,630,000
2047	1,390,000	1,360,000	990,000	1,230,000	1,660,000	1,400,000	1,240,000	1,320,000	990,000	1,660,000
2048	1,360,000	1,280,000	990,000	1,180,000	1,610,000	1,390,000	1,290,000	1,300,000	990,000	1,610,000
2049	1,350,000	1,320,000	980,000	1,220,000	1,620,000	1,350,000	1,290,000	1,300,000	980,000	1,620,000
2050	1,320,000	1,320,000	950,000	1,200,000	1,590,000	1,350,000	1,280,000	1,290,000	950,000	1,590,000
2051	1,290,000	1,360,000	990,000	1,250,000	1,740,000	1,400,000	1,330,000	1,330,000	990,000	1,740,000
2052	1,410,000	1,410,000	1,060,000	1,340,000	1,720,000	1,450,000	1,360,000	1,380,000	1,060,000	1,720,000
2053	1,370,000	1,370,000	1,010,000	1,300,000	1,640,000	1,400,000	1,360,000	1,340,000	1,010,000	1,640,000
2054	1,480,000	1,500,000	1,290,000	1,500,000	1,770,000	1,550,000	1,420,000	1,500,000	1,290,000	1,770,000
2055	1,630,000	1,340,000	1,260,000	1,400,000	1,760,000	1,800,000	1,420,000	1,530,000	1,260,000	1,800,000
2056	1,650,000	1,590,000	1,140,000	1,510,000	1,830,000	1,730,000	1,490,000	1,550,000	1,140,000	1,830,000

Sources: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/Modelling%20Results%20for%20Report/CAPR003306_Report_Scenario_Results_Tracker_RevB_20250911.xlsx?web=1

5.2 Discharge Window Compliance

The discharge windows for the project are designed as approximations to ensure compliance with minimum flow requirements in Ruisseau à L'Eau Morte. Specifically, site discharge is not permitted unless the flow in the creek exceeds 182 L/s (SRK, 2025). Due to limited available data, a discharge window approach was adopted, using seasonal estimates of when flows are likely to exceed this threshold. It is important to note that this method is proposed to simplify compliance modeling; however, the simplicity of this approach introduces a risk that some discharges may be modeled outside of the target windows.

The established discharge periods are:

- January 1 – March 15: No discharge (flows generally expected to be less than 182 L/s)
- March 16 – June 30 (Spring freshet)
- July 1 – September 30: No discharge (flows generally expected to be less than 182 L/s)
- October 1 – December 30 (Fall rainfall)

Operational decisions are also tied to the MOWLs of the ponds. According to the Design Basis (SRK, 2025), when water levels in BC-2 exceed the MOWL, treated water from the WTP is automatically routed to the environment—even if the discharge window is closed. This safeguard is in place to accommodate the Environmental Design Flood (EDF) and means that modelled discharge can sometimes occur outside the formal discharge window.

Discharge volumes for each discharge period are summarized in **Table 5-2** for the Scenario 1(Baseline). Results for alternative scenarios are similar and are included in **Appendix A**. Model results indicate that no discharge is expected prior to March 16, although occasional exceedances are projected later in the mine life. These unintended releases are expected to be avoided through pond water management by adjusting storage between ponds.

Discharges predominantly occur during the spring window as snowmelt increases runoff. Discharge during the spring is typically five times greater than discharge during the fall window. This seasonal trend is expected as more water is stored in the ponds in the final months of the year to ensure sufficient supply for winter concentrator operations.

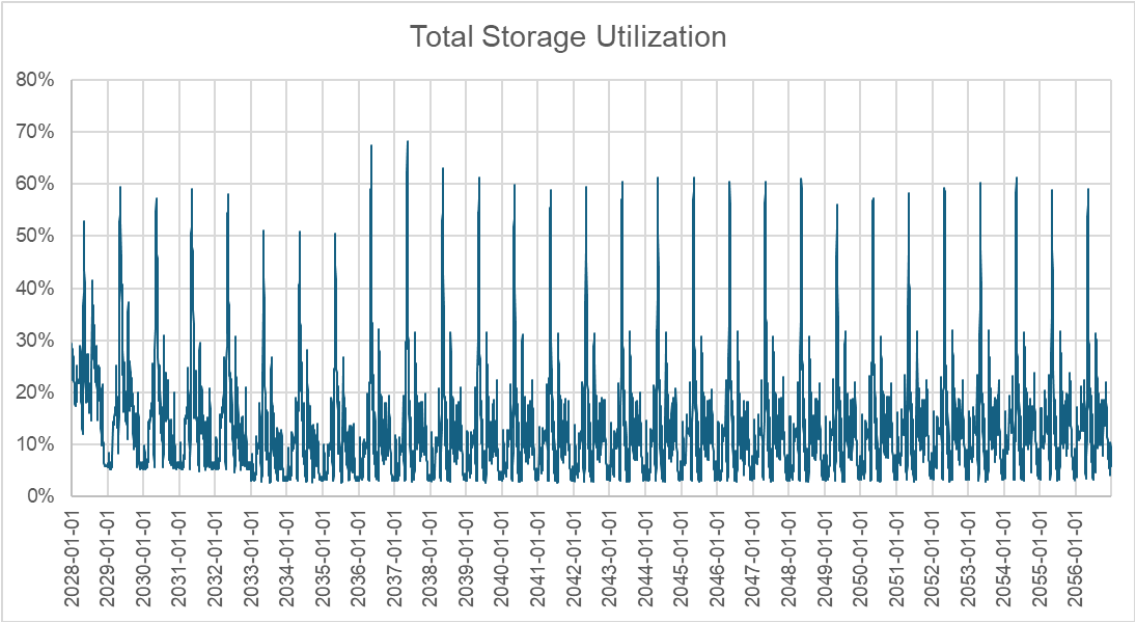
During the summer non-discharge window, releases may occur when midsummer storms cause water in BC-2 to reach its MOWL, triggering an outflow to the environment. However, at such times, BC-1 and BC-Sud generally have spare capacity, suggesting that optimized water transfers between ponds could reduce unnecessary discharges. Furthermore, storm events would likely increase streamflow in Ruisseau à L'Eau Morte above the 182 L/s threshold, suggesting these summer discharges would likely remain compliant with discharge conditions. **Figure 5-1** illustrates water storage and discharge patterns, aside from the temporary peaking from freshet each spring, the system has substantial unused pond capacity during the summer period. This indicates that improvements to operational management and better coordination between BC-1, BC-2, and BC-Sud could further mitigate potential compliance issues.

Table 5-2: Annual Discharge by Seasonal Window (m^3)

Scenario 1: Baseline				
Year	**Jan 1 - Mar 15**	**Mar 16 - Jun 30**	**Jul 1 - Sept 30**	**Oct 1 - Dec 31**
2028	-	280,000	10,000	110,000
2029	-	350,000	-	50,000
2030	-	330,000	-	40,000
2031	-	310,000	-	40,000
2032	-	350,000	-	40,000
2033	-	690,000	40,000	150,000
2034	-	710,000	40,000	160,000
2035	-	710,000	40,000	170,000
2036	-	970,000	150,000	170,000
2037	-	910,000	110,000	210,000
2038	-	930,000	110,000	240,000
2039	-	920,000	110,000	260,000
2040	-	930,000	150,000	200,000
2041	-	920,000	110,000	260,000
2042	-	930,000	110,000	240,000
2043	-	890,000	150,000	240,000
2044	38,000	890,000	150,000	190,000
2045	-	900,000	150,000	240,000
2046	40,000	930,000	110,000	300,000
2047	38,000	920,000	150,000	280,000
2048	40,000	930,000	190,000	210,000
2049	38,000	920,000	150,000	240,000
2050	38,000	890,000	150,000	240,000
2051	40,000	850,000	150,000	250,000
2052	40,000	970,000	190,000	210,000
2053	-	930,000	150,000	290,000
2054	45,000	930,000	190,000	310,000
2055	82,000	1,030,000	190,000	340,000
2056	54,000	1,080,000	280,000	240,000

Sources: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/Modelling%20Results%20for%20Report/CAPR003306_Report_Scenario_Results_Tracker_RevB_20250911.xlsx?web=1

Figure 5-1: Life of Mine Total Storage Utilization (Based on Scenario 1: Baseline)



Sources: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/Modelling %20Results%20for%20Report/CAPR003306_Report_Scenario_Results_Tracker_RevB_20250911.xlsx?web=1

5.3 Groundwater Pumping Requirements

Groundwater pumping will play an important role in supporting operations, primarily to ensure a reliable water supply for the concentrator during periods of low water inventory (winter). The site currently has existing groundwater wells that have been tested and have established sustainable long-term pumping rates (Richelieu, 2023; SRK, 2025). However, modelling indicates that supplemental pumping wells may be needed to provide additional groundwater, beyond what is currently available to meet operational demands. Within the WBM, groundwater was assumed to be pumped directly to BC-2. Existing wells were assumed to activate when the volume in BC-2 drops below 50,000 m³, and supplemental wells were engaged when the volume falls below 20,000 m³.

The volume of groundwater required is influenced by several factors, including storage levels in BC-1, BC-Sud, and BC-2, discharge limitations, water storage targets and various site water needs such as those for the concentrator and dust suppression. Storing more water during critical times can reduce groundwater demand, but it also heightens the risk of exceeding storage limits and having to discharge water outside of the designated window. Therefore, careful consideration should be given to increasing onsite storage if additional groundwater extraction is not preferred, or if maintaining higher pond levels poses operational risks.

Groundwater demand is projected to be highest during the initial phases of operation when the site's footprint is smaller, and less storage is available. As mining progresses and more contact water is generated, groundwater demand is expected to decrease. The commissioning of BC-Sud will significantly expand available storage, nearly doubling total site capacity. The potential for optimizing

groundwater use by targeting storage more strategically throughout the year and refining the logic for water transfers between BC-1, BC-Sud, and BC-2 has not yet been explored but could lead to substantial reductions in groundwater demand.

Current modelling results (**Table 5-3**) suggest that supplemental groundwater supply may need to be three to four times the existing system's capacity to meet peak demands. An additional strategy worth considering is bringing BC-Sud online earlier in the project, allowing it to collect water that can be used by the concentrator, thus reducing reliance on groundwater pumping. Re-evaluating pumping rates and logic from BC-Sud during periods when BC-2 is requesting additional groundwater could further optimize system performance.

Table 5-3: Annual Groundwater Demand (m^3) - Summary Volumes Pumped from Existing and Supplemental Wells (All Scenarios)

Year	Average			Minimums			Maximums		
	Existing	Supplemental	Total	Existing	Supplemental	Total	Existing	Supplemental	Total
2028	220,000	280,000	500,000	180,000	210,000	400,000	250,000	360,000	610,000
2029	230,000	570,000	790,000	200,000	450,000	650,000	240,000	680,000	920,000
2030	230,000	580,000	810,000	200,000	460,000	660,000	240,000	650,000	890,000
2031	230,000	590,000	820,000	210,000	480,000	690,000	240,000	650,000	890,000
2032	240,000	590,000	830,000	230,000	480,000	700,000	250,000	690,000	940,000
2033	190,000	410,000	600,000	170,000	370,000	540,000	220,000	500,000	720,000
2034	180,000	380,000	550,000	150,000	310,000	470,000	210,000	490,000	710,000
2035	180,000	370,000	550,000	160,000	290,000	450,000	220,000	480,000	700,000
2036	160,000	330,000	480,000	150,000	280,000	440,000	170,000	380,000	550,000
2037	150,000	310,000	460,000	120,000	270,000	400,000	170,000	330,000	500,000
2038	150,000	300,000	450,000	130,000	250,000	400,000	180,000	370,000	550,000
2039	160,000	300,000	450,000	140,000	240,000	390,000	180,000	400,000	580,000
2040	160,000	290,000	440,000	150,000	250,000	390,000	180,000	400,000	580,000
2041	150,000	270,000	420,000	140,000	210,000	350,000	180,000	390,000	560,000
2042	150,000	270,000	420,000	140,000	220,000	370,000	180,000	370,000	550,000
2043	150,000	270,000	420,000	140,000	210,000	350,000	170,000	390,000	560,000
2044	150,000	270,000	420,000	140,000	190,000	340,000	170,000	380,000	550,000
2045	150,000	260,000	410,000	140,000	200,000	340,000	170,000	380,000	550,000
2046	160,000	260,000	420,000	150,000	180,000	340,000	170,000	360,000	530,000
2047	150,000	240,000	390,000	140,000	170,000	320,000	170,000	350,000	520,000
2048	150,000	250,000	400,000	140,000	160,000	300,000	170,000	360,000	540,000
2049	160,000	250,000	410,000	150,000	190,000	350,000	180,000	360,000	540,000
2050	150,000	240,000	390,000	140,000	150,000	280,000	180,000	350,000	530,000
2051	150,000	220,000	370,000	140,000	170,000	320,000	170,000	320,000	490,000
2052	150,000	210,000	360,000	140,000	160,000	310,000	170,000	320,000	490,000
2053	150,000	200,000	350,000	140,000	150,000	290,000	170,000	300,000	470,000
2054	130,000	150,000	280,000	120,000	110,000	230,000	150,000	230,000	380,000
2055	140,000	150,000	280,000	120,000	110,000	240,000	150,000	240,000	390,000
2056	100,000	80,000	180,000	90,000	50,000	130,000	120,000	140,000	260,000

Sources: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/Modelling%20Results%20for%20Report/CAPR003306_Report_Scenario_Results_Tracker_RevB_20250911.xlsx?web=1

5.4 Directive 019 Compliance

The Directive 019 event was modelled as a stress test to evaluate whether the ponds and overall water management system can comply with regulatory requirements and prevent discharge during a significant storm event. The modelling assumptions for this analysis are detailed in the Design Basis (**Attachment B**).

The Directive 019 event was tested using the spring event (1-in-2,000-year 24-hour rain event combined with the average 30-day snowmelt derived from the 1:100-year snowpack) as this has been previously shown to be the critical event for the site (SRK, 2024).

In this scenario, success was defined by the absence of overflow during the event, should an overflow occur, it would indicate a need to revisit pumping rates, operational logic, or pond sizing.

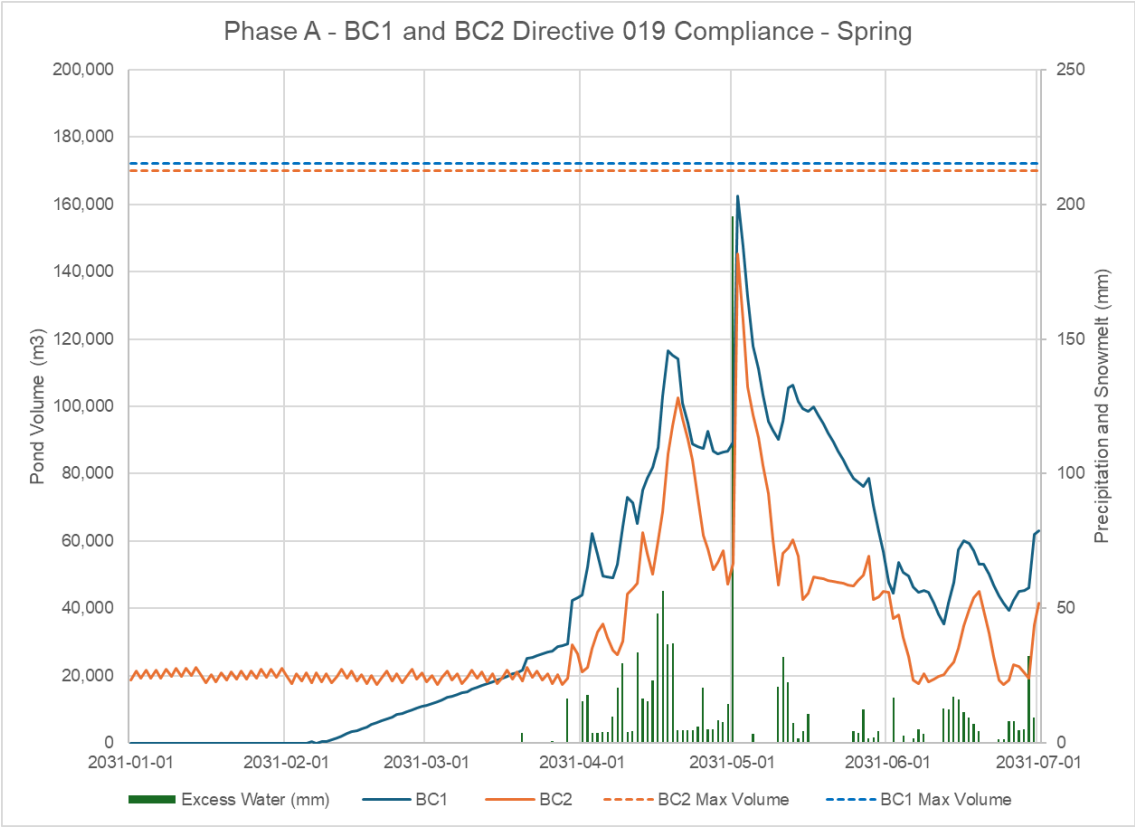
The event was simulated for two critical time periods:

- the end of Phase A (year 2031)
  - This period was selected to stress test the initial water management infrastructure. This year was selected as it highlights the most contributing area prior to expansion of the system in Phase B1.
- the start of Phase B2 (year 2038)
  - This period was selected to stress test the complete water management system at the point in the mine plan when the entirety of the planned catchment is active. The intention was to demonstrate the performance of the system and identify whether additional expansions are required later in the mine plan.

Results for Phase A (**Figure 5-2**) demonstrate that neither pond experiences overflow during the event. Similarly, Phase B2 results (**Figure 5-3**) confirm that all ponds avoid overflow, though BC-Sud approaches its maximum storage volume. Pond utilization volumes are shown as solid lines (blue for BC1, orange for BC2, and green for BC-Sud), while maximum pond volumes are represented by dashed lines in the same colors. Daily precipitation and snowmelt (referred to as "Excess Water" in modeling terminology) are depicted by vertical bars.

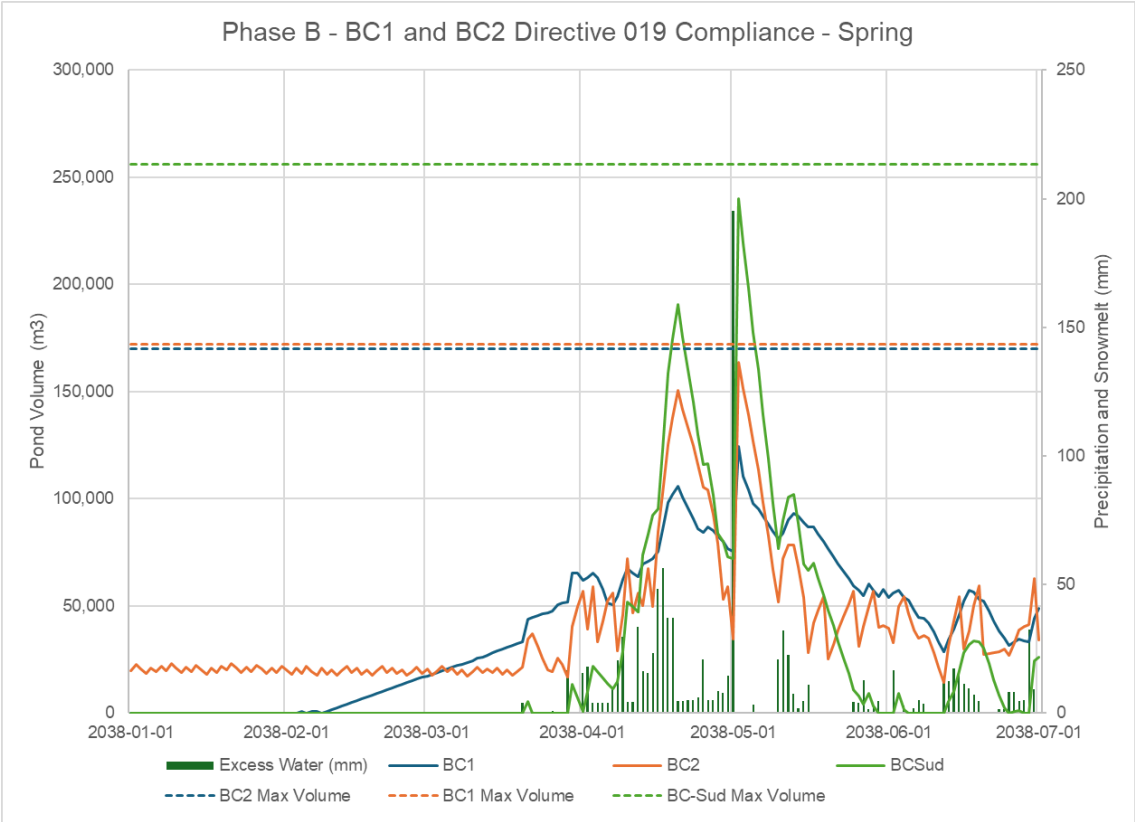
Overall, the ponds appear capable of containing and managing the Directive 019 event across all tested scenarios. However, each pond operates near its capacity limit—BC1 in Phase A, and both BC2 and BC-Sud in Phase B2.

Figure 5-2: Directive 019 Compliance for Phase A (2031)



Sources: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/Modelling %20Results%20for%20Report/CAPR003306_Report_Scenario_Results_Tracker_RevB_20250911.xlsx?web=1

Figure 5-3: Directive 019 Compliance for Phase B2 (2038)



Sources: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/Modelling %20Results%20for%20Report/CAPR003306_Report_Scenario_Results_Tracker_RevB_20250911.xlsx?web=1

6 Summary and Conclusions

6.1 Annual Discharge

Estimates of annual discharge to Ruisseau a L'Eau Morte are summarized in **Table 6-1**.

Table 6-1: Estimated Discharge to Ruisseau a L'Eau Morte (All scenarios)

Phase	Annual Discharge (m^3)		
	Mean	Minimum	Maximum
A	390,000	240,000	550,000
B1	790,000	590,000	1,030,000
B2	1,330,000	1,020,000	1,640,000

Sources: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/Modelling%20Results%20for%20Report/CAPR003306_Report_Scenario_Results_Tracker_RevB_20250911.xlsx?web=1

Mean annual discharge volumes align closely with those projected for Scenario 1 (Baseline). The minimum and maximum annual volumes correspond to Scenario 5 (Dust Suppression -50%) and Scenario 4 (Dust Suppression +50%), respectively, highlighting the sensitivity of the water balance to variations in dust suppression demand.

6.2 Discharge Window Compliance

Estimated annual discharge compliance for the LOM are summarized in **Table 6-2**.

Table 6-2: Estimated Discharge Window Discharge for Baseline scenario

Phase	Jan 1 - Mar 15			Mar 16 - Jun 30			Jul 1 - Sep 30			Oct 1 - Dec 31		
	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
A	-	-	-	318,000	280,000	350,000	3,000	-	10,000	60,000	40,000	110,000
B1	-	-	-	615,000	350,000	710,000	30,000	-	40,000	130,000	40,000	170,000
B2	23,000	-	82,000	932,000	850,000	1,080,000	152,000	110,000	280,000	246,000	170,000	340,000

Sources: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/Modelling%20Results%20for%20Report/CAPR003306_Report_Scenario_Results_Tracker_RevB_20250911.xlsx?web=1

These results indicate that:

- Discharge windows are seasonally defined to ensure site water is only released when flows in Ruisseau à L'Eau Morte exceed 182 L/s, with no discharge planned during winter and summer low-flow periods. The stored water in the ponds will be used to supply the concentrator.

- Exceeding pond maximum operating water levels can trigger treated water releases outside of designated discharge windows, but optimizing storage and transfers between ponds can help prevent unnecessary discharges.
- Permitting considerations should allow for the discharge of treated water to the environment during periods when pond water levels need to be lowered to reduce the risk of exceeding the maximum allowable water level.
- Although not modelled in this report, NMG expects that treated water could be discharged outside of the designated discharge windows when Ruisseau à L'Eau Morte exceeds 182 L/s (such as during or after a rainfall event).

6.3 Groundwater Pumping Requirements

Estimated annual groundwater requirements for the LOM are summarized in **Table 6-3**.

Table 6-3: Estimated Summary of Groundwater Pumping Requirements per Phase (All scenarios)

Phase	Average			Min			Max		
	Existing	Supplemental	Total	Existing	Supplemental	Total	Existing	Supplemental	Total
A	228,000	505,000	730,000	198,000	400,000	600,000	243,000	585,000	828,000
B1	198,000	438,000	633,000	178,000	363,000	540,000	225,000	540,000	768,000
B2	149,000	244,000	390,000	136,000	187,000	328,000	169,000	339,000	508,000

Sources: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/Modelling%20Results%20for%20Report/CAPR003306_Report_Scenario_Results_Tracker_RevB_20250911.xlsx?web=1

These results indicate that:

- Groundwater pumping is essential to ensure a reliable water supply for the concentrator, especially during low inventory periods. Supplemental wells may be needed to meet demand as operations expand.
- The amount of groundwater required depends on storage levels in site ponds, discharge opportunities, and site water needs; carefully balancing storage and extraction is needed to avoid excess discharge outside approved windows.
- Optimizing water transfers between ponds, bringing BC-Sud online earlier, and revising current pumping strategies could significantly reduce groundwater demand and reliance on supplemental wells.

6.4 Directive 019 Compliance

The model results indicate that BC-1, BC-2, and BC-Sud have sufficient capacity to contain and manage the Directive 019 event for both Phase A and Phase B. However, it is important to note that both BC-1 and BC-Sud utilize nearly all their available storage during this event.

A mitigation option is the potential to pump back water from the ponds to the pit during/after later events to utilize the pit's temporary storage capacity. This should be modelled to assess the potential benefits for managing risk during the D019 event.

NMG should review these findings to ensure they are consistent with the operator's risk tolerance and consider whether additional contingency measures are required.

6.5 Limitations

6.5.1 Pumping Logic

- The pumping logic used in the model (see Design Basis Memo for decision trees) is straightforward and effective for high-level flow management. However, given the complexity of the site water management system, this simplified approach leads to inefficiencies when simulating pond operations.
- As a result, the current pumping logic allows discharge to occur outside the designated discharge window even when there is still available storage capacity within the system.

6.5.2 Discharge Windows and Streamflow

- The discharge windows in the current model do not account for actual environmental flows, which may result in predicted non-compliance events. Streamflow could be higher due to precipitation, potentially allowing for compliant discharges during these periods.

6.6 Recommendations

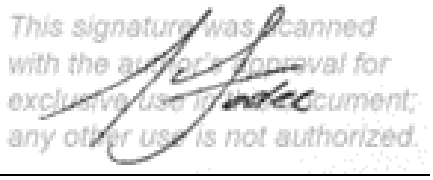
To improve this analysis, SRK offers the following recommendations for NMG's consideration:

- Revise the pumping logic to optimize water storage to both meet concentrator demand and satisfy environmental discharge constraints. This revision should be developed collaboratively with the NMG operational team and must include detailed operational logic for minimum, functional, normal, and maximum operating levels for each pond.
- To represent streamflow dynamics more realistically and reduce reliance on fixed discharge windows, a dedicated precipitation-runoff model for Ruisseau à L'Eau Morte is recommended. Calibrating such a model would allow discharge to be dynamically linked to actual streamflow, providing a more accurate and defensible approach for compliance management.
- Site-specific studies should be conducted for future WBM updates to improve confidence in runoff coefficients.

- Consider installing supplemental groundwater wells to meet operational water demands, especially during periods of low water inventory.
- Evaluate the benefits and risks of increasing onsite water storage to reduce reliance on groundwater pumping, while balancing the risk of needing to discharge outside of designated windows.
- Explore optimization of groundwater demand by strategically targeting storage levels throughout the year and refining water transfer logic between BC-1, BC-Sud, and BC-2.
- The implementation of BC-Sud should be coordinated with the CDF development plan schedule and mining sequence to ensure that water collection infrastructure and the water balance model remain aligned. Additionally, the construction sequence for surface water management infrastructure should be assessed for potential optimization, with the goal of increasing operational flexibility and reducing groundwater pumping requirements.
- Update the LOM catchment evolution within the model whenever mine plan details, such as pit progression and CDF deposition schedules, are revised. This will help ensure that changes remain consistent with water management infrastructure and operational water requirements.
- Re-evaluate the pumping rates from BC-Sud to ensure efficient transfer of water to BC-2, especially when BC-Sud has available water and BC-2 is requesting groundwater supply.
- Monitor and adapt to changing groundwater needs as the mine footprint, storage capacity, and contact water generation evolve over the life of the mine.
- Review and discuss the planned storage volume for BC-Sud. While the current storage volume meets Directive 019 requirements, there is no additional contingency capacity. Consider potential operational risks and explore options for increasing storage flexibility or contingency planning.

Closure

This report, GoldSim Model Build: Water Balance Model, was prepared by



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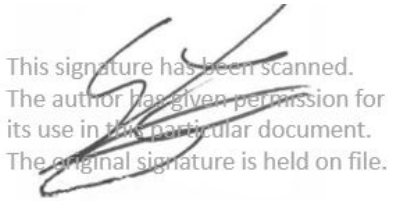
Senior Consultant

and reviewed by



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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

References

Richelieu Hydrogéologie Inc., 2023. Nouveau monde Graphite. Etude Hydrologique. Alimentation en eau potable Project Matawinie. September 2023.

SRK Consulting (Canada) Inc., 2024. Site overall Water Balance for BC1 and BC2 Sizing. Memo. Prepared for Nouveau Monde Graphite – Matawinie Site. Saint-Michel-des-Saints. Québec. Project number: CAPR002717. Issued July 19, 2024

SRK, 2025a. GoldSim Design Basis Memorandum. FINAL. Prepared for Nouveau Monde Graphite – Matawinie Site. Saint-Michel-des-Saints. Québec. Project number: CAPR003306.

SRK Consulting (Canada) Inc., 2025b.Baseline Climate Analysis. FINAL. Prepared for Nouveau Monde Graphite – Matawinie Site. Saint-Michel-des-Saints. Québec. Project number: CAPR003306. Issued April 8, 2025.

SRK Consulting (Canada) Inc., 2025c Climate Change Analysis. FINAL. . Prepared for Nouveau Monde Graphite – Matawinie Site. Saint-Michel-des-Saints. Québec. Project number: CAPR003306. Issued April 7, 2025.

Appendix A Additional Table

All Scenario Summary Results

Year	Baseline + CC			Wet			Dry			Dust +50%			Dust -50%			GW +50%			GW -50%			Average			Min			Max		
	Existing	Supplemental	Total	Existing	Supplemental	Total	Existing	Supplemental	Total	Existing	Supplemental	Total	Existing	Supplemental	Total	Existing	Supplemental	Total	Existing	Supplemental	Total	Existing	Supplemental	Total	Existing	Supplemental	Total	Existing	Supplemental	Total
2028	218,000	261,000	478,000	218,000	261,000	478,000	250,000	364,000	613,000	243,000	316,000	558,000	182,000	214,000	396,000	207,000	238,000	444,000	224,000	285,000	509,000	218,000	261,000	478,000	218,000	261,000	478,000	250,000	364,000	613,000
2029	226,000	560,000	786,000	226,000	560,000	786,000	244,000	675,000	919,000	237,000	638,000	875,000	197,000	453,000	650,000	219,000	497,000	716,000	230,000	600,000	831,000	226,000	560,000	786,000	226,000	560,000	786,000	244,000	675,000	919,000
2030	233,000	597,000	830,000	228,000	554,000	782,000	239,000	647,000	886,000	239,000	646,000	885,000	203,000	461,000	664,000	230,000	546,000	777,000	232,000	634,000	866,000	233,000	597,000	830,000	228,000	554,000	782,000	239,000	647,000	886,000
2031	233,000	621,000	854,000	208,000	519,000	727,000	242,000	637,000	880,000	239,000	638,000	877,000	208,000	480,000	688,000	231,000	569,000	800,000	233,000	654,000	886,000	233,000	621,000	854,000	208,000	519,000	727,000	242,000	637,000	880,000
2032	244,000	600,000	845,000	234,000	543,000	777,000	246,000	690,000	936,000	239,000	624,000	862,000	225,000	475,000	701,000	244,000	538,000	781,000	242,000	636,000	878,000	244,000	600,000	845,000	234,000	543,000	777,000	246,000	690,000	936,000
2033	180,000	408,000	588,000	180,000	408,000	588,000	216,000	504,000	720,000	182,000	389,000	570,000	169,000	370,000	539,000	180,000	370,000	550,000	189,000	422,000	612,000	180,000	408,000	588,000	180,000	408,000	588,000	216,000	504,000	720,000
2034	172,000	355,000	527,000	172,000	355,000	527,000	211,000	494,000	706,000	180,000	384,000	564,000	153,000	311,000	465,000	174,000	336,000	510,000	178,000	398,000	576,000	172,000	355,000	527,000	172,000	355,000	527,000	211,000	494,000	706,000
2035	177,000	365,000	542,000	177,000	366,000	543,000	215,000	482,000	696,000	179,000	368,000	547,000	161,000	293,000	454,000	171,000	311,000	482,000	187,000	427,000	614,000	177,000	365,000	542,000	177,000	366,000	543,000	215,000	482,000	696,000
2036	156,000	317,000	473,000	153,000	312,000	465,000	174,000	376,000	550,000	159,000	335,000	494,000	154,000	298,000	452,000	154,000	282,000	437,000	159,000	355,000	514,000	156,000	317,000	473,000	153,000	312,000	465,000	174,000	376,000	550,000
2037	147,000	305,000	451,000	121,000	274,000	395,000	171,000	326,000	497,000	154,000	310,000	464,000	160,000	323,000	483,000	156,000	288,000	444,000	152,000	317,000	469,000	147,000	305,000	451,000	121,000	274,000	395,000	171,000	326,000	497,000
2038	154,000	287,000	441,000	132,000	269,000	401,000	179,000	368,000	547,000	154,000	296,000	449,000	148,000	281,000	429,000	155,000	250,000	404,000	153,000	322,000	475,000	154,000	287,000	441,000	132,000	269,000	401,000	179,000	368,000	547,000
2039	155,000	274,000	429,000	156,000	277,000	434,000	179,000	403,000	582,000	149,000	274,000	423,000	143,000	274,000	417,000	152,000	235,000	387,000	161,000	331,000	493,000	155,000	274,000	429,000	156,000	277,000	434,000	179,000	403,000	582,000
2040	150,000	264,000	415,000	150,000	264,000	415,000	181,000	399,000	580,000	150,000	264,000	414,000	149,000	245,000	393,000	155,000	250,000	405,000	166,000	321,000	486,000	150,000	264,000	415,000	150,000	264,000	415,000	181,000	399,000	580,000
2041	157,000	254,000	411,000	156,000	269,000	424,000	176,000	385,000	561,000	149,000	245,000	394,000	140,000	235,000	375,000	147,000	205,000	353,000	154,000	298,000	451,000	157,000	254,000	411,000	156,000	269,000	424,000	176,000	385,000	561,000
2042	150,000	257,000	407,000	148,000	253,000	402,000	177,000	371,000	548,000	154,000	257,000	410,000	143,000	230,000	374,000	156,000	221,000	377,000	151,000	285,000	435,000	150,000	257,000	407,000	148,000	253,000	402,000	177,000	371,000	548,000
2043	149,000	254,000	404,000	148,000	247,000	394,000	174,000	387,000	561,000	143,000	250,000	393,000	142,000	235,000	378,000	147,000	206,000	354,000	153,000	315,000	468,000	149,000	254,000	404,000	148,000	247,000	394,000	174,000	387,000	561,000
2044	153,000	269,000	421,000	152,000	264,000	416,000	171,000	378,000	549,000	146,000	269,000	414,000	140,000	211,000	351,000	151,000	193,000	344,000	157,000	306,000	462,000	153,000	269,000	421,000	152,000	264,000	416,000	171,000	378,000	549,000
2045	144,000	247,000	392,000	151,000	264,000	415,000	173,000	377,000	550,000	141,000	235,000	376,000	137,000	221,000	358,000	138,000	202,000	339,000	161,000	302,000	463,000	144,000	247,000	392,000	151,000	264,000	415,000	173,000	377,000	550,000
2046	154,000	248,000	402,000	155,000	255,000	411,000	172,000	356,000	529,000	156,000	259,000	415,000	150,000	232,000	381,000	155,000	182,000	337,000	159,000	303,000	462,000	154,000	248,000	402,000	155,000	255,000	411,000	172,000	356,000	529,000
2047	152,000	233,000	384,000	151,000	230,000	381,000	170,000	354,000	524,000	143,000	213,000	355,000	135,000	211,000	346,000	144,000	171,000	316,000	151,000	273,000	424,000	152,000	233,000	384,000	151,000	230,000	381,000	170,000	354,000	524,000
2048	154,000	256,000	409,000	154,000	231,000	385,000	171,000	363,000	535,000	152,000	230,000	382,000	143,000	207,000	351,000	140,000	163,000	303,000	153,000	279,000	432,000	154,000	256,000	409,000	154,000	231,000	385,000	171,000	363,000	535,000
2049	154,000	234,000	388,000	152,000	229,000	381,000	179,000	356,000	535,000	156,000	248,000	404,000	147,000	206,000	354,000	154,000	193,000	347,000	154,000	288,000	442,000	154,000	234,000	388,000	152,000	229,000	381,000	179,000	356,000	535,000
2050	152,000	235,000	387,000	149,000	211,000	360,000	178,000	347,000	525,000	152,000	216,000	368,000	146,000	224,000	370,000	135,000	149,000	284,000	158,000	289,000	447,000	152,000	235,000	387,000	149,000	211,000	360,000	178,000	347,000	525,000
2051	151,000	192,000	343,000	148,000	197,000	345,000	170,000	324,000	494,000	145,000	192,000	337,000	138,000	204,000	342,000	151,000	167,000	318,000	152,000	251,000	404,000	151,000	192,000	343,000	148,000	197,000	345,000	170,000	324,000	494,000
2052	152,000	182,000	335,000	152,000	182,000	335,000	172,000	317,000	489,000	147,000	178,000	324,000	142,000	206,000	348,000	148,000	163,000	311,000	150,000	254,000	404,000	152,000	182,000	335,000	152,000	182,000	335,000	172,000	317,000	489,000
2053	146,000	174,000	320,000	150,000	173,000	323,000	166,000	303,000	469,000	140,000	173,000	313,000	140,000	173,000	313,000	138,000	148,000	286,000	151,000	254,000	404,000	146,000	174,000	320,000	150,000	173,000	323,000	166,000	303,000	469,000
2054	129,000	129,000	258,000	130,000	123,000	253,000	149,000	234,000	383,000	126,000	132,000	258,000	123,000	118,000	241,000	123,000	110,000	233,000	136,000	179,000	315,000	129,000	129,000	258,000	130,000	123,000	253,000	149,000	234,000	383,000
2055	123,000	133,000	256,000	144,000	124,000	268,000	150,000	241,000	391,000	134,000	125,000	259,000	136,000	119,000	255,000	129,000	105,000	235,000	145,000	185,000	329,000	123,000	133,000	256,000	144,000	124,000	268,000	150,000	241,000	391,000
2056	91,000	73,000	164,000	94,000	69,000	162,000	115,000	143,000	258,000	92,000	72,000	164,000	90,000	70,000	160,000	85,000	46,000	130,000	110,000	107,000	217,000	91,000	73,000	164,000	94,000	69,000	162,000	115,000	143,000	258,000

Appendix B Design Basis Memo

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FINAL

Memo

To	Kevin Ducharme	**Client**	Nouveau Monde Graphite Inc.
From	Tony Fedec, EIT (BC), MEng	**Project**	CAPR003306
Cc	Jean-François St-Laurent, ing, PEng (ON), MSc, # OIQ 140 657 Charles Veilleux, ing, # OIQ 5 038 360 Camilo Gllard, ing, PEng (BC), MScEng, # OIQ 6 033 031 Brandon Smith, PEng (ON), MEng	**Date**	September 12, 2025
Subject	GoldSim Water Balance Design Basis Memorandum		

File name: NMG_Matawinie_CAPR003306_Water_Balance_Design_Basis_FINAL_20250912.docx

1 Introduction

Nouveau Monde Graphite Inc. (NMG) aims to be a major contributor to the energy transition from fossil fuels and to be a leader in the mining industry by developing, operating, and restoring the Matawinie graphite project, in accordance with the highest environmental, social, and governance (ESG) standards.

NMG will operate a world-class graphite open pit mine. Ore will be concentrated at the Matawinie plant site before being transported to Bécancour, Québec for further processing, an approach that will result in a high purity graphite concentrate intended for use in the manufacturing of battery anode materials. The planned Life-of-Mine (LoM) for the Matawinie project is 28 years, including construction and pre-mining phases (BBA, 2022).

In addition to the open pit mine and industrial area, a co-disposal facility (CDF) for tailings and waste rock, surface water management infrastructure (i.e., ditches and collection ponds), and an overburden (OVB) stockpile will be constructed on the mine site (the site).

SRK Consulting (Canada) Inc. (SRK) was engaged in 2023 to review and update a previously developed MS Excel-based water balance model (WBM) to support the sizing of storm management ponds (referred to as “BC” for *Bassin collecteur* in French). One of SRK’s recommendations from that work was to transition the model into a GoldSim format to allow for improved forecasting and modelling scenarios to support surface water management planning.

1.1 Project Location

The project is located in the Lanaudière region of Quebec, approximately 5 km southwest of the municipality of Saint-Michel-des-Saints, and 400 m west of Lac aux Pierres (**Figure 1-1**). An unpaved access road (Chemin de la Sagacité) between the project and Road 131/Chemin Brassard (**Figure 1-2**) was constructed by NMG between 2021 and 2022.

1.2 Scope of Work

SRK was retained by NMG to develop an operational WBM that would align with recommendations made during a past water balance modelling scope (SRK, 2024). These recommendations stated:

> *SRK understands that NMG requires an operational water balance tool to inform pond water levels during operations and to test detailed scenarios. The current Microsoft Excel-based WBM is not an optimal tool to achieve this, due to the structural limitations of spreadsheet models. SRK recommends building a new GoldSim-based model using the information from the existing WBM as a starting point. A GoldSim model will provide greater flexibility in testing scenarios and can be calibrated to observed data (pumping rates, pond water levels, temperature, precipitation, etc.) to create a more robust tool for operational decision making. The operational WBM should be developed to assess the response of subsequent events after the design storm.*

This memo provides the design basis for the GoldSim model and is expected to be a living document for NMG to revise and SRK to update as the mine plan and operational design are finalized.

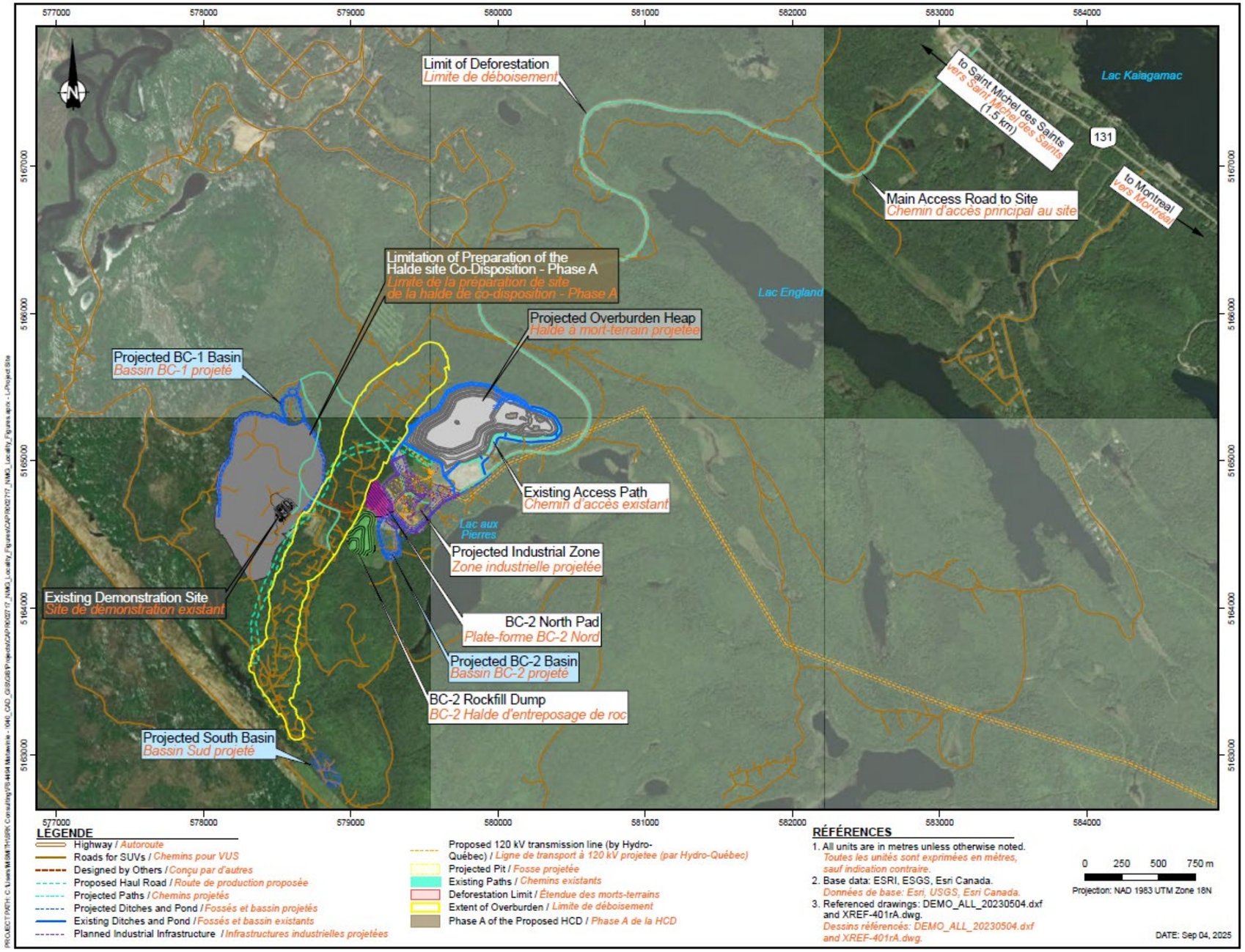
1.3 Memo Content

This memo is intended to summarize and present the WBM that will be used for the engineering of water ponds BC-1, BC-2, and BC-Sud. This memo is divided into the following sections:

- **Section 2**: Basis of Engineering / Modelling
  - Presents the design objectives, criteria, assumptions, parameters, and inputs.
- **Section 3**: Conceptual Model
  - Presents the conceptual water balance model and process flow diagram (PFD).
- **Section 4**: Water Management Objectives
  - Details the discharge strategy, concentrator storage requirements, pond operating water levels, operating rules and conditions, and pumping rates.
- **Section 5**: Closure

Figure 1-1: Matawinie Mining Project Location

Figure 1-2: Detailed Location Map



2 Basis of Modelling

2.1 Design Objectives

The main objective of the WBM was to determine how to optimally collect, store, and discharge water throughout the LoM while complying with environmental and operational objectives. Previous modelling efforts (SRK, 2024) were focused on sizing collection basins and associated infrastructure for the LoM. This stage of modelling was completed using the completed infrastructure sizing to support LoM operations and assess the performance of the site water management system under different climatic scenarios (e.g., wet years, dry years, etc.).

Specifically, the objective was to develop a surface water management plan that will:

- Inform collection, storage, treatment, and discharge of water to the environment while respecting discharge limits
- Ensure a supply of water to the concentrator year-round to maintain operations
- Ensure a supply of water for dust suppression to maintain safe operations
- Ensure that all collection basins are operated in compliance with applicable freeboard requirements (e.g., Environmental Design Flood).

2.2 Design Criteria

The main water management design criteria for the project are as follows:

- BCs shall be capable of holding the 24-hour 1:2,000-year rainfall event combined with the 1:100-year 30-day snowmelt, per Directive 019 (D019) (MDDELCC, 2025).
- The concentrator shall be supplied with water at all times of the year.

The WBM was therefore constructed to adhere to these criteria.

2.3 Phasing, Conditions, and Operating Rules

The GoldSim WBM was built to simulate the LoM, from 2028 (Year 0) through 2056 (Year 28) (with the option to model the closure phase as part of a future phase of work).

The project phases and key milestones pertaining to water management are as follows:

- Phase A – 2028 to 2032 (Year 0 – 4)
  - Early operations: the pit is established and in development, the CDF and the concentrator are built and operating, initial water management infrastructure is in place (i.e., BC-1, BC-2), and the first phase of the water treatment plant is operational.
  - Most of the planned mine catchments are contributing to ponds at this time.

- Phase B1 – 2033 to 2035 (Year 5 – 7)
  - The CDF is expanded towards the south and the impacted catchment area is increased.
  - The pit catchment will be fully developed in this phase.
  - BC-Sud Phase 1 is constructed and operational by 2033 and is collecting runoff in the southern portion of the site.
  - The WTP is doubled in size to reflect the additional runoff from BC-Sud.
- Phase B2 – 2036 to 2056 (Year 8 – 28) (**Figure 2-2**)
  - Catchment areas increase to reflect the expansion of the CDF and the pit. Catchments are now contributing the maximum runoff to site water management in Year 8.
  - BC-Sud Phase 2 is operational in 2036.
  - The pit will continue to increase in depth, but the catchment area will not expand. The CDF will overlap, resulting in in-pit tailings and mine rock disposal later in mining operations.
- Closure – 2057+
  - Closure details are not yet defined in the model.

The focus of the model was the current iteration of Phase A (**Figure 2-1**) to support early operational planning, using available information for relevant infrastructure (e.g., pond stage storage curves, production forecasts, etc.).

The WBM does not account for any progressive reclamation work to be completed on the CDF, which may reduce water collection needs over time.

Figure 2-1: Mining Phase A

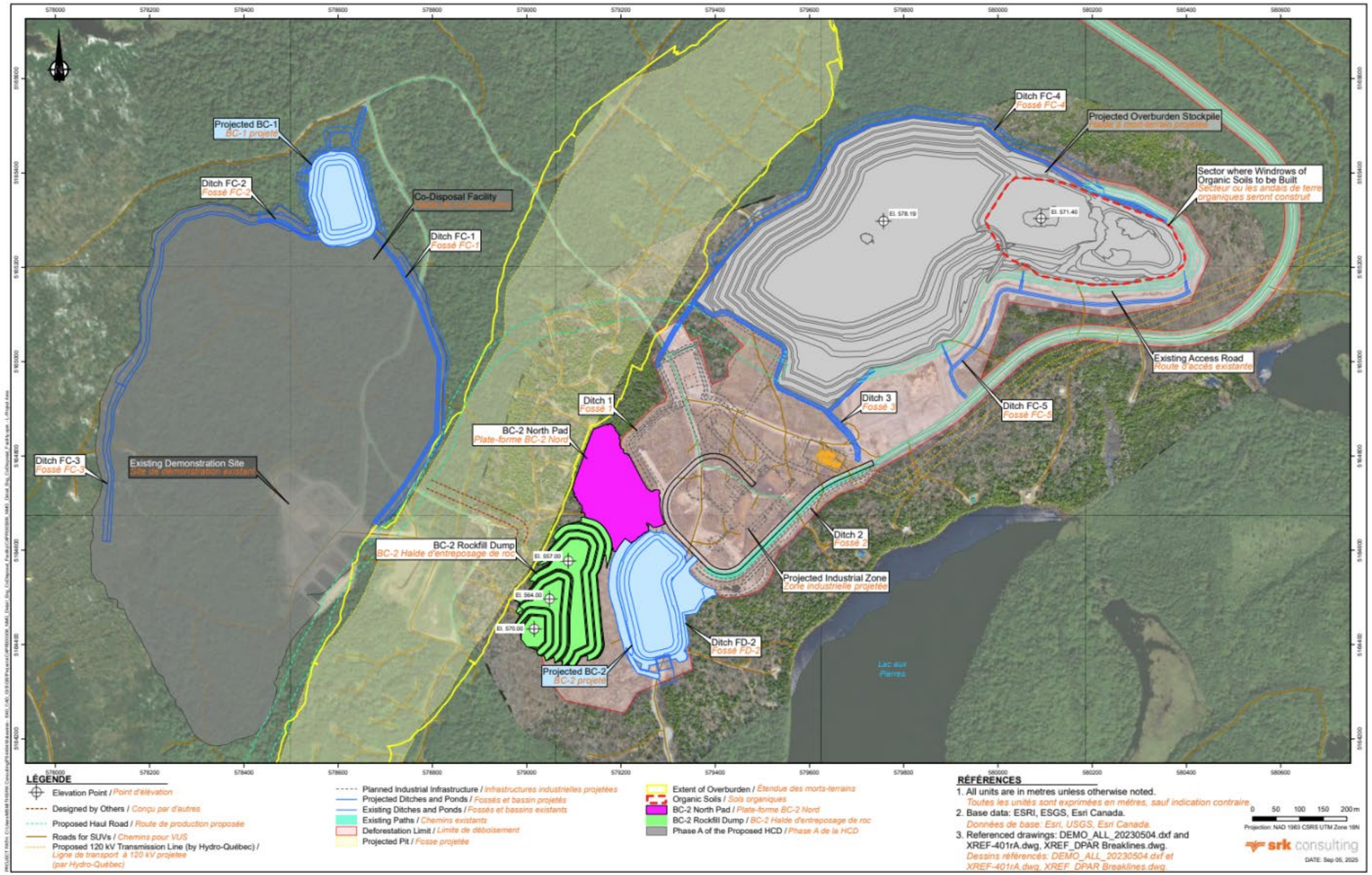


Figure 2-2: Mining Phase B

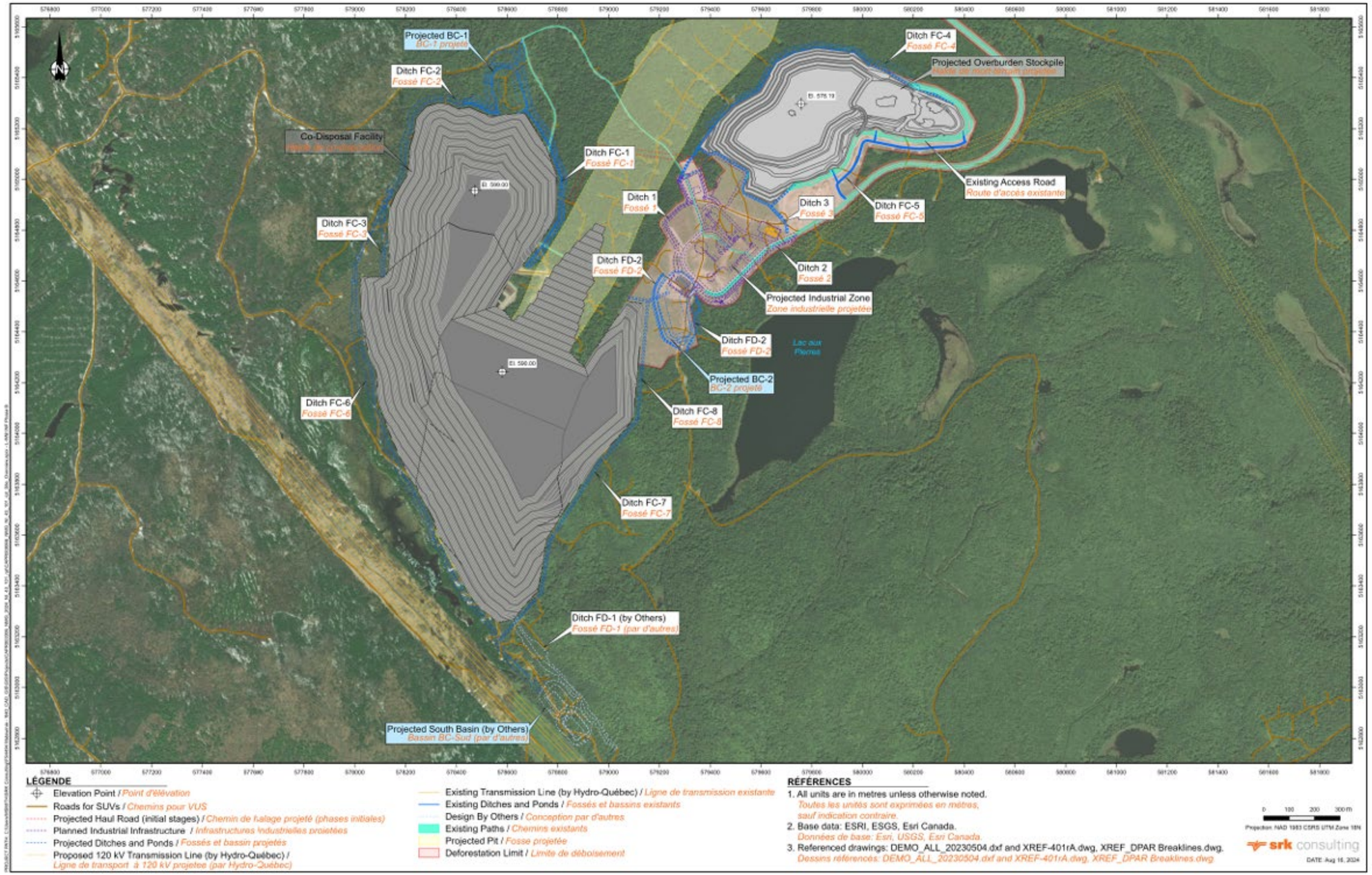


Table 2-1 and **Table 2-2** summarize the operating conditions and rules used to develop the WBM.

Table 2-1: WBM Operating Conditions

Facility	Condition/Rule	Value	Description
WTP	Maximum flow rate (Phase A)	900 m^3/h	Based on criteria established by NMG and Mabarex during a previous engineering phase (SRK, 2024).
	Maximum flow rate (Phase B1, B2)	1,800 m^3/h	Based on criteria established by NMG and Mabarex during a previous engineering phase.
BC-1	Minimum pond volume	2,400 m^3	This pond can be operated empty. Minimum volume established to account for sediment accumulation over time.
	Maximum pond volume	172,000 m^3	Per SRK (2024).
BC-2	Minimum pond volume	10,000 m^3	Minimum water level to be maintained to provide water for the mill and fire suppression.
	Maximum pond volume	170,000	Per SRK (2024).
BC-Sud	Minimum pond volume	2,400 m^3	This pond can be operated empty. Minimum volume established to account for sediment accumulation over time.
	Maximum pond volume	86,000 m^3 / 256,000 m^3	Per SRK (2024).

Source: Compiled in text

Table 2-2: WBM Operating Rules

Flows from	Operating Window	Water Source	Flows to	Description
BC-1	Year-round	Direct precipitation, contributing catchment, pit water	BC-2, Dust Suppression	▪ Collects water throughout the year, majority of runoff occurs between April and December. ▪ Receives pit water and provides settlement capacity. ▪ Operating objective is to strategically store and manage water to supply BC-2 to support concentrator operations during winter months.
Pit	Year-round	Direction precipitation, contributing catchment, groundwater inflow	BC-1, BC-2	▪ Pit receives water from direct precipitation, contributing catchment, and from groundwater inflow, all flows will be captured through pit dewatering. ▪ During winter months, groundwater will be the main inflows pumped from the pit.
Freshwater Tank	Year-round	WTP	Concentrator	▪ Treated water from WTP feeds the Freshwater Tank. ▪ Concentrator sources treated water from tank, as required. ▪ Tank has fixed volume (300 m^3) (Atkin comms, 2025).
Process Water Tank	Year-round	Freshwater Tank	Concentrator	▪ Water is sourced from the Freshwater Tank to the Process Water Tank. ▪ Concentrator sources treated water from tank, as required. ▪ Tank has fixed volume (300 m^3) (Atkin comms, 2025).
Concentrator	Year-round	Freshwater Tank, Process Water Tank	BC-2	▪ Concentrator sources water from the Freshwater Tank and Process Water Tank and discharges water back to BC-2 throughout the year. ▪ Concentrator freshwater demand ranges from 249.8 – 345.5 m^3/hr and returns 214 – 309.7 m^3/hr to BC-2. The concentrator runs a water deficit and requires a constant source to maintain operations throughout the year. ▪ Additional information found in Atkins Réalis (2023).
WTP	Year-round	BC-2	Freshwater Tank, BC-2, Environment	▪ Operating rates are fixed at low or high rates (350 m^3/hr, 900 m^3/hr / 1,800 m^3/hr). ▪ WTP required to support concentrator operations. ▪ Treated water can either be discharged to BC-2, Freshwater Tank, the Environment, or a combination of the three.
BC-Sud	Year-round	Direct precipitation, contributing catchment	BC-2	▪ Collects water throughout the year, majority of runoff occurs between April and December. ▪ Operating objective is to strategically store and manage water to supply BC-2 to support concentrator operations during winter months.
BC-2	Year-round	Direct precipitation, contributing catchment - Pumped water from BC-1, Concentrator return and eventually BC-Sud (+Y4)	WTP & Concentrator	▪ Operates year-round to collect water from contribution catchments and receives pumped water from all other ponds and the open pit. ▪ Provides water source to the concentrator, a portion of the water used is returned. ▪ Acts as a head pond for the WTP. ▪ Minimum operating volume is defined by fire suppression requirement (10,000 m^3)

Source: Compiled in text

2.4 Mine Plan

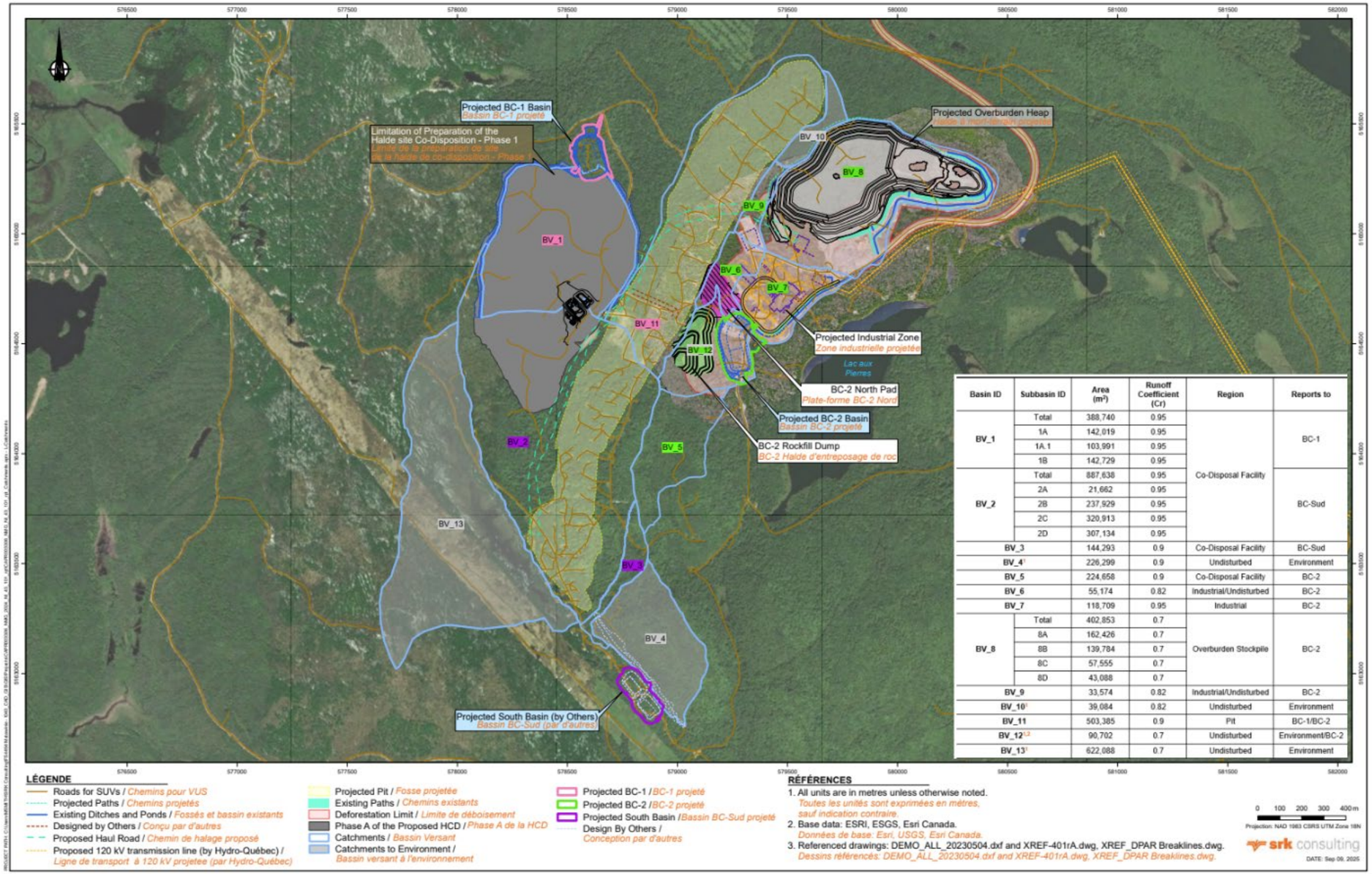
Catchment areas evolve throughout the project LoM, influencing runoff volume and BC storage availability over time. Changes in catchment areas are driven by the development of the pit, and the expansion of the CDF and the OVB stockpile. A detailed monthly breakdown of catchment areas over the LoM is provided as **Attachment 1**.

Catchment areas and sequencing used within the GoldSim model are the same as the Excel model. If catchment areas or deposition planning are updated in the future, the WBM will be updated to reflect the changes.

2.5 Catchment Areas and Runoff Model

Figure 2-3 illustrates the catchment areas used in the WBM. **Table 2-3** presents the catchment area details including area and estimated runoff coefficient (C_r). These runoff coefficients remain the same as the Excel model. During future WBM updates, site-specific studies should be conducted to improve confidence in runoff coefficients.

Figure 2-3: Matawinie Project Catchments



Basin ID	Subbasin ID	Area (m^2)	Runoff Coefficient (Cr)	Region	Reports to
BV_1	Total	388,740	0.95	Co-Disposal Facility	BC-1
	1A	142,019	0.95		
	1A.1	103,991	0.95		
	1B	142,729	0.95		
BV_2	Total	887,638	0.95		BC-Sud
	2A	21,662	0.95		
	2B	237,929	0.95		
	2C	320,913	0.95		
	2D	307,134	0.95		
BV_3		144,293	0.9	Co-Disposal Facility	BC-Sud
BV_4[1]		226,299	0.9	Undisturbed	Environment
BV_5		224,658	0.9	Co-Disposal Facility	BC-2
BV_6		55,174	0.82	Industrial/Undisturbed	BC-2
BV_7		118,709	0.95	Industrial	BC-2
BV_8	Total	402,853	0.7	Overburden Stockpile	BC-2
	8A	162,426	0.7		
	8B	139,784	0.7		
	8C	57,555	0.7		
	8D	43,088	0.7		
BV_9		33,574	0.82	Industrial/Undisturbed	BC-2
BV_10[1]		39,084	0.82	Undisturbed	Environment
BV_11		503,385	0.9	Pit	BC-1/BC-2
BV_12[1,3]		90,702	0.7	Undisturbed	Environment/BC-2
BV_13[1]		622,088	0.7	Undisturbed	Environment

Table 2-3: Catchment Summary (SRK, 2024)

Basin ID	Subbasin ID	Area (m^2)	Runoff Coefficient (Cr)	Region	Reports to
BV_1	Total	388,740	0.95	Co-Disposal Facility	BC-1
	1A	142,019	0.95		
	1A.1	103,991	0.95		
	1B	142,729	0.95		
BV_2	Total	887,638	0.95		BC-Sud
	2A	21,662	0.95		
	2B	237,929	0.95		
	2C	320,913	0.95		
	2D	307,134	0.95		
BV_3		144,293	0.9	Co-Disposal Facility	BC-Sud
BV_4[1]		226,299	0.9	Undisturbed	Environment
BV_5		224,658	0.9	Co-Disposal Facility	BC-2
BV_6		55,174	0.82	Industrial/Undisturbed	BC-2
BV_7		118,709	0.95	Industrial	BC-2
BV_8	Total	402,853	0.7	Overburden Stockpile	BC-2
	8A	162,426	0.7		
	8B	139,784	0.7		
	8C	57,555	0.7		
	8D	43,088	0.7		
BV_9		33,574	0.82	Industrial/Undisturbed	BC-2
BV_10[1]		39,084	0.82	Undisturbed	Environment
BV_11		503,385	0.9	Pit	BC-1/BC-2
BV_12[1,2]		90,702	0.7	Undisturbed	Environment/BC-2
BV_13[1]		622,088	0.7	Undisturbed	Environment

Notes:

1 Does not report to collection pond and is not accounted for in the model

2 BV-12 will be diverted for portions of the LOM to the receiving environment when no material is placed within the catchment. When material is present, runoff will report to BC-2

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

2.6 Ore Production

Mine plan throughputs are presented as tonnes per day from the pit to the concentrator. Throughput is based on estimates presented in **Table 2-4** (more detail is provided in **Attachment 4**). Throughput is expected to be consistent throughout operations, with a ramp-up at the start of operations and a ramp-down at the end.

Table 2-4: Daily Concentrator Throughput

Year	Daily Ore Input (tonnes/d)
2028	7,099
2029 – 2050	9,810
2051 – 2053	9,376
2054 – 2055	8,587
2056	7,491

Note: Reference data is not in sync with project schedule, data was updated to be aligned.

Source: 3936022-000000-4M-ECA-0011-RAA (NMG, 2025)

2.7 Concentrator

The concentrator requires water to process ore into concentrate. Water inputs and outputs are related to the throughput of the operation (**Section 2.6**) . Concentrator values are sourced from the updated feasibility study (BBA, 2025) (**Table 2-5**).

Table 2-5: Concentrator Operational Parameters (BBA, 2025)

Stream	Dry Solids (tpd)	Water (m^3/d)	Ratio (m^3 water /tonne)
Ore to Concentrator	7,764	409	0.053
Final Concentrate	322	1	0.003
Sulphide Filter Cake (PAG)	1,563	276	0.177
Non-Sulphide Filter Cake (NAG)	5,879	1,038	0.177
Evaporation from Dryer	-	56	0.006

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

The maximum design throughput values for estimating concentrator demand are listed in **Table 2-6**. A detailed breakdown of the inflow demands is provided in **Table 2-7**.

Table 2-6: Concentrator Inflow Requirements (NMG, 2025)

Parameter	Value	Unit
Max Freshwater Demand	249.8-345.5	m^3/hr
Max Design Throughput	9,837	tpd

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

Table 2-7: Concentrator Inflow Demand Details (Atkins comms, 2025)

	Constant flow (fresh water)	Nominal (m^3/h)	Max (m^3/h)	Notes
W121	Mill multidrive VFD cooling water	40.5	60	
W122	SAG mill lube system cooling water	2.4	5	
W123	Ball mill lube system cooling water	1.8	3.6	
W124	Polishing mill lube system cooling water	1.8	3.6	
W125	Compressors cooling loop heat exchanger	58.1	58.1	
W503	Water to graphite concentrate cooling screws	27	32.4	
W904	Total gland seal water	15.3	30.6	100% Design Factor vs Estimated Value in 2021
W903	Fresh water to process water tank	98.4	147.7	50% design factor
	Total Constant Flow Demand	**245.3**	**341**	
	Intermittent flow (fresh water)	**Average (m^3/h)**	**Inst. Flow (m^3/h)**	
W810	Fresh Water to Lime mix tank	0.1	0.1	Negligible flow rate. Marked as 0.1 for now (TBC)
W811	Fresh Water to Xanthate mix tank	0.2	10	10 m^3/h for 14 min, 0.6 to 1.3 times per day
W502	Concentrate Filter Press - Cloth wash water (Fresh Water)	1.5	10	10 m^3/h for 8 min, 27 times per day
W800	Fresh water to flocculant mix tank - graphite conc.	0.1	6	6 m^3/h for 5 min, 3 to 6 times per day
W809	Fresh water to flocculant mix tank - PAG, NAG, Tailings	2.6	24	24 m^3/h for 50 min, 3 to 6 times per day
	Total Intermittent Flow Demand	**4.5**	**50.1**	
	Total Concentrator Demand	**249.8**	**345.5**	Max = Max Constant Flow + Average Int Flow

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400- 4%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

Using the values from **Table 2-5** and **Table 2-6**, the forecasted water process inflows and outflows for the concentrator were generated (**Table 2-8**).

Table 2-8: Concentrator Inflow and Outflow Summary

Year	Water In with Ore (m^3/d)	Water Out with Final Concentrate (m^3/d)	Water out with PAG (m^3/d)	Water out with NAG (m^3/d)	Water out with Evaporation (m^3/d)
2028	374	22	252	949	40.4
2029 – 2050	518	31	350	1,315	56.0
2051 – 2053	494	29	333	1,254	53.4
2054 – 2055	452	27	305	1,148	48.9
2056	395	23	266	1,002	42.6

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG %20Input%20Tables%20202520512.xlsm?web=1

2.8 Climate

Climate inputs inform the quantity and timing of water that reports to collection basins at the site. Climate inputs include precipitation, air temperature, and evaporation.

SRK conducted a baseline climate analysis for the Matawinie Mine (SRK, 2025a) to provide site-specific climatic inputs for surface water management and engineering design. The results of this analysis serve as the baseline climate inputs for the WBM. In consultation with NMG, this information was used to select climate conditions for assessing the performance of the water management system. The WBM includes daily climate inputs for long-term average, 1-in-100-year dry year (Dry100), and 1-in-100-year wet year (Wet100) conditions.

The historical year 2018 was determined to be a representative year of average conditions. Representative timeseries of Wet100 and Dry100 years were synthesized using representative months from historical records to create composites. Further information is detailed in **Attachment 5**. These climate data were then used as inputs to model hydrological processes (e.g., evaporation, snowmelt).

Climate change scenarios were evaluated (SRK, 2025b) and the results of the study are included in the model for scenario evaluation.

2.8.1 Precipitation

Monthly precipitation inputs for Average, Dry100, and Wet100 climate regimes are summarized in **Table 2-9**.

Table 2-9: Monthly Precipitation Inputs Summary (mm)

Month	Average	Dry100	Wet100
January	78.7	38.1	63.9
February	66.5	33.5	90.0
March	60.3	68.6	119.3
April	94.1	37.3	105.6
May	70.7	61.2	128.0
June	102.3	114.3	185.2
July	143.7	82.2	98.6
August	91.4	53.8	110.3
September	89.1	142.8	142.8
October	84.1	63.4	122.8
November	118.9	82.1	82.1
December	85.0	84.6	94.8
Total	1084.9	862.0	1343.5

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

2.8.2 Environmental Design Flood

Directive 019, issued by Quebec's Ministry of the Environment, sets out environmental requirements for the mining industry, including criteria for the design and sizing of water management infrastructure such as sedimentation ponds, polishing ponds, and water retention structures.

Directive 019 designates that the environmental design flood (EDF) ponds must contain the 1-in-2,000-year 24-hour rainfall event combined with the average 30-day snowmelt from the 1:100-year snowpack (MDDELCC, 2025).

Design storms can vary in intensity between spring and summer (**Table 2-10**).

Table 2-10: Spring and Annual Design 24h Storms (SRK, 2025)

Return Period (Years)	Spring Daily Precipitation (mm)	Summer Daily Precipitation (mm)
2	32	56
2.3	34	60
5	45	76
10	55	89
20	66	102
25	70	107
50	83	120
100	96	134
200	111	148
500	133	168
1,000	151	183
2,000	171	199
10,000	224	239

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

- The D019 conditions, defined as a 1-in-2,000-year 24-hour rain event combined with the average 30-day snowmelt derived from the 1:100-year snowpack, were assessed based on the framework and assumptions outlined in the guidance provided by NMG.
- Spring rain-on-snow event modelling approach:
  - Two consecutive 1-in-100 wet years are modelled to ensure that a 1-in-100-year snowpack (snowpack is expected to accumulate between November and April) is developed for testing the design event. This ensures that the full hydrologic year is captured for the snowpack depth. 171 mm of rainfall attributable to the 1-in-2000-year 24-hour spring rainfall (SRK, 2025; Attachment 5). The rainfall event will occur at the end of the snowpack melt, when the remaining snowpack depth equals the snowmelt potential of the rainfall design event.
- Summer/Fall rainfall event:
  - The design summer/fall flood (i.e., 1-in-2,000-year 24-hour rainfall event) corresponds to a storm depth of 199 mm with no snowpack or snowmelt involved.

This information was used to determine EDF volumes as part of the operating water level assignment (**Section 4.3**).

2.8.3 Air Temperature

Air temperature inputs from the NMG Baseline Climate Analysis (SRK, 2025) were reviewed and updated by SRK for use in the WBM. Results from SRK (2025) were used to generate temperatures associated with three chosen climatic scenarios (i.e., long-term average, Dry100, Wet100).

Further details on rationale for these scenarios are presented in SRK (2025). The range is intended to present suitably variable conditions that could occur during the LoM (28 years). Monthly averaged air temperatures are summarized in **Table 2-11**.

Table 2-11: Monthly Averaged Air Temperature

Month	Average			Dry100			Wet100		
	Tmax	Tmin	Tavg	Tmax	Tmin	Tavg	Tmax	Tmin	Tavg
January	-8.2	-20.2	-14.2	-7.4	-20.0	-13.7	-5.2	-20.1	-12.7
February	-2.9	-16.7	-9.8	-7.9	-22.5	-15.2	-6.2	-21.0	-13.6
March	0.1	-8.9	-4.4	3.7	-8.2	-2.2	2.0	-11.0	-4.5
April	4.0	-7.6	-1.8	13.2	-1.2	6.0	8.0	-4.0	2.0
May	18.6	2.0	10.3	16.1	1.5	8.8	15.3	2.7	9.0
June	21.4	7.0	14.2	20.4	8.7	14.5	20.6	9.7	15.1
July	25.5	12.4	18.9	25.0	11.6	18.3	24.1	11.0	17.5
August	24.2	12.7	18.5	20.8	7.7	14.3	23.3	11.9	17.6
September	18.8	6.7	12.8	18.0	4.8	11.4	18.0	4.8	11.4
October	6.7	-1.1	2.8	9.0	-0.8	4.1	7.8	-0.1	3.8
November	-2.0	-9.2	-5.6	3.8	-4.5	-0.4	3.8	-4.5	-0.4
December	-5.2	-16.4	-10.8	-4.4	-13.1	-8.7	-8.6	-19.4	-14.0
Annual	**8.4**	**-3.3**	**2.6**	**9.2**	**-3.0**	**3.1**	**8.6**	**-3.3**	**2.6**

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG %20Input%20Tables%20202520512.xlsm?web=1

2.8.4 Evaporation

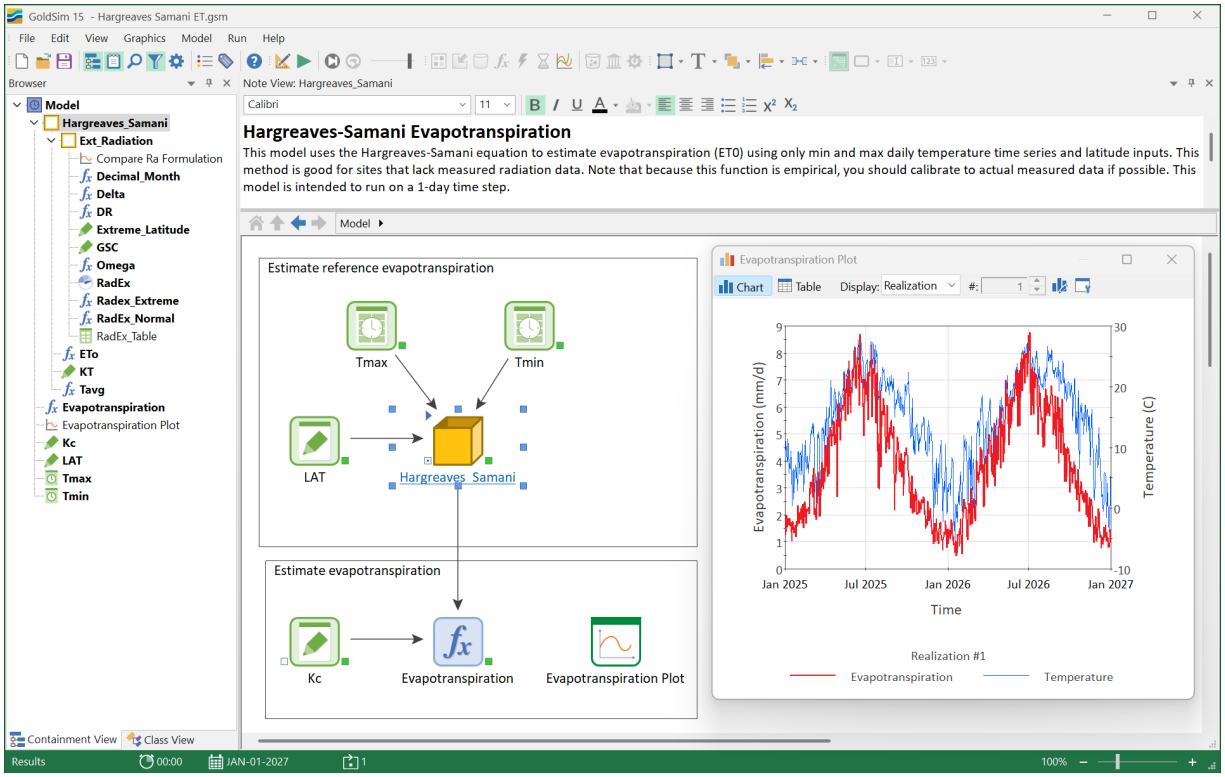
The Hargreaves-Samani evapotranspiration (ET) model is an empirical method used to estimate reference ET based on temperature data (Hargreaves & Samani,1985). It simplifies the more complex Penman-Monteith equation by relying primarily on daily maximum and minimum temperatures, along with extraterrestrial solar radiation. The model is expressed as:

$$ET_0 = 0.0023 \times (T_mean + 17.8) \times (T_max - T_min)^{0.5} \times R_a$$

where T_mean is the average temperature, T_max and T_min are the daily maximum and minimum temperatures, and R_a is the extraterrestrial radiation. Due to its minimal data requirements, it is widely used in areas where detailed meteorological data (e.g., humidity, wind speed) are unavailable.

The Hargraves-Samani method was used to estimate potential evapotranspiration (PET) using maximum and minimum air temperature data (**Section 2.8.3**), and extraterrestrial radiation estimated from site latitude. PET was estimated within the NMG model using the GoldSim Hargreaves-Samani package (**Figure 2-4**) with air temperature data series from the Average, Dry100, and Wet100 datasets (**Table 2-11**). The results are three evaporation ranges available for running scenarios, Average, Dry100, and Wet100 evaporation data series (**Table 2-12**). The model assumes that PET is equal to actual evapotranspiration (AET).

Figure 2-4: GoldSim Hargreaves-Samani ET Model



Source: https://support.goldsim.com/hc/en-us/articles/360000991667-Hargreaves-Samani-Evapotranspiration

Table 2-12: Monthly Evaporation Rates (mm/d)

Month	Average	Dry100	Wet100
January	0.2	0.2	0.3
February	0.6	0.3	0.4
March	1.1	1.5	1.3
April	2.1	3.6	2.7
May	5.4	4.8	4.4
June	6.1	5.5	5.4
July	6.4	6.4	6.2
August	5.2	4.8	5.0
September	3.5	3.4	3.4
October	1.3	1.5	1.4
November	0.4	0.7	0.7
December	0.2	0.3	0.2

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400 04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

2.8.5 Snow Accumulation and Snowmelt Model

The Snow-17 model (Anderson, 2006), developed by the U.S. National Weather Service, is a conceptual tool designed to simulate snow accumulation and ablation processes. It primarily requires two inputs: air temperature and precipitation. By using air temperature as an index for energy exchange at the snow-air interface, the model estimates snowpack dynamics, including accumulation, melt, heat storage, and liquid water retention or transmission. This simplicity makes Snow-17 useful in data limited scenarios.

In the WBM, snow accumulation and snowmelt are estimated using the Snow-17 module for Goldsim[1]. which uses daily temperature, daily precipitation, and site latitude to model the state (i.e., rain or snow) of precipitation, the storage of the snow pack (in millimeters Snow Water Equivalent, mm SWE), and snowmelt processes (**Figure 2-5**). The model operates on a daily time step and reports snowmelt as runoff (in mm).

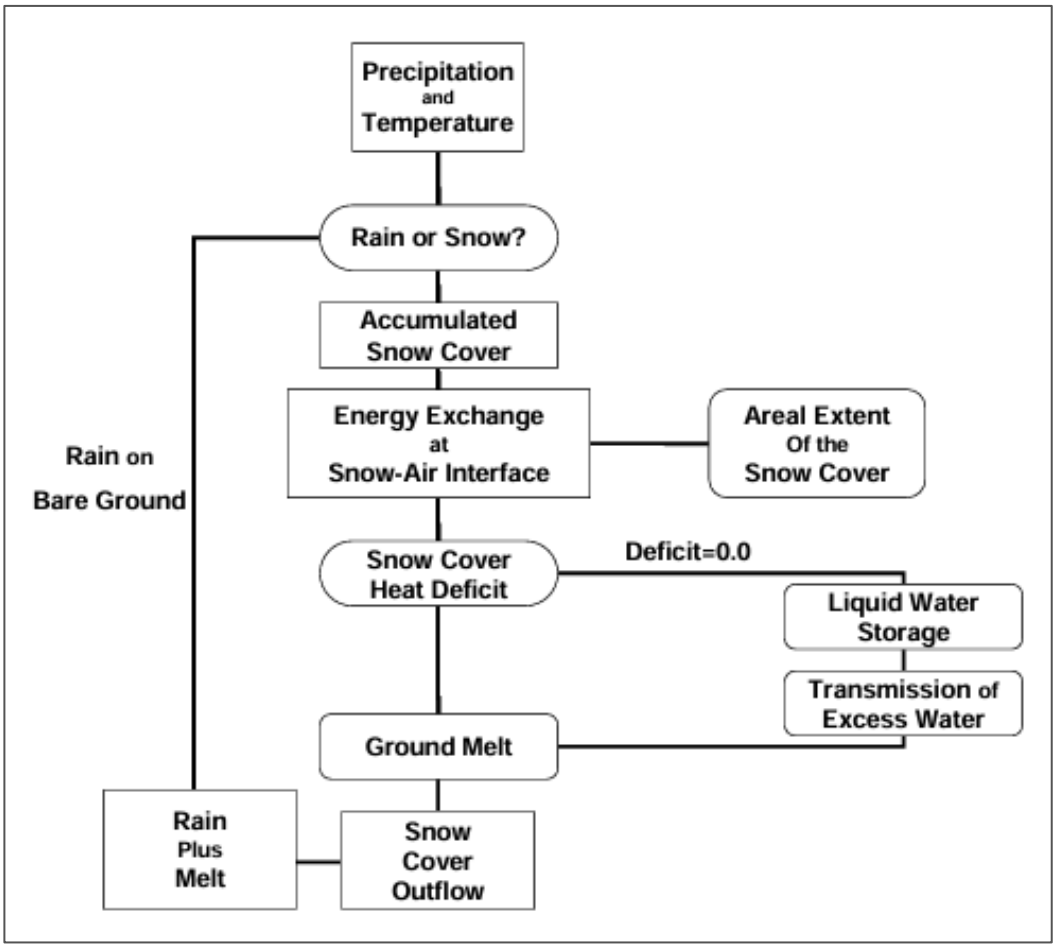
Key processes simulated by Snow-17 include:

- Precipitation Division: Determines whether precipitation falls as rain or snow based on temperature thresholds.
- Snow Accumulation: Adjusts new snowfall amounts and computes the density and depth of the snowpack.

[1] Documentation for the Snow-17 model can be found at https://support.goldsim.com/hc/en-us/articles/360001100167-Snow-Accumulation-and-Ablation-Model-Snow-17.

- Energy Exchange: Calculates net radiation, latent and sensible heat transfer, and heat from precipitation at the snow-air interface.
- Heat Deficit: Tracks the heat deficit within the snowpack, which affects the ripeness and melt potential of the snow.
- Ground Melt: Accounts for melt at the snow-soil interface based on a constant daily melt rate.
- Outflow Calculation: Computes the outflow from the snowpack into the catchment area, considering the snowpack ripeness and liquid water content.

Figure 2-5: Snow-17 Model



Source: Anderson (2006)

The Snow-17 model tracks snow accumulation and melt by dynamically adjusting snowpack properties based on incoming precipitation and energy fluxes (temperature). When precipitation occurs, the model determines whether it falls as rain or snow using a temperature threshold. Snowfall increases the SWE, while rain can percolate into the snowpack or contribute directly to runoff. The model tracks changes in snow density, affecting the snow depth over time. Snowmelt is primarily controlled by energy exchanges, including net radiation, latent and sensible heat fluxes, and heat from precipitation. A crucial component of Snow-17 is its treatment of the heat deficit, which represents the cold content of the snowpack; a higher heat deficit means more energy is required before melting can begin. Once the heat deficit is overcome, the snowpack reaches a state wherein further energy input leads directly to meltwater production.

2.8.6 Climate Change

Estimates of climate change impacts on precipitation, air temperature, and evaporation were developed and reported on in SRK's Climate Change Analysis for NMG (SRK, 2025). These values present the average of the Highest Density Intervals for Shared Socioeconomic Pathway (SSP) climate change scenarios SSP2-4.5 and SSP5-8.5, for each period (i.e., 2015 – 2040, 2041 – 2071, 2071 – 2100). These scenarios were selected as they provide a range of possible climatic scenarios in the future (SRK, 2025). Because the future is uncertain, there is no consensus in the literature on the criteria for the selection of a specific emission scenario or a specific global circulation model (GCM).

Climate change adjustments for Mean Annual Precipitation (MAP), Mean Annual Air Temperature (MAAT), Evaporation, and Design Storms are found in **Table 2-13** through **Table 2-16**. The values are used to adjust the climate inputs (precipitation, temperature, and evaporation) within each period and are constant throughout a given year (i.e. the values do not fluctuate monthly).

Table 2-13: Mean Annual Precipitation Climate Change Adjustments

Time Frame	MAP Median (%)
2015-2040	5
2041-2071	9
2071-2100	13

Source: SRK (2025)

Table 2-14: Mean Annual Average Temperature Climate Change Adjustments

Time Frame	MAAT Median (°C)
2015-2040	1.4
2041-2071	3.0
2071-2100	4.9

Source: SRK (2025)

Table 2-15: Evaporation Climate Change Adjustments

Time Frame	Evaporation Increase (%)
2015-2040	5
2041-2070	12
2071-2100	19

Source: SRK (2025)

Table 2-16: Climate Change Adjustment for 1-in-2000 Year Return Period Design Storm

Time Frame	IDF Median Rate of Change
2015-2040	6%
2041-2071	14%
2071-2100	25%

Source: SRK (2025)

Climate change adjustments are included to assess the impacts of changes to precipitation, temperature and evaporation on the water balance over time. Regardless of scenario, climate change is currently expected to result in increased precipitation at site, resulting in more runoff. Temperature changes are also expected to increase, which may result in changes to timing, depth, and melt rate of the snowpack. Similarly, evaporation is expected to increase which will impact the amount of stored water in ponds over time.

2.9 Dust Suppression Demands

Dust suppression will be required to manage environmental and operational standards. No data was available from site to estimate demand; therefore, assumptions were made based on data available from a regionally similar location to develop a unit rate (m^3/ha/d) for expected dust suppression usage. The model was constructed under the assumption that dust suppression water would be required from May through October, annually.

To estimate future dust suppression usage, SRK estimated the total service area as follows:

- SRK assumed that haul and access roads would be 10 m in width.
- Period maps were used to estimate the total length of active roadways in each year.
- SRK also assumed that the entire CDF footprint would require dust water to be applied each day during the dust suppression window.
- A dust suppression usage of 50 m^3/ha/d was estimated by SRK from experience at a regionally comparable mining operation.

The estimated annual dust suppression daily requirements are shown in **Table 2-17**. **Attachment 2** contains figures outlining the areas used to develop these inputs.

Table 2-17: Estimated Daily Dust Suppression

Year	Total Dust Suppression Area (ha)	Daily Dust Suppression Water (m^3/d)
2028 - 2030	41	2,052
2031 - 2033	71	3,560
2034 - 2056	115	5,769
2056	115	5,769

Note: 2030, 2033, 2042 development figures were used to estimate dust suppression areas. Volumes are carried over life of mine to estimate demand.

Source: Compiled in text

During operations, SRK recommends that dust suppression water usage be measured to verify these estimates.

2.10 Hydrogeology Inputs

Table 2-18 presents estimates of groundwater flows to the open-pit during development and active phases, as estimated by Richelieu Hydrogéologie Inc. (PH00-PH05) (Richelieu Hydrogéologie Inc., 2022).

Table 2-18: Groundwater Inflow Results per Pit Phase

Phase of work	Cumulative area (m^2)	Groundwater input (m^3/day)	Precipitation input (m^3/day)	Total infiltration rate (m^3/day)
PH-00	114239	289	169	458
PH-01	243727	659	360	1019
PH-02	360705	714	533	1247
PH-03	450813	798	666	1465
PH-04	622247	1075	920	1995
PH-05	784591	1144	1160	2304

Source: Richelieu Hydrogéologie (2022)

These inflows would be collected in sumps and pumped to either BC-1 or BC-2. The ponds and system were designed for pit water to be sent to BC-1, however pit water may be sent to BC-2 during periods of the year if the site determines it to be efficient.

The open pit development schedule was applied to the WBM.

A breakdown of groundwater inflow rates and open pit progression is presented in **Attachment 3**.

SRK understands that these groundwater estimates are being revised. Once new information is available, the WBM can be updated to reflect the most recent information.

2.11 Groundwater Supply Wells

There are three existing groundwater supply wells (HG-21-03, HG-17-05, HG-17-02) that have undergone pump testing investigations to determine long term pumping rates available. The results of the study (Richelieu, 2023) indicate that two pumping wells (HG-17-05 and HG-17-02) can provide meaningful amounts of water to support operations (446 m^3/d and 288 m^3/d, respectively). The model accounts for this additional water to be pumped to BC-2 for concentrator supply.

Additional supplemental groundwater supply wells are being considered as a contingency measure for water supply during dry periods. Pumping from groundwater wells would be triggered by a minimum operational water level target in BC-2. These pumps were assumed to convey groundwater at a rate of 100 m^3/hr.

This pumping logic and estimated rates for the wells are subject to change based on future scenario modelling. Where possible, the water management plan will be optimized to minimize or eliminate the need for supplemental groundwater.

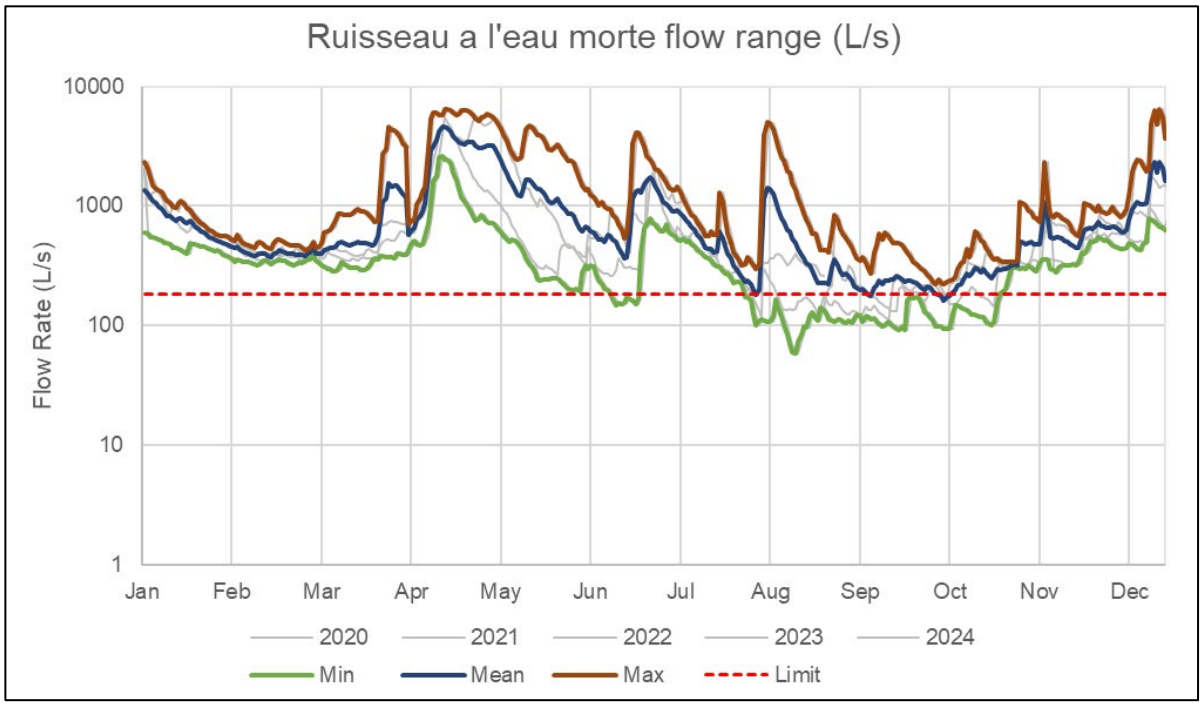
2.12 Discharge Limit at Ruisseau à l'Eau Morte

The receiving environment for discharge from the project will be Ruisseau à l'Eau Morte. Discharge from site will be required to comply with requirements for annual treated volume and minimum flow thresholds. The annual maximum discharge of treated water from site is set at 2,800,000 m^3 for the LoM (NMG comms, 2025). NMG established a hydrometric station within Ruisseau à l'Eau Morte, and flow data is collected by Atkins-Realis (Atkins, 2024a) to support baseline flow for estimating minimum creek flows and associated discharge permissions. The monitoring results are provided by source and summarized in **Figure 2-6**.

The project has established a minimum creek flow of 182 L/s, below which the site cannot discharge to Ruisseau à l'Eau Morte (Atkins, 2024b). Based on flow data collected, annual low flows appear to occur between the summer and fall months, typically between late July and early October (based on mean observed flow rates).

These flow rate data and discharge limits will be used to inform the water management objectives and discharge strategy (**Section 4**).

Figure 2-6: Ruisseau à l'Eau Morte Hydrometric Data



Note: The red hatched line denotes the minimum creek flow of 182 L/s.

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/Site%20Files/Environmental%20Flows/REM_novembre2024.xlsx?web=1

3 Conceptual Model

3.1 Model Overview

Table 3-1 summarizes the conceptual model for the overall site water balance.

Table 3-1: Site Water Balance Conceptual Model

Parameter	Model Input	Comments	Source
		MODEL STAGING	
Model Start Date	2028	Start of mining (Y1)	NMG
Model End Date	2056	End of mining (Y28)	NMG
Model Time Step	Daily		SRK
Model Results	Daily/Summarized by Year or Phase		SRK
Year Start Date	January 1st		SRK
Year End Date	December 31st		SRK
Environmental Discharge Window	March 16th – June 30th October 1st – December 31st	Treated water can be discharged to the receiving environment during these periods	NMG
No Environmental Discharge	January 1st – March 15th July 1st – September 30th	Treated water cannot be discharged to the receiving environment during these periods. Treated water must be sent back to BC-2 and stored.	NMG
Phase A	2028 - 2032	**Section 2.3**	NMG
Phase B1	2033 - 2035	**Section 2.3**	NMG
Phase B2	2036 - 2056	**Section 2.3**	NMG
		CLIMATE INPUTS	
Precipitation		**Section 2.8.1**	**SRK**
Air Temperature		**Section 2.8.3**	**SRK**
Evaporation		**Section 2.8.4**	**SRK**
		CONCENTRATOR INPUTS	
Mill Daily Ore Throughput	7,099 – 9,810 tonnes/d	**Section 2.6**	NMG
Treated Water Demand	Up to 345.5 m^3/hr	**Section 2.7**	NMG

Source: Compiled in text

3.2 GoldSim Structure

The Matawinie WBM is constructed using GoldSim. GoldSim is a graphical, object-oriented computer simulation program used for carrying out dynamic, probabilistic simulations (GoldSim, 2018). In GoldSim, users can create, document, and present model components by manipulating graphical objects that represent the various components of a system. In a sense, GoldSim can be interpreted as a "visual spreadsheet" that allows users to visually create and manipulate data and equations (GoldSim, 2018).

The components that make up the GoldSim visual interface and that are used to construct the model, are categorized as either "Elements" or "Containers". Elements represent the building blocks of the GoldSim model; they can be used to represent data inputs (e.g., scalar, vector, matrices, or probability distributions), mathematical functions or expressions, indications of status (i.e., true/false), or conditional statements leading to one of a selection of decisions (using if/then logic). In GoldSim, Elements are identified by their individual icons, while the exchange of information between communicating Elements (i.e., linkages) are indicated by arrows.

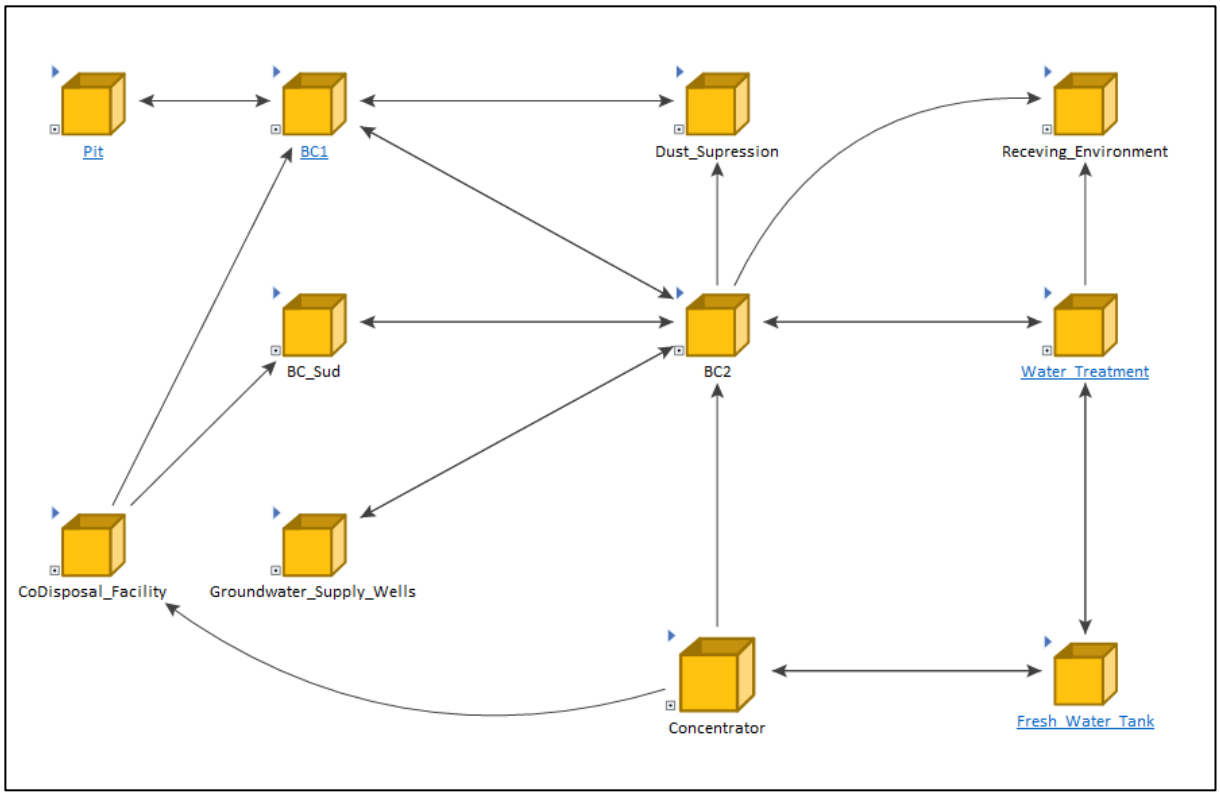
Containers are used to construct complex, multi-layered models often with numerous Elements connected by dozens, or even hundreds, of linkages across a model domain. Containers, which by default are illustrated as boxes within GoldSim (though icons can be changed by the modeller), provide a means of organizing and categorizing larger models. For a project like a mine site WBM, Containers are an effective way to represent a subsystem within the larger overall system (e.g., an open pit, a tailings cell, or a stockpile).

3.3 Model Layout

Each Matawinie facility relevant to the WBM has been assigned a Container within GoldSim, like those shown in **Figure 3-1**. Within each Container, Elements have been used to characterize how water will be generated, stored, and/or directed. Flow exchanges expected to occur during the operations phase of the mine life, for each facility, are summarized in **Table 3-2**. Further detail regarding the current and future water management objectives at Matawinie Mine, and flows between these structures, is provided in the following sections.

Figure 3-1 and **Figure 3-2** present the GoldSim flow network and PFD between the BCs, open pit, processing plant, and WTP, while **Table 3-2** provides an overview of the inflows, outflows, and BC storage capacities considered within the WBM.

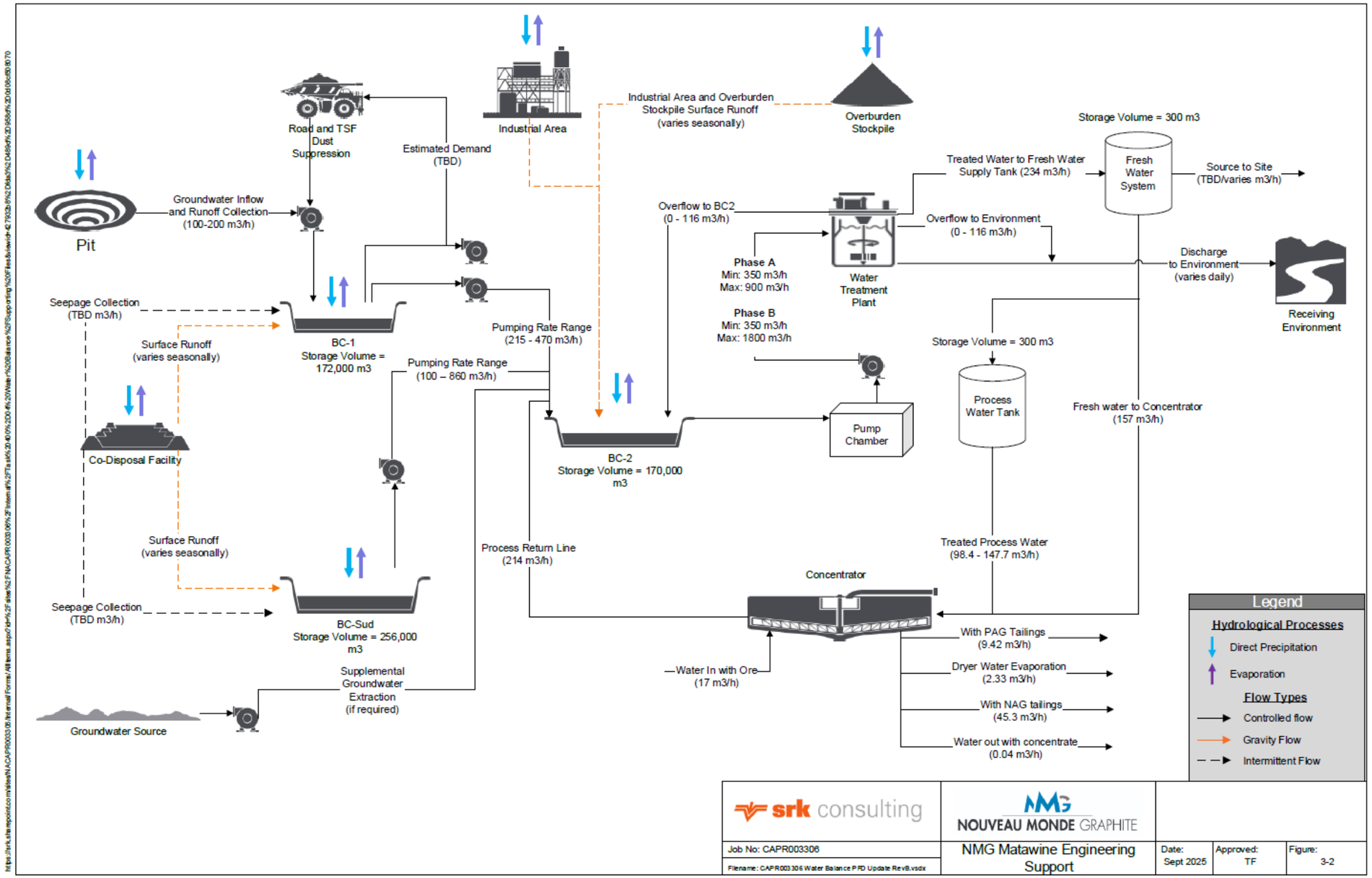
Figure 3-1: GoldSim Containers Used Within the Matawinie WBM



Source: CAPR003306_NMG Water Balance RevA.gsm

The water management plan (**Section 2.3**) will continuously evolve throughout the LoM of the project.

Figure 3-2: WBM Conceptual Framework



Source: CAPR003306_Water_Balance_PFD_Update_RevC.vsdx

Table 3-2: Water Flows and Volumes Modelled

Facility	Inflows	Outflows	Storage
Open-Pit	▪ Direct precipitation ▪ Groundwater inflows	▪ Water pumped directly to BC-1 ▪ Evaporation	▪ Water temporarily held in inventory
BC-1	▪ Direct precipitation ▪ Upstream runoff ▪ Water pumped from Pit	▪ Water pumped directly to BC-2 ▪ Evaporation ▪ Dust Suppression Supply	▪ Water temporarily held in inventory
BC-2	▪ Direct precipitation ▪ Upstream runoff ▪ Water pumped from BC-1 ▪ Water pumped from BC-Sud ▪ Water pumped from Pit ▪ Water from Mill ▪ Supplemental groundwater wells	▪ Water treatment facility ▪ Evaporation	▪ Water temporarily held in inventory ▪ Maintain target amount for fire suppression
BC-Sud	▪ Direct precipitation ▪ Upstream runoff	▪ Water pumped directly to BC-2 ▪ Evaporation	▪ Water temporarily held in inventory
WTP	▪ BC-2	▪ Freshwater Tank ▪ BC-2 Return	▪ N/A
Freshwater Tank	▪ BC-2	▪ Site ▪ Concentrator	▪ N/A
Concentrator	▪ Freshwater Tank ▪ Ore	▪ BC-2 ▪ Concentrate ▪ Tailings	▪ N/A

Source: Compiled in text

4 Water Management Objectives

4.1 Discharge Strategy

The overall discharge strategy for the site is described as:

- Collect, treat, and discharge water to the receiving environment during the discharge window.
- Provide treated water for the concentrator to maintain production throughout the year.
- Respect the operating water levels of the ponds while storing enough water to supply the concentrator through the winter months while not exceeding operating water levels.
- Respect applicable discharge restrictions (i.e., no discharge when flow in Ruisseau à l'Eau Morte is below 182 L/s, and annual discharge limit of 2,800,000 m^3).

There are periods of the year where the site cannot discharge to the receiving environment. During these periods, water levels in the ponds will need to be carefully managed to meet storage plans and ensure water levels are maintained to respect EDF requirements. The environmental discharge window (when treated water can be sent to the environment) is presented in **Table 4-1**.

Table 4-1: Environmental Discharge Windows

Window	Description
January 1st – March 15th	▪ No discharge, all water must remain on site
March 16th – June 30th	▪ Treated water can be discharged to the environment as required, discharge limits need to reflect minimum flow requirements at Ruisseau à l'Eau Morte (no discharge when flows are <182 L/s)
July 1st – September 30th	▪ No discharge, all water must remain on site
October 1st – December 31st	▪ Treated water can be discharged to the environment as required, discharge limits need to reflect minimum flow requirements at Ruisseau à l'Eau Morte (no discharge when flows are <182 L/s)

Source: Compiled in text

The discharge strategy needs to consider that winter inventory requirements are met, however too much water storage will pose issues in the event of a wet winter. Summer discharge limits require the ponds to be drawn down before the end of June to ensure the ponds can store summer precipitation events. Excess water needs to be consumed by the concentrator and dust suppression. If the ponds are not drawn down enough by then, it could result in either operating at a reduced capacity or needing to discharge outside of the discharge window.

4.2 Concentrator Storage Requirements

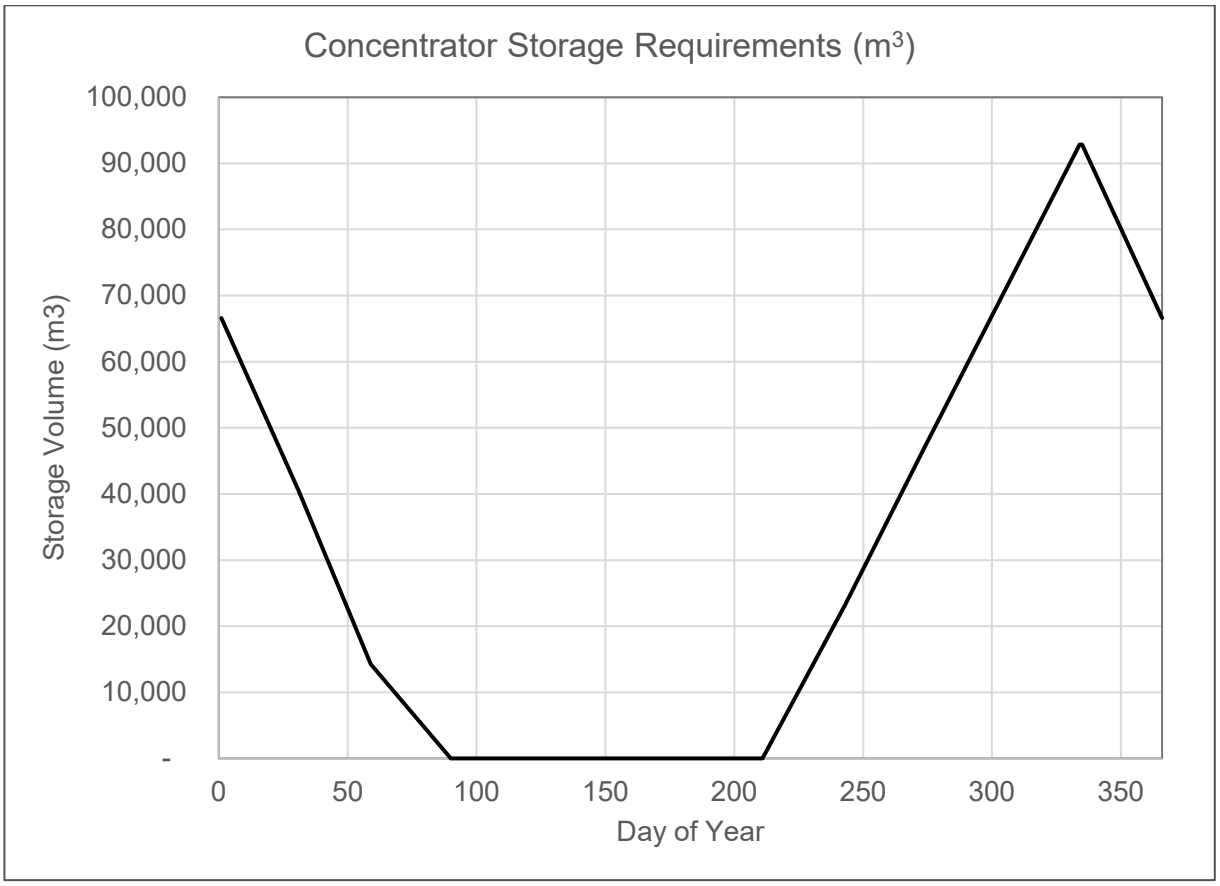
The concentrator is the critical component of mining operations and requires water year-round (planned shutdowns excluded). The concentrator requires treated water sourced the WTP via the Freshwater and Process Water Tanks. During the open water season (i.e., April – November), there is likely to be sufficient water supplied to BC-2 through rainfall and runoff processes. However, during the winter months, when little new runoff is generated, sufficient inventory will need to be stored by the end of wet season to supply the concentrator until the following spring.

The concentrator storage approach is summarized as follows:

- The concentrator sources water from the WTP via the Fresh Water Tank and Process Water Tanks (**Figure 3-2**).
- The concentrator requires up to 345.5 m^3/hr of water to operate, with up to 309.7 m^3/hr being returned to BC-2 and 35.8 m^3/hr lost to concentrator outputs (i.e., tailings, concentrate, and dryer evaporation) (**Section 2.7**).
  - Storage requirements assume the normal concentrator requirements as the maximum values are rated for additional cooling needs during summer periods (**Table 2-7**).
- Additional site water demands for general use (showers, washrooms, etc.) are estimated at 25 m^3/d.
- A storage estimate was developed, equal to the minimum supply to the concentrator for four months, as follows (assuming no new inputs to the system):
  - December 1 through March 15: 105 days at 35.8 m^3/hr + 25 m^3/d = 92,841 m^3 of storage required by December 1, annually.
  - Stored water is expected to be split between BC-1 and BC-2. The proportion of the split will need to include consideration for operational water levels (**Section 4.4**) and will be evaluated during scenario modelling (next stage of work).

Using this logic, a storage plan was developed for the purpose of collecting and storing water to supply the concentrator during the winter period (**Figure 4-1**). This plan provides a timeline to track the amount of water stored in the fall and to manage water levels throughout the winter.

Figure 4-1: Concentrator Winter Storage Plan



Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

4.3 Pond Operating Water Levels

Pond operating water levels refer to the range of water elevations maintained under normal operating conditions. These levels are typically designed to balance storage capacity, water quality, and system functionality while accommodating seasonal variations in inflow and evaporation. These operating levels for the project were established based on site-specific climate conditions, regulatory requirements, and engineering design criteria, and may be adjusted over time based on monitoring data and operational experience.

Currently EDF volumes, operating volumes, and operating levels were established for each pond (**Table 4-2** through **Table 4-4**). These values varied for each pond based on catchment area, additional water sources reporting to the pond, and operational use. Reference water levels are defined as:

- Minimum operating water level (MinOWL): Level which triggers to stop all pumping out of the facility. This level is often selected as the base of the facility or based on a minimum storage requirement for sedimentation purposes or mill reclaim purposes.
- Functional operating water level (FOWL): Level below the MOWL that triggers pumping actions to reduce the risk of exceeding the NOWL. Actions vary per facility, but may include stopping pumped inflows or activating additional dewatering systems.
  - FOWL to be developed as water management strategy advances.
- Normal operating water level (NOWL): Level that initiates emergency action and provides EDF contingency storage below the spillway, where applicable.
  - NOWL to be developed as water management strategy advances.
- Maximum operating water level (MOWL): Level above the NOWL that allows emergency use of the EDF storage before pumping water to other systems. Developed specifically to reduce the likelihood of pumping non-contact water into contact water systems or vice-versa.
  - The EDF volume is based on Directive 019 (**Section 2.8.2**). This volume must be always maintained.
- Maximum Water Level (MAX): Level in which ponds will start to spill to the environment. Dictated by pond spillway inverts.

Table 4-2: EDF Volumes

Pond	Catchment Area (m^2)	Spring (m^3)	Summer (m^3)
BC-1	388,739	81,810	73,491
BC-2	567,115	103,973	89,319
BC-Sud	1,031,931	215,405	165,873

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

Table 4-3: Pond Operating Volumes (m^3)

Pond	Base	Min OWL	FOWL[4]	NOWL[4]	MOWL[3] (Spring/Summer)	MAX
BC-1	0	2,400[1]	TBD	TBD	90,190 / 98,5098	172,000
BC-2	0	10,000[2]	TBD	TBD	66,027 / 80,681	170,000
BC-Sud	0	2,400[1]	TBD	TBD	40,595 / 90,127[5]	256,000

Notes:

1 Assumed that the ponds should be allowed to drop to zero for storm capacity, the ponds do not directly feed the plant and can be emptied

2 Minimum water volume for BC-2 set to 10,000 m^3 for fire suppression system

3 Maximum Operating Level = MAX – Directive 019 Storm (Spring/Summer)

4 FOWL and NOWL volumes to be defined, currently not critical to discharge strategy logic

5 BC-Sud MOWL are temporary values, to be updated once designs are advanced

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

Table 4-4: Pond Operating Levels (m)

Pond	Base	Min OWL	FOWL[4]	NOWL[4]	MOWL[3] (Spring/Summer)	MAX
BC-1	504.0	504.3[1]	TBD	TBD	512.2 / 512.8	517.0
BC-2	532.0	532.8[2]	TBD	TBD	536.3 / 537.1	541.5
BC-Sud	0	0[1]	TBD	TBD	TBC/TBC[5]	TBC[5]

Notes:

1 Assumed that the ponds should be allowed to drop to zero for storm capacity, ponds do not directly the plant and be emptied

2 Minimum water volume for BC-2 set to 10,000 m^3 for fire suppression system

3 Maximum Operating Level = MAX – Directive 019 Storm (Spring/Summer)

4 FOWL and NOWL volumes to be defined, currently not critical to discharge strategy logic

5 BC-Sud pond design not yet developed, stage storage curve not available

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

4.4 Operating Rules and Conditions

Pumping logic are the rules developed to determine when water is pumped from a pond. This logic must reflect the various demands and constraints across the site, including:

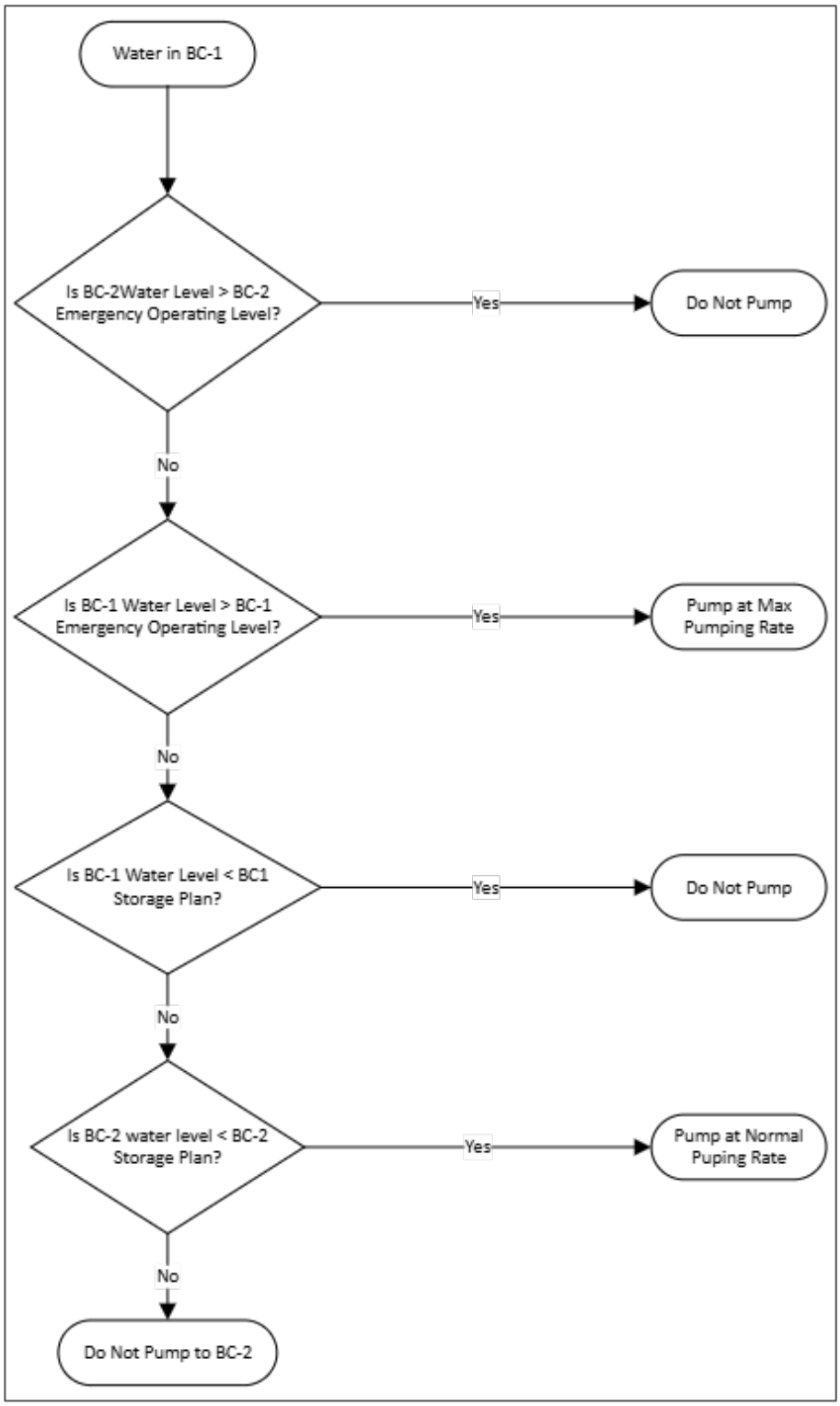
- Concentrator winter storage requirements
- Pond water levels: MOWL and EOL
- Environmental discharge windows
- Operating demands
  - BC-1: Runoff collection, pit water collection, dust suppression source, BC-2 storage offsetting
  - BC-Sud: Runoff collection, BC-2 storage offsetting
  - BC-2: Operational primary runoff collection, concentrator water source, WTP intake point.

Decision trees were developed to determine when and how much water should be pumped. This logic was then translated into logic controls embedded in the GoldSim model. The following sections outline the decision trees for:

- BC-1 (**Figure 4-2**)
- BC-Sud (**Figure 4-3**)
- BC-2 (**Figure 4-4**)
- the WTP (**Figure 4-5**).

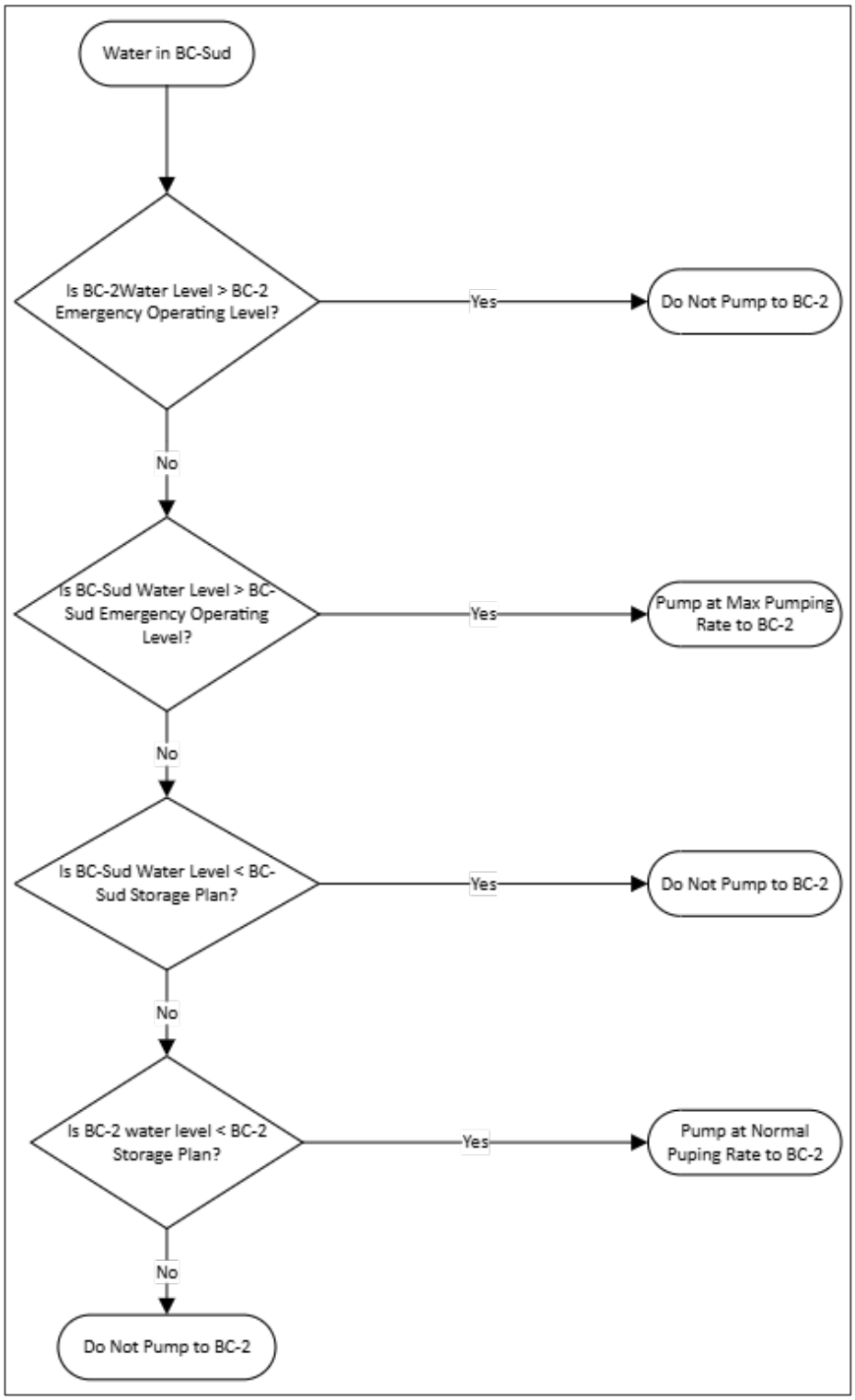
These decision trees will be updated as the modelling scenarios and discharge strategy are advanced.

Figure 4-2: BC-1 Pumping Decision Tree



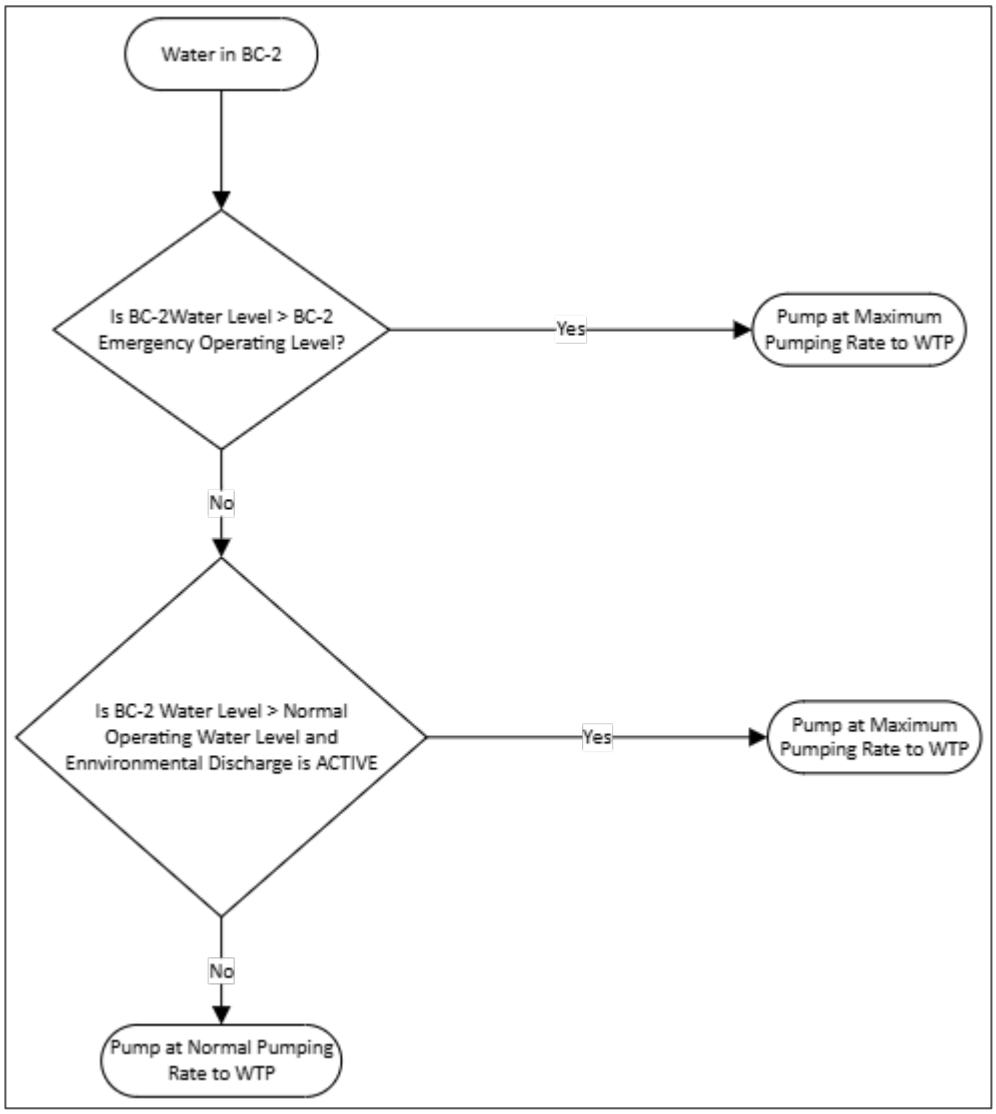
Source: CAPR003306 Pumping Decision Trees RevA.vsdx

Figure 4-3: BC-Sud Pumping Decision Tree



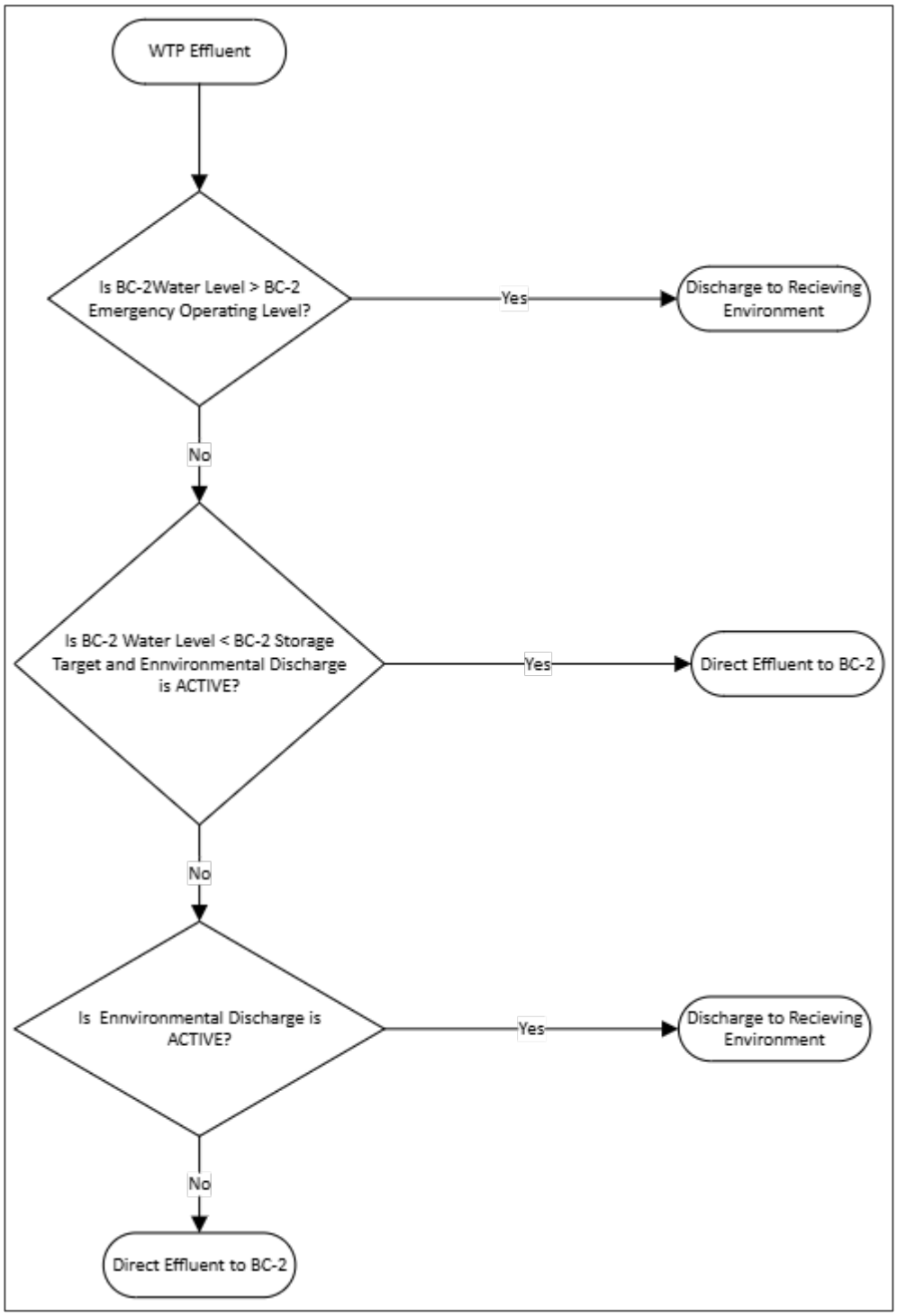
Source: CAPR003306 Pumping Decision Trees RevA.vsdx

Figure 4-4: BC-2 Pumping Decision Tree



Source: CAPR003306 Pumping Decision Trees RevA.vsdx

Figure 4-5: Water Treatment Plant Discharge Decision Tree



Source: CAPR003306 Pumping Decision Trees RevA.vsdx

4.5 Pumping Rates

Pumping between ponds and the WTP can be operated at either normal or maximum rates (there is no control to operate between normal and maximum) or off. Pumping rates (**Table 4-5**) used in the WBM were previously developed by SRK (2024) and remain unchanged.

Table 4-5: Pumping Rate Schedule (m^3/hr)

Year	BC-1 Normal	BC-1 Max	BC-2/WTP Normal	BC-2/WTP Max	BC-Sud Normal	BC-Sud Max
2027	0	0	0	0	0	0
2028 - 2032	255	470	350	900	0	0
2033 - 2035	215	470	350	1800	100	780
2035 - 2056	215	345	350	1800	100	860

Source: SRK (2024)

4.6 Model Calibration

At the time of reporting, there was no operational data to calibrate the model. Once operational data becomes available, the WBM will be calibrated.

5 Closure

Regards,
SRK Consulting (Canada) Inc.

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Attachments:

Attachment 1	Catchment Evolution
Attachment 2	Period Maps for Dust Suppression Estimates
Attachment 3	Hydrogeology Evolution Summary
Attachment 4	Concentrator Inputs
Attachment 5	Precipitation Analysis

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References

Anderson, E. A. (2006). Snow Accumulation and Ablation Model – SNOW-17. NOAA's National Weather Service, Office of Hydrologic Development, Silver Spring, MD.

AtkinsRéalis, 2023. Matawinie Concentrateur de graphite. Process Flowsheet Diagram Ponds and Water Treatment Plan. 669469-0505-49DG02-0004_PC_2023-11-06.

AtkinsRéalis, 2024a. AMP-15 et 19 – QC38. Project 653897.

AtkinsRéalis, 2024b. Données brute débit REM November 2024. AtkinsRéalis, 2025. Email communication via Ducharme, April 2025.

BBA, 2025. NI 43-101 Updated Technical Feasibility Study Report for The Matawinie Mine and the Bécancour Battery Material Plant Integrated Graphite Projects. Bécancour, Québec, Canada. Prepared for: Nouveau Monde Graphite.

GoldSim Technology Group. (2018). GoldSim User's Guide. GoldSim Technology Group LLC, Issaquah, WA, USA.

Hargreaves, G. H., & Samani, Z. A. (1985). Reference crop evapotranspiration from temperature. Applied Engineering in Agriculture, 1(2), 96–99.

MDDELCC, 2012. Directive 019 sur l'industrie minière

NMG, 2025. Email communication via Ducharme. February 18, 2025.

Ouranos, 2015. Vers l'adaptation. Synthèse des connaissances sur les changements climatiques au Québec. Édition 2015. Montréal, Québec : Ouranos. 415 p.

Richelieu Hydrogéologie Inc, 2022. Projet de graphite Mattawinie. Modélisation hydrogéologique des phases de développement

Richelieu Hydrogéologie Inc, 2023. Nouveau monde Graphite. Etude Hydrologique. Alimentation en eau potable – Project Matawinie. September 2023.

SNC-Lavalin, 2020 Rapport 654068-4000-40 ER-0001 (SNC-Lavalin, 2020), Rapport de faisabilité sur la gestion de l'eau, des résidus et stériles miniers.

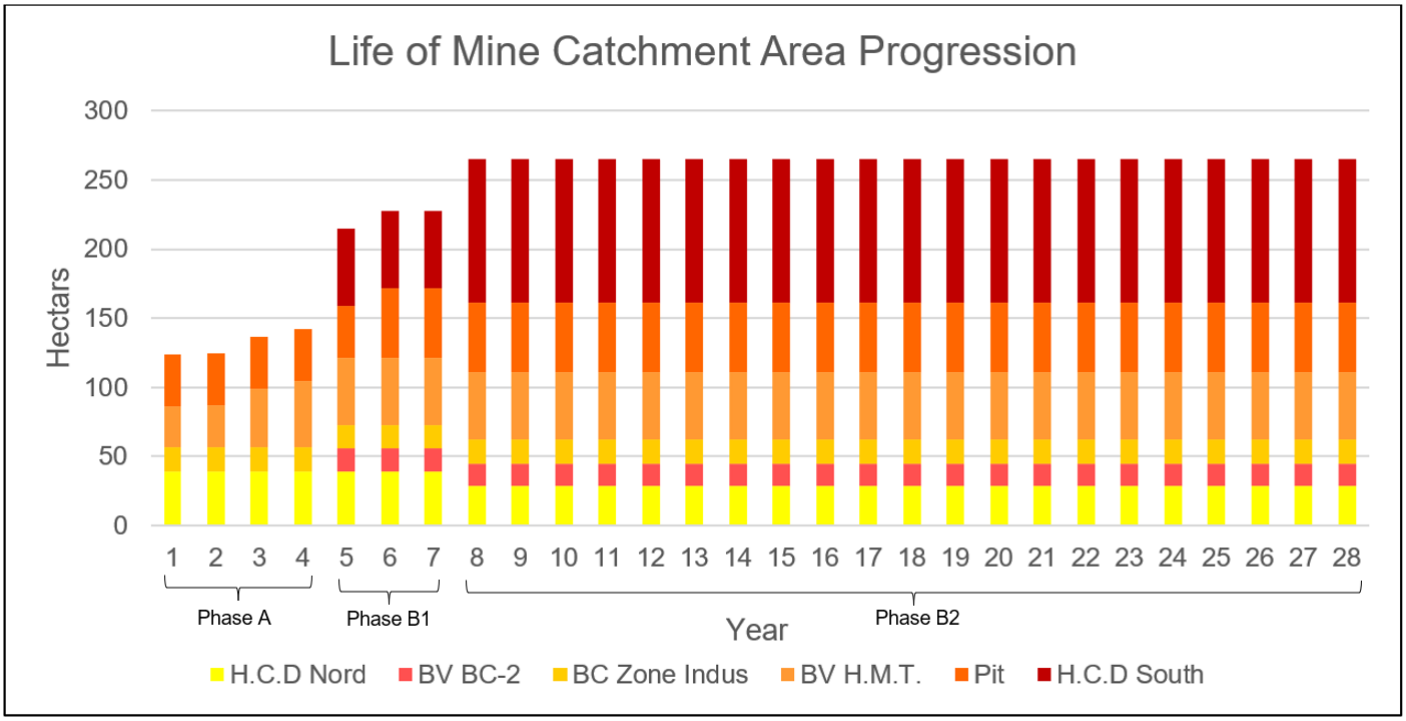
SRK Consulting (Canada) Inc., 2024. Site overall Water Balance for BC1 and BC2 Sizing. Memo. Prepared for Nouveau Monde Graphite – Matawinie Site. Saint-Michel-des-Saints. Québec. Project number: CAPR002717. Issued July 19, 2024

SRK Consulting (Canada) Inc., 2025a.Baseline Climate Analysis. FINAL. Prepared for Nouveau Monde Graphite – Matawinie Site. Saint-Michel-des-Saints. Québec. Project number: CAPR003306. Issued April 8, 2025.

SRK Consulting (Canada) Inc., 2025b Climate Change Analysis. FINAL. . Prepared for Nouveau Monde Graphite – Matawinie Site. Saint-Michel-des-Saints. Québec. Project number: CAPR003306. Issued April 7, 2025.

Wood, 2020. Nouveau Monde Graphite – Projet Matawinie. Ingénierie détaillée - Données de base et critères de conception. TX20035103-02000-NGE-0001-B. 2020-11-25. Wood – Solutions en environnement & infrastructure, une division de Wood Canada limitée.

Attachment 1 Catchment Evolution


Life of Mine Catchment Area Progression
Hectars
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
Phase A
Phase B1
Phase B2
Year
H.C.D Nord
BV BC-2
BC Zone Indus
BV H.M.T.
Pit
H.C.D South

Life of Mine Catchment Progression (Hectares)

Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
1	A	1					37.4	
1	A	2					37.4	
1	A	3					37.4	
1	A	4					37.4	
1	A	5					37.4	
1	A	6		0.0	17.5	30.2	37.4	
1	A	7		0.0	17.5	30.2	37.4	
1	A	8		0.0	17.5	30.2	37.4	
1	A	9		0.0	17.5	30.2	37.4	
1	A	10	38.9	0.0	17.5	30.2	37.4	
1	A	11	38.9	0.0	17.5	30.2	37.4	
1	A	12	38.9	0.0	17.5	30.2	37.4	
2	A	1	38.9	0.0	17.5	30.2	37.4	
2	A	2	38.9	0.0	17.5	30.2	37.4	
2	A	3	38.9	0.0	17.5	30.2	37.4	
2	A	4	38.9	0.0	17.5	30.2	37.4	
2	A	5	38.9	0.0	17.5	30.2	37.4	
2	A	6	38.9	0.0	17.5	30.2	37.4	
2	A	7	38.9	0.0	17.5	30.2	37.4	
2	A	8	38.9	0.0	17.5	30.2	37.4	
2	A	9	38.9	0.0	17.5	30.2	37.4	
2	A	10	38.9	0.0	17.5	30.2	37.4	
2	A	11	38.9	0.0	17.5	31.7	37.4	
2	A	12	38.9	0.0	17.5	33.3	37.4	
3	A	1	38.9	0.0	17.5	34.8	37.4	
3	A	2	38.9	0.0	17.5	36.3	37.4	
3	A	3	38.9	0.0	17.5	37.8	37.4	
3	A	4	38.9	0.0	17.5	39.4	37.4	
3	A	5	38.9	0.0	17.5	40.9	37.4	
3	A	6	38.9	0.0	17.5	42.4	37.4	

Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
3	A	7	38.9	0.0	17.5	43.9	37.4	
3	A	8	38.9	0.0	17.5	45.5	37.4	
3	A	9	38.9	0.0	17.5	47.0	37.4	
3	A	10	38.9	0.0	17.5	48.5	37.4	
3	A	11	38.9	0.0	17.5	48.5	37.4	
3	A	12	38.9	0.0	17.5	48.5	37.4	
4	A	1	38.9	0.0	17.5	48.5	37.4	
4	A	2	38.9	0.0	17.5	48.5	37.4	
4	A	3	38.9	0.0	17.5	48.5	37.4	
4	A	4	38.9	0.0	17.5	48.5	37.4	
4	A	5	38.9	0.0	17.5	48.5	37.4	
4	A	6	38.9	0.0	17.5	48.5	37.4	
4	A	7	38.9	0.0	17.5	48.5	37.4	
4	A	8	38.9	0.0	17.5	48.5	37.4	
4	A	9	38.9	0.0	17.5	48.5	37.4	
4	A	10	38.9	0.0	17.5	48.5	37.4	
4	A	11	38.9	0.0	17.5	48.5	37.4	
4	A	12	38.9	0.0	17.5	48.5	37.4	
5	B	1	38.9	16.7	17.5	48.5	37.4	55.9
5	B	2	38.9	16.7	17.5	48.5	37.4	55.9
5	B	3	38.9	16.7	17.5	48.5	37.4	55.9
5	B	4	38.9	16.7	17.5	48.5	37.4	55.9
5	B	5	38.9	16.7	17.5	48.5	37.4	55.9
5	B	6	38.9	16.7	17.5	48.5	37.4	55.9
5	B	7	38.9	16.7	17.5	48.5	37.4	55.9
5	B	8	38.9	16.7	17.5	48.5	37.4	55.9
5	B	9	38.9	16.7	17.5	48.5	37.4	55.9
5	B	10	38.9	16.7	17.5	48.5	37.4	55.9
5	B	11	38.9	16.7	17.5	48.5	37.4	55.9
5	B	12	38.9	16.7	17.5	48.5	37.4	55.9
6	B	1	38.9	16.7	17.5	48.5	50.3	55.9

Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
6	B	2	38.9	16.7	17.5	48.5	50.3	55.9
6	B	3	38.9	16.7	17.5	48.5	50.3	55.9
6	B	4	38.9	16.7	17.5	48.5	50.3	55.9
6	B	5	38.9	16.7	17.5	48.5	50.3	55.9
6	B	6	38.9	16.7	17.5	48.5	50.3	55.9
6	B	7	38.9	16.7	17.5	48.5	50.3	55.9
6	B	8	38.9	16.7	17.5	48.5	50.3	55.9
6	B	9	38.9	16.7	17.5	48.5	50.3	55.9
6	B	10	38.9	16.7	17.5	48.5	50.3	55.9
6	B	11	38.9	16.7	17.5	48.5	50.3	55.9
6	B	12	38.9	16.7	17.5	48.5	50.3	55.9
7	B	1	38.9	16.7	17.5	48.5	50.3	55.9
7	B	2	38.9	16.7	17.5	48.5	50.3	55.9
7	B	3	38.9	16.7	17.5	48.5	50.3	55.9
7	B	4	38.9	16.7	17.5	48.5	50.3	55.9
7	B	5	38.9	16.7	17.5	48.5	50.3	55.9
7	B	6	38.9	16.7	17.5	48.5	50.3	55.9
7	B	7	38.9	16.7	17.5	48.5	50.3	55.9
7	B	8	38.9	16.7	17.5	48.5	50.3	55.9
7	B	9	38.9	16.7	17.5	48.5	50.3	55.9
7	B	10	38.9	16.7	17.5	48.5	50.3	55.9
7	B	11	38.9	16.7	17.5	48.5	50.3	55.9
7	B	12	38.9	16.7	17.5	48.5	50.3	55.9
8	B	1	28.5	16.7	17.5	48.5	50.3	103.2
8	B	2	28.5	16.7	17.5	48.5	50.3	103.2
8	B	3	28.5	16.7	17.5	48.5	50.3	103.2
8	B	4	28.5	16.7	17.5	48.5	50.3	103.2
8	B	5	28.5	16.7	17.5	48.5	50.3	103.2
8	B	6	28.5	16.7	17.5	48.5	50.3	103.2
8	B	7	28.5	16.7	17.5	48.5	50.3	103.2
8	B	8	28.5	16.7	17.5	48.5	50.3	103.2

Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
8	B	9	28.5	16.7	17.5	48.5	50.3	103.2
8	B	10	28.5	16.7	17.5	48.5	50.3	103.2
8	B	11	28.5	16.7	17.5	48.5	50.3	103.2
8	B	12	28.5	16.7	17.5	48.5	50.3	103.2
9	B	1	28.5	16.7	17.5	48.5	50.3	103.2
9	B	2	28.5	16.7	17.5	48.5	50.3	103.2
9	B	3	28.5	16.7	17.5	48.5	50.3	103.2
9	B	4	28.5	16.7	17.5	48.5	50.3	103.2
9	B	5	28.5	16.7	17.5	48.5	50.3	103.2
9	B	6	28.5	16.7	17.5	48.5	50.3	103.2
9	B	7	28.5	16.7	17.5	48.5	50.3	103.2
9	B	8	28.5	16.7	17.5	48.5	50.3	103.2
9	B	9	28.5	16.7	17.5	48.5	50.3	103.2
9	B	10	28.5	16.7	17.5	48.5	50.3	103.2
9	B	11	28.5	16.7	17.5	48.5	50.3	103.2
9	B	12	28.5	16.7	17.5	48.5	50.3	103.2
10	B	1	28.5	16.7	17.5	48.5	50.3	103.2
10	B	2	28.5	16.7	17.5	48.5	50.3	103.2
10	B	3	28.5	16.7	17.5	48.5	50.3	103.2
10	B	4	28.5	16.7	17.5	48.5	50.3	103.2
10	B	5	28.5	16.7	17.5	48.5	50.3	103.2
10	B	6	28.5	16.7	17.5	48.5	50.3	103.2
10	B	7	28.5	16.7	17.5	48.5	50.3	103.2
10	B	8	28.5	16.7	17.5	48.5	50.3	103.2
10	B	9	28.5	16.7	17.5	48.5	50.3	103.2
10	B	10	28.5	16.7	17.5	48.5	50.3	103.2
10	B	11	28.5	16.7	17.5	48.5	50.3	103.2
10	B	12	28.5	16.7	17.5	48.5	50.3	103.2
11	B	1	28.5	16.7	17.5	48.5	50.3	103.2
11	B	2	28.5	16.7	17.5	48.5	50.3	103.2
11	B	3	28.5	16.7	17.5	48.5	50.3	103.2

Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
11	B	4	28.5	16.7	17.5	48.5	50.3	103.2
11	B	5	28.5	16.7	17.5	48.5	50.3	103.2
11	B	6	28.5	16.7	17.5	48.5	50.3	103.2
11	B	7	28.5	16.7	17.5	48.5	50.3	103.2
11	B	8	28.5	16.7	17.5	48.5	50.3	103.2
11	B	9	28.5	16.7	17.5	48.5	50.3	103.2
11	B	10	28.5	16.7	17.5	48.5	50.3	103.2
11	B	11	28.5	16.7	17.5	48.5	50.3	103.2
11	B	12	28.5	16.7	17.5	48.5	50.3	103.2
12	B	1	28.5	16.7	17.5	48.5	50.3	103.2
12	B	2	28.5	16.7	17.5	48.5	50.3	103.2
12	B	3	28.5	16.7	17.5	48.5	50.3	103.2
12	B	4	28.5	16.7	17.5	48.5	50.3	103.2
12	B	5	28.5	16.7	17.5	48.5	50.3	103.2
12	B	6	28.5	16.7	17.5	48.5	50.3	103.2
12	B	7	28.5	16.7	17.5	48.5	50.3	103.2
12	B	8	28.5	16.7	17.5	48.5	50.3	103.2
12	B	9	28.5	16.7	17.5	48.5	50.3	103.2
12	B	10	28.5	16.7	17.5	48.5	50.3	103.2
12	B	11	28.5	16.7	17.5	48.5	50.3	103.2
12	B	12	28.5	16.7	17.5	48.5	50.3	103.2
13	B	1	28.5	16.7	17.5	48.5	50.3	103.2
13	B	2	28.5	16.7	17.5	48.5	50.3	103.2
13	B	3	28.5	16.7	17.5	48.5	50.3	103.2
13	B	4	28.5	16.7	17.5	48.5	50.3	103.2
13	B	5	28.5	16.7	17.5	48.5	50.3	103.2
13	B	6	28.5	16.7	17.5	48.5	50.3	103.2
13	B	7	28.5	16.7	17.5	48.5	50.3	103.2
13	B	8	28.5	16.7	17.5	48.5	50.3	103.2
13	B	9	28.5	16.7	17.5	48.5	50.3	103.2
13	B	10	28.5	16.7	17.5	48.5	50.3	103.2

Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
13	B	11	28.5	16.7	17.5	48.5	50.3	103.2
13	B	12	28.5	16.7	17.5	48.5	50.3	103.2
14	B	1	28.5	16.7	17.5	48.5	50.3	103.2
14	B	2	28.5	16.7	17.5	48.5	50.3	103.2
14	B	3	28.5	16.7	17.5	48.5	50.3	103.2
14	B	4	28.5	16.7	17.5	48.5	50.3	103.2
14	B	5	28.5	16.7	17.5	48.5	50.3	103.2
14	B	6	28.5	16.7	17.5	48.5	50.3	103.2
14	B	7	28.5	16.7	17.5	48.5	50.3	103.2
14	B	8	28.5	16.7	17.5	48.5	50.3	103.2
14	B	9	28.5	16.7	17.5	48.5	50.3	103.2
14	B	10	28.5	16.7	17.5	48.5	50.3	103.2
14	B	11	28.5	16.7	17.5	48.5	50.3	103.2
14	B	12	28.5	16.7	17.5	48.5	50.3	103.2
15	B	1	28.5	16.7	17.5	48.5	50.3	103.2
15	B	2	28.5	16.7	17.5	48.5	50.3	103.2
15	B	3	28.5	16.7	17.5	48.5	50.3	103.2
15	B	4	28.5	16.7	17.5	48.5	50.3	103.2
15	B	5	28.5	16.7	17.5	48.5	50.3	103.2
15	B	6	28.5	16.7	17.5	48.5	50.3	103.2
15	B	7	28.5	16.7	17.5	48.5	50.3	103.2
15	B	8	28.5	16.7	17.5	48.5	50.3	103.2
15	B	9	28.5	16.7	17.5	48.5	50.3	103.2
15	B	10	28.5	16.7	17.5	48.5	50.3	103.2
15	B	11	28.5	16.7	17.5	48.5	50.3	103.2
15	B	12	28.5	16.7	17.5	48.5	50.3	103.2
16	B	1	28.5	16.7	17.5	48.5	50.3	103.2
16	B	2	28.5	16.7	17.5	48.5	50.3	103.2
16	B	3	28.5	16.7	17.5	48.5	50.3	103.2
16	B	4	28.5	16.7	17.5	48.5	50.3	103.2
16	B	5	28.5	16.7	17.5	48.5	50.3	103.2

Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
16	B	6	28.5	16.7	17.5	48.5	50.3	103.2
16	B	7	28.5	16.7	17.5	48.5	50.3	103.2
16	B	8	28.5	16.7	17.5	48.5	50.3	103.2
16	B	9	28.5	16.7	17.5	48.5	50.3	103.2
16	B	10	28.5	16.7	17.5	48.5	50.3	103.2
16	B	11	28.5	16.7	17.5	48.5	50.3	103.2
16	B	12	28.5	16.7	17.5	48.5	50.3	103.2
17	B	1	28.5	16.7	17.5	48.5	50.3	103.2
17	B	2	28.5	16.7	17.5	48.5	50.3	103.2
17	B	3	28.5	16.7	17.5	48.5	50.3	103.2
17	B	4	28.5	16.7	17.5	48.5	50.3	103.2
17	B	5	28.5	16.7	17.5	48.5	50.3	103.2
17	B	6	28.5	16.7	17.5	48.5	50.3	103.2
17	B	7	28.5	16.7	17.5	48.5	50.3	103.2
17	B	8	28.5	16.7	17.5	48.5	50.3	103.2
17	B	9	28.5	16.7	17.5	48.5	50.3	103.2
17	B	10	28.5	16.7	17.5	48.5	50.3	103.2
17	B	11	28.5	16.7	17.5	48.5	50.3	103.2
17	B	12	28.5	16.7	17.5	48.5	50.3	103.2
18	B	1	28.5	16.7	17.5	48.5	50.3	103.2
18	B	2	28.5	16.7	17.5	48.5	50.3	103.2
18	B	3	28.5	16.7	17.5	48.5	50.3	103.2
18	B	4	28.5	16.7	17.5	48.5	50.3	103.2
18	B	5	28.5	16.7	17.5	48.5	50.3	103.2
18	B	6	28.5	16.7	17.5	48.5	50.3	103.2
18	B	7	28.5	16.7	17.5	48.5	50.3	103.2
18	B	8	28.5	16.7	17.5	48.5	50.3	103.2
18	B	9	28.5	16.7	17.5	48.5	50.3	103.2
18	B	10	28.5	16.7	17.5	48.5	50.3	103.2
18	B	11	28.5	16.7	17.5	48.5	50.3	103.2
18	B	12	28.5	16.7	17.5	48.5	50.3	103.2

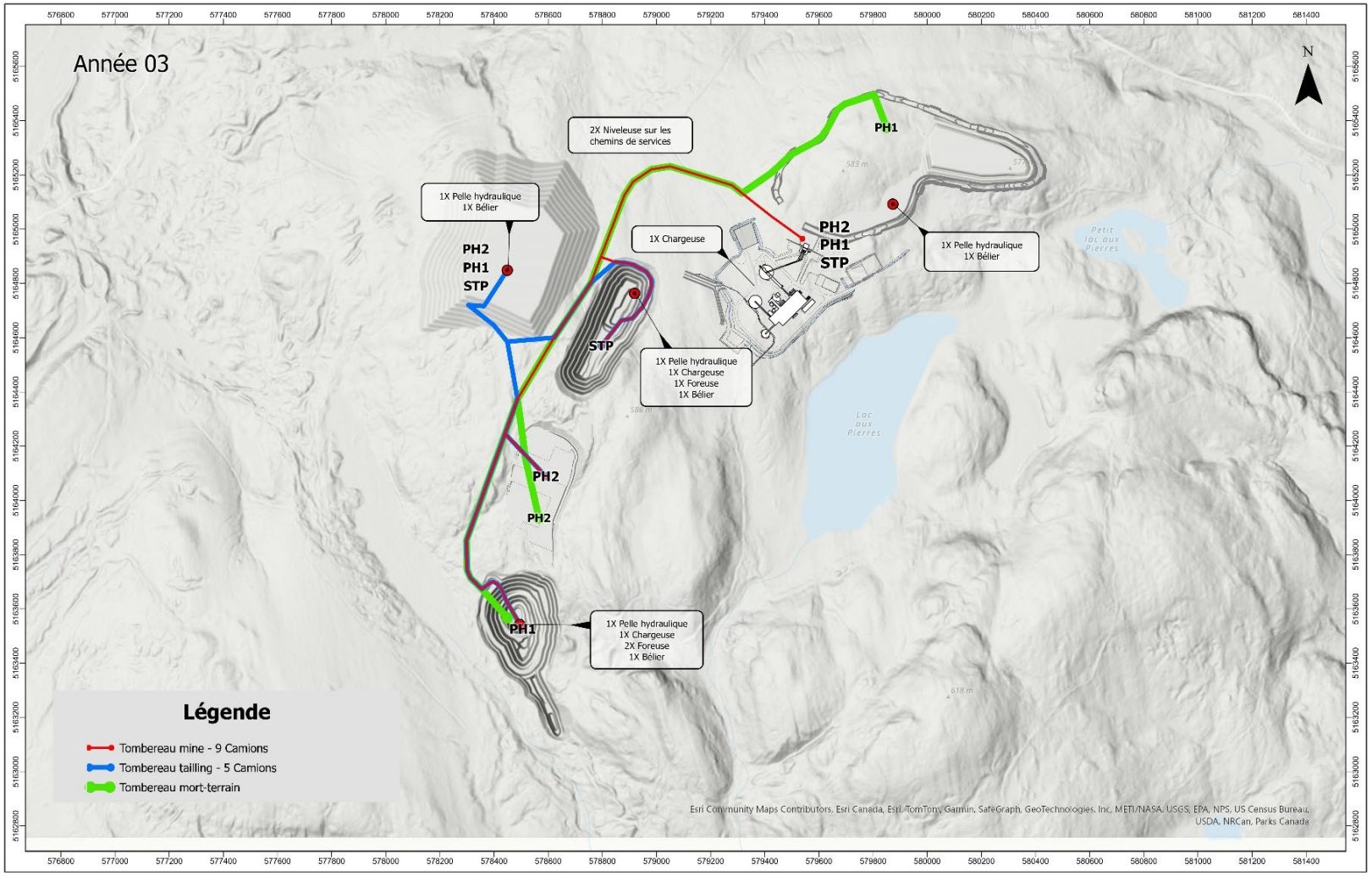
Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
19	B	1	28.5	16.7	17.5	48.5	50.3	103.2
19	B	2	28.5	16.7	17.5	48.5	50.3	103.2
19	B	3	28.5	16.7	17.5	48.5	50.3	103.2
19	B	4	28.5	16.7	17.5	48.5	50.3	103.2
19	B	5	28.5	16.7	17.5	48.5	50.3	103.2
19	B	6	28.5	16.7	17.5	48.5	50.3	103.2
19	B	7	28.5	16.7	17.5	48.5	50.3	103.2
19	B	8	28.5	16.7	17.5	48.5	50.3	103.2
19	B	9	28.5	16.7	17.5	48.5	50.3	103.2
19	B	10	28.5	16.7	17.5	48.5	50.3	103.2
19	B	11	28.5	16.7	17.5	48.5	50.3	103.2
19	B	12	28.5	16.7	17.5	48.5	50.3	103.2
20	B	1	28.5	16.7	17.5	48.5	50.3	103.2
20	B	2	28.5	16.7	17.5	48.5	50.3	103.2
20	B	3	28.5	16.7	17.5	48.5	50.3	103.2
20	B	4	28.5	16.7	17.5	48.5	50.3	103.2
20	B	5	28.5	16.7	17.5	48.5	50.3	103.2
20	B	6	28.5	16.7	17.5	48.5	50.3	103.2
20	B	7	28.5	16.7	17.5	48.5	50.3	103.2
20	B	8	28.5	16.7	17.5	48.5	50.3	103.2
20	B	9	28.5	16.7	17.5	48.5	50.3	103.2
20	B	10	28.5	16.7	17.5	48.5	50.3	103.2
20	B	11	28.5	16.7	17.5	48.5	50.3	103.2
20	B	12	28.5	16.7	17.5	48.5	50.3	103.2
21	B	1	28.5	16.7	17.5	48.5	50.3	103.2
21	B	2	28.5	16.7	17.5	48.5	50.3	103.2
21	B	3	28.5	16.7	17.5	48.5	50.3	103.2
21	B	4	28.5	16.7	17.5	48.5	50.3	103.2
21	B	5	28.5	16.7	17.5	48.5	50.3	103.2
21	B	6	28.5	16.7	17.5	48.5	50.3	103.2
21	B	7	28.5	16.7	17.5	48.5	50.3	103.2

Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
21	B	8	28.5	16.7	17.5	48.5	50.3	103.2
21	B	9	28.5	16.7	17.5	48.5	50.3	103.2
21	B	10	28.5	16.7	17.5	48.5	50.3	103.2
21	B	11	28.5	16.7	17.5	48.5	50.3	103.2
21	B	12	28.5	16.7	17.5	48.5	50.3	103.2
22	B	1	28.5	16.7	17.5	48.5	50.3	103.2
22	B	2	28.5	16.7	17.5	48.5	50.3	103.2
22	B	3	28.5	16.7	17.5	48.5	50.3	103.2
22	B	4	28.5	16.7	17.5	48.5	50.3	103.2
22	B	5	28.5	16.7	17.5	48.5	50.3	103.2
22	B	6	28.5	16.7	17.5	48.5	50.3	103.2
22	B	7	28.5	16.7	17.5	48.5	50.3	103.2
22	B	8	28.5	16.7	17.5	48.5	50.3	103.2
22	B	9	28.5	16.7	17.5	48.5	50.3	103.2
22	B	10	28.5	16.7	17.5	48.5	50.3	103.2
22	B	11	28.5	16.7	17.5	48.5	50.3	103.2
22	B	12	28.5	16.7	17.5	48.5	50.3	103.2
23	B	1	28.5	16.7	17.5	48.5	50.3	103.2
23	B	2	28.5	16.7	17.5	48.5	50.3	103.2
23	B	3	28.5	16.7	17.5	48.5	50.3	103.2
23	B	4	28.5	16.7	17.5	48.5	50.3	103.2
23	B	5	28.5	16.7	17.5	48.5	50.3	103.2
23	B	6	28.5	16.7	17.5	48.5	50.3	103.2
23	B	7	28.5	16.7	17.5	48.5	50.3	103.2
23	B	8	28.5	16.7	17.5	48.5	50.3	103.2
23	B	9	28.5	16.7	17.5	48.5	50.3	103.2
23	B	10	28.5	16.7	17.5	48.5	50.3	103.2
23	B	11	28.5	16.7	17.5	48.5	50.3	103.2
23	B	12	28.5	16.7	17.5	48.5	50.3	103.2
24	B	1	28.5	16.7	17.5	48.5	50.3	103.2
24	B	2	28.5	16.7	17.5	48.5	50.3	103.2

Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
24	B	3	28.5	16.7	17.5	48.5	50.3	103.2
24	B	4	28.5	16.7	17.5	48.5	50.3	103.2
24	B	5	28.5	16.7	17.5	48.5	50.3	103.2
24	B	6	28.5	16.7	17.5	48.5	50.3	103.2
24	B	7	28.5	16.7	17.5	48.5	50.3	103.2
24	B	8	28.5	16.7	17.5	48.5	50.3	103.2
24	B	9	28.5	16.7	17.5	48.5	50.3	103.2
24	B	10	28.5	16.7	17.5	48.5	50.3	103.2
24	B	11	28.5	16.7	17.5	48.5	50.3	103.2
24	B	12	28.5	16.7	17.5	48.5	50.3	103.2
25	B	1	28.5	16.7	17.5	48.5	50.3	103.2
25	B	2	28.5	16.7	17.5	48.5	50.3	103.2
25	B	3	28.5	16.7	17.5	48.5	50.3	103.2
25	B	4	28.5	16.7	17.5	48.5	50.3	103.2
25	B	5	28.5	16.7	17.5	48.5	50.3	103.2
25	B	6	28.5	16.7	17.5	48.5	50.3	103.2
25	B	7	28.5	16.7	17.5	48.5	50.3	103.2
25	B	8	28.5	16.7	17.5	48.5	50.3	103.2
25	B	9	28.5	16.7	17.5	48.5	50.3	103.2
25	B	10	28.5	16.7	17.5	48.5	50.3	103.2
25	B	11	28.5	16.7	17.5	48.5	50.3	103.2
25	B	12	28.5	16.7	17.5	48.5	50.3	103.2
26	B	1	28.5	16.7	17.5	48.5	50.3	103.2
26	B	2	28.5	16.7	17.5	48.5	50.3	103.2
26	B	3	28.5	16.7	17.5	48.5	50.3	103.2
26	B	4	28.5	16.7	17.5	48.5	50.3	103.2
26	B	5	28.5	16.7	17.5	48.5	50.3	103.2
26	B	6	28.5	16.7	17.5	48.5	50.3	103.2
26	B	7	28.5	16.7	17.5	48.5	50.3	103.2
26	B	8	28.5	16.7	17.5	48.5	50.3	103.2
26	B	9	28.5	16.7	17.5	48.5	50.3	103.2

Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
26	B	10	28.5	16.7	17.5	48.5	50.3	103.2
26	B	11	28.5	16.7	17.5	48.5	50.3	103.2
26	B	12	28.5	16.7	17.5	48.5	50.3	103.2
27	B	1	28.5	16.7	17.5	48.5	50.3	103.2
27	B	2	28.5	16.7	17.5	48.5	50.3	103.2
27	B	3	28.5	16.7	17.5	48.5	50.3	103.2
27	B	4	28.5	16.7	17.5	48.5	50.3	103.2
27	B	5	28.5	16.7	17.5	48.5	50.3	103.2
27	B	6	28.5	16.7	17.5	48.5	50.3	103.2
27	B	7	28.5	16.7	17.5	48.5	50.3	103.2
27	B	8	28.5	16.7	17.5	48.5	50.3	103.2
27	B	9	28.5	16.7	17.5	48.5	50.3	103.2
27	B	10	28.5	16.7	17.5	48.5	50.3	103.2
27	B	11	28.5	16.7	17.5	48.5	50.3	103.2
27	B	12	28.5	16.7	17.5	48.5	50.3	103.2
28	B	1	28.5	16.7	17.5	48.5	50.3	103.2
28	B	2	28.5	16.7	17.5	48.5	50.3	103.2
28	B	3	28.5	16.7	17.5	48.5	50.3	103.2
28	B	4	28.5	16.7	17.5	48.5	50.3	103.2
28	B	5	28.5	16.7	17.5	48.5	50.3	103.2
28	B	6	28.5	16.7	17.5	48.5	50.3	103.2
28	B	7	28.5	16.7	17.5	48.5	50.3	103.2
28	B	8	28.5	16.7	17.5	48.5	50.3	103.2
28	B	9	28.5	16.7	17.5	48.5	50.3	103.2
28	B	10	28.5	16.7	17.5	48.5	50.3	103.2
28	B	11	28.5	16.7	17.5	48.5	50.3	103.2
28	B	12	28.5	16.7	17.5	48.5	50.3	103.2

Attachment 2 Period Maps for Dust Suppression Estimates


Année 03
N
2X Niveleuse sur les chemins de services
1X Pelle hydraulique
1X Bélier
PH2
PH1
STP
1X Chargeuse
1X Pelle hydraulique
1X Chargeuse
1X Foreuse
1X Bélier
PH2
PH1
STP
1X Pelle hydraulique
1X Bélier
PH1
STP
PH2
PH2
PH1
1X Pelle hydraulique
1X Chargeuse
2X Foreuse
1X Bélier
Petit lac aux Pierres
Lac aux Pierres
Légende
Tombereau mine - 9 Camions
Tombereau tailling - 5 Camions
Tombereau mort-terrain
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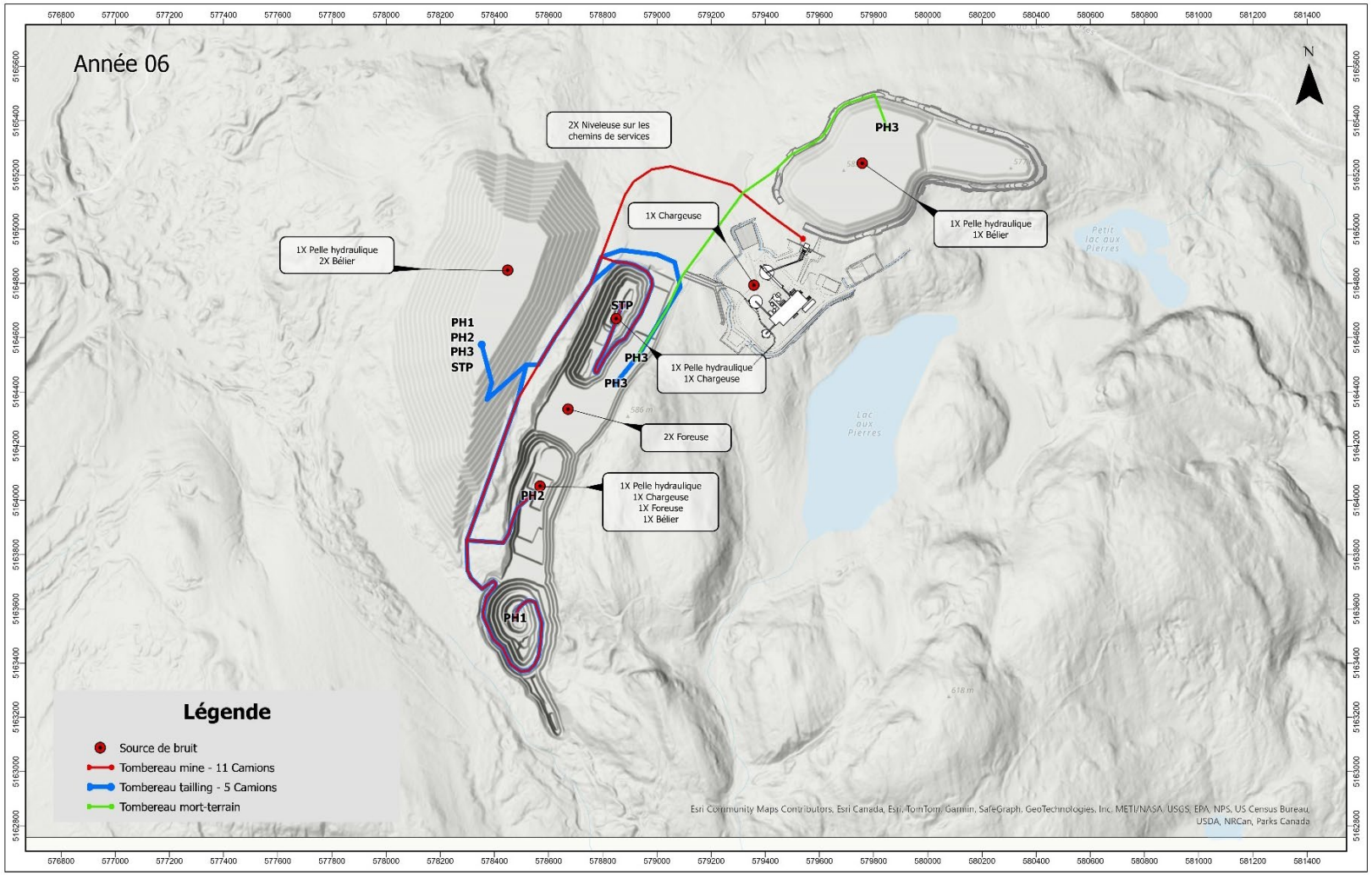
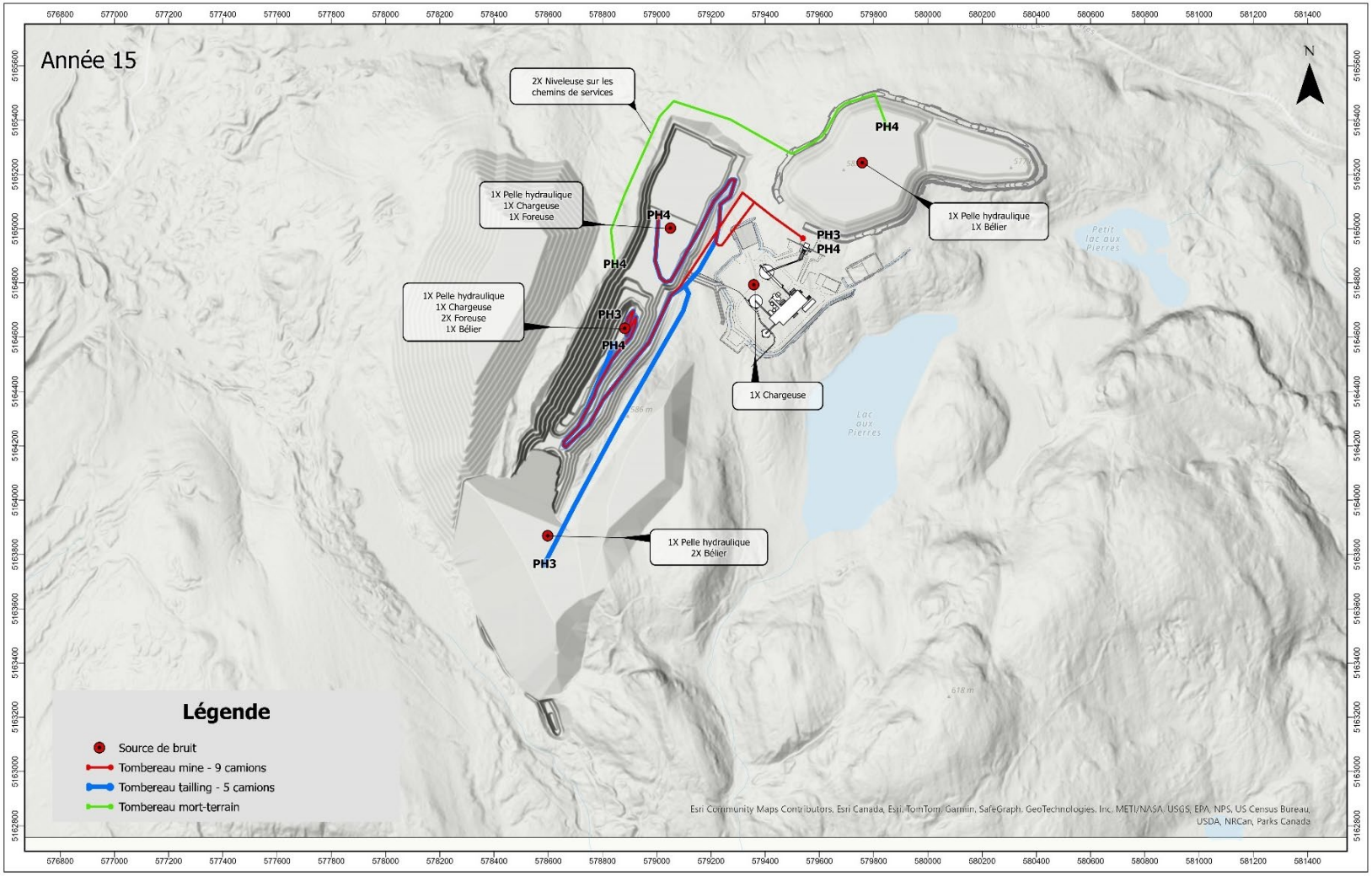
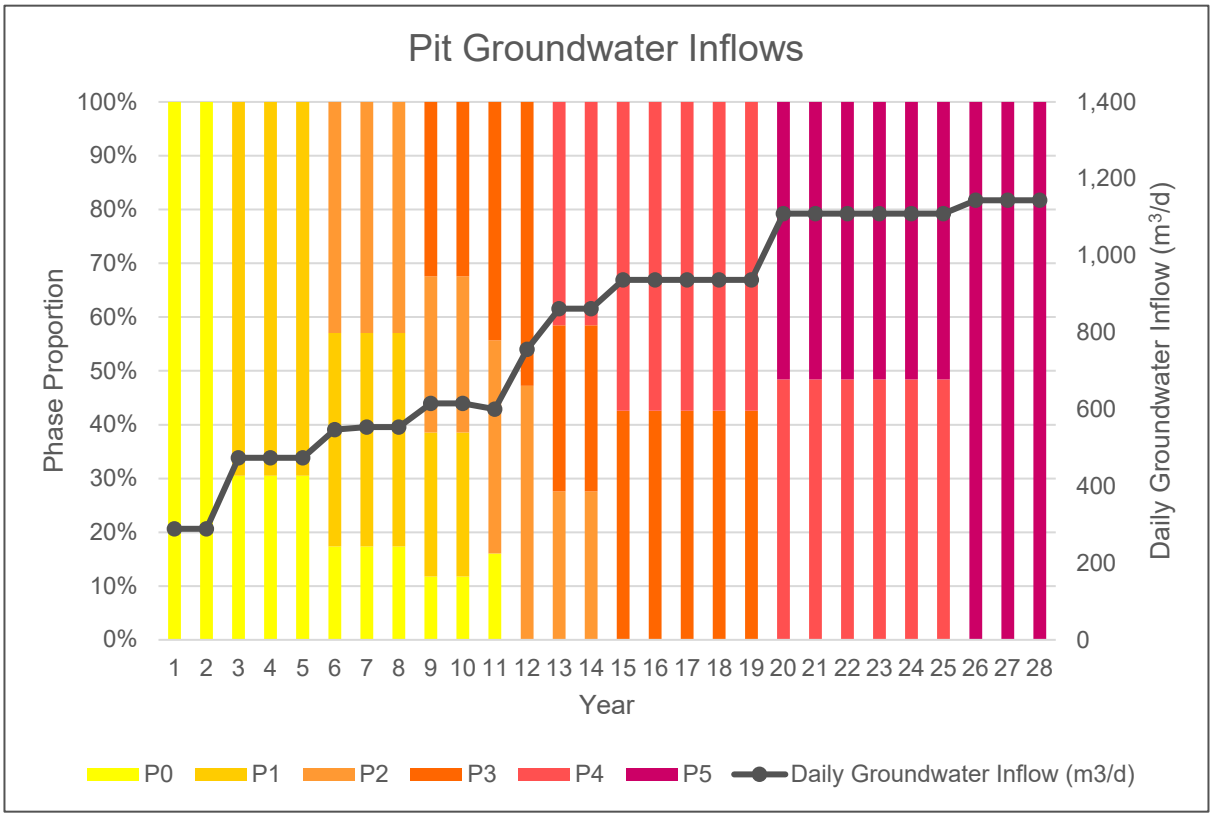

Année 06
N
2X Niveleuse sur les chemins de services
1X Chargeuse
1X Pelle hydraulique 1X Bélier
1X Pelle hydraulique 2X Bélier
1X Pelle hydraulique 1X Chargeuse
2X Foreuse
1X Pelle hydraulique 1X Chargeuse 1X Foreuse 1X Bélier
PH1
PH2
PH3
STP
Petit lac aux Pierres
Lac aux Pierres
Légende
Source de bruit
Tombereau mine - 11 Camions
Tombereau tailling - 5 Camions
Tombereau mort-terrain
Esri Community Maps Contributors, Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, NRCan, Parks Canada


Année 15
N
2X Niveleuse sur les chemins de services
1X Pelle hydraulique
1X Chargeuse
1X Foreuse
1X Pelle hydraulique
1X Chargeuse
2X Foreuse
1X Bélier
1X Pelle hydraulique
1X Bélier
1X Chargeuse
1X Pelle hydraulique
2X Bélier
PH4
PH3
Petit lac aux Pierres
Lac aux Pierres
Légende
Source de bruit
Tombereau mine - 9 camions
Tombereau tailling - 5 camions
Tombereau mort-terrain
Esri Community Maps Contributors, Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, NRCan, Parks Canada

Attachment 3 Hydrogeology Evolution Summary


Pit Groundwater Inflows
Phase Proportion
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1,400
1,200
1,000
800
600
400
200
0
Daily Groundwater Inflow (m3/d)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
Year
P0
P1
P2
P3
P4
P5
Daily Groundwater Inflow (m3/d)

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
1	1	289	289					
1	2	289	289					
1	3	289	289					
1	4	289	289					
1	5	289	289					
1	6	289	289					
1	7	289	289					
1	8	289	289					
1	9	289	289					
1	10	289	289					
1	11	289	289					
1	12	289	289					
2	1	289	289					
2	2	289	289					
2	3	289	289					
2	4	289	289					
2	5	289	289					
2	6	289	289					
2	7	289	289					
2	8	289	289					
2	9	289	289					
2	10	289	289					
2	11	289	289					
2	12	289	289					
3	1	474	289	659				
3	2	474	289	659				
3	3	474	289	659				
3	4	474	289	659				
3	5	474	289	659				
3	6	474	289	659				
3	7	474	289	659				
3	8	474	289	659				
3	9	474	289	659				
3	10	474	289	659				

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
3	11	474	289	659				
3	12	474	289	659				
4	1	474	289	659				
4	2	474	289	659				
4	3	474	289	659				
4	4	474	289	659				
4	5	474	289	659				
4	6	474	289	659				
4	7	474	289	659				
4	8	474	289	659				
4	9	474	289	659				
4	10	474	289	659				
4	11	474	289	659				
4	12	474	289	659				
5	1	474	289	659				
5	2	474	289	659				
5	3	474	289	659				
5	4	474	289	659				
5	5	474	289	659				
5	6	474	289	659				
5	7	474	289	659				
5	8	474	289	659				
5	9	474	289	659				
5	10	474	289	659				
5	11	474	289	659				
5	12	474	289	659				
6	1	474	289	659				
6	2	554	289	659	714			
6	3	554	289	659	714			
6	4	554	289	659	714			
6	5	554	289	659	714			
6	6	554	289	659	714			
6	7	554	289	659	714			
6	8	554	289	659	714			

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
6	9	554	289	659	714			
6	10	554	289	659	714			
6	11	554	289	659	714			
6	12	554	289	659	714			
7	1	554	289	659	714			
7	2	554	289	659	714			
7	3	554	289	659	714			
7	4	554	289	659	714			
7	5	554	289	659	714			
7	6	554	289	659	714			
7	7	554	289	659	714			
7	8	554	289	659	714			
7	9	554	289	659	714			
7	10	554	289	659	714			
7	11	554	289	659	714			
7	12	554	289	659	714			
8	1	554	289	659	714			
8	2	554	289	659	714			
8	3	554	289	659	714			
8	4	554	289	659	714			
8	5	554	289	659	714			
8	6	554	289	659	714			
8	7	554	289	659	714			
8	8	554	289	659	714			
8	9	554	289	659	714			
8	10	554	289	659	714			
8	11	554	289	659	714			
8	12	554	289	659	714			
9	1	615	289	659	714	798		
9	2	615	289	659	714	798		
9	3	615	289	659	714	798		
9	4	615	289	659	714	798		
9	5	615	289	659	714	798		
9	6	615	289	659	714	798		

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
9	7	615	289	659	714	798		
9	8	615	289	659	714	798		
9	9	615	289	659	714	798		
9	10	615	289	659	714	798		
9	11	615	289	659	714	798		
9	12	615	289	659	714	798		
10	1	615	289	659	714	798		
10	2	615	289	659	714	798		
10	3	615	289	659	714	798		
10	4	615	289	659	714	798		
10	5	615	289	659	714	798		
10	6	615	289	659	714	798		
10	7	615	289	659	714	798		
10	8	615	289	659	714	798		
10	9	615	289	659	714	798		
10	10	615	289	659	714	798		
10	11	615	289	659	714	798		
10	12	615	289	659	714	798		
11	1	600	289		714	798		
11	2	600	289		714	798		
11	3	600	289		714	798		
11	4	600	289		714	798		
11	5	600	289		714	798		
11	6	600	289		714	798		
11	7	600	289		714	798		
11	8	600	289		714	798		
11	9	600	289		714	798		
11	10	600	289		714	798		
11	11	600	289		714	798		
11	12	600	289		714	798		
12	1	756			714	798		
12	2	756			714	798		
12	3	756			714	798		
12	4	756			714	798		

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
12	5	756			714	798		
12	6	756			714	798		
12	7	756			714	798		
12	8	756			714	798		
12	9	756			714	798		
12	10	756			714	798		
12	11	756			714	798		
12	12	756			714	798		
13	1	862			714	798	1075	
13	2	862			714	798	1075	
13	3	862			714	798	1075	
13	4	862			714	798	1075	
13	5	862			714	798	1075	
13	6	862			714	798	1075	
13	7	862			714	798	1075	
13	8	862			714	798	1075	
13	9	862			714	798	1075	
13	10	862			714	798	1075	
13	11	862			714	798	1075	
13	12	862			714	798	1075	
14	1	862			714	798	1075	
14	2	862			714	798	1075	
14	3	862			714	798	1075	
14	4	862			714	798	1075	
14	5	862			714	798	1075	
14	6	862			714	798	1075	
14	7	862			714	798	1075	
14	8	862			714	798	1075	
14	9	862			714	798	1075	
14	10	862			714	798	1075	
14	11	862			714	798	1075	
14	12	862			714	798	1075	
15	1	937				798	1075	
15	2	937				798	1075	

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
15	3	937				798	1075	
15	4	937				798	1075	
15	5	937				798	1075	
15	6	937				798	1075	
15	7	937				798	1075	
15	8	937				798	1075	
15	9	937				798	1075	
15	10	937				798	1075	
15	11	937				798	1075	
15	12	937				798	1075	
16	1	937				798	1075	
16	2	937				798	1075	
16	3	937				798	1075	
16	4	937				798	1075	
16	5	937				798	1075	
16	6	937				798	1075	
16	7	937				798	1075	
16	8	937				798	1075	
16	9	937				798	1075	
16	10	937				798	1075	
16	11	937				798	1075	
16	12	937				798	1075	
17	1	937				798	1075	
17	2	937				798	1075	
17	3	937				798	1075	
17	4	937				798	1075	
17	5	937				798	1075	
17	6	937				798	1075	
17	7	937				798	1075	
17	8	937				798	1075	
17	9	937				798	1075	
17	10	937				798	1075	
17	11	937				798	1075	
17	12	937				798	1075	

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
18	1	937				798	1075	
18	2	937				798	1075	
18	3	937				798	1075	
18	4	937				798	1075	
18	5	937				798	1075	
18	6	937				798	1075	
18	7	937				798	1075	
18	8	937				798	1075	
18	9	937				798	1075	
18	10	937				798	1075	
18	11	937				798	1075	
18	12	937				798	1075	
19	1	937				798	1075	
19	2	937				798	1075	
19	3	937				798	1075	
19	4	937				798	1075	
19	5	937				798	1075	
19	6	937				798	1075	
19	7	937				798	1075	
19	8	937				798	1075	
19	9	937				798	1075	
19	10	937				798	1075	
19	11	937				798	1075	
19	12	937				798	1075	
20	1	1110					1075	1144
20	2	1110					1075	1144
20	3	1110					1075	1144
20	4	1110					1075	1144
20	5	1110					1075	1144
20	6	1110					1075	1144
20	7	1110					1075	1144
20	8	1110					1075	1144
20	9	1110					1075	1144
20	10	1110					1075	1144

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
20	11	1110					1075	1144
20	12	1110					1075	1144
21	1	1110					1075	1144
21	2	1110					1075	1144
21	3	1110					1075	1144
21	4	1110					1075	1144
21	5	1110					1075	1144
21	6	1110					1075	1144
21	7	1110					1075	1144
21	8	1110					1075	1144
21	9	1110					1075	1144
21	10	1110					1075	1144
21	11	1110					1075	1144
21	12	1110					1075	1144
22	1	1110					1075	1144
22	2	1110					1075	1144
22	3	1110					1075	1144
22	4	1110					1075	1144
22	5	1110					1075	1144
22	6	1110					1075	1144
22	7	1110					1075	1144
22	8	1110					1075	1144
22	9	1110					1075	1144
22	10	1110					1075	1144
22	11	1110					1075	1144
22	12	1110					1075	1144
23	1	1110					1075	1144
23	2	1110					1075	1144
23	3	1110					1075	1144
23	4	1110					1075	1144
23	5	1110					1075	1144
23	6	1110					1075	1144
23	7	1110					1075	1144
23	8	1110					1075	1144

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
23	9	1110					1075	1144
23	10	1110					1075	1144
23	11	1110					1075	1144
23	12	1110					1075	1144
24	1	1110					1075	1144
24	2	1110					1075	1144
24	3	1110					1075	1144
24	4	1110					1075	1144
24	5	1110					1075	1144
24	6	1110					1075	1144
24	7	1110					1075	1144
24	8	1110					1075	1144
24	9	1110					1075	1144
24	10	1110					1075	1144
24	11	1110					1075	1144
24	12	1110					1075	1144
25	1	1110					1075	1144
25	2	1110					1075	1144
25	3	1110					1075	1144
25	4	1110					1075	1144
25	5	1110					1075	1144
25	6	1110					1075	1144
25	7	1110					1075	1144
25	8	1110					1075	1144
25	9	1110					1075	1144
25	10	1110					1075	1144
25	11	1110					1075	1144
25	12	1110					1075	1144
26	1	1144						1144
26	2	1144						1144
26	3	1144						1144
26	4	1144						1144
26	5	1144						1144
26	6	1144						1144

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
26	7	1144						1144
26	8	1144						1144
26	9	1144						1144
26	10	1144						1144
26	11	1144						1144
26	12	1144						1144
27	1	1144						1144
27	2	1144						1144
27	3	1144						1144
27	4	1144						1144
27	5	1144						1144
27	6	1144						1144
27	7	1144						1144
27	8	1144						1144
27	9	1144						1144
27	10	1144						1144
27	11	1144						1144
27	12	1144						1144
28	1	1144						1144
28	2	1144						1144
28	3	1144						1144
28	4	1144						1144
28	5	1144						1144
28	6	1144						1144
28	7	1144						1144
28	8	1144						1144
28	9	1144						1144
28	10	1144						1144
28	11	1144						1144
28	12	1144						1144

Source: https://srk.sharepoint.com/sites/NACAPR002717/Internal/!020_Project_Data/010_SRK/Water%20Balance/CAPR002717%2520NMG-WaterBlanaceModel_DRAFT_2023-12-19_SRK_REV_C.xlsx?web=1

Attachment 4 Concentrator Inputs

MOYENNES QUOTIDIENNES TRANSPORTÉES

Description	Unité	PP	Y01	Y02	Y03	Y04	Y05	Y06	Y07	Y08	Y09	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23	Y24	Y25
De la fosse au concentrateur	tpj	0	7,099	9,810	9,810	9,810	9,837	9,810	9,810	9,810	9,837	9,810	9,810	9,810	9,810	9,810	9,810	9,810	9,810	9,810	9,810	9,376	9,376	9,376	8,587	8,587	7,491
De la fosse à la pile de minerai	tpj	903	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
De la pile de minerai au concasseur	tpj	0	903	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mort-terrain	tpj	1,203	3,731	2,490	3,623	853	534	1,348	2,018	2,304	65	1,855	3,177	4,189	3,872	534	534	534	4,132	4,132	4,132	4,790	4,790	4,790	0	0	0
Stériles	tpj	779	5,764	7,956	10,328	8,276	9,317	11,919	11,249	10,963	13,175	11,412	10,090	9,079	9,396	9,793	9,793	9,793	7,079	7,079	7,079	8,801	8,801	8,801	4,523	4,523	788
Matériaux deplacés	tpj	2,885	17,498	20,255	23,761	18,939	19,688	23,077	23,077	23,077	23,077	23,077	23,077	23,077	23,077	20,136	20,136	20,136	21,021	21,021	21,021	22,966	22,966	22,966	13,110	13,110	8,279

Attachment 5 Precipitation Analysis

3. NMG - Matawinie Precipitation Analysis

CAPR003306

Camilo Gallard

February 12, 2025

Abstract

This report compiles the precipitation anlaysis that was carried out by SRK Consulting (Canada) Inc. for the Nouveau Monde Graphite Matawinie Site in 2024 to support Engineering Design. The data compilation and subsequent analysis was conducted in the R Software environment.

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Chapter 1

Glossary

- **AMS**: Annual Maximum Series.
- **Daymet**: Reanalysis tool developed by the Oak Ridge National Laboratory and supported by NASA (Thornton et al. 2022).
- **ECCC**: Environment and Climate Change Canada.
- **ERA5**: Reanalysis tool developed by the European Centre for Medium-Range Weather Forecasts (Hersbach et al. 2020).
- **ERA5-Land**: Reanalysis tool based on ERA5 but for Land surfaces and a smaller grid, and developed by the European Centre for Medium-Range Weather Forecasts (Muñoz-Sabater et al. 2021).
- **ET**: Evapotranspiration
- **ET0**: Reference Evapotranspiration
- **IDF**: Intensity-Duration-Frequency (IDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
- **KST**: Kolmogorov–Smirnov Test.
- **MAAT**: Mean Annual Air Temperature.
- **MAP**: Mean Annual Precipitation.
- **MERRA2**: Modern-Era Retrospective analysis from Research and Applications, Version 2, is a global climate reanalysis model from the U.S. National Aeronautics and Space Administration (Gelaro et al. 2017).
- **NMG**: Nouveau Monde Graphite.
- **PCC**: Pearson Correlation Coefficient.
- **PDF**: Precipitation-Duration-Frequency (PDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
- **PMP**: Probable Maximum Precipitation.
- **RH**: Relative Humidity.

- **SRAD**: Shortwave (solar) radiation. Incident shortwave radiation flux density in watts per square meter.
- **SRK**: SRK Consulting (Canada) Inc.
- **SSR**: Surface net shortwave (solar) radiation. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth (both direct and diffuse) minus the amount reflected by the Earth's surface (which is governed by the albedo).
- **SSRD**: Surface short-wave (solar) radiation downwards. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth. This parameter comprises both direct and diffuse solar radiation.
- **Tavg**: Mean or Average Air Temperature over a given temporal unit (day, month, year…).
- **Tdew**: Mean or Average Dew Point Temperature over a given temporal unit (day, month, year…).
- **Tmax**: Maximum Air Temperature over a given temporal unit (day, month, year…).
- **Tmin**: Minimum Air Temperature over a given temporal unit (day, month, year…).

Chapter 2

General Parameters

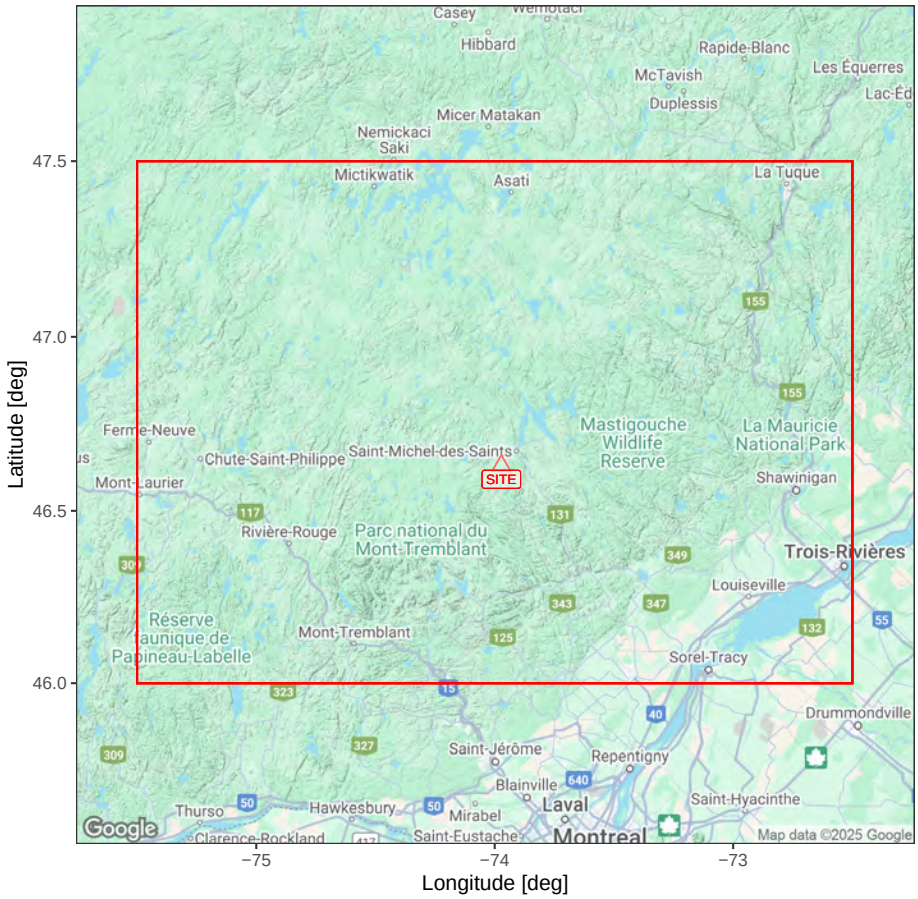
The NMG Matawinie site is located in southern Quebec, 125 km north of Montreal. Site latitude is 46.63 degrees, and longitude is -73.97 degrees, at an elevation of 562 masl. These coordinates were selected to match the location of the meteorological station on site.

For the purpose of this meteorological analysis, an area of interest was defined around site to capture regional data and climate trends, and was defined as the region between:

- 46° and 47.5° Latitude
- -75.5° and -72.5° Longitude

Site Location and Area of Interest for this Study

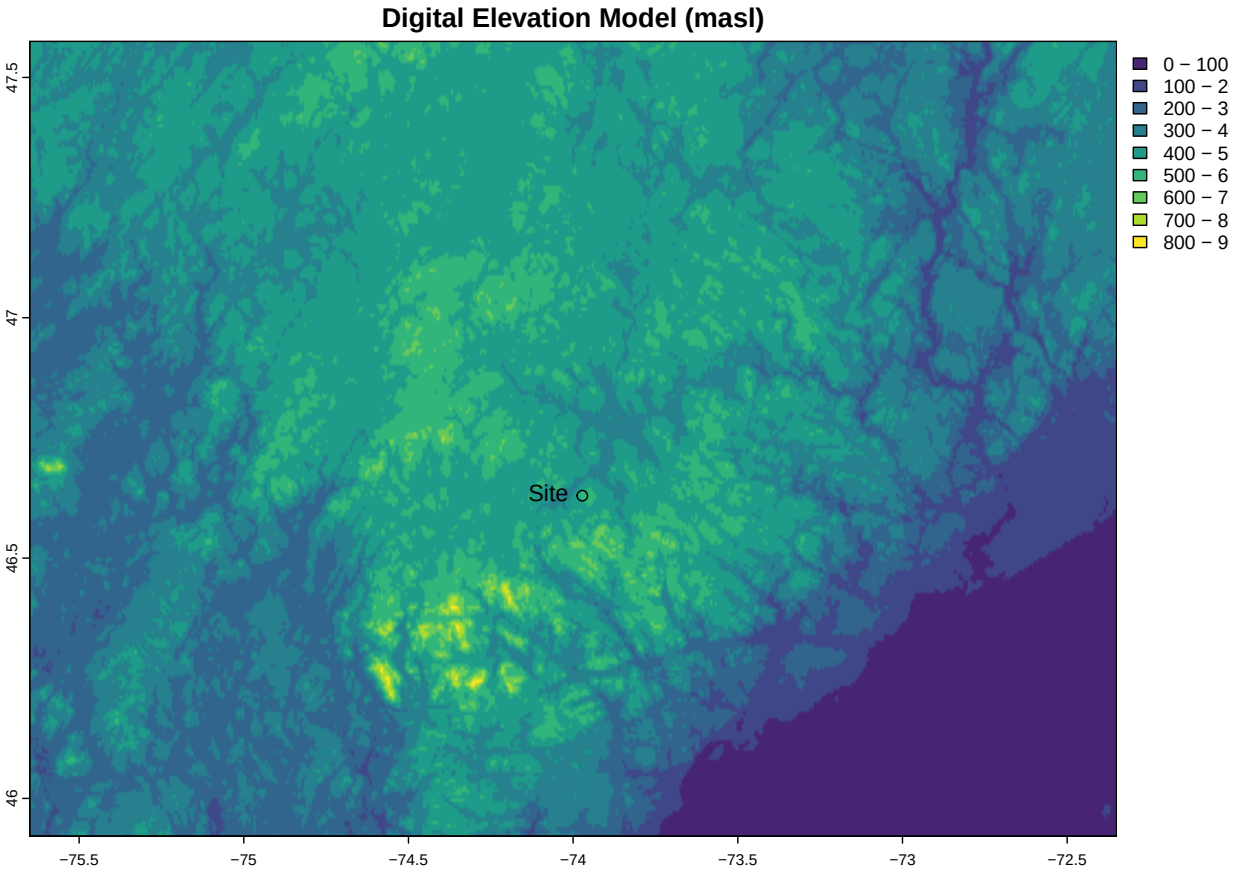
Area of interest covers a distance of up to 125km from Site



Chapter 3

Digital Elevation Model

Digital elevation model from the region was downloaded from the Shuttle Radar Topography Mission (SRTM) dataset. The SRTM database contains global elevation data with 3 arc-second (90 m) spatial resolution, which is deemed sufficient for climate analysis.



Chapter 4

NMG Precipitation Data

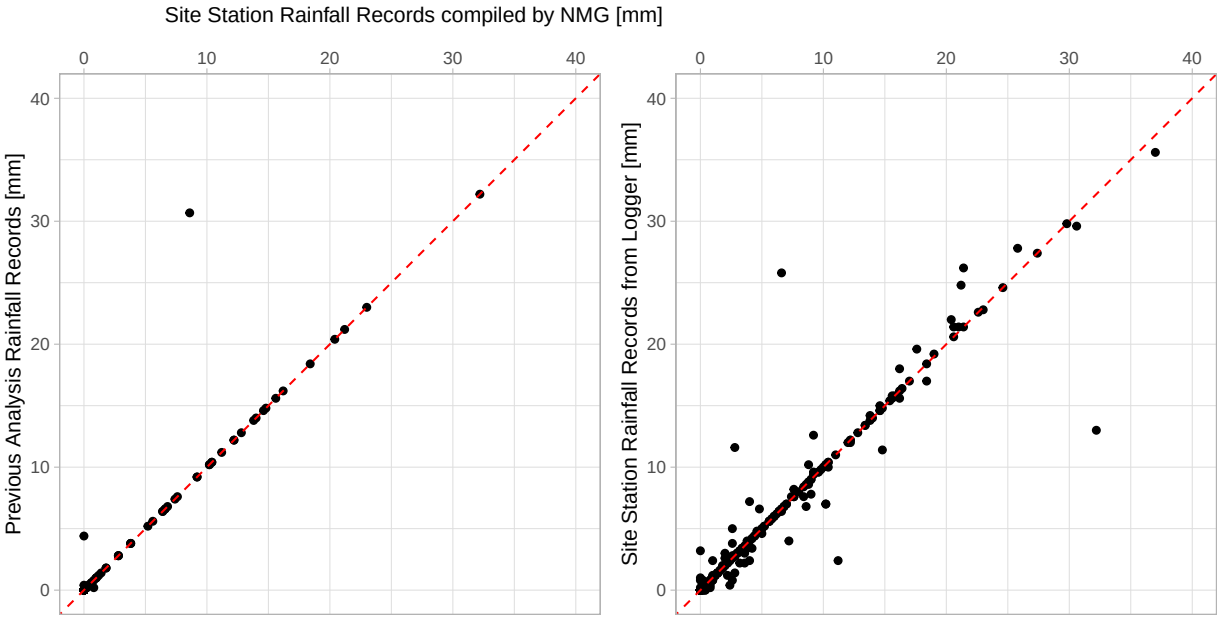
Site data is collected by NMG from two meteorological stations. The first station is located on Site, and the second station, called SoftdB, is located 1.5 km north at the following address: 200 Chemin des Hauteurs, Saint-Michel-des-Saints. Both records appear to only collect rainfall data.

Multiple data files were available for site. In the following section these were compiled and compared. Site records are consistent and the source file compiled by NMG has the longest records and is therefore selected for further analysis.

Note: SoftdB data is different from ECCC station 48188 data, so both records were kept.

NMG Stations Records and Missing Data
NMG Site Station
NMG SoftdB Station
Previous Analysis Site
Site Logger data
Daily Rainfall [mm]
0
50
100
2021
2022
2023
2024

Comparison between all the Site Station data files for Precipitation



Chapter 5

Regional Precipitation Analysis

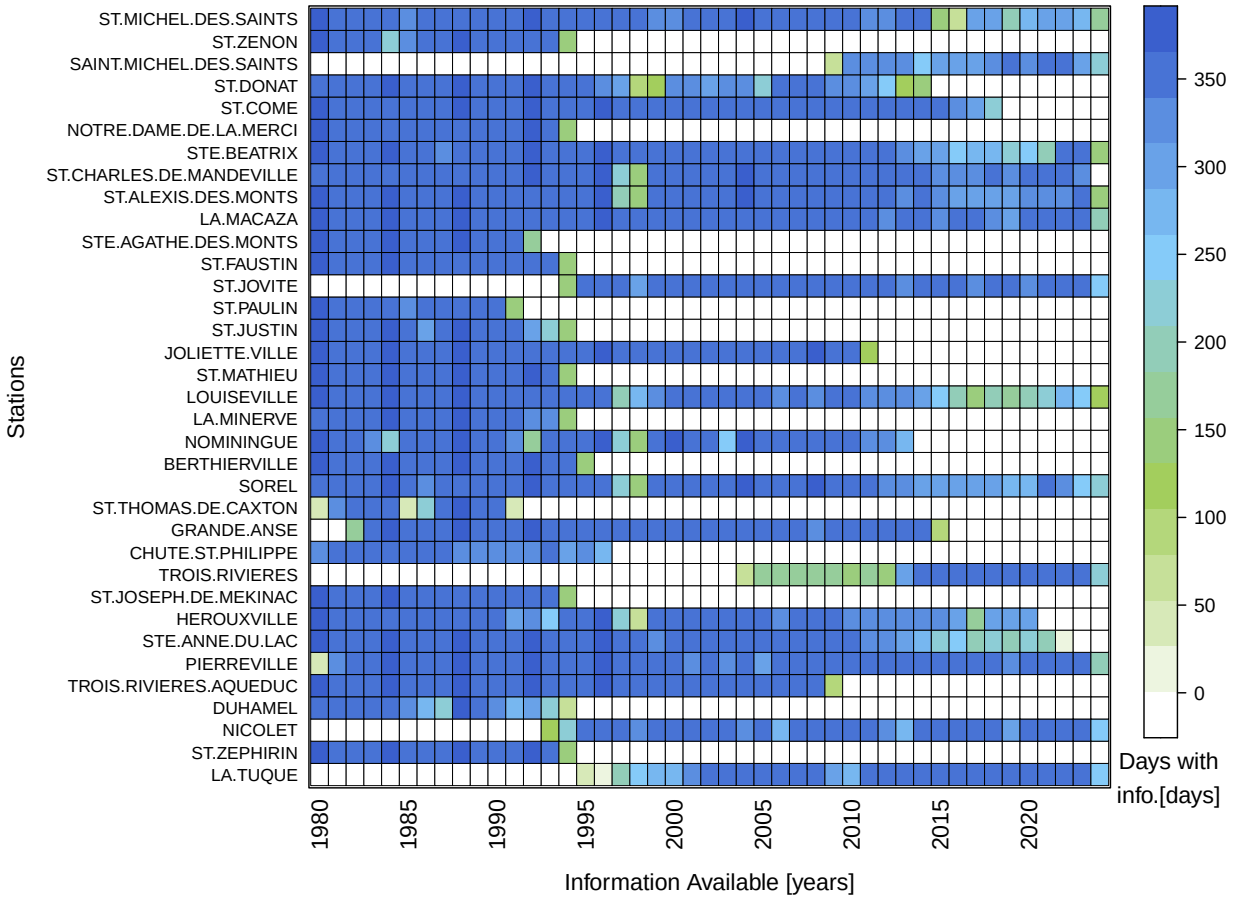
5.1 ECCC Precipitation Data

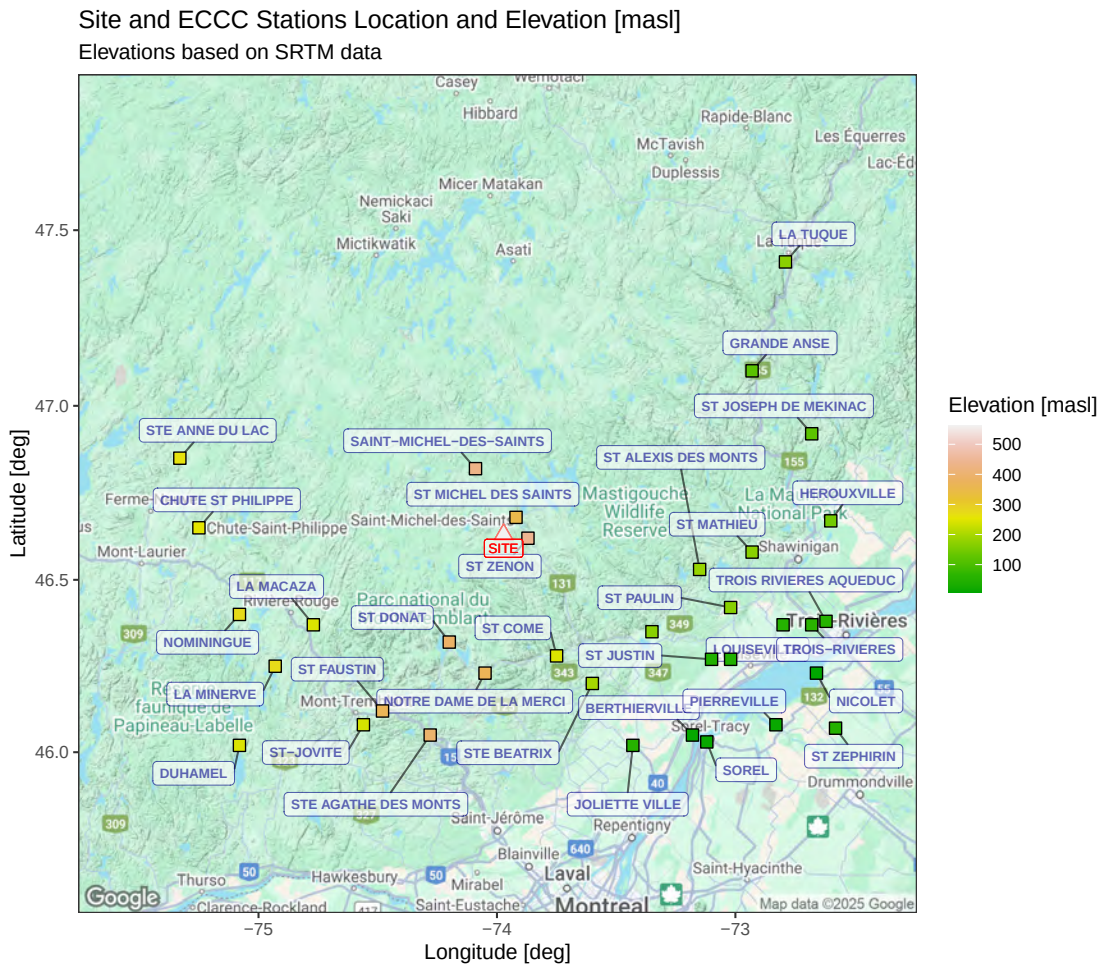
Environment and Climate Change Canada (ECCC) data was downloaded and prepared for analysis. The information is captured on a daily or hourly timestep when available. No complementary/redundant stations were detected so patching was not required for stations within the area of interest.

The following figures show:

1. Data availability over time at each station (only records from 1980 to 2023 were considered for this analysis).
2. Selected ECCC stations location and elevation.

Refer to the "eccc_read.r" for pre-processing details.


ST.MICHEL.DES.SAINTS
ST.ZENON
SAINT.MICHEL.DES.SAINTS
ST.DONAT
ST.COME
NOTRE.DAME.DE.LA.MERCI
STE.BEATRIX
ST.CHARLES.DE.MANDEVILLE
ST.ALEXIS.DES.MONTS
LA.MACAZA
STE.AGATHE.DES.MONTS
ST.FAUSTIN
ST.JOVITE
ST.PAULIN
ST.JUSTIN
JOLIETTE.VILLE
ST.MATHIEU
LOUISEVILLE
LA.MINERVE
NOMININGUE
BERTHIERVILLE
SOREL
ST.THOMAS.DE.CAXTON
GRANDE.ANSE
CHUTE.ST.PHILIPPE
TROIS.RIVIERES
ST.JOSEPH.DE.MEKINAC
HEROUXVILLE
STE.ANNE.DU.LAC
PIERREVILLE
TROIS.RIVIERES.AQUEDUC
DUHAMEL
NICOLET
ST.ZEPHIRIN
LA.TUQUE
Stations
1980
1985
1990
1995
2000
2005
2010
2015
2020
Information Available [years]
350
300
250
200
150
100
50
0
Days with
info.[days]



5.2 Reanalysis Regional Overview

Climate reanalysis combines gridded global models with observed historical data to produce historical climate and to incorporate adjustments based on developed relationships. Multiple reanalysis datasets are available in different spatio-temporal resolutions.

For this project four reanalysis datasets were evaluated. These are presented as gridded climate models and cover an area of interest defined between

5.2.1 Gridded Dataset Analysis Function

A general function is created to review each selected gridded dataset and compare it to station records. Four graphs are presented as outputs including:

- Graph 1: Mean annual precipitation (MAP) as a gridded map over the analysis extents, compared to station results. This aims to help visualize any regional trends in mean precipitation.
- Graph 2: Mean Annual Precipitation Elevation gradient over the analysis extents and regression, compared to station results.
- Graph 3: Mean Monthly Precipitation Elevation gradient over the analysis extents, compared to station results. Results and regressions split by month.

- Graph 4: Mean Annual Precipitation Elevation gradient and regression, compared to station results, split by location by latitude and longitude increments of 0.5 degrees. This graph offers a visualization of any local trends that might be more significant than regional trends.

5.2.2 Daymet

Daymet is a reanalysis tool developed by the Oak Ridge National Laboratory and supported by NASA, Daymet provides long-term, continuous, gridded estimates of daily weather and climatology in North America (Thornton et al. 2022) including variables such as daily maximum and minimum temperatures, precipitation, and shortwave radiation.

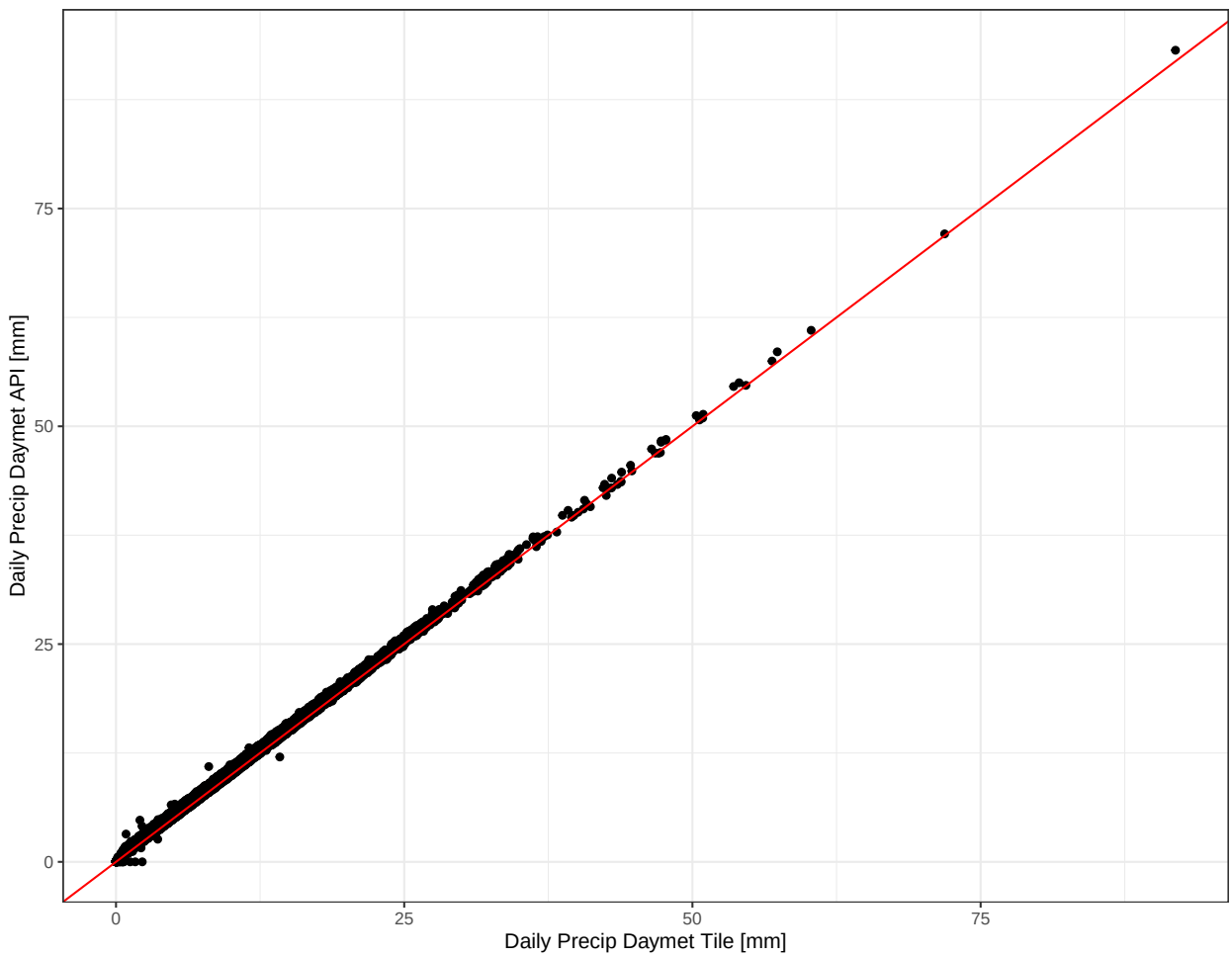
Daymet uses a set of spatial interpolation algorithms to estimate weather and climate patterns at a 1 km spatial resolution. Daymet is particularly useful for ecological and hydrological modeling. It offers high spatial resolution data covering an extended time period, making it suitable for analyzing long-term climate trends and their impacts on various environmental processes.

5.2.2.1 Daymet Source Selection

Two Daymet sources are compared:

1. API: data retrieved directly for a location from the Daymet site (interpolation function used)
2. Tiles: data extracted from the raster dataset

Both are mostly equivalent although slight differences are observed, likely due to interpolation/re-projection methods.

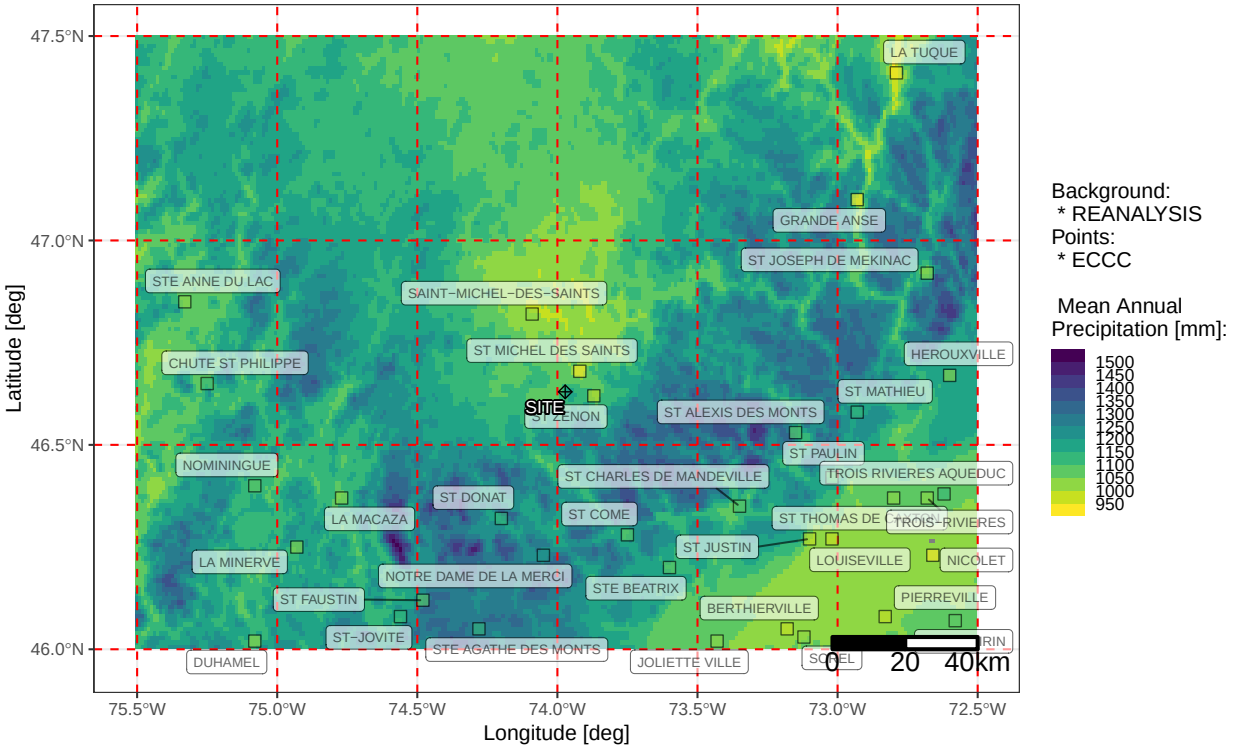


5.2.2.2 Daymet Regional Overview for Precipitation

The main findings of the Daymet regional overview are listed below (the corresponding figures follow):

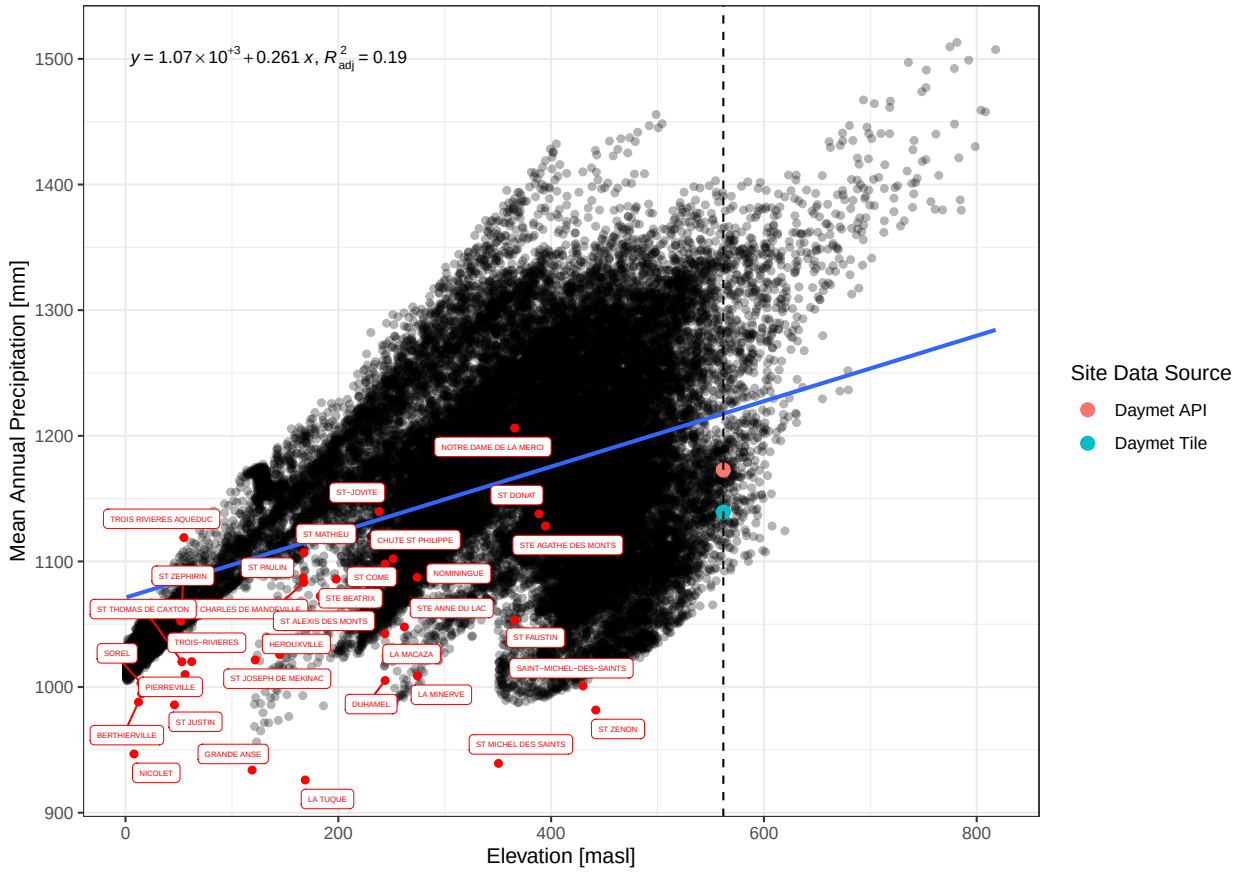
- On a regional scale, Daymet is consistent with ECCC in terms of spatial trends on MAP (Graph 1).
- The MAP versus Elevation gradient (Graph 2) shows a slight overprediction of MAP for Daymet on a regional scale. This observation is generally consistent with the monthly breakdown of this data (Graph 3).
- The localized breakdown of MAP vs Elevation (Graph 4) shows signifantly improved correlations between elevation and MAP, suggesting the existence of localized orthographic effects that don't follow a regional trend. Daymet overprediction of MAP appears to be consistent across the smaller areas.

Graph 1: Mean Annual Precipitation [mm]:
(1980 − 2023)



Graph 2: Regional Elevation Gradient

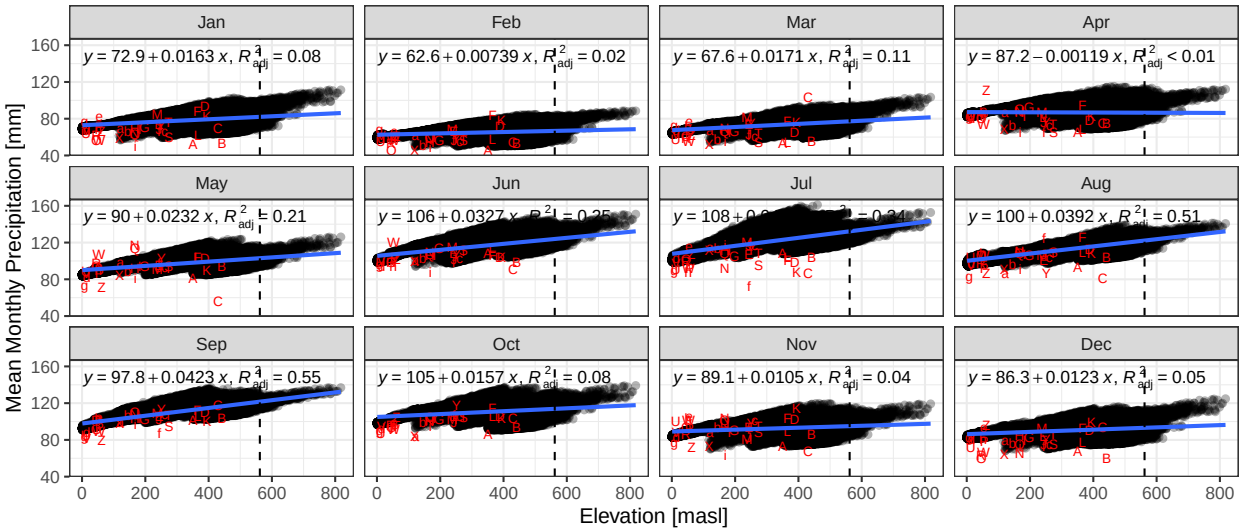
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

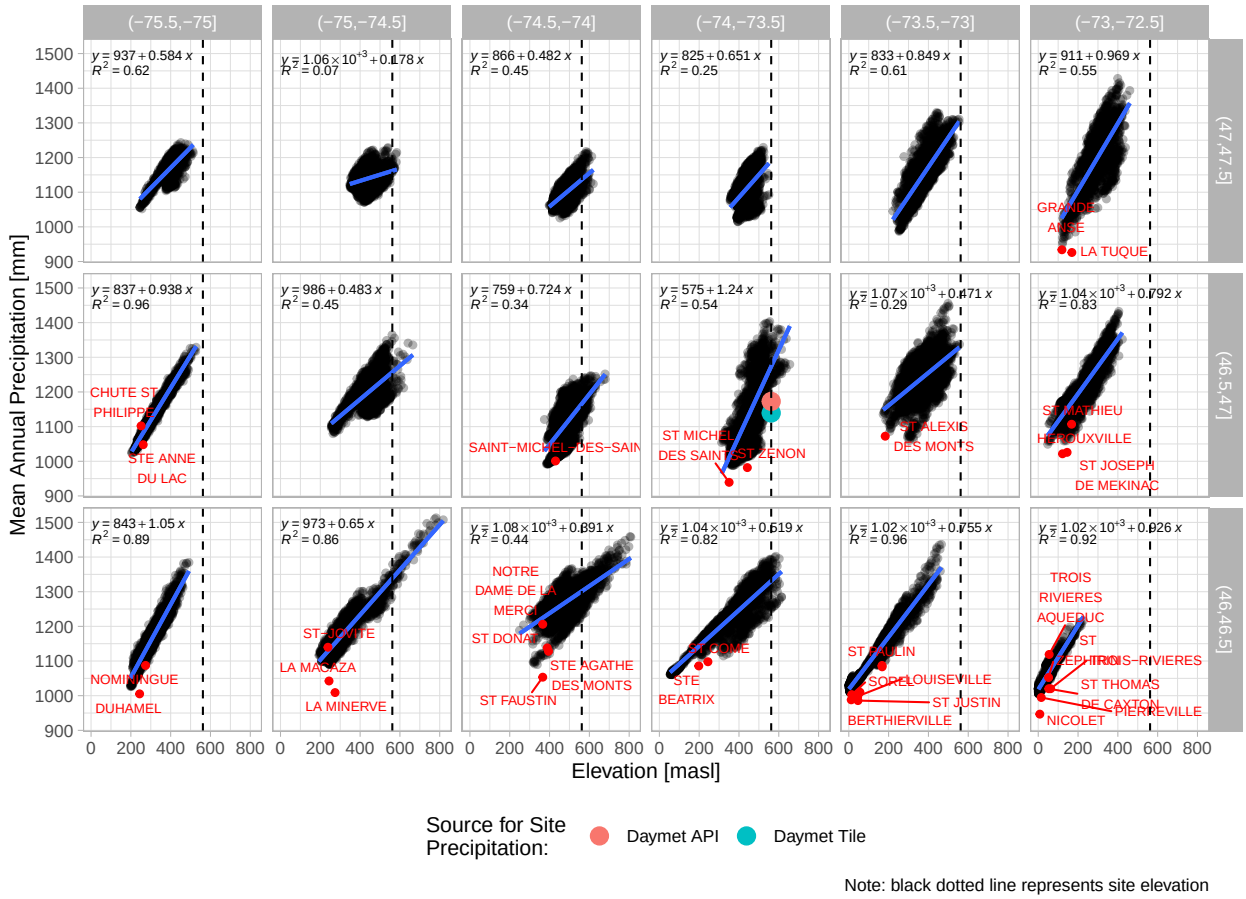
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



A	ST MICHEL DES SAINTS	H	ST CHARLES DE MANDEVILLE	O	ST JUSTIN	V	SOREL	c	STE ANNE DU
B	ST ZENON	I	ST ALEXIS DES MONTS	P	JOLIETTE VILLE	W	ST THOMAS DE CAXTON	d	PIERREVILLE
C	SAINT−MICHEL−DES−SAINTS	J	LA MACAZA	Q	ST MATHIEU	X	GRANDE ANSE	e	TROIS RIVIERE
D	ST DONAT	K	STE AGATHE DES MONTS	R	LOUISEVILLE	Y	CHUTE ST PHILIPPE	f	DUHAMEL
E	ST COME	L	ST FAUSTIN	S	LA MINERVE	Z	TROIS−RIVIERES	g	NICOLET
F	NOTRE DAME DE LA MERCI	M	ST−JOVITE	T	NOMININGUE	a	ST JOSEPH DE MEKINAC	h	ST ZEPHIRIN
G	STE BEATRIX	N	ST PAULIN	U	BERTHIERVILLE	b	HEROUXVILLE	i	LA TUQUE

Note: black dotted line represents site elevation

Graph 4: Mean Annual Precipitation [mm] versus Elevation [masl] (1980 − 2023)
Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



5.2.3 ERA5 Regional Overview for Precipitation

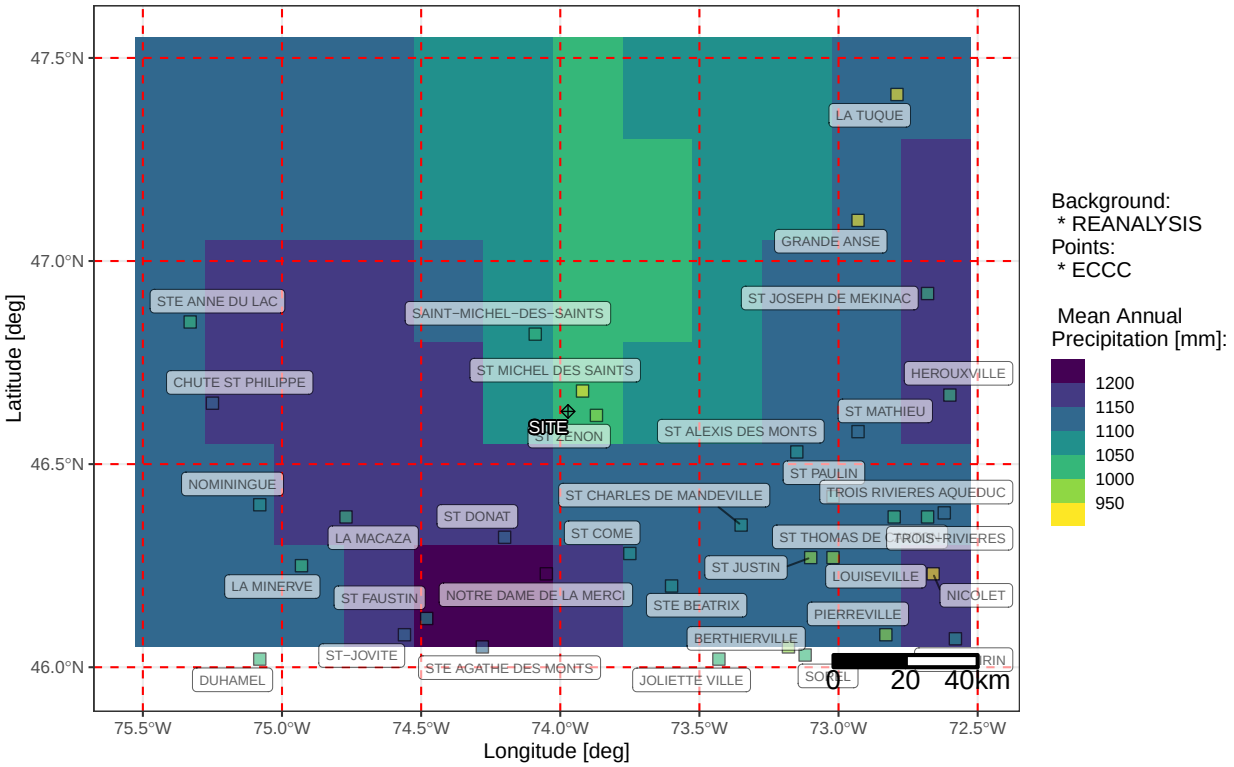
ERA5 is the fifth generation ECMWF atmospheric reanalysis of the global climate covering the period from January 1940 to present (Hersbach et al. 2020). ERA5 is produced by the Copernicus Climate Change Service (C3S) at the European Centre for Medium-Range Weather Forecasts (ECMWF). It offers information about multiple meteorological parameters.

ERA5 provides hourly estimates of a large number of atmospheric, land and oceanic climate variables. The data cover the Earth on a 31km grid and resolve the atmosphere using 137 levels from the surface up to a height of 80km. Surface level parameters were evaluated in this analysis.

The main findings of the ERA5 regional overview are listed below (the corresponding figures follow):

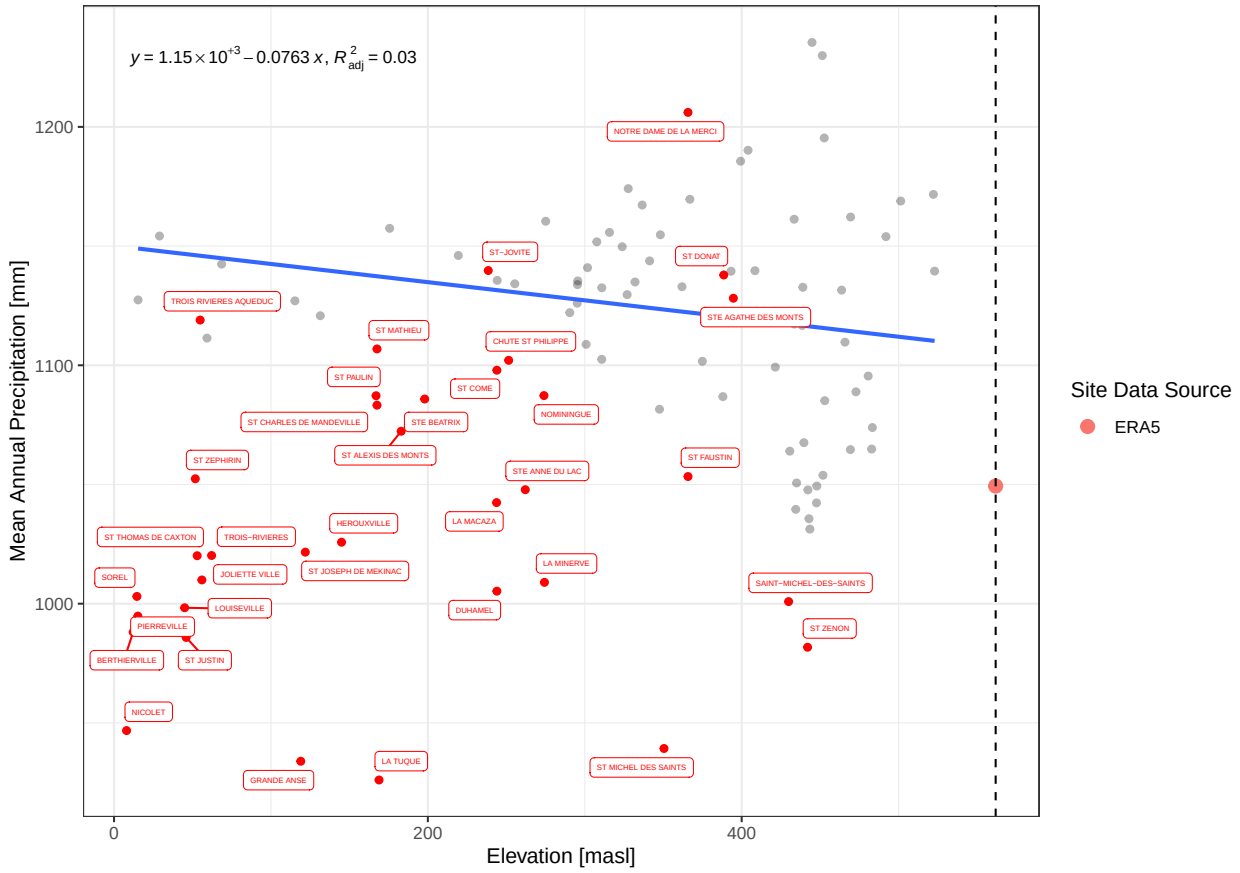
- On a regional scale, ERA5 is consistent with ECCC in terms of spatial trends on MAP (Graph 1).
- The MAP versus Elevation gradient (Graph 2) shows a slight overprediction of MAP for ERA5 on a regional scale. This observation is generally consistent with the monthly breakdown of this data (Graph 3). Mean grid elevation is generally higher than the stations elevation due to the mountainous nature of the region.
- The localized breakdown of MAP vs Elevation (Graph 4) is not relevant for precipitation analysis due to the lower resolution of the ERA5 dataset. Note that mean grid elevation is generally higher than the stations elevation due to the mountainous nature of the region.

Graph 1: Mean Annual Precipitation [mm]:
(1980 – 2023)



Graph 2: Regional Elevation Gradient

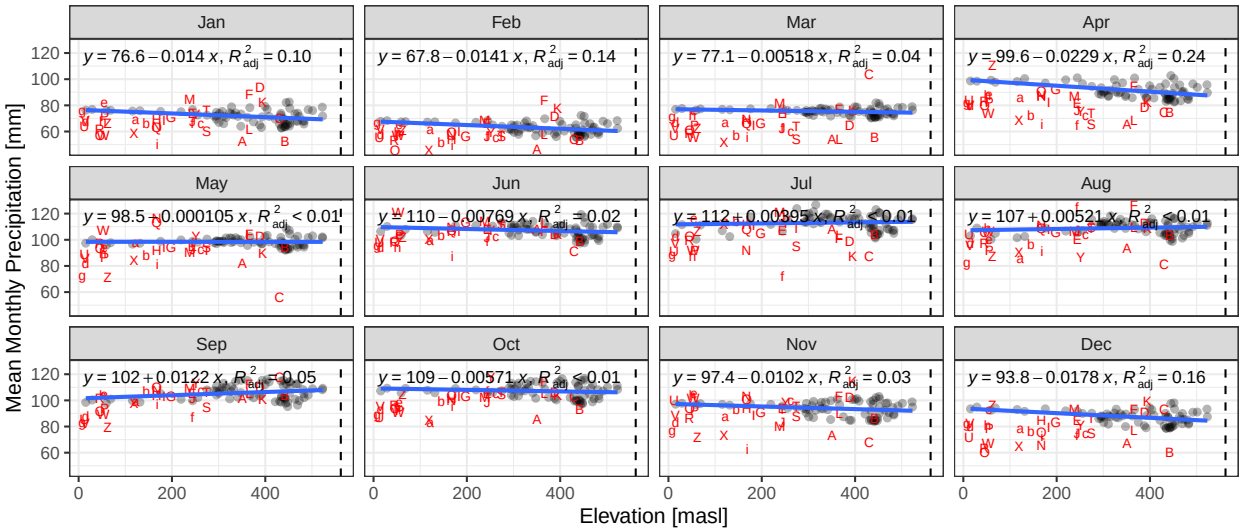
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

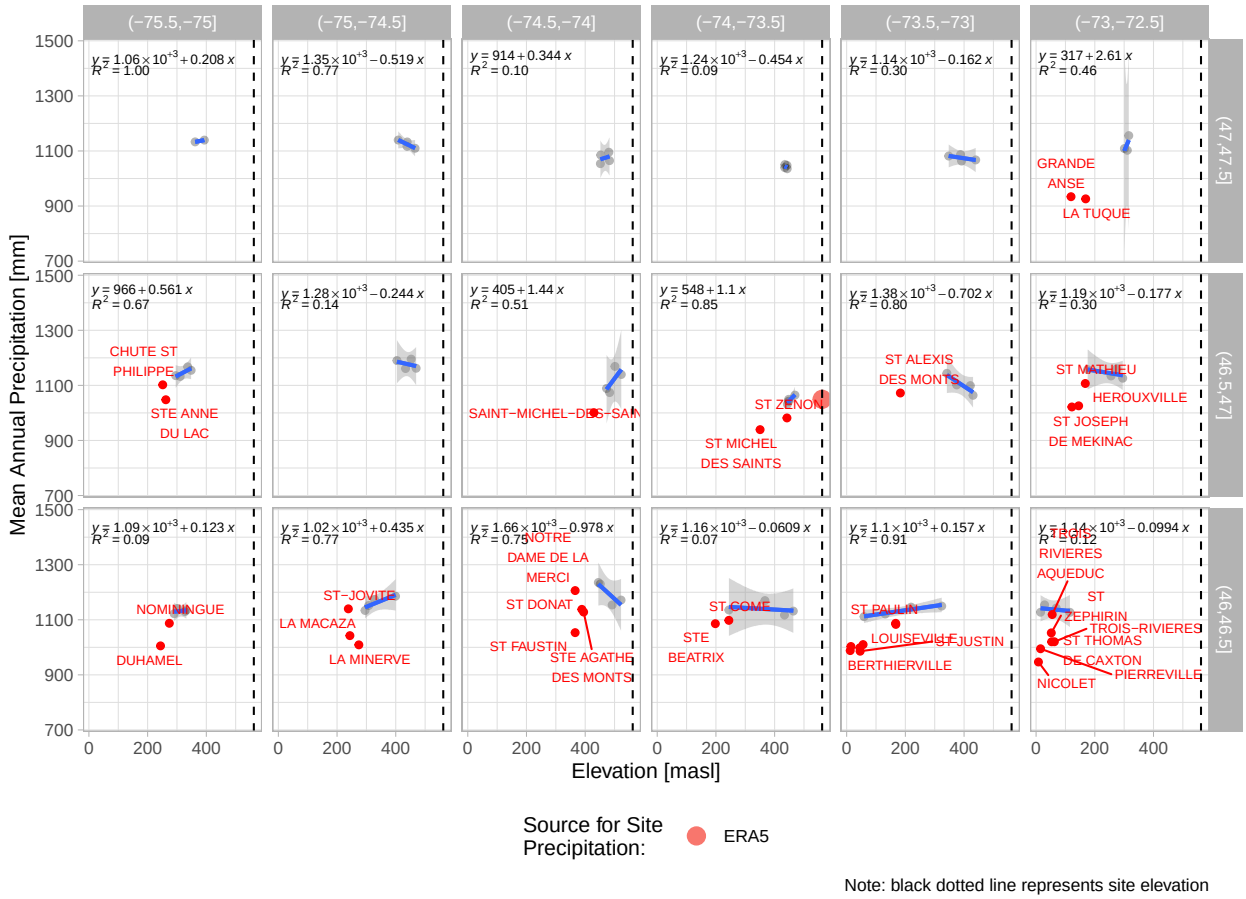
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



A	ST MICHEL DES SAINTS	H	ST CHARLES DE MANDEVILLE	O	ST JUSTIN	V	SOREL	c	STE ANNE DU
B	ST ZENON	I	ST ALEXIS DES MONTS	P	JOLIETTE VILLE	W	ST THOMAS DE CAXTON	d	PIERREVILLE
C	SAINT−MICHEL−DES−SAINTS	J	LA MACAZA	Q	ST MATHIEU	X	GRANDE ANSE	e	TROIS RIVIERE
D	ST DONAT	K	STE AGATHE DES MONTS	R	LOUISEVILLE	Y	CHUTE ST PHILIPPE	f	DUHAMEL
E	ST COME	L	ST FAUSTIN	S	LA MINERVE	Z	TROIS−RIVIERES	g	NICOLET
F	NOTRE DAME DE LA MERCI	M	ST−JOVITE	T	NOMININGUE	a	ST JOSEPH DE MEKINAC	h	ST ZEPHIRIN
G	STE BEATRIX	N	ST PAULIN	U	BERTHIERVILLE	b	HEROUXVILLE	i	LA TUQUE

Note: black dotted line represents site elevation

Graph 4: Mean Annual Precipitation [mm] versus Elevation [masl] (1980 − 2023)
Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



Note: black dotted line represents site elevation

5.2.4 ERA5-Land Regional Overview for Precipitation

ERA5-Land is a higher spatial and temporal resolution reanalysis dataset produced by the European Centre for Medium-Range Weather Forecasts (ECMWF) (Muñoz-Sabater et al. 2021). It offers detailed information about a large number of atmospheric, land and oceanic climate variables.

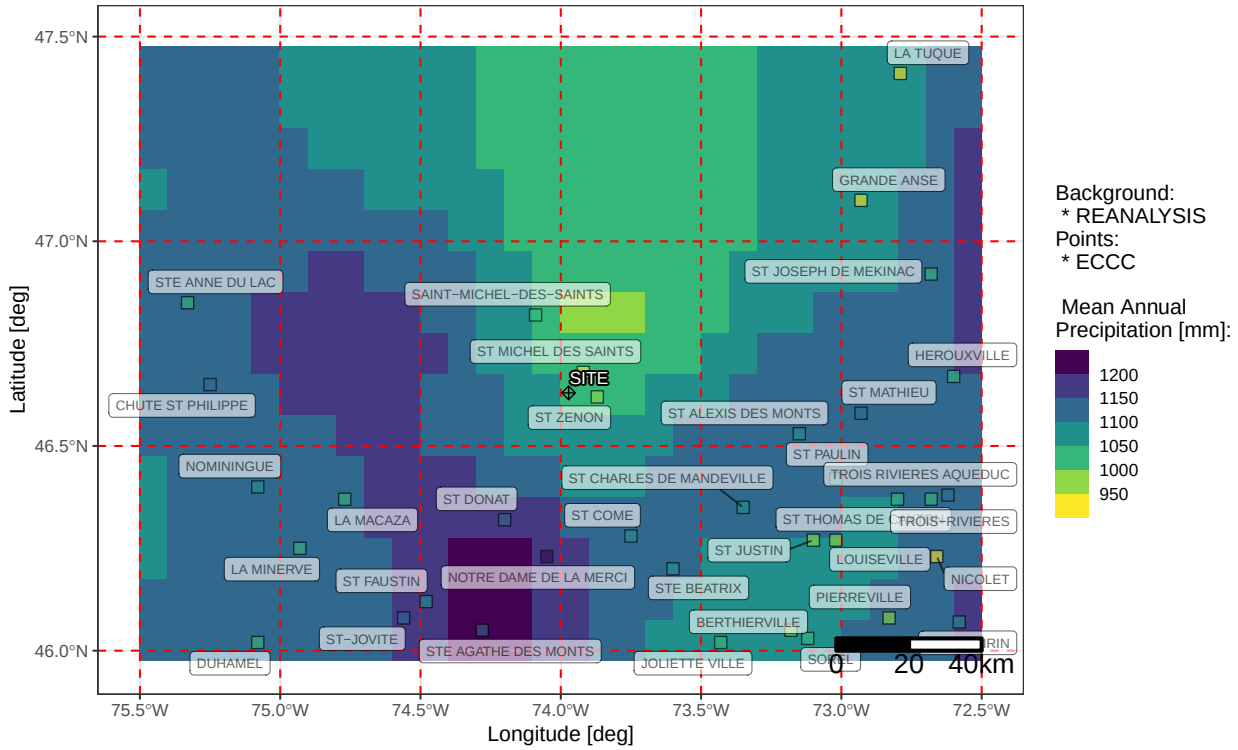
ERA5-Land operates at a spatial resolution of approximately 9 km and provides data at hourly intervals, making it particularly useful for hydrological and environmental studies. This dataset is widely used in research and operational applications due to its comprehensive coverage and high accuracy in representing land-surface conditions.

The main findings of the Era5-Land regional overview are listed below (the corresponding figures follow):

- On a regional scale, Era5-Land is consistent with ECCC in terms of spatial trends on MAP (Graph 1).
- Similarly to ERA5, the MAP versus Elevation gradient (Graph 2) shows a slight overprediction of MAP for Era5-Land on a regional scale. This observation is generally consistent with the monthly breakdown of this data (Graph 3).
- The localized breakdown of MAP vs Elevation (Graph 4) shows slightly improved correlations between elevation and MAP in some areas, suggesting the existence of some localized orthographic effects. Era5-Land overprediction of MAP appears to be consistent across the smaller

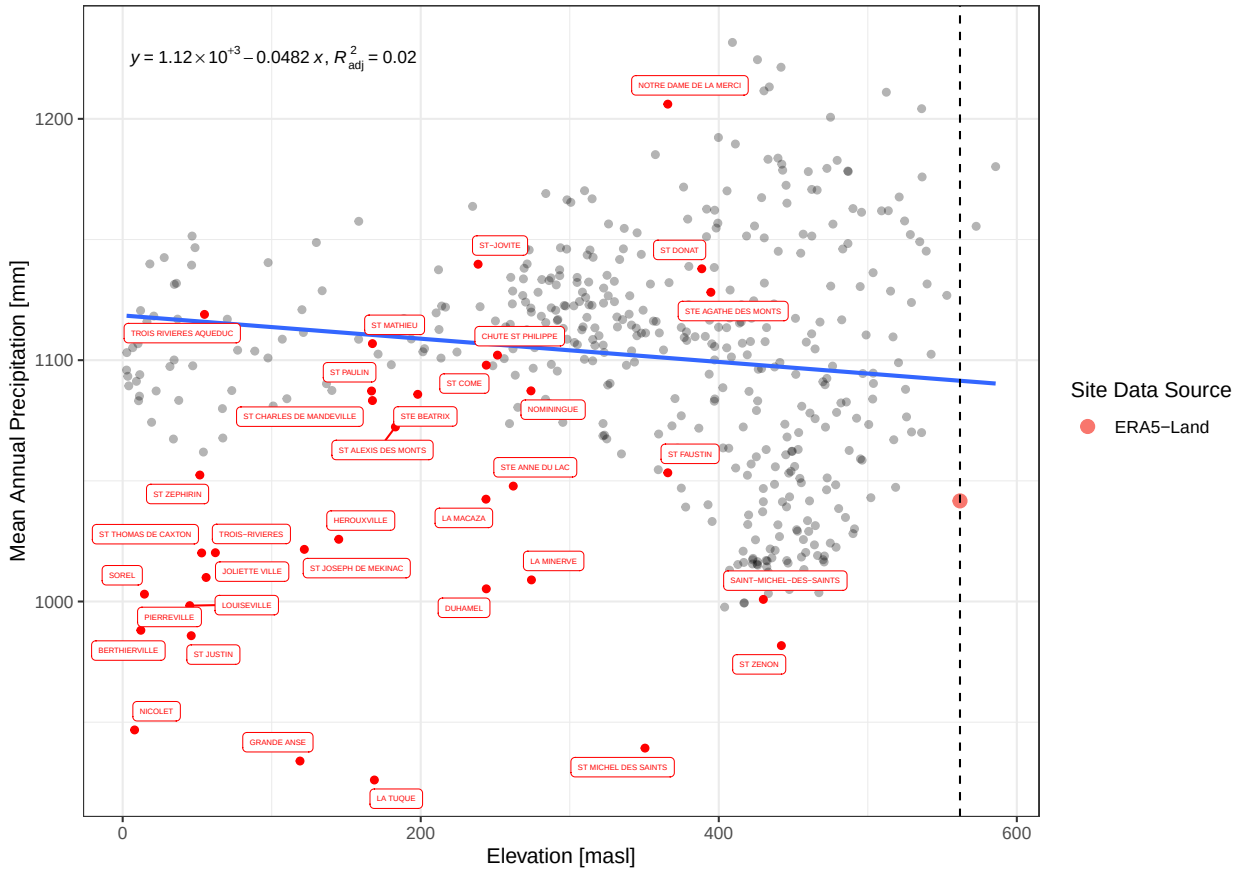
areas.

Graph 1: Mean Annual Precipitation [mm]:
(1980 − 2023)



Graph 2: Regional Elevation Gradient

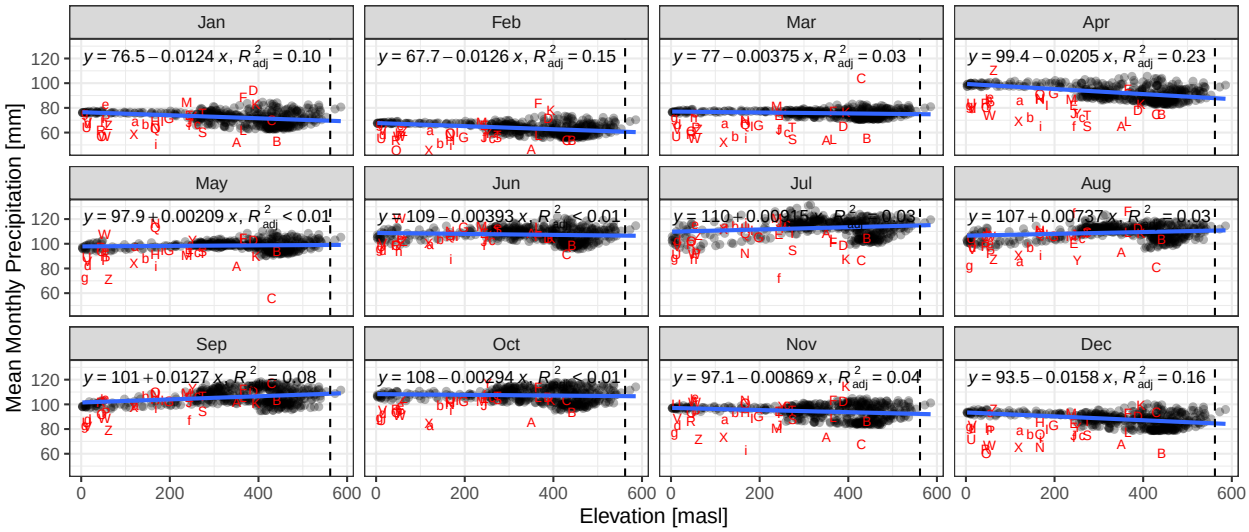
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

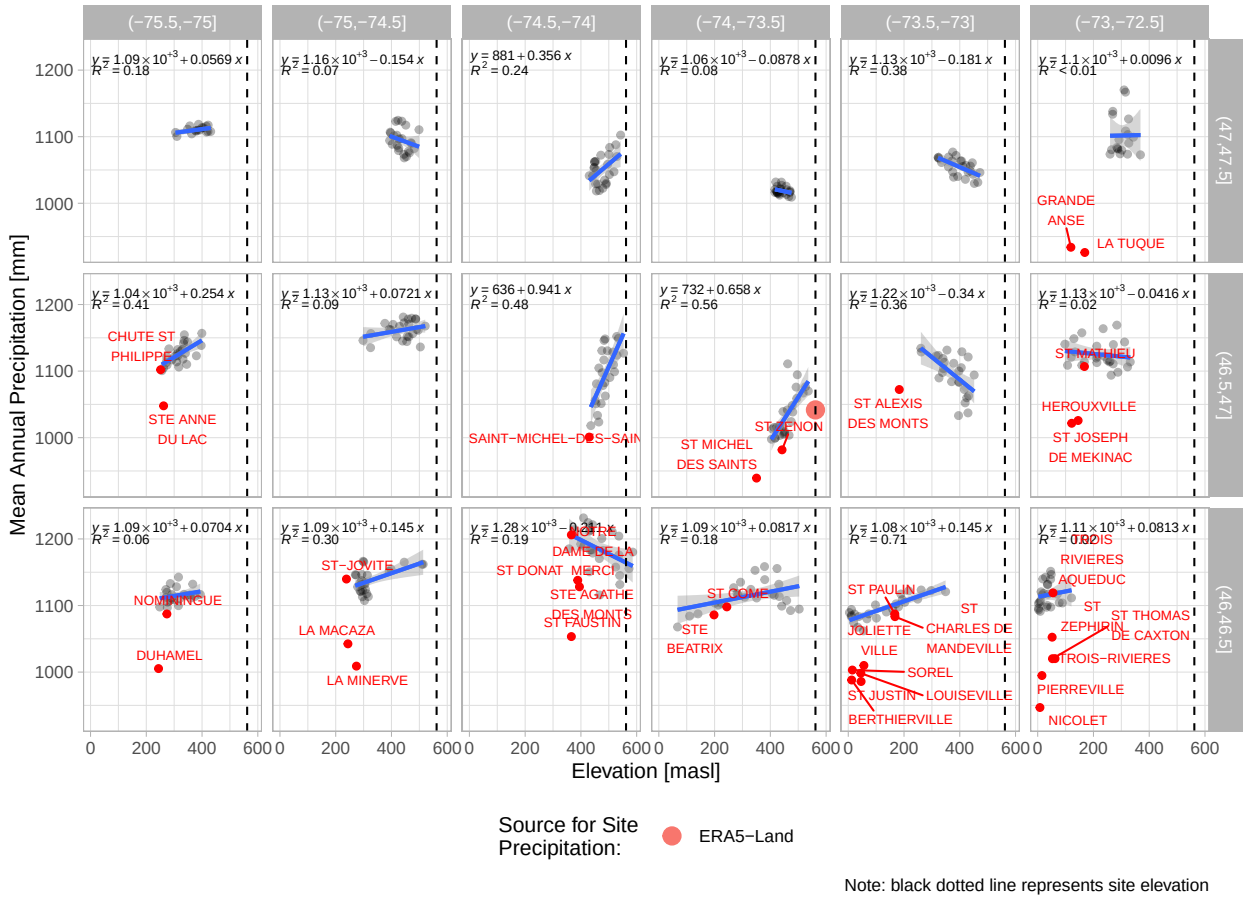
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



A ST MICHEL DES SAINTS	H ST CHARLES DE MANDEVILLE	O ST JUSTIN	V SOREL	c STE ANNE DU
B ST ZENON	I ST ALEXIS DES MONTS	P JOLIETTE VILLE	W ST THOMAS DE CAXTON	d PIERREVILLE
C SAINT−MICHEL−DES−SAINTS	J LA MACAZA	Q ST MATHIEU	X GRANDE ANSE	e TROIS RIVIERE
D ST DONAT	K STE AGATHE DES MONTS	R LOUISEVILLE	Y CHUTE ST PHILIPPE	f DUHAMEL
E ST COME	L ST FAUSTIN	S LA MINERVE	Z TROIS−RIVIERES	g NICOLET
F NOTRE DAME DE LA MERCI	M ST−JOVITE	T NOMININGUE	a ST JOSEPH DE MEKINAC	h ST ZEPHIRIN
G STE BEATRIX	N ST PAULIN	U BERTHIERVILLE	b HEROUXVILLE	i LA TUQUE

Note: black dotted line represents site elevation

Graph 4: Mean Annual Precipitation [mm] versus Elevation [masl] (1980 − 2023)
Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



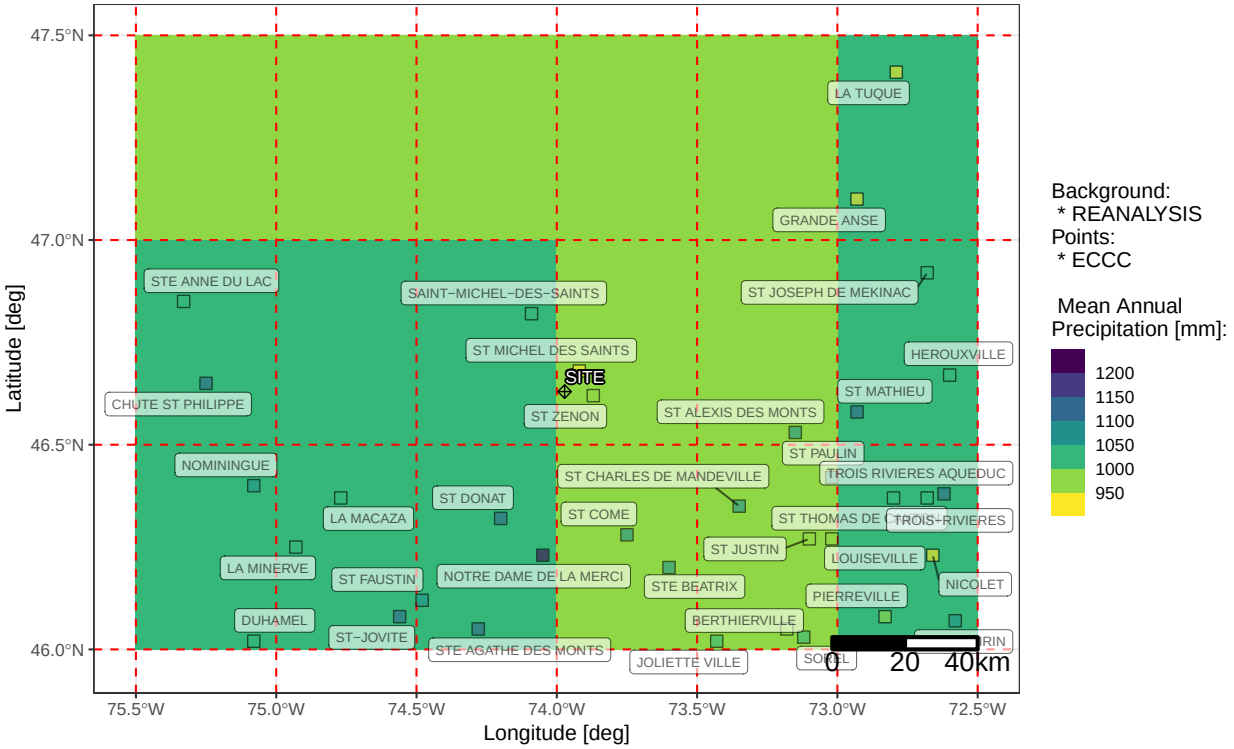
5.2.5 MERRA2 Regional Overview for Precipitation

MERRA2 (Modern-Era Retrospective analysis from Research and Applications, Version 2) is a global climate reanalysis model from the U.S. National Aeronautics and Space Administration (NASA) (Gelaro et al. 2017). MERRA2 offers daily data from 1981 to present (2024) on a grid of 0.5 degrees latitude by 0.5 degrees longitude covering the entire globe.

The main findings of the MERRA2 regional overview are listed below (the corresponding figures follow):

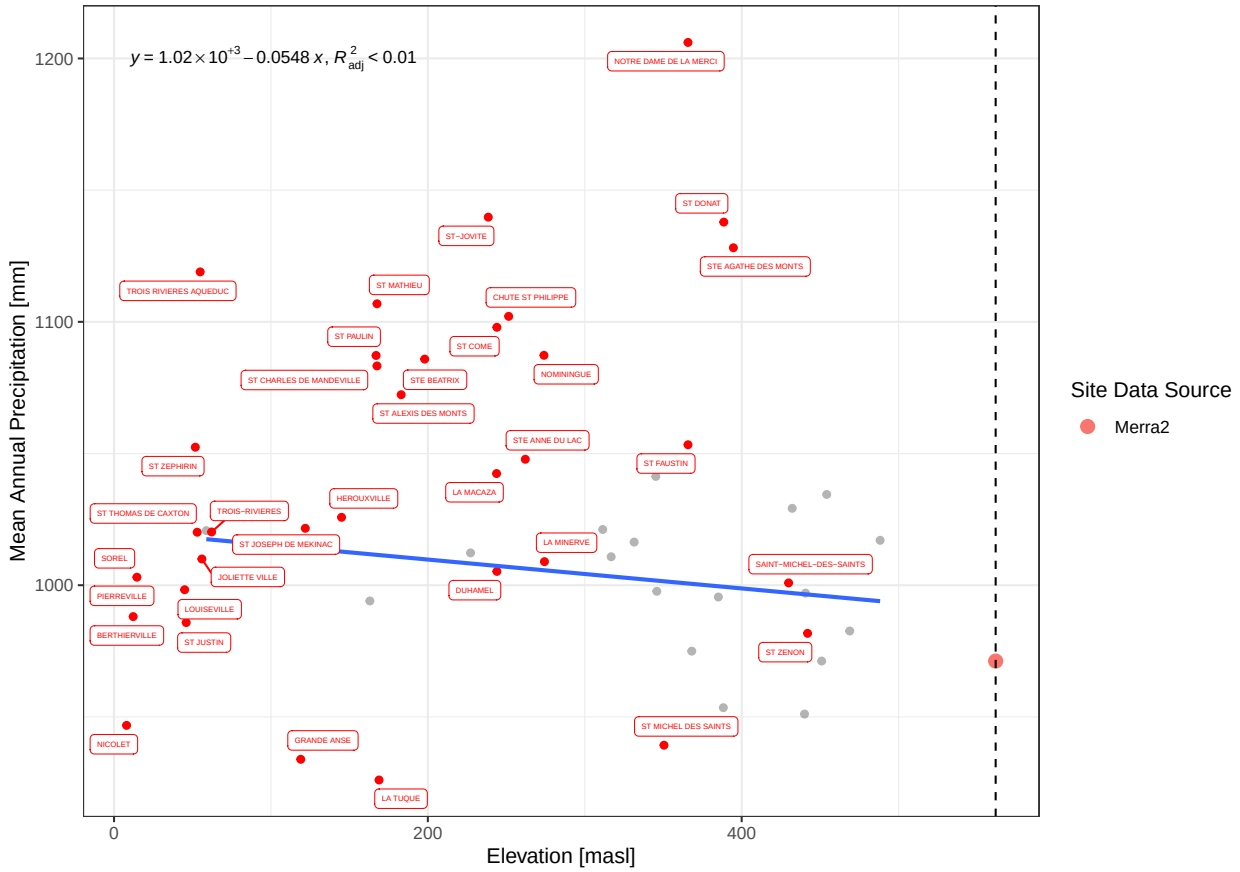
- On a regional scale, MERRA2 appears to be somewhat consistent with ECCC in terms of spatial trends on MAP (Graph 1).
- The MAP versus Elevation gradient (Graph 2) shows MAP predictions below the range of station data for MERRA2 on a regional scale, although mean grid elevation is generally higher than the stations elevation . This observation is generally consistent with the monthly breakdown of this data (Graph 3).
- The localized breakdown of MAP vs Elevation (Graph 4) is not relevant for precipitation analysis due to the lower resolution of the MERRA2 dataset. Note that mean grid elevation is generally higher than the stations elevation due to the mountainous nature of the region.

Graph 1: Mean Annual Precipitation [mm]:
(1980 – 2023)



Graph 2: Regional Elevation Gradient

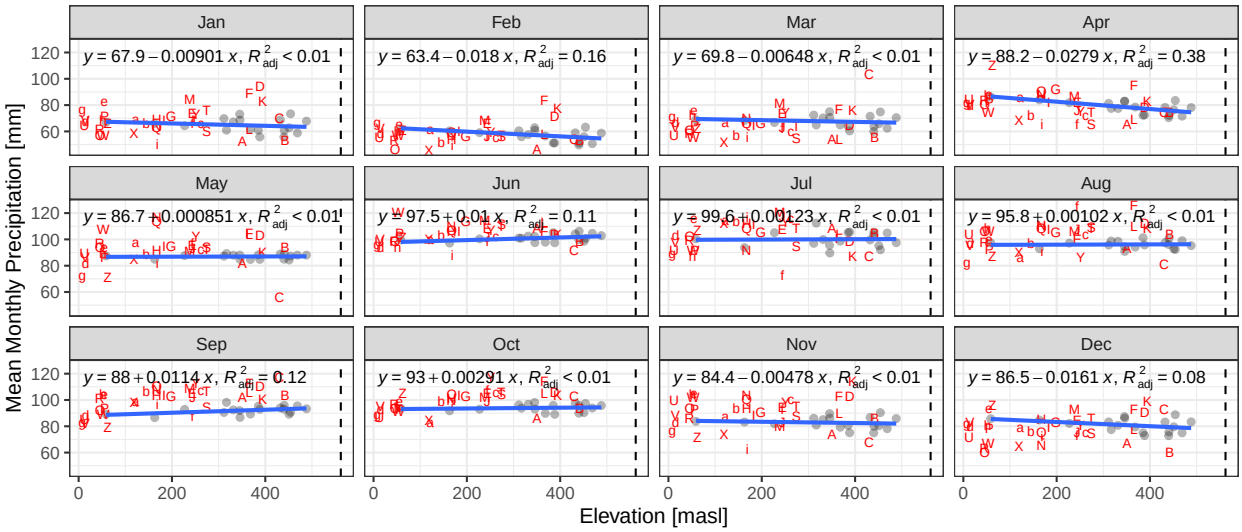
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

Reanalsis source as background: 1980 to 2023 (distance 125 km from site)

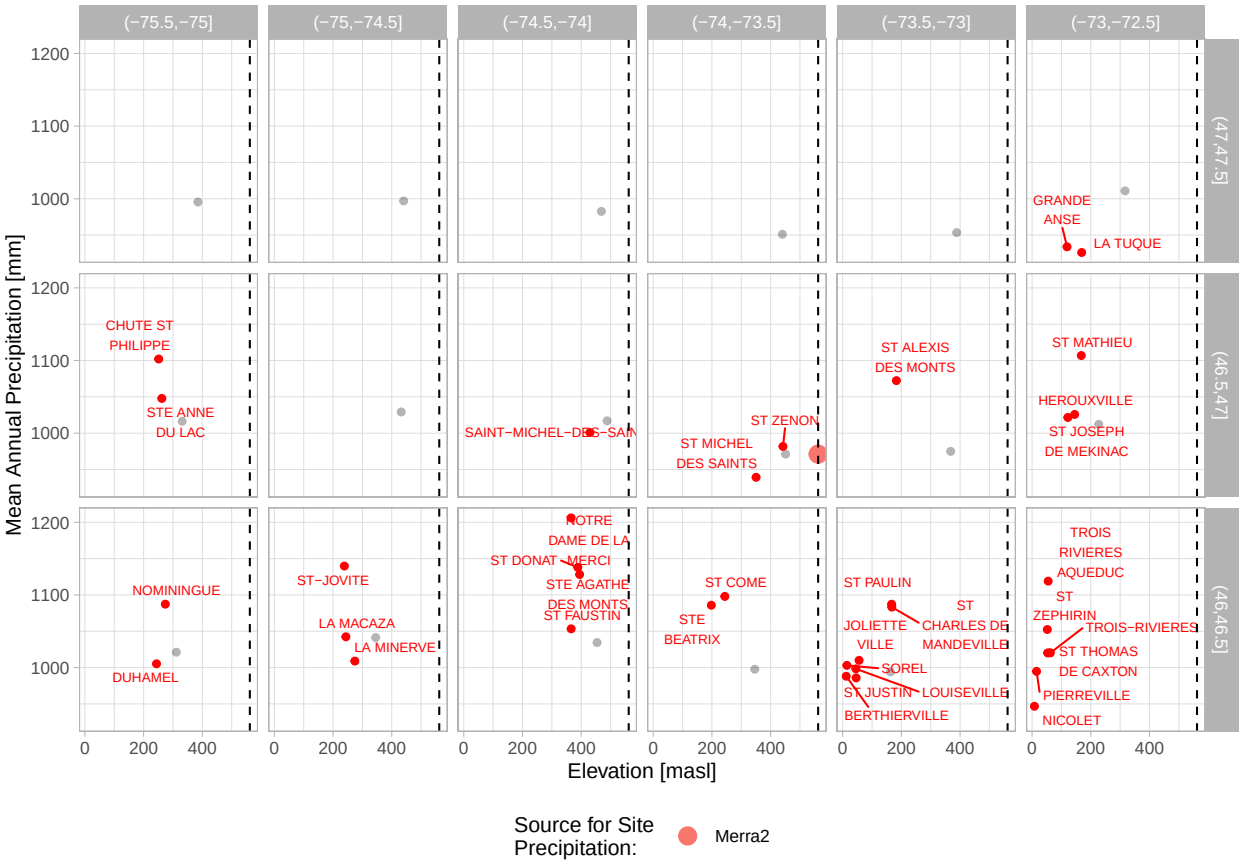


A ST MICHEL DES SAINTS	H ST CHARLES DE MANDEVILLE	O ST JUSTIN	V SOREL	c STE ANNE DU
B ST ZENON	I ST ALEXIS DES MONTS	P JOLIETTE VILLE	W ST THOMAS DE CAXTON	d PIERREVILLE
C SAINT−MICHEL−DES−SAINTS	J LA MACAZA	Q ST MATHIEU	X GRANDE ANSE	e TROIS RIVIERE
D ST DONAT	K STE AGATHE DES MONTS	R LOUISEVILLE	Y CHUTE ST PHILIPPE	f DUHAMEL
E ST COME	L ST FAUSTIN	S LA MINERVE	Z TROIS−RIVIERES	g NICOLET
F NOTRE DAME DE LA MERCI	M ST−JOVITE	T NOMININGUE	a ST JOSEPH DE MEKINAC	h ST ZEPHIRIN
G STE BEATRIX	N ST PAULIN	U BERTHIERVILLE	b HEROUXVILLE	i LA TUQUE

Note: black dotted line represents site elevation

Graph 4: Mean Annual Precipitation [mm] versus Elevation [masl] (1980 − 2023)

Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



Note: black dotted line represents site elevation

Chapter 6

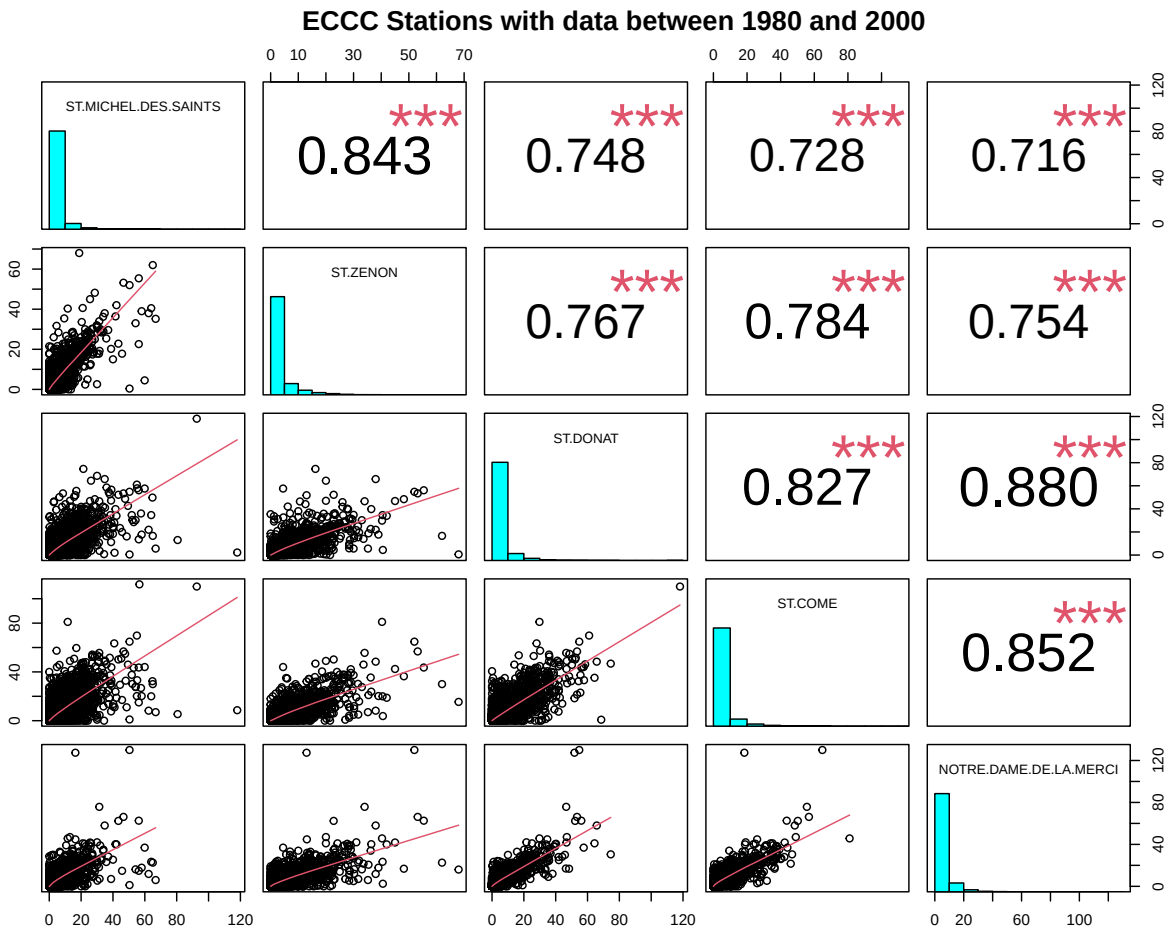
Local Analysis

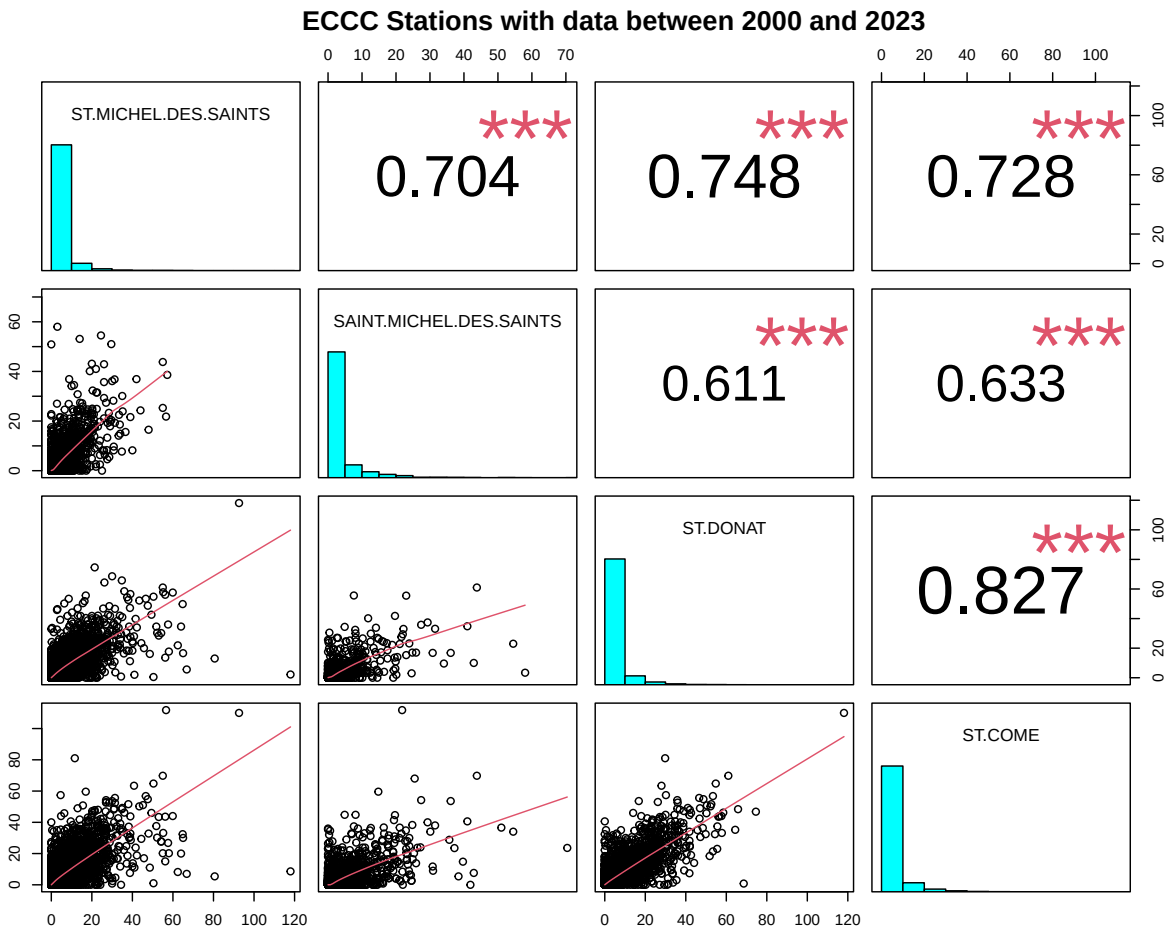
The regional analysis shows that local orographic effects are prominent and variable in the region, therefore a smaller area around Site should be more representative of its climate. The following analysis only considers data within 50km of the Matawinie Site.

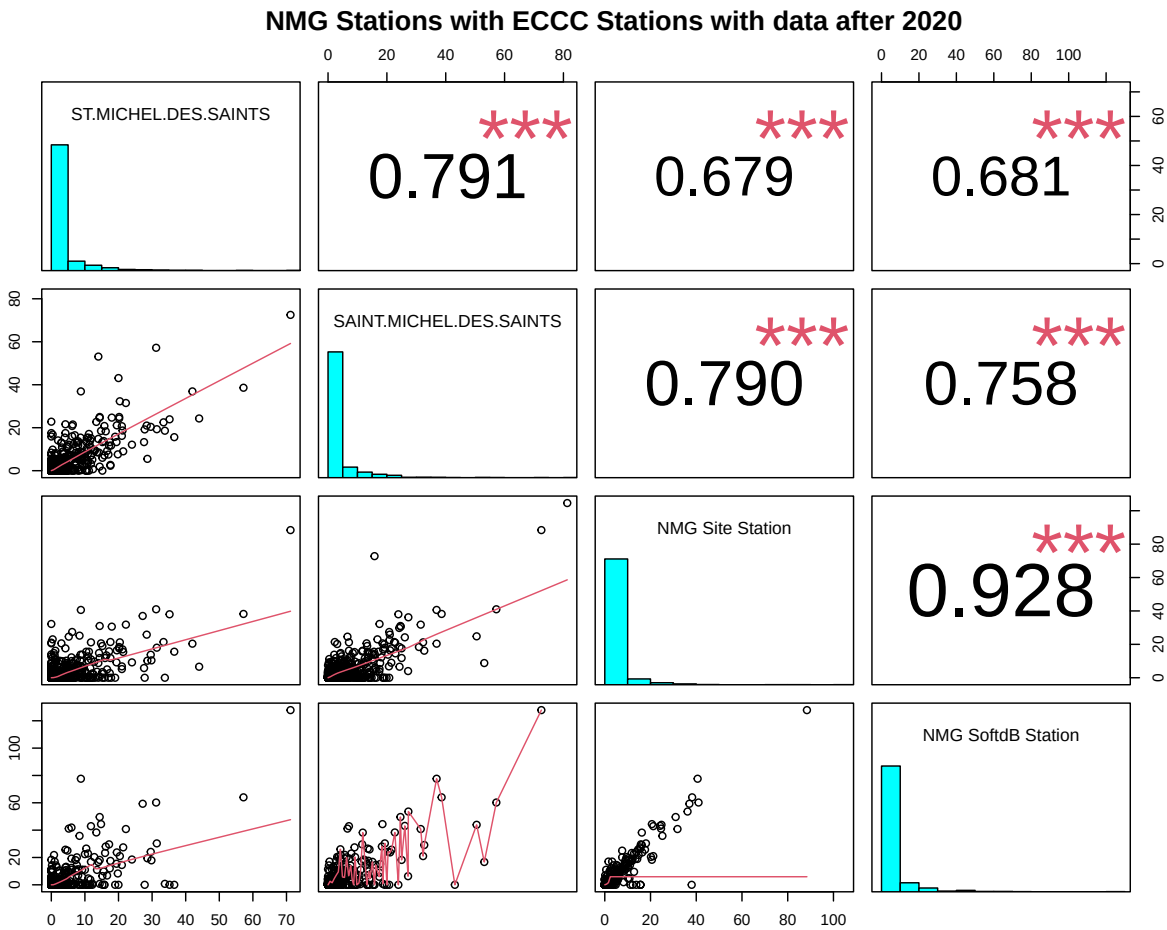
6.1 ECCC and NMG Stations data correlations

The following visualization is a correlation matrix between daily precipitation records from stations close to site. On the top right quadrant, the (absolute) value of the correlation is presented together with the result of the Pearson's product moment correlation coefficient as stars. On bottom-left quadrant the bivariate scatterplots, with a fitted line are presented. On the diagonal there is an histogram of each variable.

Precipitation from the ECCC stations close to site correlate well between each other. Similarly, NMG station records correlate well with both ECCC Saint Michel des Saints stations, but the best correlation is found between both NMG stations.


ECCC Stations with data between 1980 and 2000
ST.MICHEL.DES.SAINTS
ST.ZENON
ST.DONAT
ST.COME
NOTRE.DAME.DE.LA.MERCI
0.843 ***
0.748 ***
0.728 ***
0.716 ***
0.767 ***
0.784 ***
0.754 ***
0.827 ***
0.880 ***
0.852 ***


ECCC Stations with data between 2000 and 2023
ST.MICHEL.DES.SAINTS
0.704
0.748
0.728
SAINT.MICHEL.DES.SAINTS
0.611
0.633
ST.DONAT
0.827
ST.COME
***



6.2 Reanalysis Evaluation Against Station Records

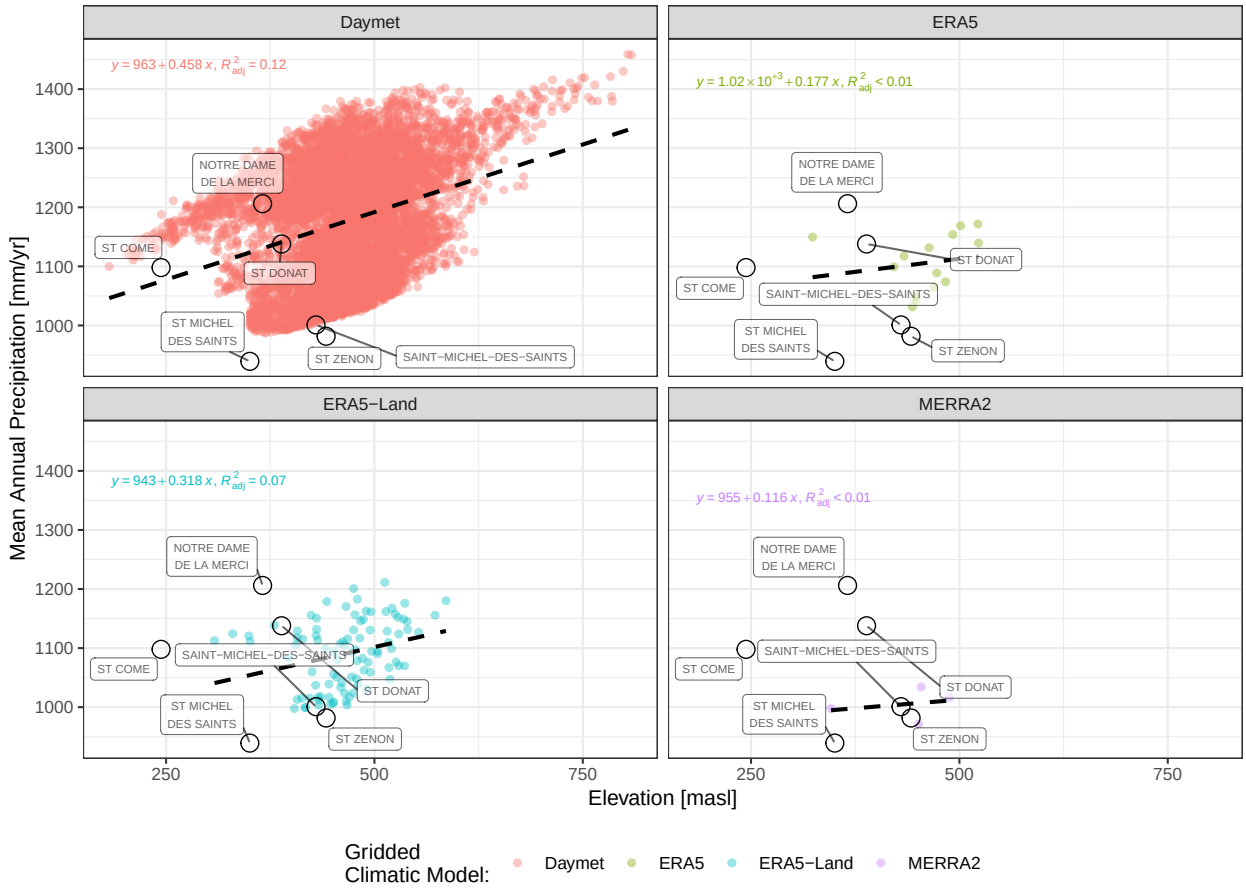
6.2.1 Local MAP Elevation Gradient Comparison

A local MAP to elevation regression is generated with data available within 50km, 30km and 10km from site. NMG stations were excluded for this graph due to only consisting of rainfall data. All the gridded climate models from the previous analysis were kept for reference.

- At an analysis distance of 50km, MAP correlations to elevation for all climate models are poor (R^2 0.2). Similarly no clear relation between MAP and Elevation is evident from the six ECCC stations records within this range.
- At an analysis distance of 30km, MAP correlations to elevation increase (0.4 R^2 0.6). This improvement is significant for Daymet. ERA5, and to a lesser extent ERA5-Land have their data population considerably reduced at this distance so the correlation improvement might not be significant. MERRA2 variability at this scale is not relevant due to it's larger grid size. Only three selected ECCC stations exist within this range.
- At an analysis distance of 10km, Daymet is the only climate model with a data population large enough (i.e. grid size small enough) to be relevant. Daymet shows a clear MAP to Elevation gradient at this scale. Only two selected ECCC stations exist within this range.

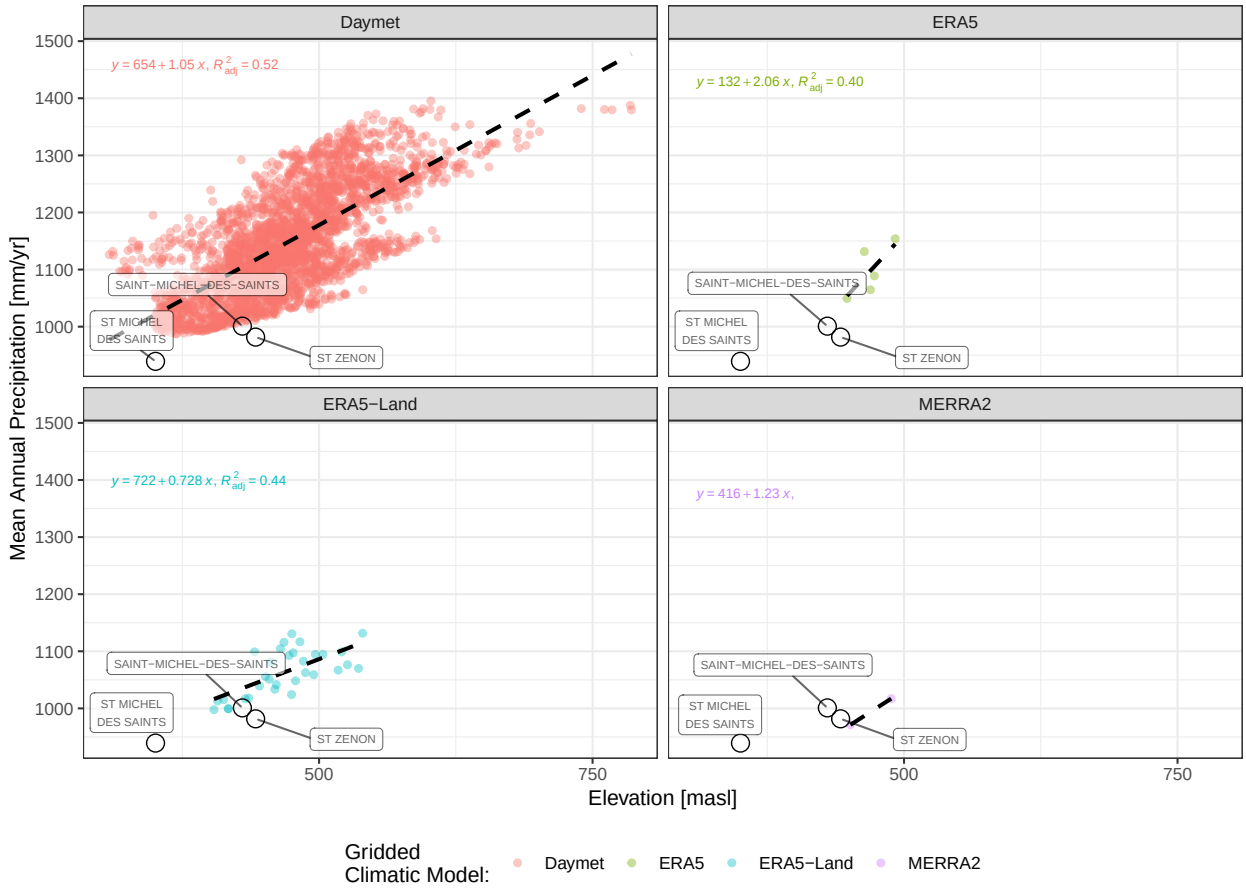
Graph 1: Elevation Gradient for MAP within 50km of Site (1980 to 2023)

Near site comparison of Gridded Climatic Models and ECCC Stations

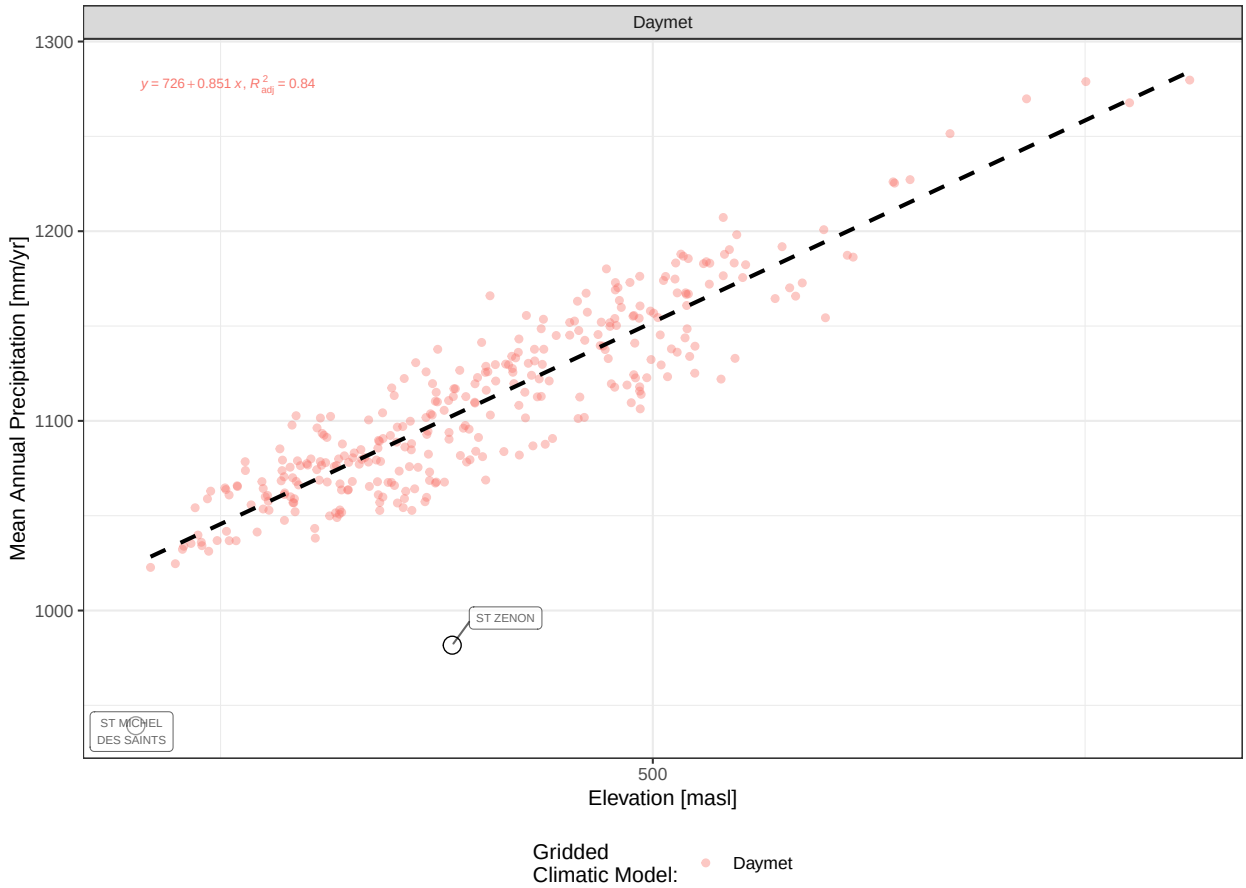


Graph 2: Elevation Gradient for MAP within 30km of Site (1980 to 2023)

Near site comparison of Gridded Climatic Models and ECCC Stations



Graph 3: Elevation Gradient for MAP within 10km of Site (1980 to 2023)
Near site comparison of Daymet and ECCC Stations



6.2.2 Station to Climate Model - Monthly Correlations

Monthly correlations between station and climate model data at each location help comparing model coherence with measured data and highlight seasonal bias. Monthly analysis allows inclusion of the NMG stations records that only collect rainfall. The ECCC stations within 50km of site were kept for this analysis.

The main findings of this section are summarized below:

- All the climate models present good correlation with ECCC station data. Daymet shows the strongest correlation with all ECCC stations for monthly precipitation.
- NMG station records are too short for the results of this test to be significant, although good correlation with all the climate models can be inferred. Site station records span four years only, but all climate models except MERRA2 appear to overestimate precipitation compared to NMG records (only considering May to Oct).

6.2.2.1 Functions Definition

A function is defined to compare monthly station records against data produced for the same location by all four climate models included in this study.

- Monthly precipitation results are summarized in a table comparing climate model results to station records for the same overlapping record period. Only May to October are presented

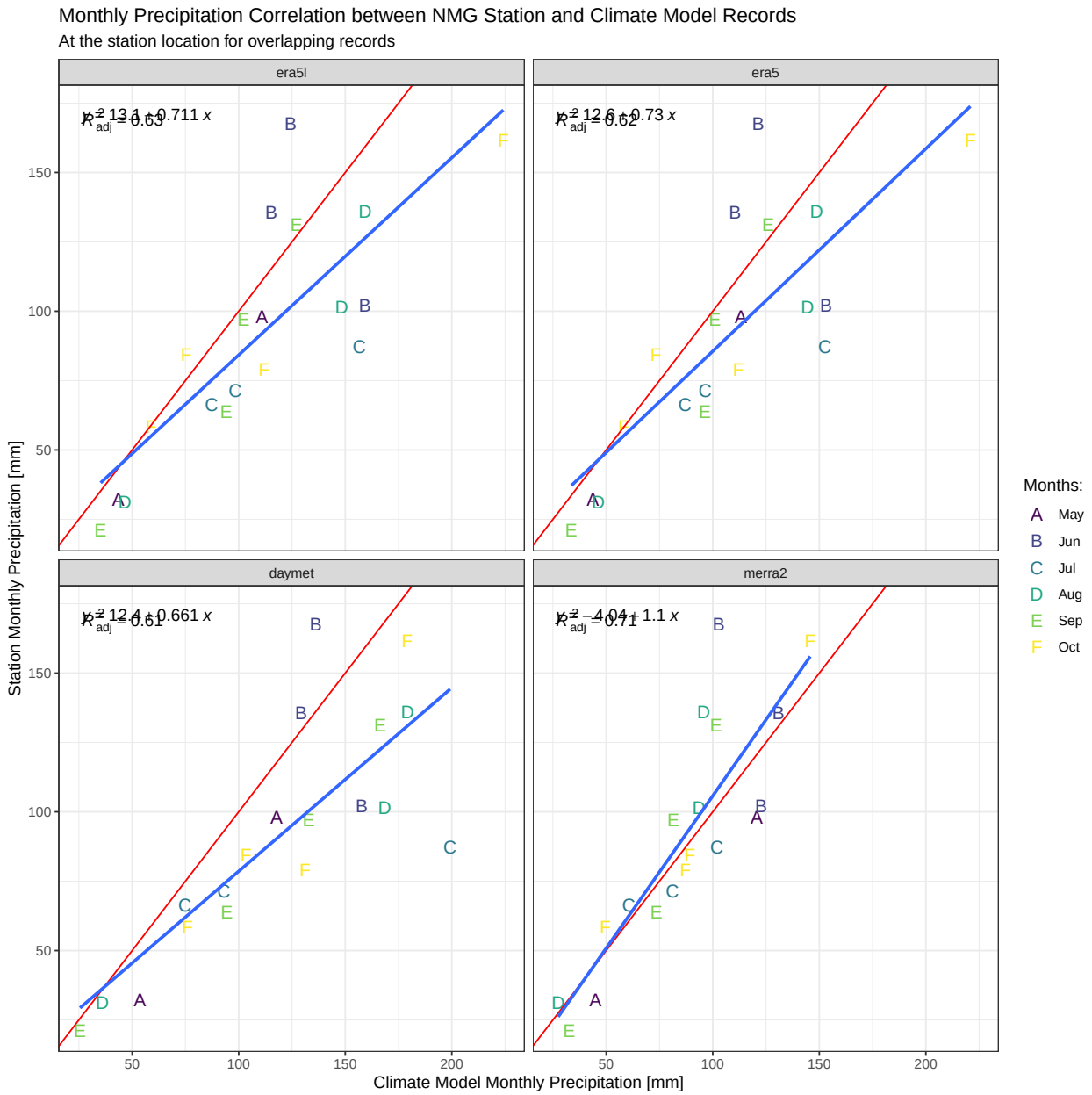
for NMG stations to remove bias related to unmeasured snowfall.

- The plot shows correlation between each station monthly data and all four climate models for the same overlapping record period.

6.2.2.2 Monthly Correlations for NMG Site

Table 6.1: Monthly Summary of Reanalysis Data matching Observed Data at NMG Site

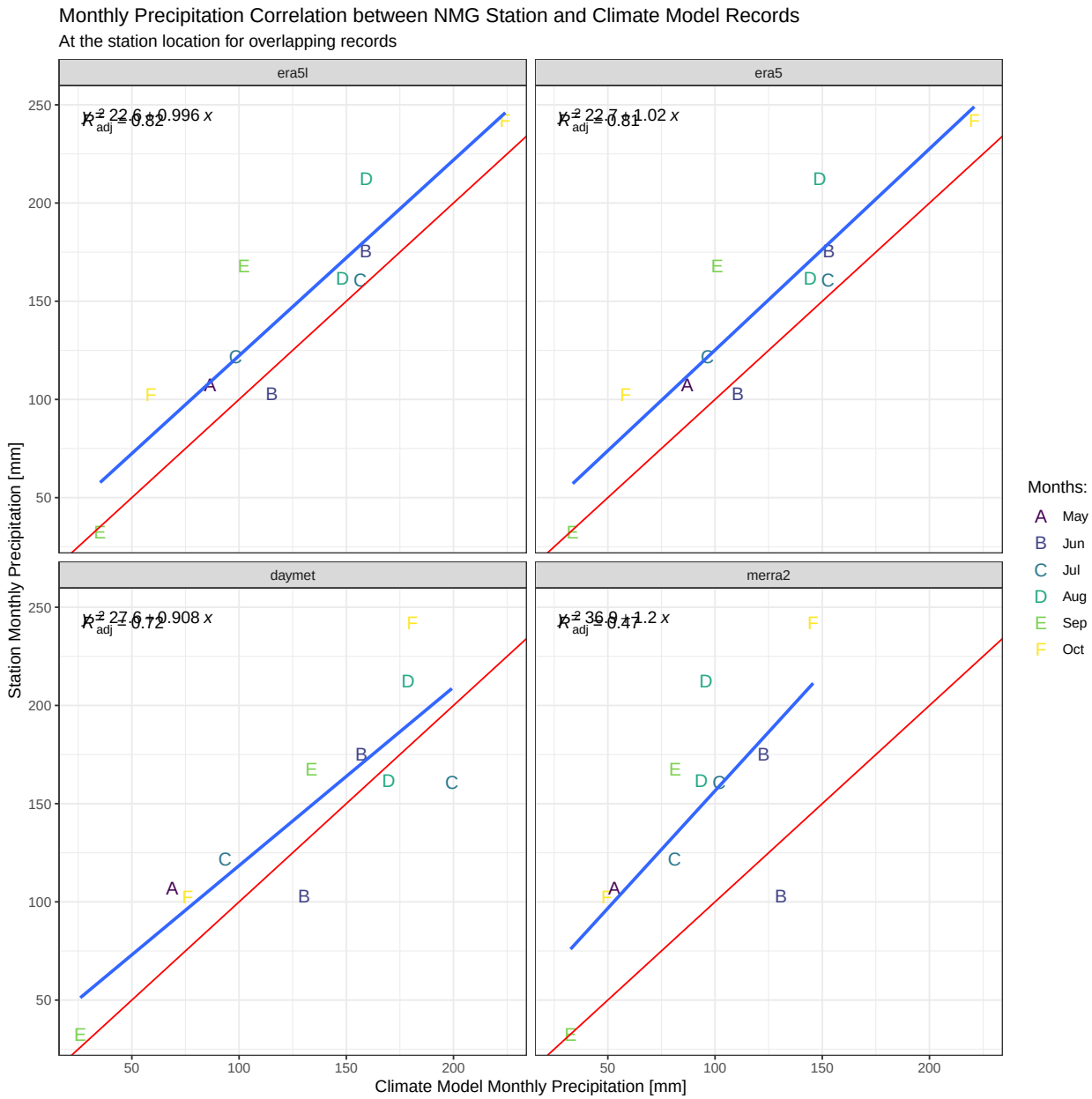
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	NA	NA	NA	NA	77.2	133	114.1	118.1	89.7	117.6	NA	NA	NA
era5	NA	NA	NA	NA	78.5	128.3	112	113.2	89.3	116.1	NA	NA	NA
daymet	NA	NA	NA	NA	85.7	141.1	122.4	128	104.8	122.4	NA	NA	NA
merra2	NA	NA	NA	NA	82.8	118.8	81.2	72.3	72.3	92.9	NA	NA	NA
station	NA	NA	NA	NA	71.7	144.6	76.2	89.6	78.4	96	NA	NA	NA



6.2.2.3 Monthly Correlations for NMG SoftdB

Table 6.2: Monthly Summary of Reanalysis Data matching Observed Data at NMG SoftdB

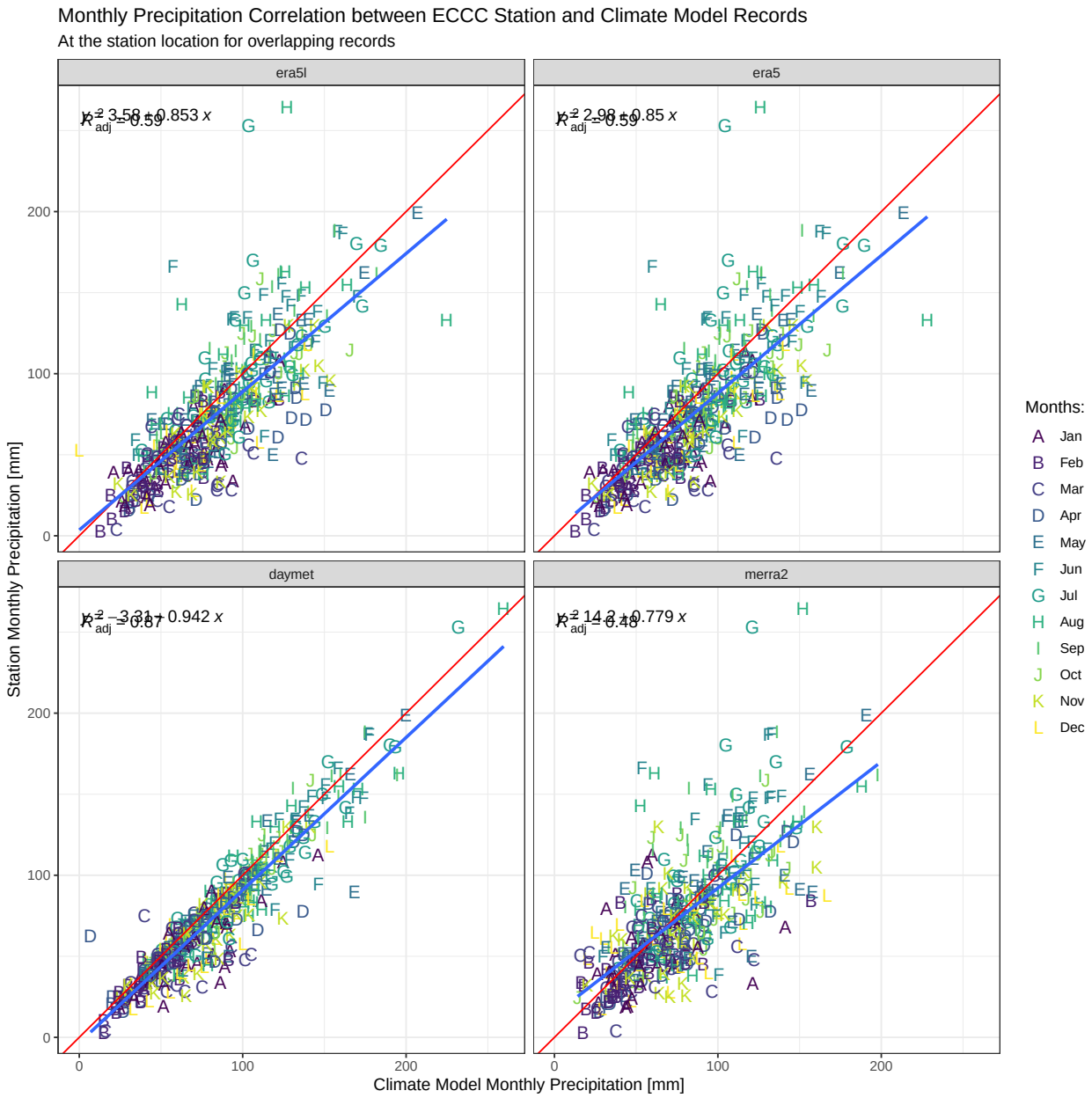
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	NA	NA	NA	NA	86.6	137.2	127.5	153.8	68.7	141.6	NA	NA	NA
era5	NA	NA	NA	NA	87	131.9	124.5	146.6	67.3	139.6	NA	NA	NA
daymet	NA	NA	NA	NA	68.8	143.8	146.3	174.3	79.9	128.4	NA	NA	NA
merra2	NA	NA	NA	NA	53.1	126.7	91.5	94.7	57	97.6	NA	NA	NA
station	NA	NA	NA	NA	108	174.6	141.4	187.2	100.2	172.4	NA	NA	NA



6.2.2.4 Monthly Correlations for ST MICHEL DES SAINTS

Table 6.3: Monthly Summary of Reanalysis Data matching Observed Data at ST MICHEL DES SAINTS

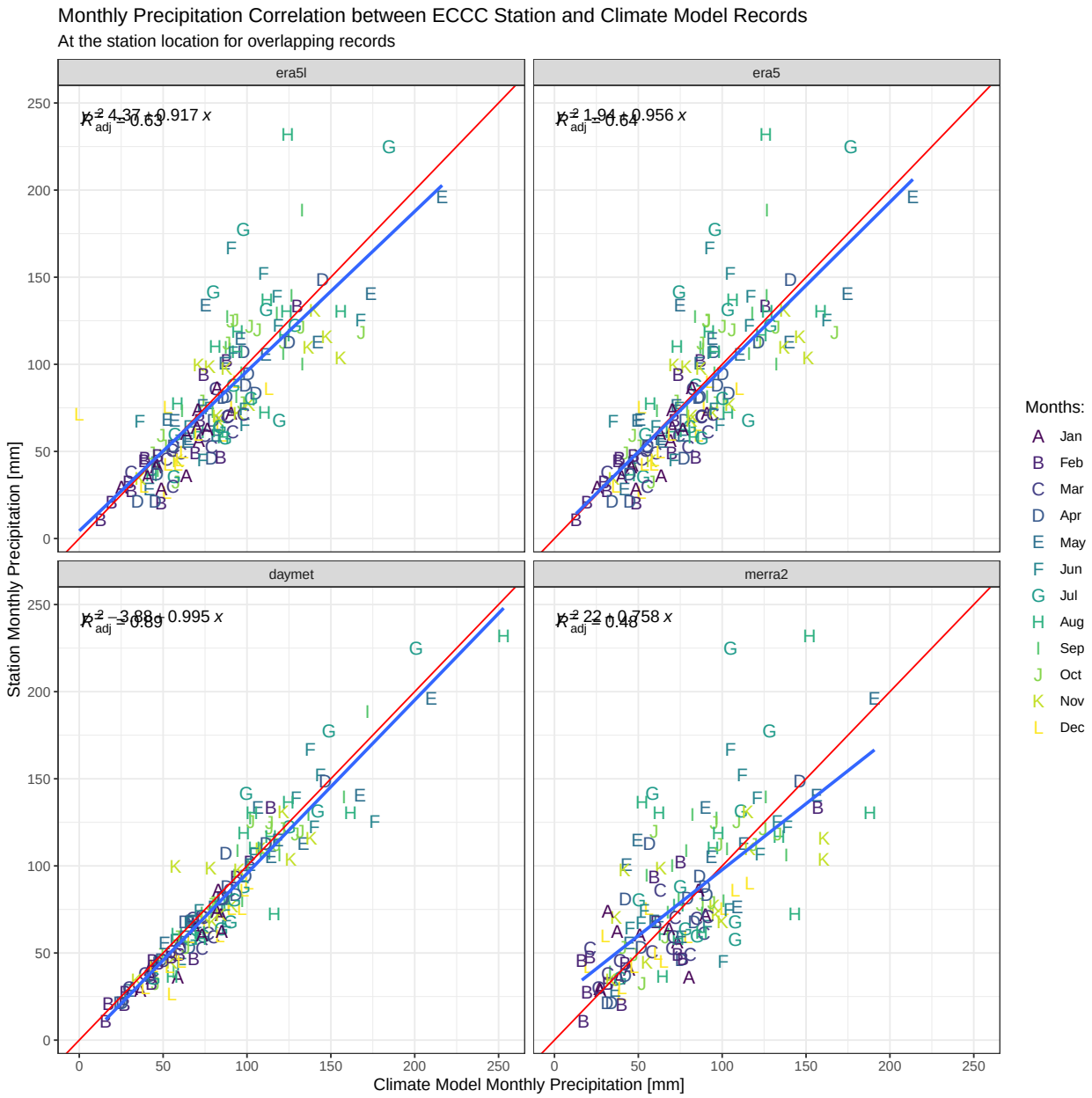
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	65.6	56.2	69.1	88.4	93.9	100.4	102.6	96	97.4	91.3	86.7	77.5	1025
era5	66.1	56.7	69.6	89.4	95.3	101.9	104.2	97	97.7	92.2	87.4	80.4	1038
daymet	66.1	51.3	61	74.4	90.3	112.8	109.7	102.5	105.4	90.1	79.9	76.3	1020
merra2	59.6	53.2	62.8	76.2	86	99.5	94.8	94.3	90.4	87	80.1	77.4	961.3
station	55.9	46.8	55.2	65.7	82.4	103.7	99.9	95.6	99.9	83.1	69.9	68.6	926.5



6.2.2.5 Monthly Correlations for ST ZENON

Table 6.4: Monthly Summary of Reanalysis Data matching Observed Data at ST ZENON

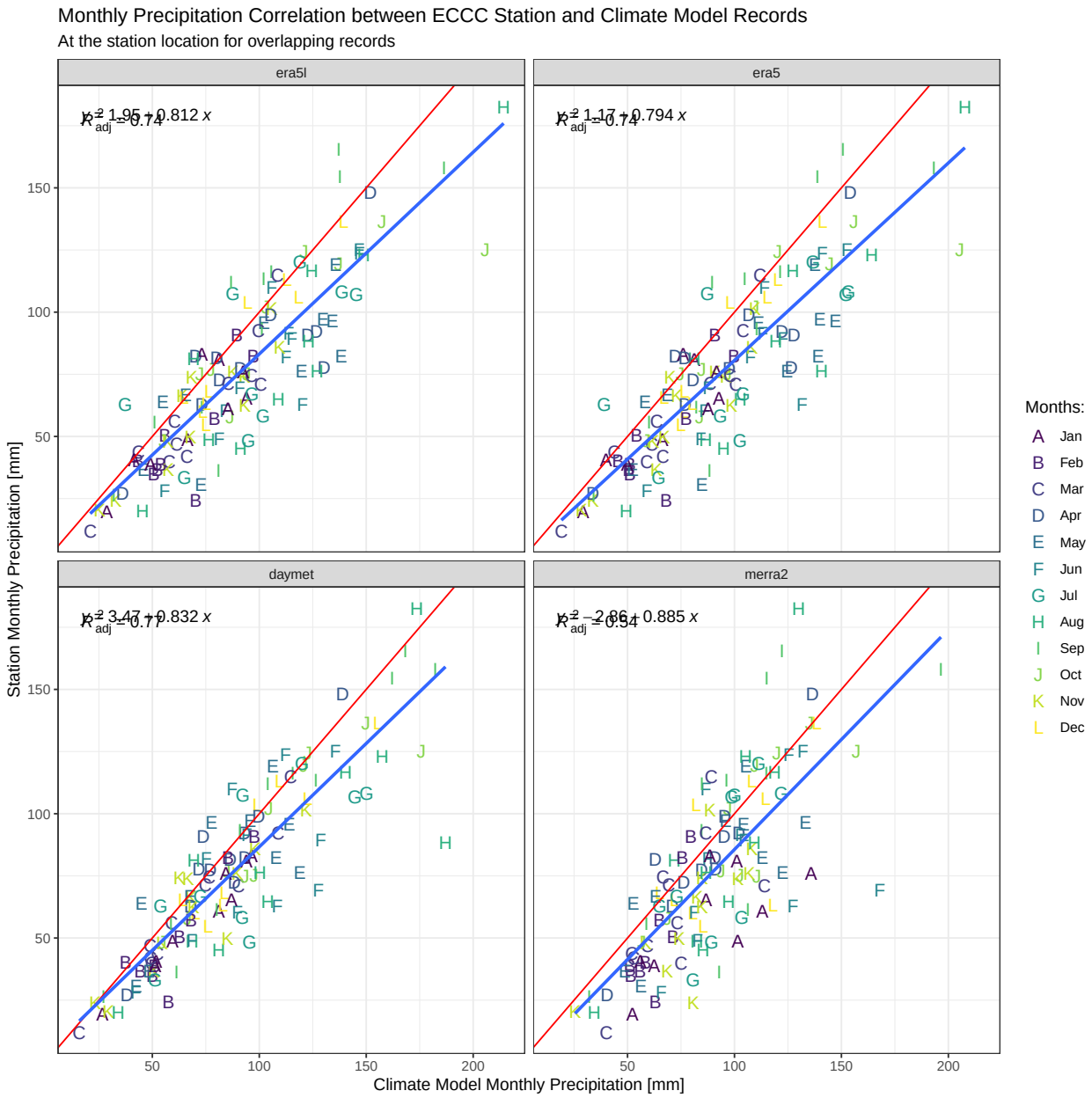
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	61.3	56	68.2	84.9	95.6	91.7	100.1	97.2	98.6	90.8	98.1	65.5	1008
era5	61	55.6	67.7	83.3	93.8	89.8	96.3	95.6	96.8	89.9	97.3	70.1	997.1
daymet	60.9	55.7	62.1	76.2	97.8	101.6	105.6	109.2	105.5	93.9	88.2	71.3	1028
merra2	54.6	53.1	61.4	70	86.4	98.2	86.1	99.2	85.7	86.6	89.7	63.9	935
station	65.6	52.6	62.1	75.2	89	100.5	92.3	105.6	104.7	94.4	88.1	71.6	1002



6.2.2.6 Monthly Correlations for SAINT-MICHEL-DES-SAINTS

Table 6.5: Monthly Summary of Reanalysis Data matching Observed Data at SAINT-MICHEL-DES-SAINTS

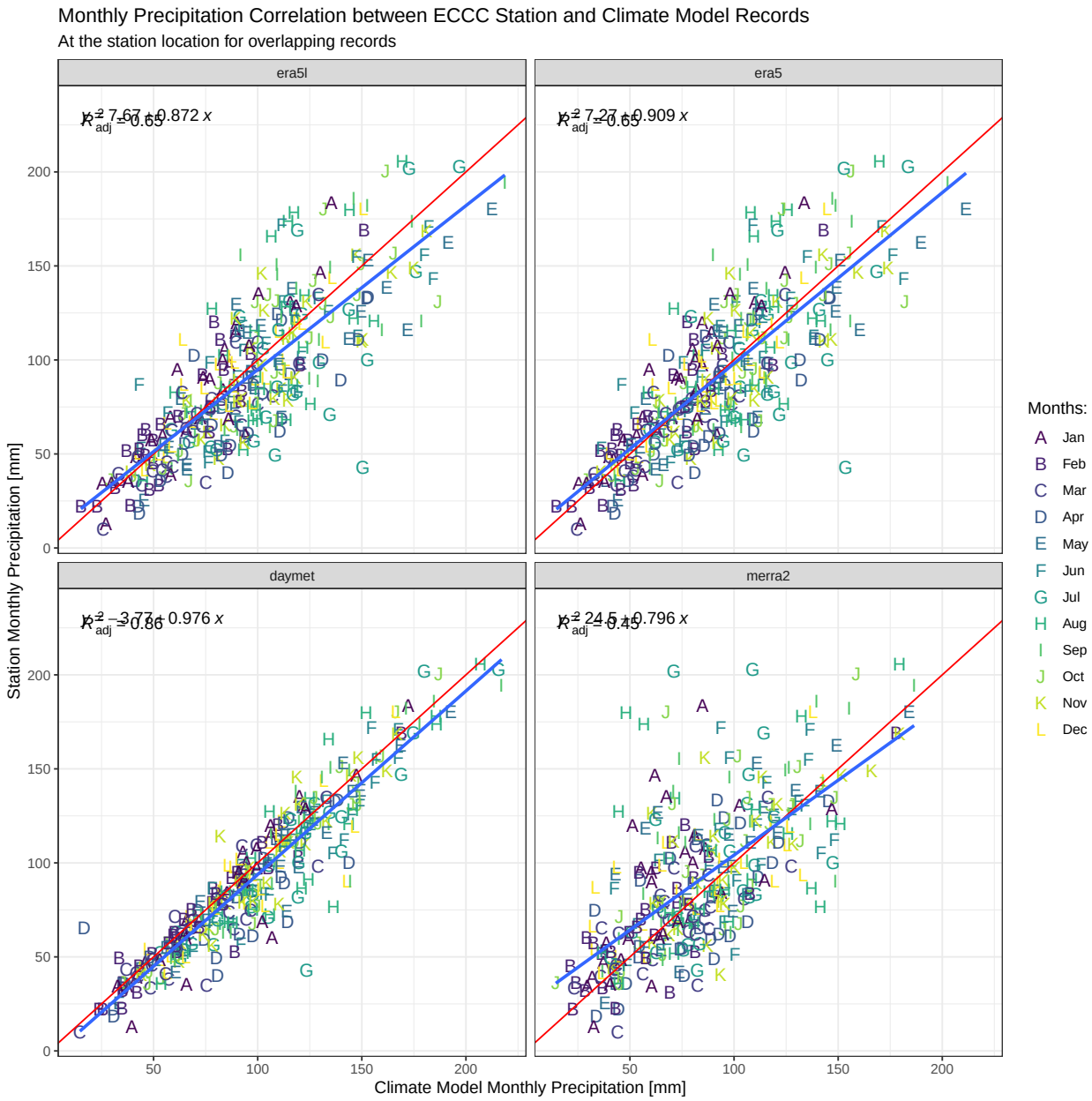
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	68	65.8	72.8	97.2	99.9	106.7	98.5	112.9	99.5	110.9	71.9	92.2	1096
era5	68.3	65.4	74.2	97.8	106.4	109.1	103.7	117.4	106.7	113.4	75.1	94.4	1132
daymet	70.3	61.6	67.3	84.4	82.4	97.3	96.9	111.6	107	107	68.3	95.9	1050
merra2	88.6	63.5	70.8	86.1	89.5	105.8	93.7	92.2	100.4	105	80.4	96	1072
station	57.1	48.6	58.6	82	78.3	87	82.2	84.8	99.5	94.2	60	85.7	918.1



6.2.2.7 Monthly Correlations for ST DONAT

Table 6.6: Monthly Summary of Reanalysis Data matching Observed Data at ST DONAT

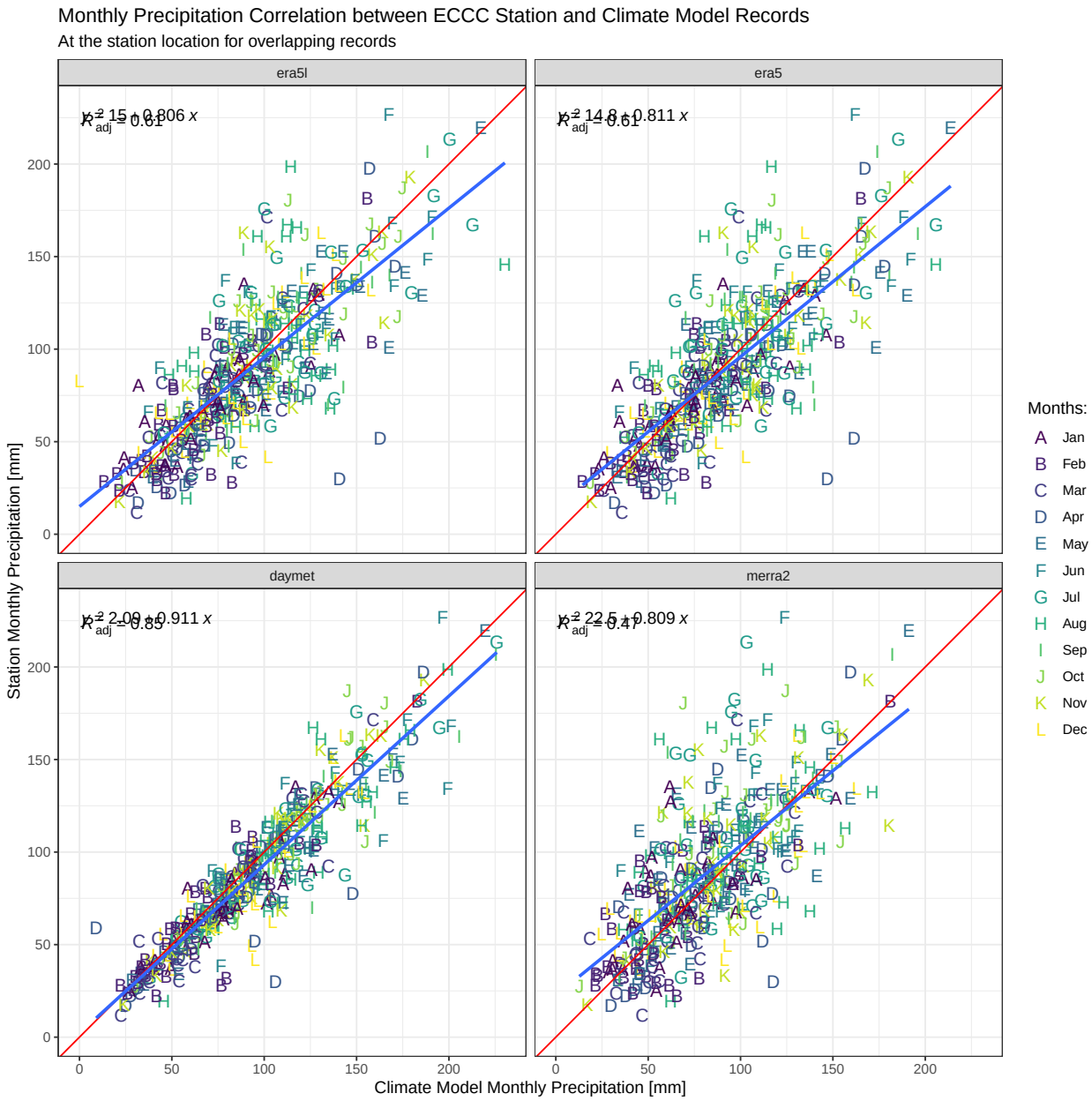
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	74.8	65.2	73.9	94.3	108.7	106.8	117.6	104.6	111.9	105.2	107	88.7	1159
era5	72.5	63.4	71.4	91.4	105.2	102.2	112.9	101.1	106.6	101.4	103.3	85.7	1117
daymet	86.3	68.5	73.2	85	106.1	112.3	114.2	115.1	112.2	107.6	101.7	93.7	1176
merra2	66.8	60.1	70.4	80.8	92.5	98.1	89.4	93.4	92.1	92.9	95.6	81.8	1014
station	84.6	66.4	69.5	72.3	95.7	105.9	102.9	102.9	105.2	101.2	95	96	1098



6.2.2.8 Monthly Correlations for ST COME

Table 6.7: Monthly Summary of Reanalysis Data matching Observed Data at ST COME

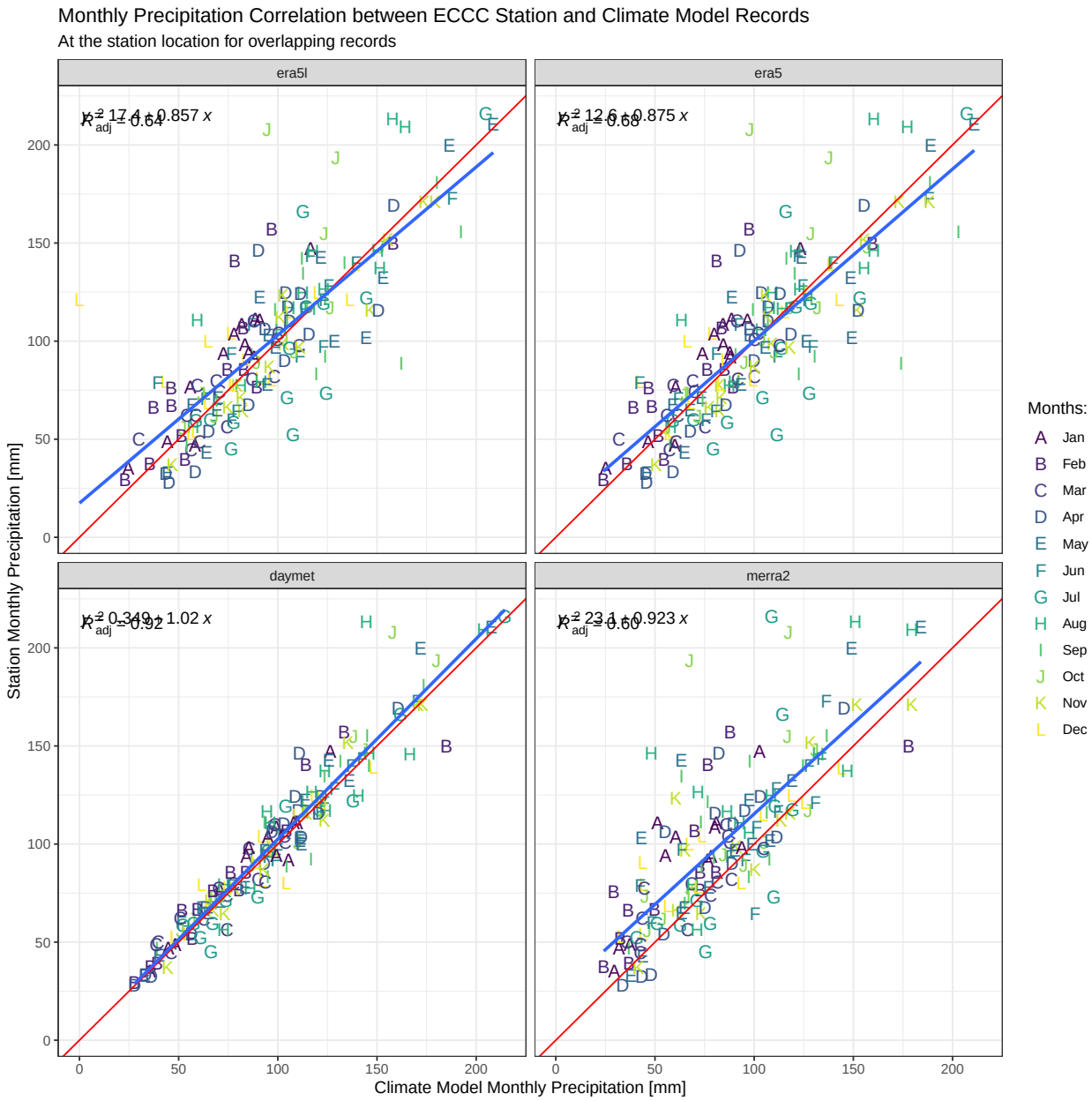
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	73.9	64.6	75.1	95.1	103.4	108	111.3	104.8	105	103	95	85.6	1125
era5	75.6	65.8	75.5	97.6	101.5	105.1	104.2	100.9	104	103.7	96.8	89.9	1120
daymet	80.8	66.5	75.4	90.5	100.1	116.6	114	112.2	111.3	109	97.4	92	1166
merra2	68.2	60.9	72	82.2	87.9	99.4	91	93.8	89.6	93.1	88	86.9	1013
station	74	64.9	71.3	72.9	87.7	102.7	100.1	98.9	103.7	95.1	91.6	89.1	1052



6.2.2.9 Monthly Correlations for NOTRE DAME DE LA MERCI

Table 6.8: Monthly Summary of Reanalysis Data matching Observed Data at NOTRE DAME DE LA MERCI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	74.5	68.3	74.5	95.8	108.5	104.6	109.4	113.7	119.6	98.7	109.6	81	1158
era5	76.9	69.5	75.9	96.8	109.7	106.8	113.7	116.4	125.2	102.9	113.4	89.8	1197
daymet	85.6	79.7	73.9	90.4	102.5	105.3	100.2	120.8	110.8	106.7	104	91.1	1171
merra2	64.9	65.2	68.4	79	88.7	99.5	87.2	101.8	87.6	87.8	96.4	78.6	1005
station	93.7	76	80.7	89.7	103.4	110.3	97.6	114.8	109	110.4	99.3	103	1188

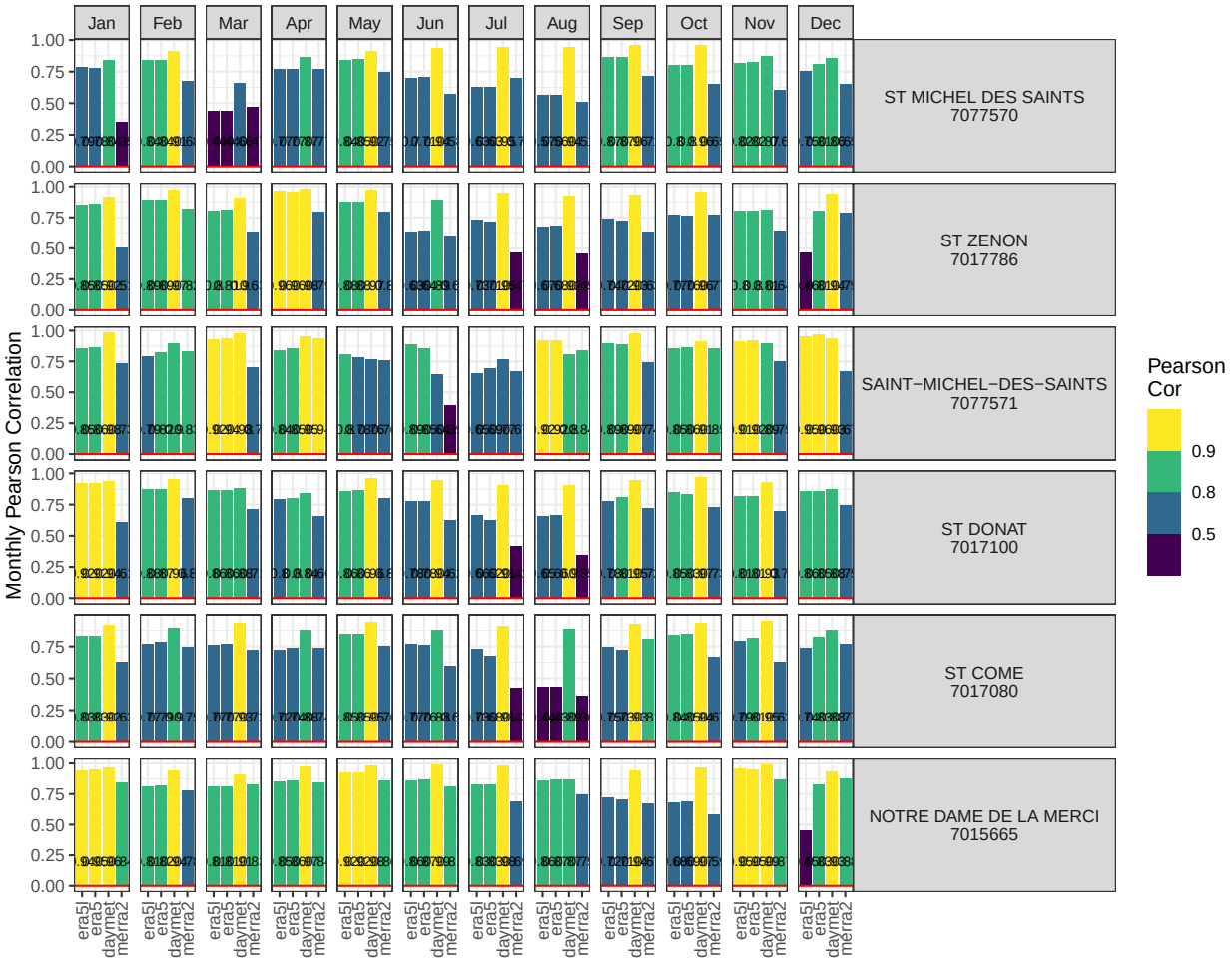


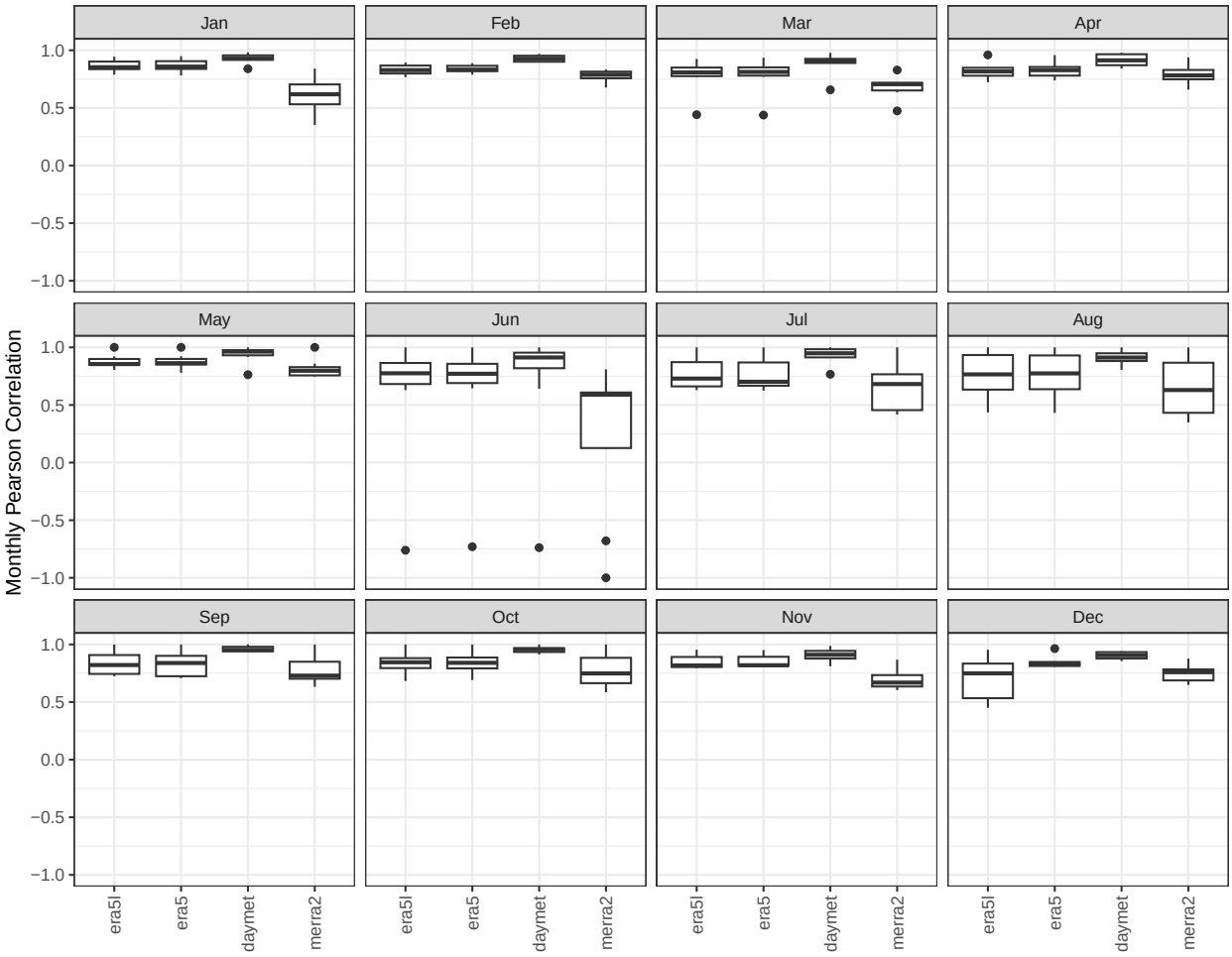
6.2.3 Monthly Pearson Correlation Coefficient

The Pearson correlation coefficient (PCC) is a correlation coefficient that measures linear correlation (and linear only) between two sets of data. It represents a normalized measurement of the covariance, such that the result always has a value between −1 and 1. A value of 0 represents no linear correlation between both datasets. A value of 1 represents perfect positive linear correlation, and a value of -1 perfect negative linear correlation.

Monthly data reviewed in the previous section is summarized in the following figures that represent PCC monthly for ECCC stations versus climate models comparisons.

Daymet generally presents the better linear correlations with station data year round.


Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
ST MICHEL DES SAINTS
7077570
ST ZENON
7017786
SAINT−MICHEL−DES−SAINTS
7077571
ST DONAT
7017100
ST COME
7017080
NOTRE DAME DE LA MERCI
7015665
Monthly Pearson Correlation
1.00
0.75
0.50
0.25
0.00
era5l
era5
daymet
merra2
Pearson
Cor
0.9
0.8
0.5


Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Monthly Pearson Correlation
1.0
0.5
0.0
−0.5
−1.0
era5l
era5
daymet
merra2

Chapter 7

Rainfall and Snowfall Analysis

Total precipitation relationships across stations and areas can be better interpreted by dividing precipitation records into components of rainfall and snowfall.

Given regional trends, the analysis was completed at a local scale (50 km) using all available ECCC records and four reanalysis products: Daymet, ERA5, ERA5-Land, and MERRA2.

The division of rainfall and snowfall for reanalysis products was directly based on zero degrees. Different methods for partitioning total precipitation for local stations and outcomes are evaluated and summarized in a subsequent review.

- Rainfall = total precipitation when Tavg>0
- Snowfall = total precipitation when Tavg 0

Main findings of this section are:

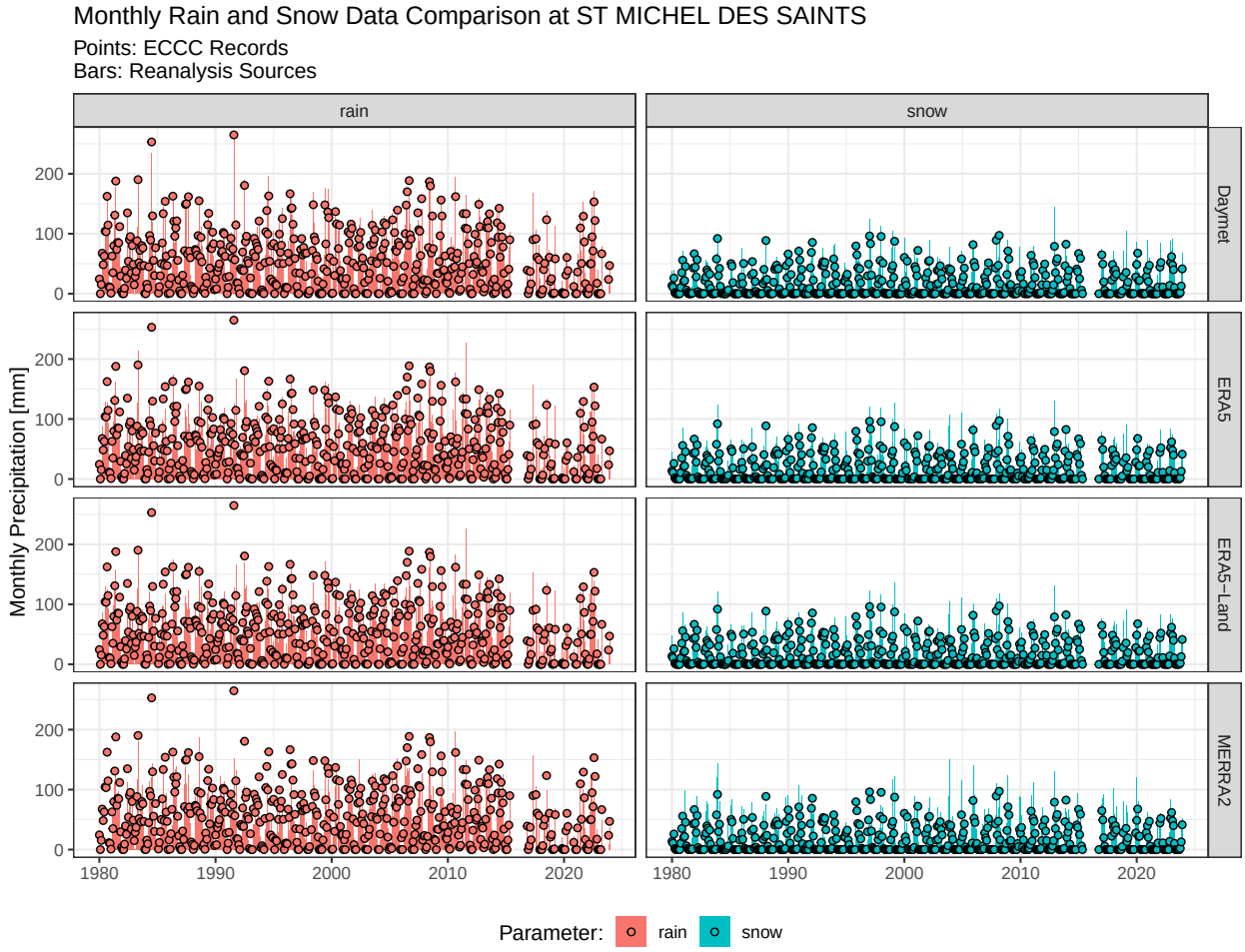
- Daymet is the reanalysis tool that best correlates with ECCC rain and snow data in the project region.
- Reanalysis tools (including Daymet) present bias compared to ECCC measured data. Generally, precipitation, rain and/or snow values presented by the reanalysis tools are greater than measured values reported by ECCC.
- Reanalysis snow records generally present more bias than reanalysis rainfall records when compared to ECCC measured data.

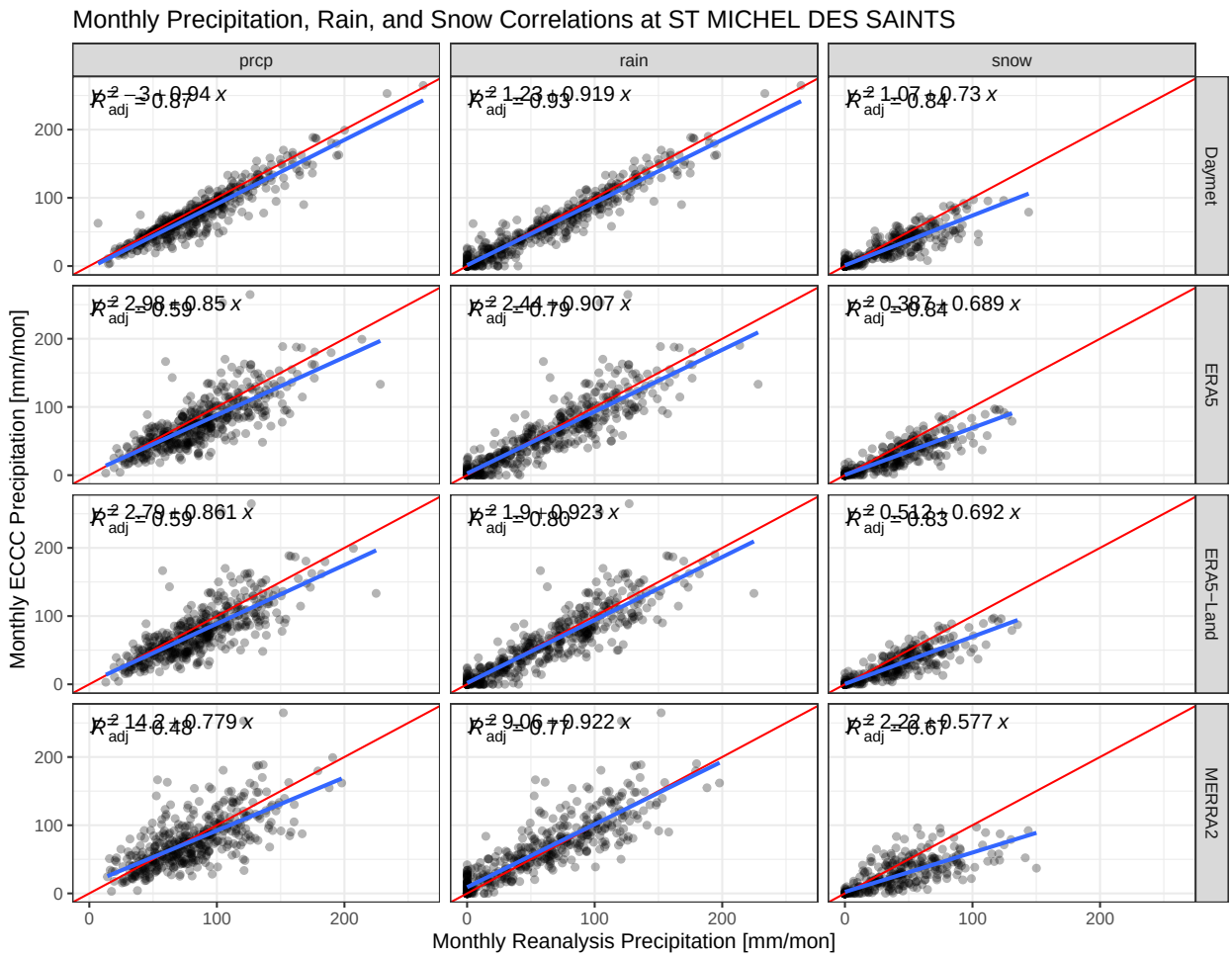
7.1 Rain/Snow ST MICHEL DES SAINTS

Table 7.1: Mean Rain and Snow Monthly Values at ST MICHEL DES SAINTS

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
prcp	ECCC	52	45	52	66	83	106	103	95	101	84	68	64	921
prcp	Daymet	66	51	61	74	90	113	110	102	105	90	80	76	1018
prcp	ERA5	66	57	70	89	95	102	104	97	98	92	87	80	1038
prcp	ERA5-Land	66	56	69	88	94	100	103	96	97	91	87	80	1027
prcp	MERRA2	60	53	63	76	86	100	95	94	90	87	80	77	961
rain	ECCC	10	6	19	52	83	106	103	95	101	81	42	12	709
rain	Daymet	7	6	19	61	90	113	110	102	105	86	44	12	756

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
rain	ERA5	7	7	22	70	95	102	104	97	98	86	45	13	746
rain	ERA5-Land	7	7	22	69	94	100	103	96	97	87	45	13	740
rain	MERRA2	2	2	8	49	86	100	95	94	90	80	37	6	649
snow	ECCC	43	39	35	13	0	0	0	0	0	3	25	50	208
snow	Daymet	60	48	42	12	0	0	0	0	0	4	36	66	268
snow	ERA5	60	52	48	19	0	0	0	0	0	6	42	68	295
snow	ERA5-Land	59	52	48	20	0	0	0	0	0	4	41	67	291
snow	MERRA2	60	52	55	27	0	0	0	0	0	7	43	70	315



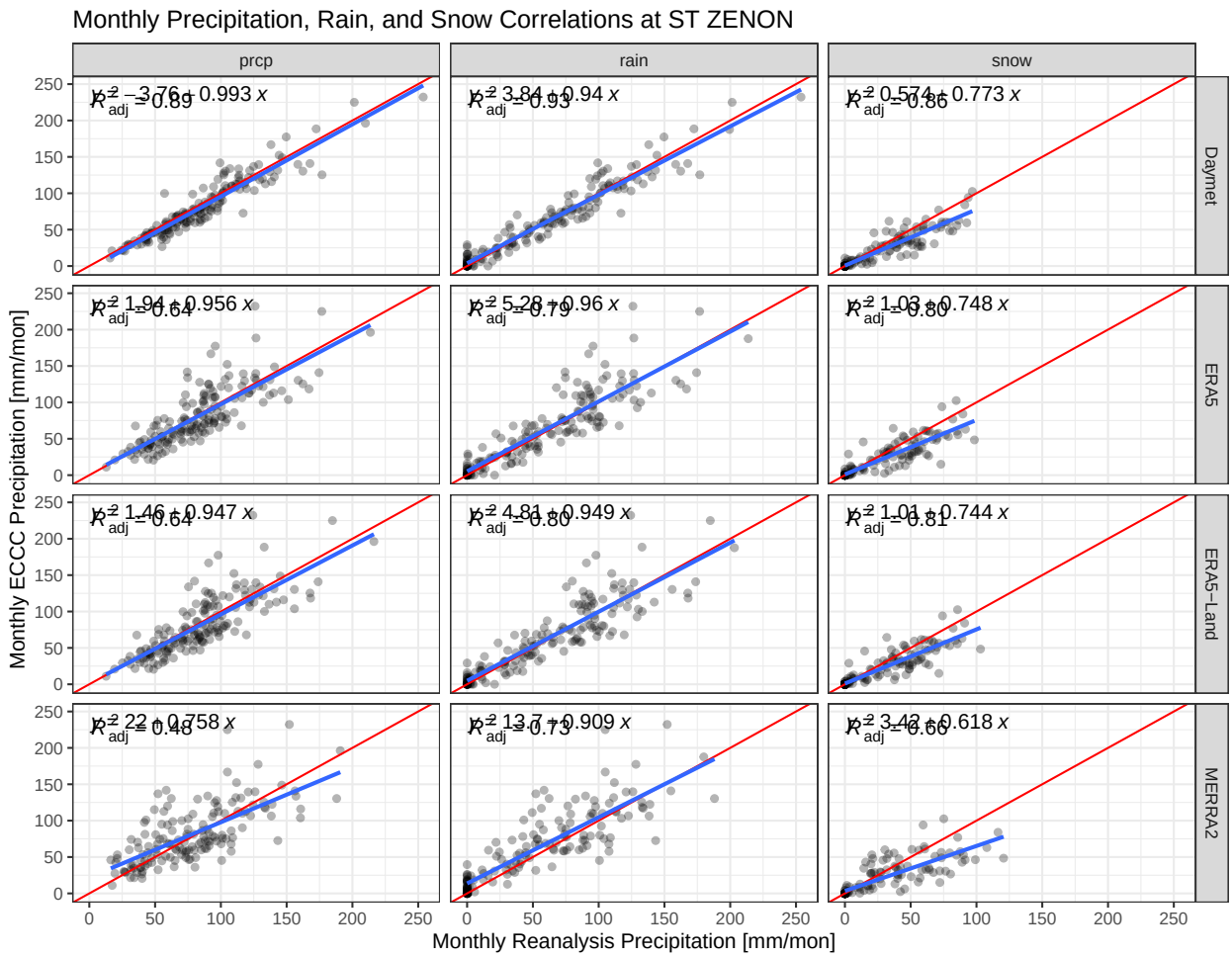


7.2 Rain/Snow ST ZENON

Table 7.2: Mean Rain and Snow Monthly Values at ST ZENON

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
prcp	ECCC	53	53	56	75	94	96	104	104	104	93	86	58	976
prcp	Daymet	61	56	62	76	98	102	106	109	106	94	88	72	1030
prcp	ERA5	61	56	68	83	94	90	96	96	97	90	97	70	997
prcp	ERA5-Land	61	56	68	85	96	92	100	97	99	91	98	71	1013
prcp	MERRA2	55	53	61	70	86	98	86	99	86	87	90	64	935
rain	ECCC	9	9	22	59	93	96	104	104	104	90	56	10	755
rain	Daymet	3	7	22	60	97	102	106	109	106	88	46	6	753
rain	ERA5	3	10	26	67	94	90	96	96	97	86	48	6	719
rain	ERA5-Land	3	8	26	67	95	92	100	97	99	89	52	6	733
rain	MERRA2	0	5	10	50	85	98	86	99	86	81	38	3	642
snow	ECCC	44	45	34	16	1	0	0	0	0	4	31	47	220
snow	Daymet	59	48	40	16	1	0	0	0	0	6	43	65	277
snow	ERA5	59	46	41	16	0	0	0	0	0	4	49	64	279
snow	ERA5-Land	60	48	42	18	1	0	0	0	0	2	46	64	281
snow	MERRA2	54	49	51	20	1	0	0	0	0	5	52	61	292

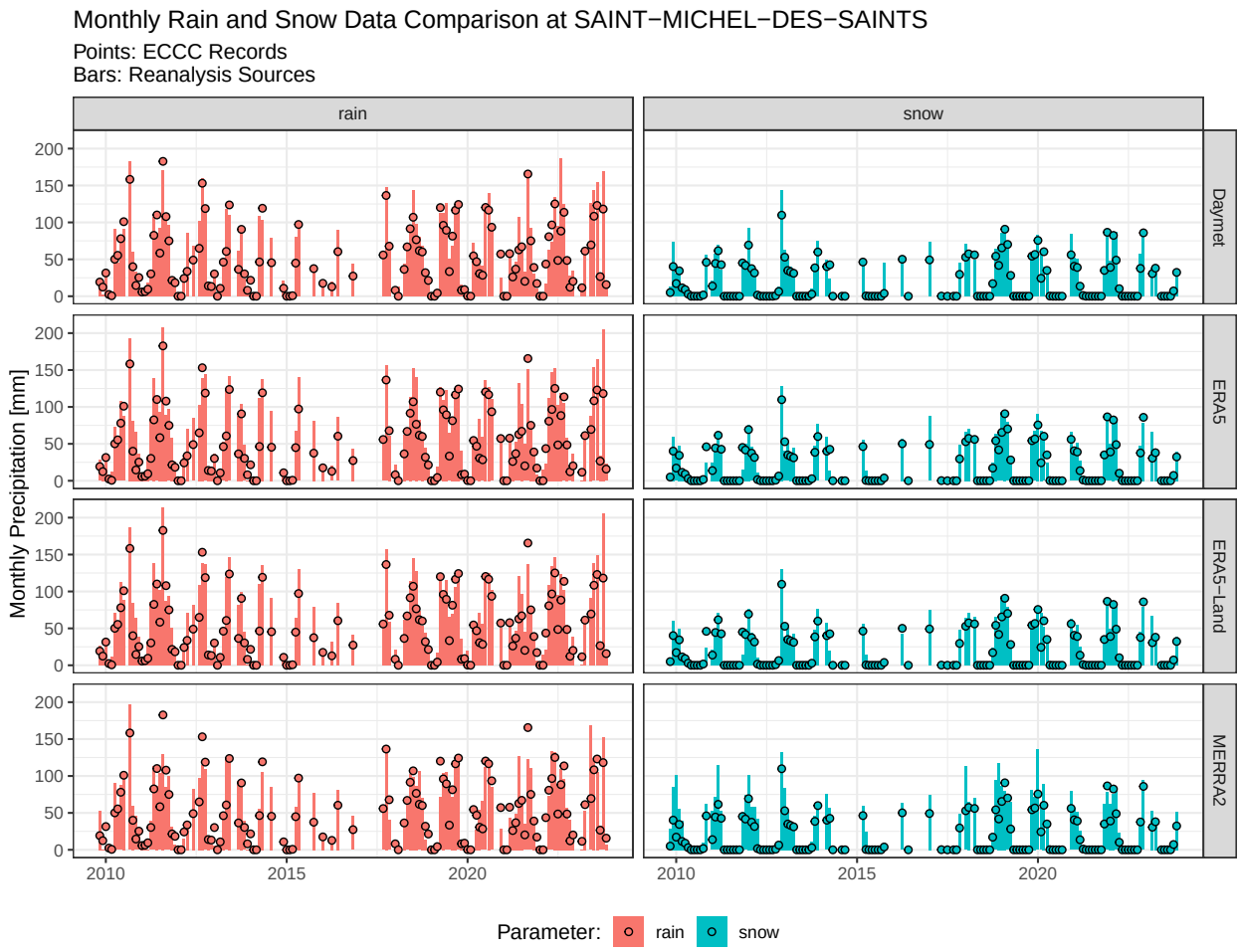
Monthly Rain and Snow Data Comparison at ST ZENON
Points: ECCC Records
Bars: Reanalysis Sources
rain
snow
Daymet
ERA5
ERA5−Land
MERRA2
Monthly Precipitation [mm]
0
50
100
150
200
250
1980
1985
1990
1995
Parameter:
rain
snow

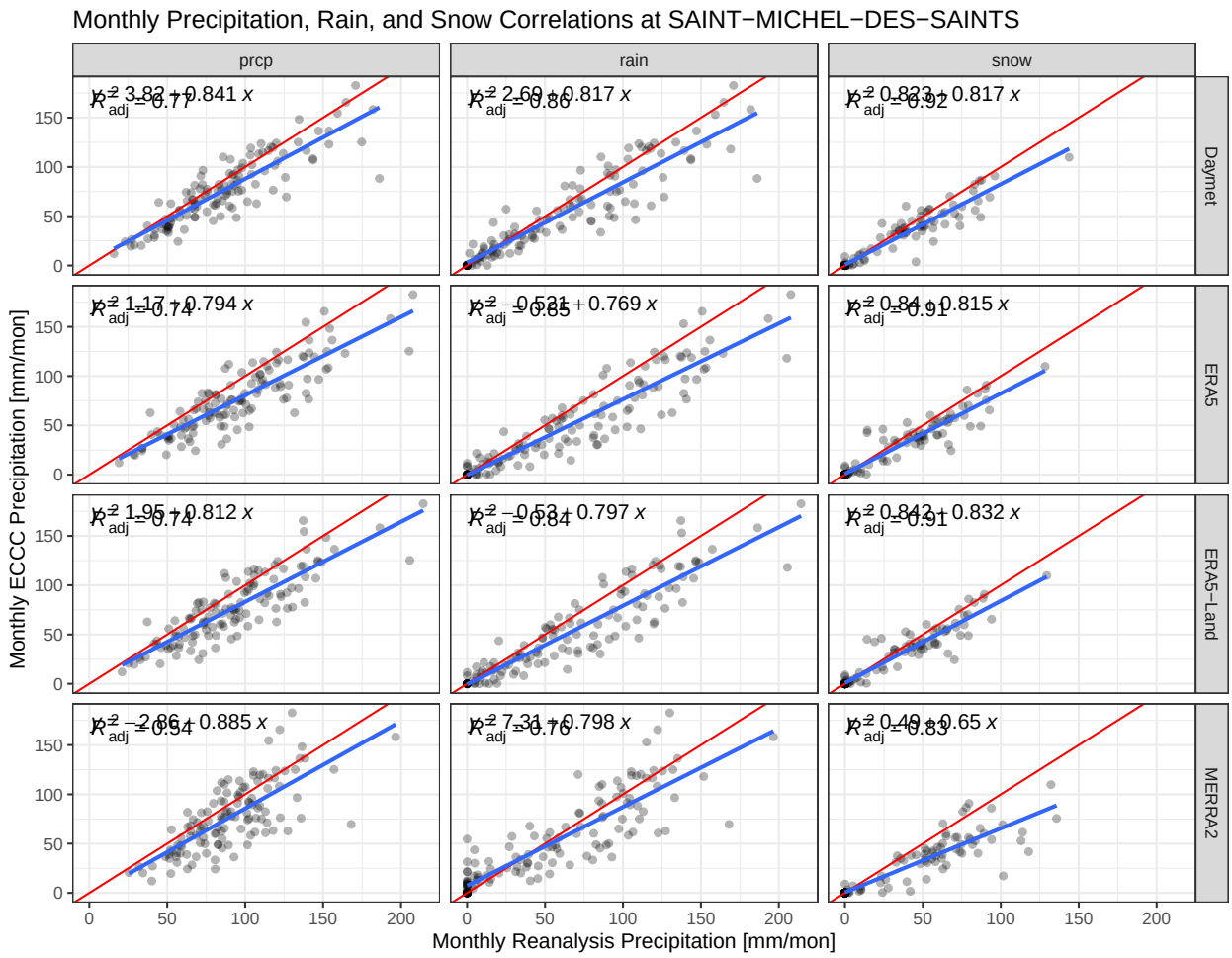


7.3 Rain/Snow SAINT-MICHEL-DES-SAINTS

Table 7.3: Mean Rain and Snow Monthly Values at SAINT-MICHEL-DES-SAINTS

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
prcp	ECCC	57	51	60	83	77	81	79	85	100	94	60	86	913
prcp	Daymet	69	61	66	83	81	96	95	110	106	105	67	95	1033
prcp	ERA5	68	65	74	98	106	109	104	117	107	113	75	94	1132
prcp	ERA5-Land	68	66	73	97	100	107	98	113	99	111	72	92	1096
prcp	MERRA2	89	63	71	86	90	106	94	92	100	105	80	96	1072
rain	ECCC	10	1	20	49	74	81	80	89	99	84	25	19	631
rain	Daymet	8	2	21	64	81	96	100	114	106	96	29	16	734
rain	ERA5	10	3	23	71	105	109	112	121	107	107	41	20	830
rain	ERA5-Land	12	3	22	71	99	107	106	117	99	105	38	20	800
rain	MERRA2	1	0	7	48	89	106	97	93	100	98	31	8	681
snow	ECCC	48	49	41	27	0	0	0	0	0	3	35	64	267
snow	Daymet	62	58	45	23	0	0	0	0	0	8	41	80	316
snow	ERA5	60	62	51	27	1	0	0	0	0	3	36	75	316
snow	ERA5-Land	57	62	51	27	0	0	0	0	0	3	35	74	309
snow	MERRA2	87	63	63	39	0	0	0	0	0	6	52	89	399

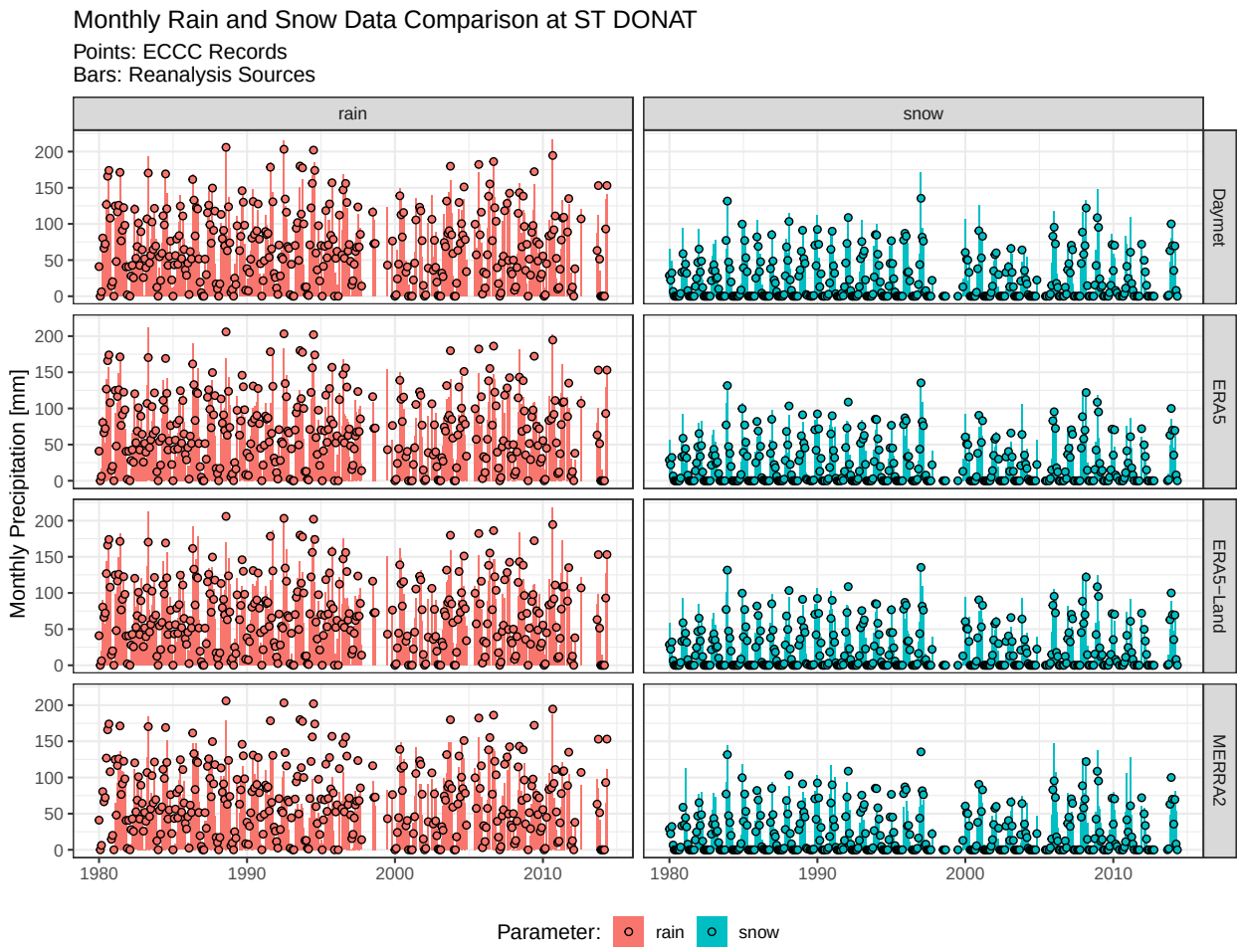

Monthly Rain and Snow Data Comparison at SAINT−MICHEL−DES−SAINTS
Points: ECCC Records
Bars: Reanalysis Sources
rain
snow
Daymet
ERA5
ERA5−Land
MERRA2
Monthly Precipitation [mm]
0
50
100
150
200
2010
2015
2020
Parameter:
rain
snow

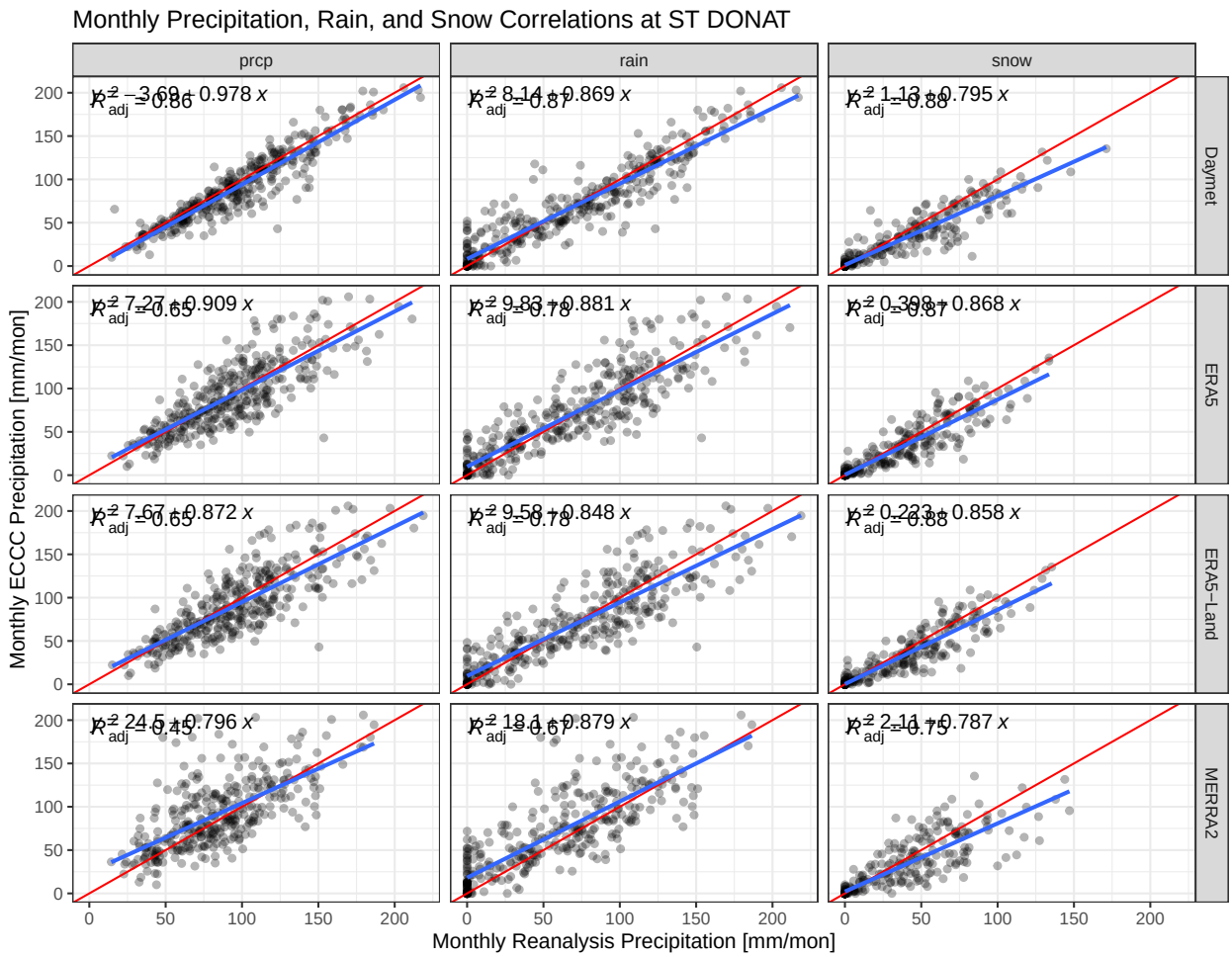


7.4 Rain/Snow ST DONAT

Table 7.4: Mean Rain and Snow Monthly Values at ST DONAT

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
prcp	ECCC	84	68	67	76	100	103	100	105	108	104	98	90	1101
prcp	Daymet	86	68	73	85	106	112	114	115	112	107	101	93	1173
prcp	ERA5	72	63	71	91	105	102	113	101	107	101	103	86	1117
prcp	ERA5-Land	75	65	74	94	109	107	118	105	112	105	107	89	1159
prcp	MERRA2	67	60	70	81	92	98	89	93	92	93	96	82	1014
rain	ECCC	21	15	27	63	99	103	100	105	108	99	65	23	828
rain	Daymet	9	9	22	71	106	112	114	115	112	102	58	12	841
rain	ERA5	8	10	23	76	105	102	113	101	107	95	55	12	807
rain	ERA5-Land	8	10	25	77	108	107	118	105	112	100	59	13	842
rain	MERRA2	4	3	14	60	92	98	89	93	92	87	50	9	691
snow	ECCC	63	52	41	15	1	0	0	0	0	6	31	68	276
snow	Daymet	77	59	51	14	0	0	0	0	0	6	42	82	331
snow	ERA5	65	53	48	18	0	0	0	0	0	7	48	74	313
snow	ERA5-Land	67	56	49	20	1	0	0	0	0	5	46	76	319
snow	MERRA2	63	57	57	21	0	0	0	0	0	6	44	73	322

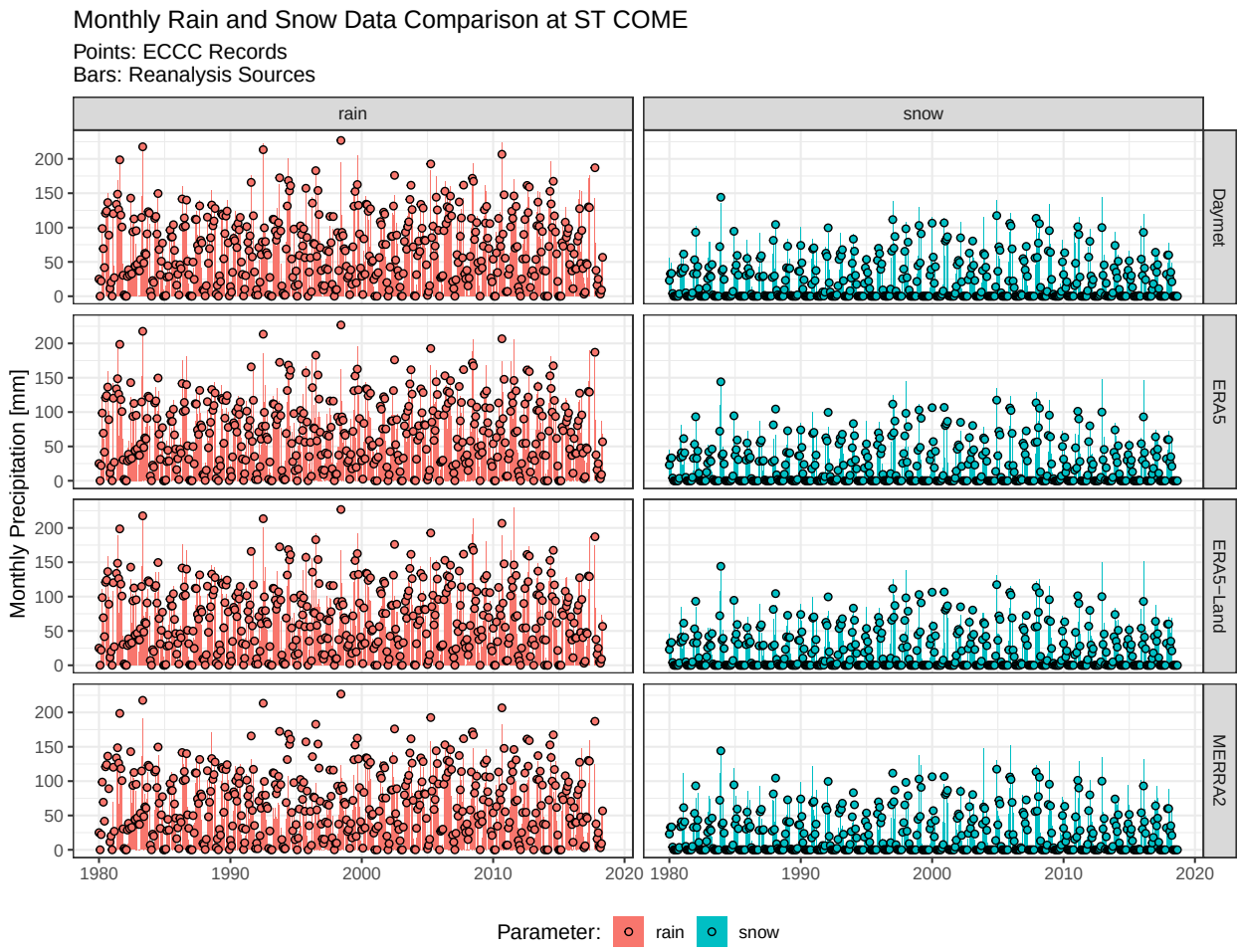

Monthly Rain and Snow Data Comparison at ST DONAT
Points: ECCC Records
Bars: Reanalysis Sources
rain
snow
Daymet
ERA5
ERA5−Land
MERRA2
Monthly Precipitation [mm]
0
50
100
150
200
1980
1990
2000
2010
Parameter:
rain
snow

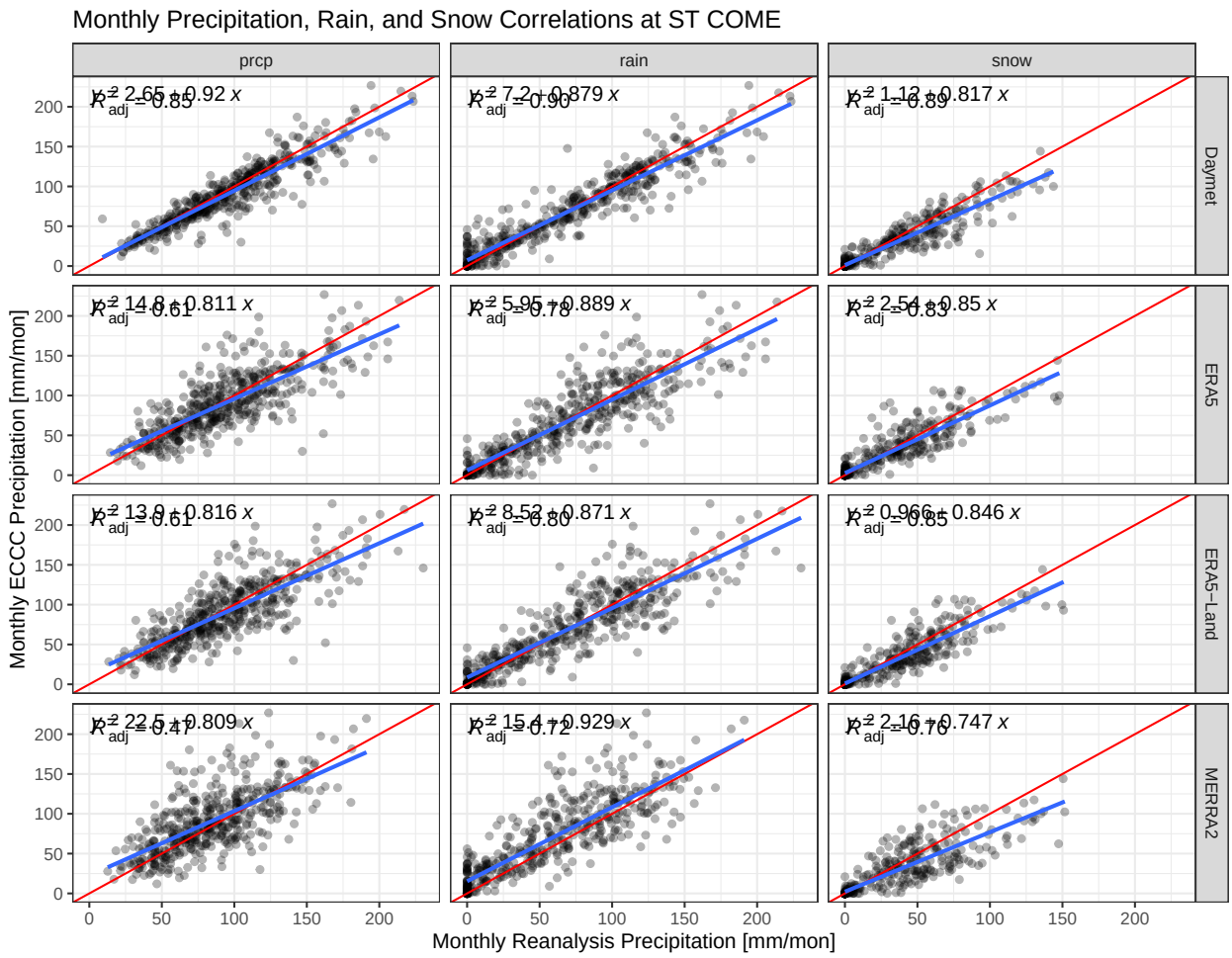


7.5 Rain/Snow ST COME

Table 7.5: Mean Rain and Snow Monthly Values at ST COME

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
prcp	ECCC	74	63	73	81	93	108	107	102	103	105	94	84	1087
prcp	Daymet	79	65	74	89	99	115	112	110	110	107	96	90	1147
prcp	ERA5	76	66	75	98	101	105	104	101	104	104	97	90	1121
prcp	ERA5-Land	74	65	75	95	103	108	111	105	105	103	95	88	1127
prcp	MERRA2	68	61	72	82	88	99	91	94	90	93	88	87	1013
rain	ECCC	16	13	30	68	93	108	107	102	103	102	68	20	829
rain	Daymet	9	9	24	79	99	115	112	110	110	104	61	12	845
rain	ERA5	12	15	33	87	101	105	104	101	104	102	67	19	850
rain	ERA5-Land	10	11	27	79	103	108	111	105	105	100	58	15	833
rain	MERRA2	4	3	15	63	88	99	91	94	90	90	49	10	695
snow	ECCC	59	51	43	14	0	0	0	0	0	3	26	64	261
snow	Daymet	70	56	50	11	0	0	0	0	0	3	35	78	303
snow	ERA5	64	51	42	12	0	0	0	0	0	2	30	71	271
snow	ERA5-Land	64	54	48	17	0	0	0	0	0	3	37	73	295
snow	MERRA2	64	58	57	20	0	0	0	0	0	4	39	76	317

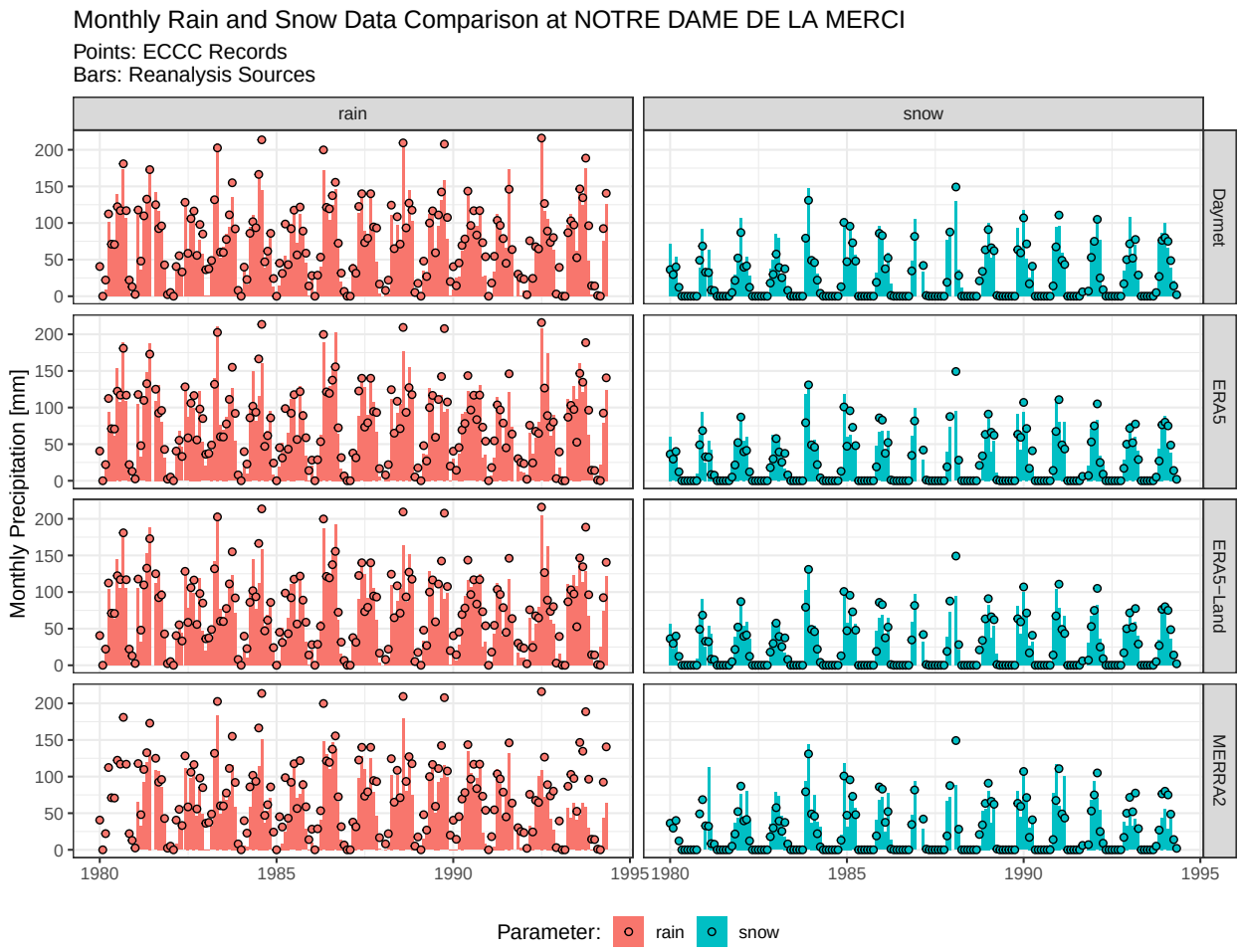

Monthly Rain and Snow Data Comparison at ST COME
Points: ECCC Records
Bars: Reanalysis Sources
rain
snow
Daymet
ERA5
ERA5−Land
MERRA2
Monthly Precipitation [mm]
0
50
100
150
200
1980
1990
2000
2010
2020
Parameter:
rain
snow

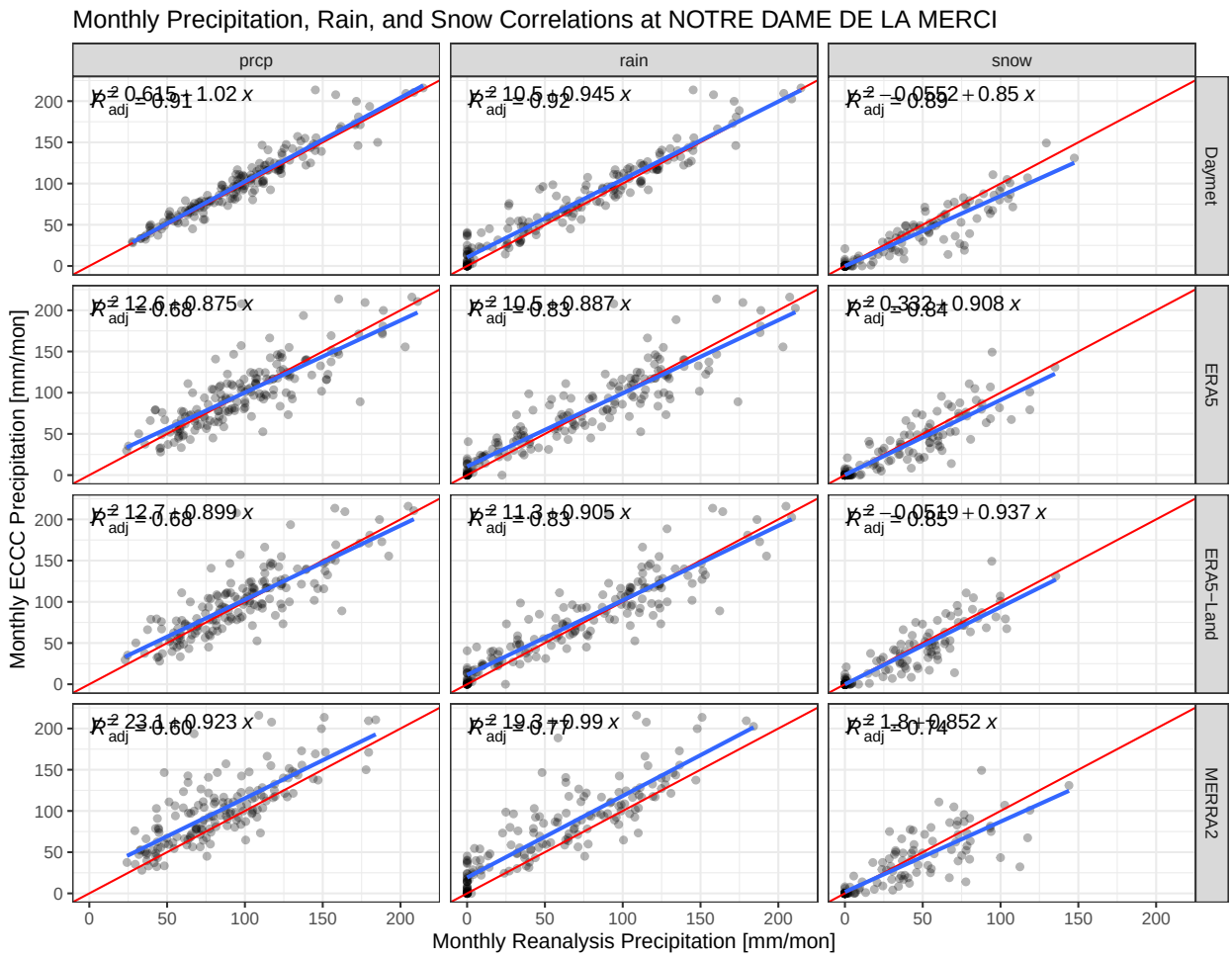


7.6 Rain/Snow NOTRE DAME DE LA MERCI

Table 7.6: Mean Rain and Snow Monthly Values at NOTRE DAME DE LA MERCI

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
prcp	ECCC	90	84	75	95	105	106	97	126	113	114	103	92	1200
prcp	Daymet	86	80	74	91	102	105	100	121	111	107	104	91	1172
prcp	ERA5	77	70	76	97	110	107	114	116	125	103	113	90	1197
prcp	ERA5-Land	75	68	74	96	109	105	109	114	120	99	110	87	1164
prcp	MERRA2	65	65	68	79	89	99	87	102	88	88	96	79	1005
rain	ECCC	18	19	35	80	104	106	97	126	112	112	74	21	904
rain	Daymet	4	14	25	74	102	105	100	121	111	104	56	8	823
rain	ERA5	7	13	31	82	110	107	114	116	125	99	62	9	876
rain	ERA5-Land	6	12	30	79	109	105	109	114	120	97	60	9	848
rain	MERRA2	1	5	15	59	89	99	87	102	88	84	48	5	681
snow	ECCC	71	63	40	14	1	0	0	0	0	2	30	72	295
snow	Daymet	82	65	49	17	0	0	0	0	0	3	48	83	348
snow	ERA5	69	55	45	15	0	0	0	0	0	4	51	80	320
snow	ERA5-Land	68	55	45	17	0	0	0	0	0	2	50	78	315
snow	MERRA2	64	60	54	20	0	0	0	0	0	4	48	74	324


Monthly Rain and Snow Data Comparison at NOTRE DAME DE LA MERCI
Points: ECCC Records
Bars: Reanalysis Sources
rain
snow
Daymet
ERA5
ERA5−Land
MERRA2
Monthly Precipitation [mm]
0
50
100
150
200
1980
1985
1990
1995
Parameter:
rain
snow


Monthly Precipitation, Rain, and Snow Correlations at NOTRE DAME DE LA MERCI
prcp
rain
snow
Daymet
ERA5
ERA5−Land
MERRA2
$R^2_{adj} = 0.91$ $0.615 + 1.02\,x$
$R^2_{adj} = 0.92$ $10.5 + 0.945\,x$
$R^2_{adj} = 0.89$ $-0.0552 + 0.85\,x$
$R^2_{adj} = 0.68$ $12.6 + 0.875\,x$
$R^2_{adj} = 0.83$ $10.5 + 0.887\,x$
$R^2_{adj} = 0.84$ $0.332 + 0.908\,x$
$R^2_{adj} = 0.68$ $12.7 + 0.899\,x$
$R^2_{adj} = 0.83$ $11.3 + 0.905\,x$
$R^2_{adj} = 0.85$ $-0.0519 + 0.937\,x$
$R^2_{adj} = 0.60$ $23.1 + 0.923\,x$
$R^2_{adj} = 0.77$ $19.3 + 0.99\,x$
$R^2_{adj} = 0.74$ $1.8 + 0.852\,x$
Monthly ECCC Precipitation [mm/mon]
Monthly Reanalysis Precipitation [mm/mon]
0
50
100
150
200

Chapter 8

Snowmelt Validation

To further assess reanalysis model results, a separate regional snowpack and snowmelt validation review was undertaken. Please refer to Report **03a Snowpack Check** for further details.

The main takeaways from this analysis are listed below:

- Overprediction bias in Snowpack model was consistent with review of reanalysis products. Further correction to Daymet to better represent site precipitation is required.
- Precipitation undercatch correction is not required due to general overprediction bias both in the reanalysis products for precipitation and the snowpack model results.

Chapter 9

Site Precipitation Selection and Results

9.1 Daymet Correction Factors for Site

Based on regional analysis, Daymet is the most reliable reanalysis source for precipitation near the project location. However, overprediction bias was generally observed when compared to observed data (See **Section 6.2**). This was consistent with snowpack modelling completed as verification (See report **03a Snowpack Check**). The analysis completed in **Section 7** indicates Daymet precipitation overprediction bias appears to be more significant for snowfall than rainfall.

For these reasons, monthly correction factors are developed to adjust the Daymet dataset, and provide a more likely representation of precipitation at Site.

The following graph shows contours of the best fit coefficients for Daymet to Measured precipitation transformations on a monthly basis, based on values calculated at stations locations by using the loess regression. Loess regression is a nonparametric technique that uses local weighted regression to fit a smooth curve through points in a scatter plot. Loess curves can reveal trends and cycles in data that might be difficult to model with a parametric curve.

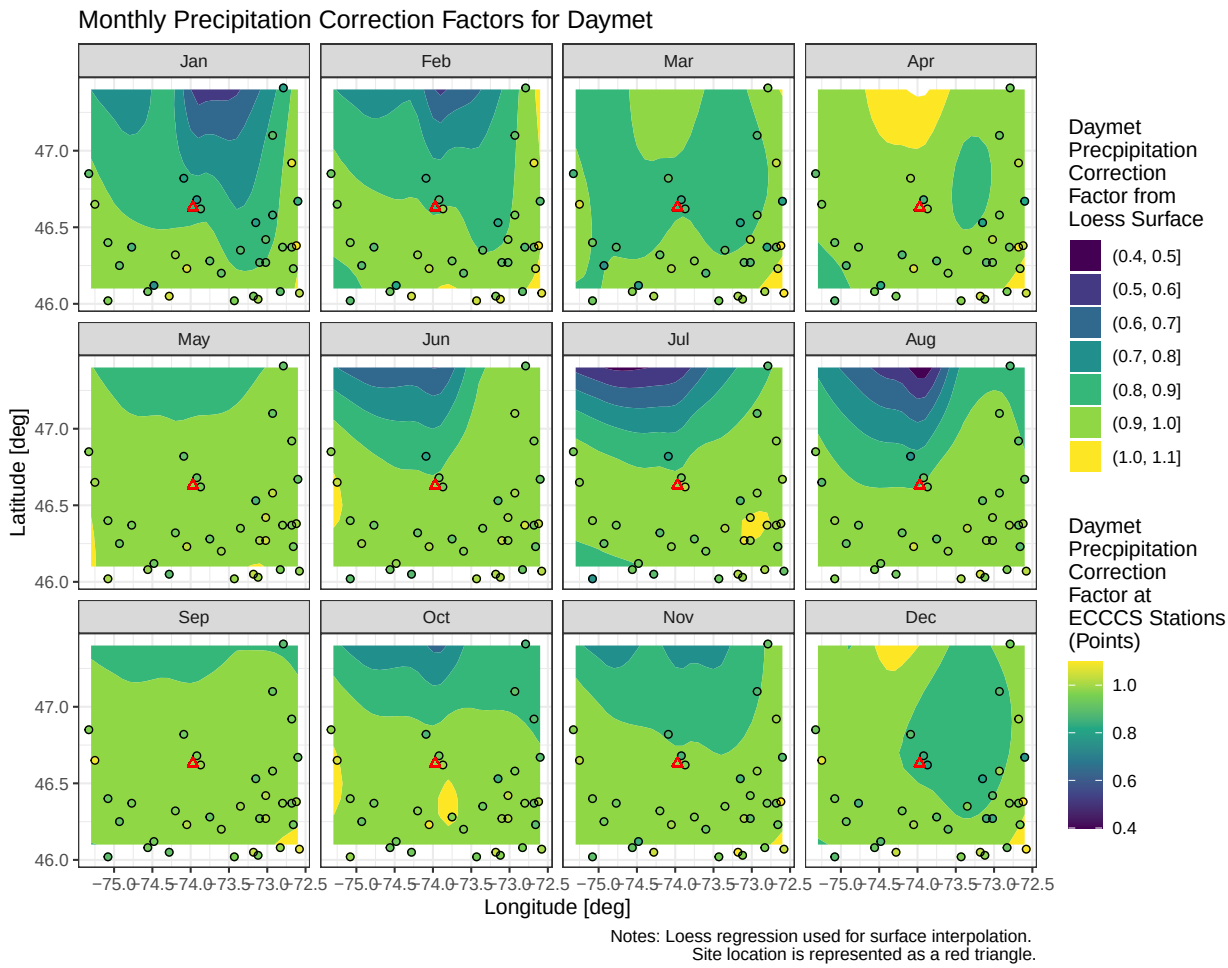
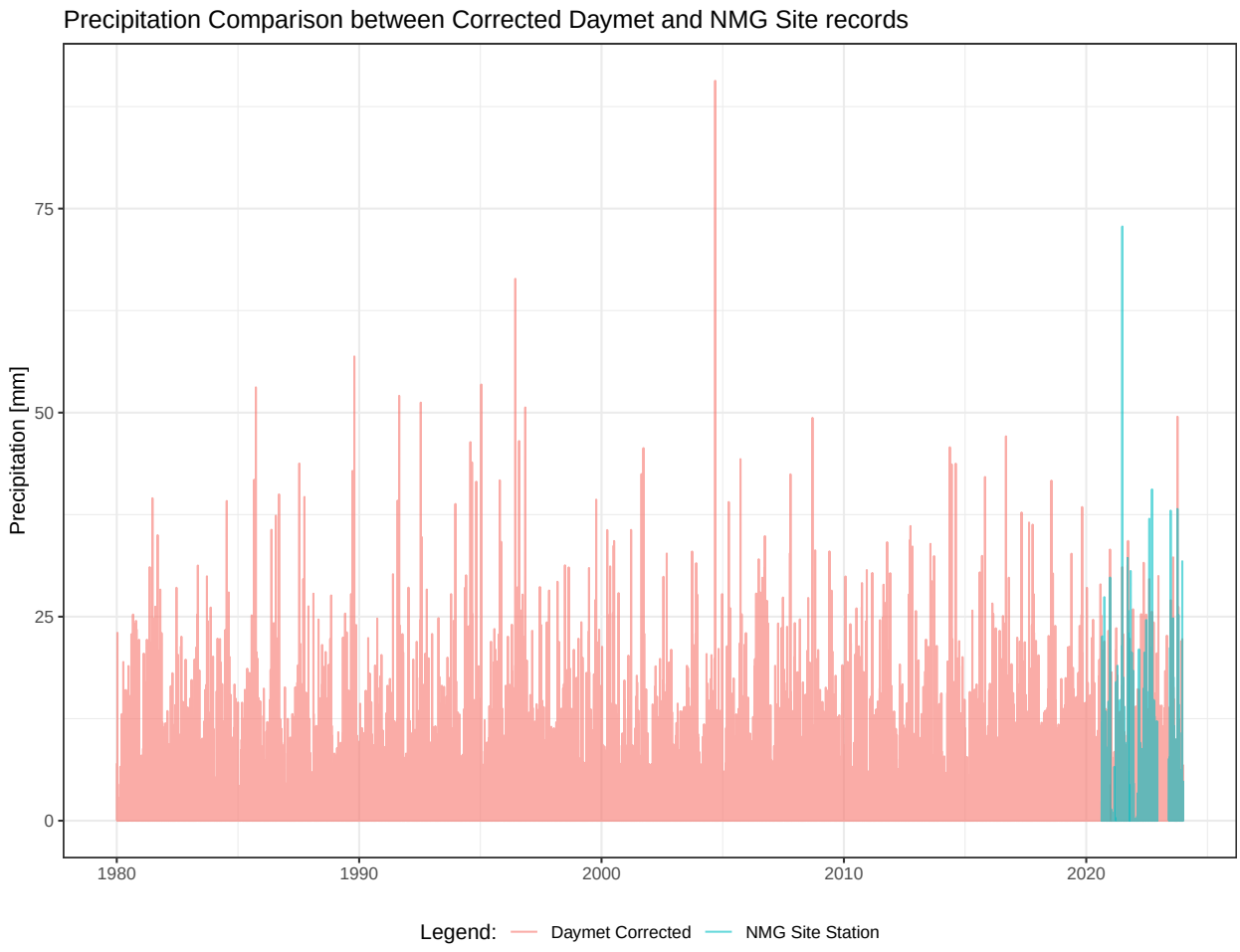


Table 9.1: Daymet Montly Correction Factors for Site

Month	Coef
Jan	0.88
Feb	0.9
Mar	0.9
Apr	0.94
May	0.95
Jun	0.92
Jul	0.93
Aug	0.91
Sep	0.97
Oct	0.97
Nov	0.93
Dec	0.89

9.2 Project Precipitation Timeseries

Coefficients from the previous analysis are applied to the raw Daymet timeseries at the site location to obtain the Project Precipitation Timeseries.



9.3 Climatogram

A climatogram, is a time-based graph that presents a location's average temperature and precipitation on a monthly basis. The following figure was produced for the Project location based on this analysis.

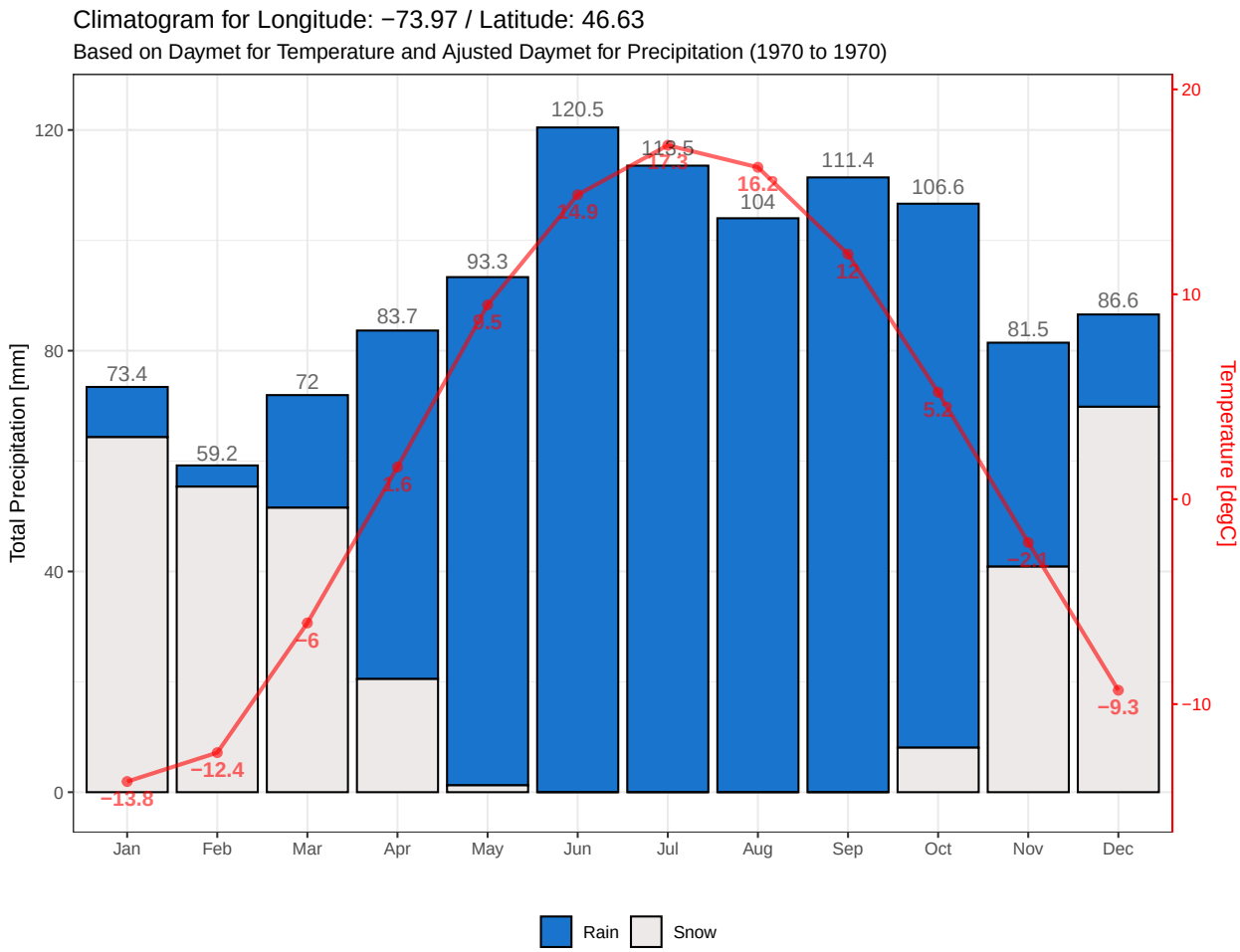


Table 9.2: Mean monthly parameters based on Daymet for Temperature and Ajusted Daymet for Precipitation

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Prcp	73.4	59.2	72	83.7	93.3	120.5	113.5	104	111.4	106.6	81.5	86.6	1106
Rain	9.1	3.8	20.4	63.1	92.1	120.5	113.5	104	111.4	98.6	40.6	16.7	793.9
Snow	64.3	55.4	51.5	20.5	1.2	0	0	0	0	8.1	40.9	69.8	311.8

Table 9.3: Precipitation Normals (1985-2014) for the Project [mm]

Par	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Prcp	73.3	53	66.2	74.6	93.8	116.2	112.7	103	114.1	101	83.5	78	1069
Snow	64.2	50	47.8	18.1	1.2	0	0	0	0.1	7.1	41.8	67.4	297.6
Rain	9.1	3	18.4	56.5	92.7	116.2	112.7	103	113.9	93.9	41.7	10.7	771.9

9.4 Annual Precipitation Frequency Analysis and Monthly Distribution

This section describes the statistical analysis that was completed on yearly precipitation for the Matawinie Site, based on the Project Precipitation Timeseries as defined in Section 9.2. Frequency

analysis were completed on a yearly and monthly basis to estimate precipitation values for typical probabilities of occurrence, or return periods.

Note that the storm event anlysis is included in a separate document. For further information about storm events analysis, please refer to Report **03b Storm Analysis**.

9.4.1 Annual Frequency Analysis

A frequency analysis was completed on yearly precipitation from the Project Precipitation Timeseries. The following results table presents return periods and corresponding monthly and annual precipitation values for the Project.

Tested distributions: [1] NORM LN GEV GUMBEL ———————— Chosen distributions: AIC AICc BIC ADC
LN LN LN LN
whose Maximum-Likelihood parameters are: NORM parameters of log(x): 6.985555 0.09873324

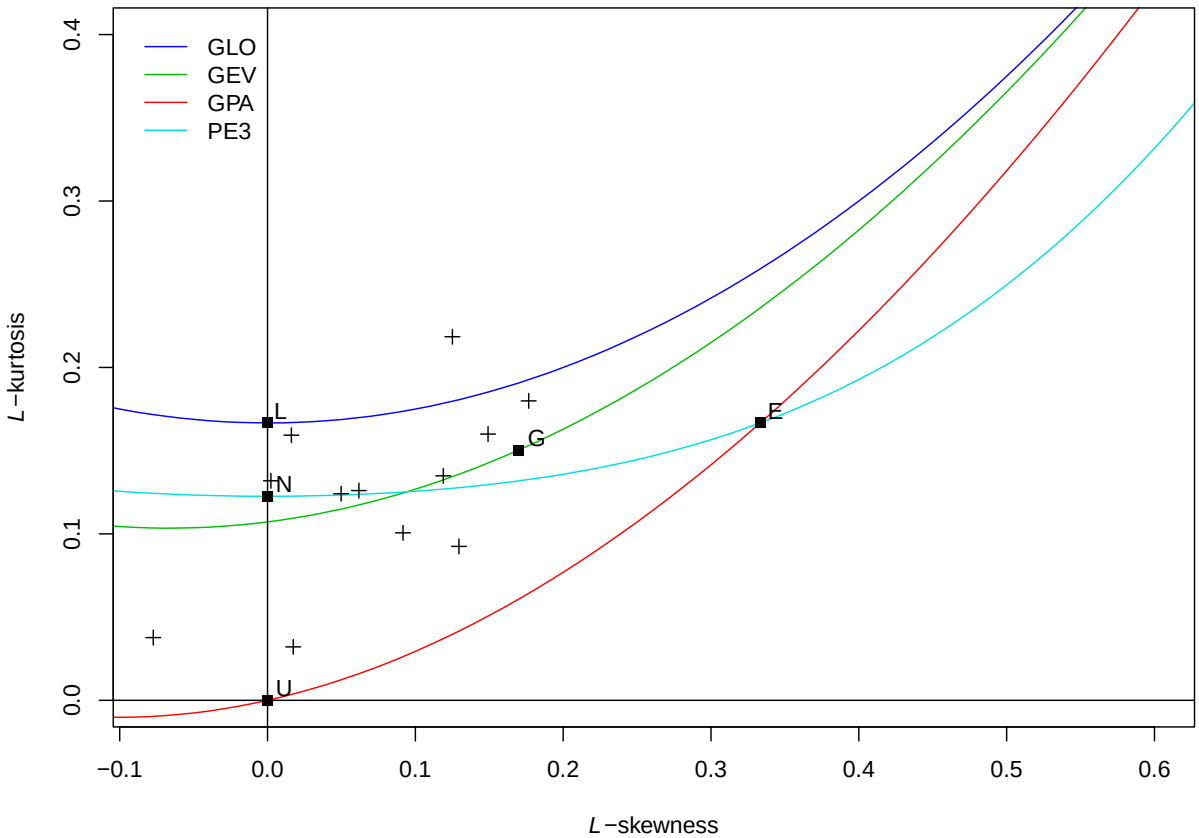
Table 9.4: Annual Precipitation Return Periods [mm]

	Return Period [years]	Annual
1	Wet 10000	1537
2	Wet 2000	1480
3	Wet 1000	1454
4	Wet 500	1426
5	Wet 200	1388
6	Wet 100	1357
7	Wet 50	1323
8	Wet 25	1286
9	Wet 20	1273
10	Wet 10	1230
11	Wet 5	1178
13	Regular 2	1083
15	Dry 5	992
16	Dry 10	946
17	Dry 20	909
18	Dry 25	898
19	Dry 50	868
20	Dry 100	841
21	Dry 200	816
22	Dry 500	787
23	Dry 1000	767
24	Dry 2000	748
25	Dry 10000	709

9.4.2 Monthly Distribution

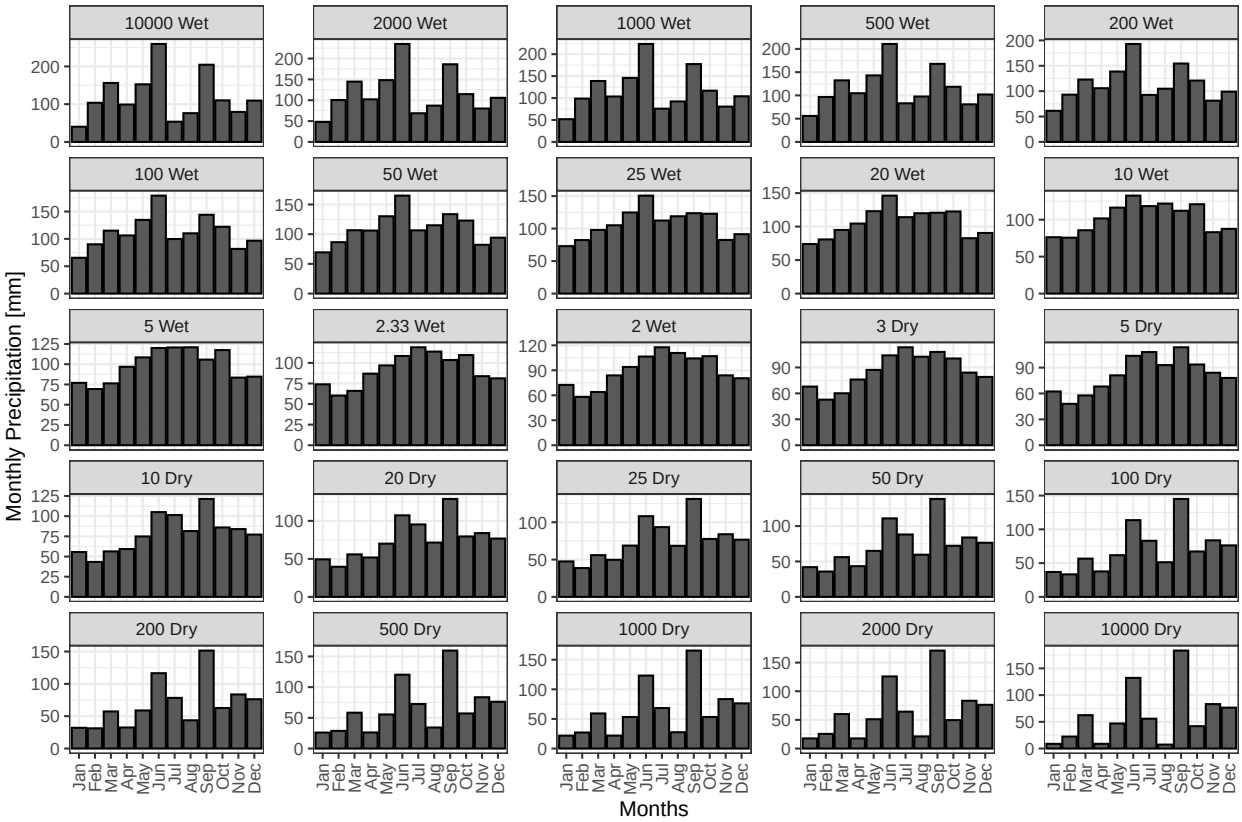
The monthly distribution of precipitation for different return periods might not follow the average distribution of the project precipitation timeseries. An incremental frequency analysis approach was developed and is described below. Note that the monthly distribution of annual precipitation is not equivalent to a monthly precipitation frequency analysis.

First, an L-moments ratio diagram was built to select representative probability distributions to assess data on a monthly basis. The L-moments ratio diagram is the plot of the sample moments on the moment-ratio diagram. The Project Precipitation was summarized monthly and grouped per calendar month. Skewness and kurtosis (L-moments) were computed and plotted in a moment-ratio diagram for each month (black crosses). On the same plot, multiple two parameter (black squares), and three-parameter (colored curves) candidate distributions to model the data are represented. The cluster of L-moments representing the samples are be closer to the distributions that better represent the data.



The generalized extreme value (GEV) distribution, the Pearson Type III (PE3), and the Log-Pearson Type III distributions were selected from this analysis.

The monthly distribution of precipitation was adjusted for each return period by completing an incremental frequency analysis month to month, resulting in the following graphs and table.


10000 Wet
2000 Wet
1000 Wet
500 Wet
200 Wet
100 Wet
50 Wet
25 Wet
20 Wet
10 Wet
5 Wet
2.33 Wet
2 Wet
3 Dry
5 Dry
10 Dry
20 Dry
25 Dry
50 Dry
100 Dry
200 Dry
500 Dry
1000 Dry
2000 Dry
10000 Dry
Monthly Precipitation [mm]
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Months

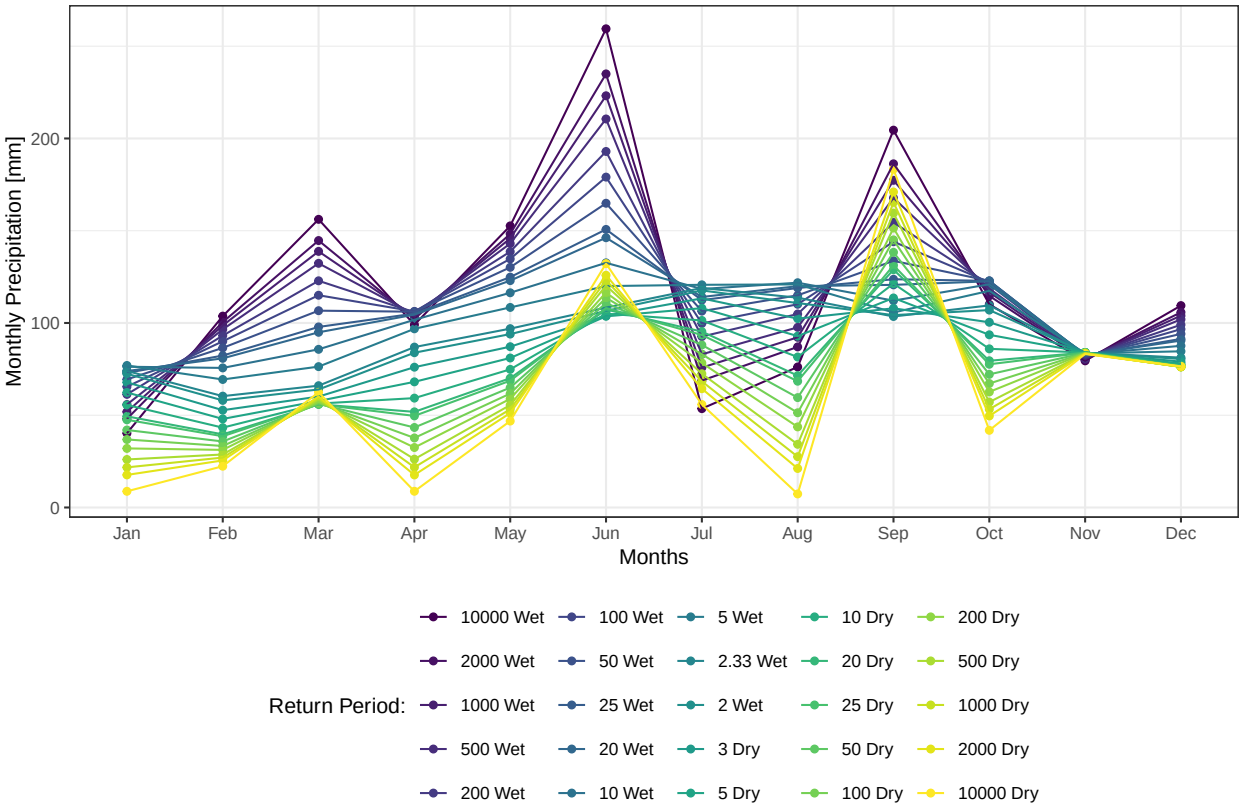

Monthly Precipitation [mm]
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Months
Return Period:
10000 Wet
2000 Wet
1000 Wet
500 Wet
200 Wet
100 Wet
50 Wet
25 Wet
20 Wet
10 Wet
5 Wet
2.33 Wet
2 Wet
3 Dry
5 Dry
10 Dry
20 Dry
25 Dry
50 Dry
100 Dry
200 Dry
500 Dry
1000 Dry
2000 Dry
10000 Dry

Table 9.5: Monthly Distribution of Annual Precipitation [mm]

RP	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
10000 Wet	40	104	156	99	153	259	54	76	205	110	79	109	1444
2000 Wet	48	100	145	102	148	235	69	87	186	115	80	106	1421
1000 Wet	52	99	139	103	146	223	76	92	177	117	80	104	1408
500 Wet	56	97	132	105	143	211	83	98	168	119	81	102	1393
200 Wet	61	93	123	106	139	193	93	105	154	121	81	99	1368
100 Wet	65	90	115	106	135	179	100	110	144	122	82	97	1345
50 Wet	69	87	107	106	130	165	106	115	134	123	82	94	1318
25 Wet	73	82	98	105	125	151	112	119	124	123	83	91	1286
20 Wet	74	81	95	105	123	146	114	120	121	123	83	90	1274
10 Wet	76	76	86	102	116	133	118	122	112	121	83	88	1232
5 Wet	77	69	76	97	108	120	121	121	106	117	83	85	1181
2.33 Wet	74	60	66	87	97	108	119	114	104	110	84	81	1103
2 Wet	72	58	64	84	94	107	118	111	104	107	84	80	1083
3 Dry	68	53	60	76	87	104	113	102	108	100	84	79	1035
5 Dry	62	48	58	68	81	104	108	93	114	94	84	78	991
10 Dry	56	43	56	59	75	105	101	82	121	86	84	77	946
20 Dry	49	40	56	52	70	107	95	71	129	80	84	77	910
25 Dry	48	39	56	50	69	108	93	68	131	78	84	77	900
50 Dry	42	36	56	43	65	111	88	60	138	72	84	76	871
100 Dry	37	33	57	38	62	114	83	51	145	67	84	76	846
200 Dry	32	31	57	32	59	116	78	44	151	63	84	76	824
500 Dry	26	29	58	26	56	120	72	34	160	57	84	76	798
1000 Dry	22	27	59	22	53	123	68	28	165	53	83	76	780
2000 Dry	18	26	60	18	51	126	64	21	171	50	83	76	764
10000 Dry	9	22	62	9	47	132	56	7	183	42	83	76	729

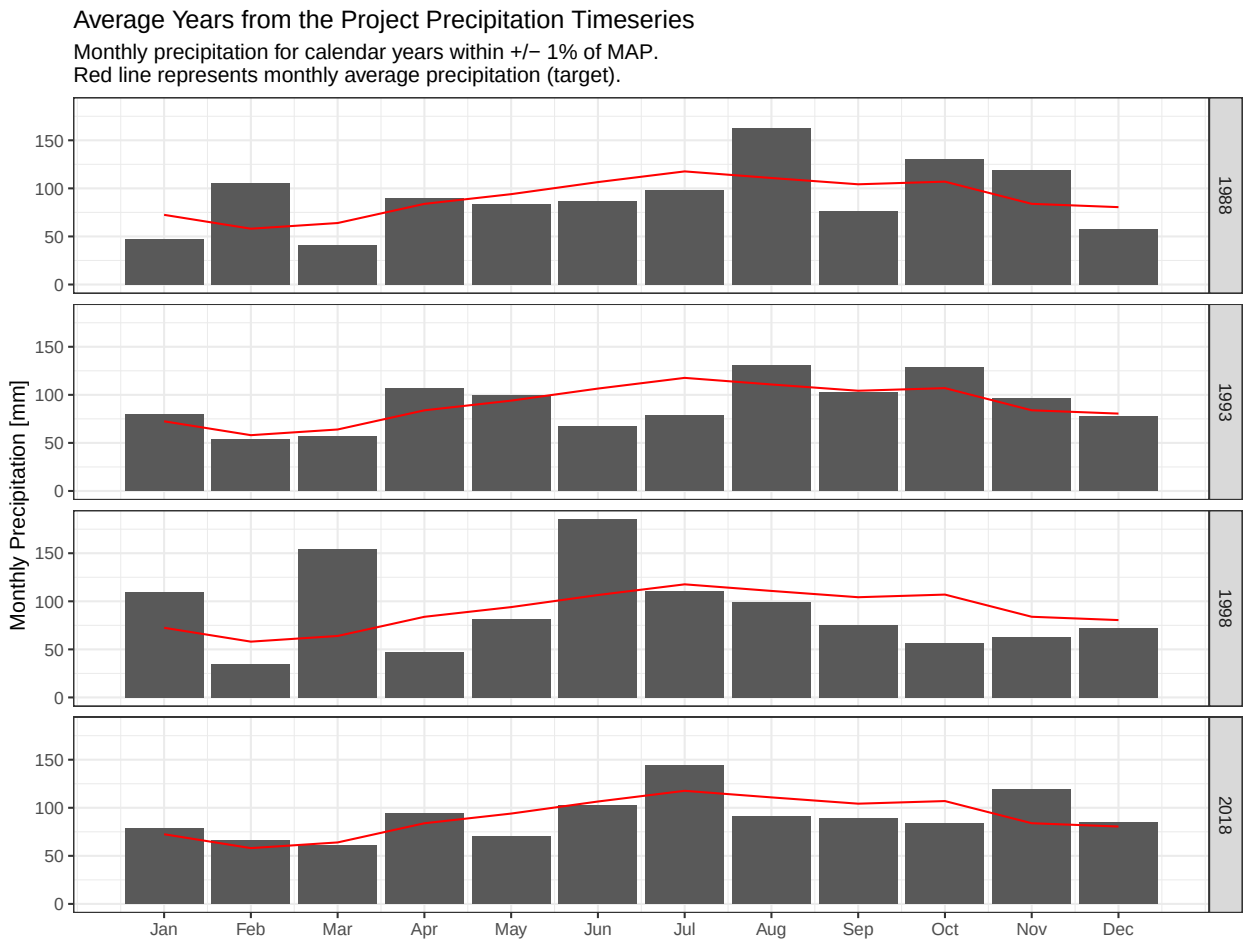
9.5 Representative Years for Water Balance

The site water balance looks to assess different hydrological scenarios. The following scenarios were requested:

- Average year
- 1 in 100 wet year
- 1 in 100 dry year

9.5.1 Average Year

The average year was selected from the project precipitation timeseries as the best matching year to the previous section results.



Based on this analysis, the calendar year 2018 from the project precipitation timeseries is the most representative of an average precipitation year for the Project for historical conditions. 2018 has a total annual precipitation of 1085 mm (target MAP of 1083 mm) and total monthly precipitations that are similar to monthly average precipitation targets.

9.5.2 Extreme Yearly Precipitation Scenarios

The wet and dry scenarios do not have a good 'as is' match within the project precipitation timeseries due to the high return period. Representative months from the project precipitation timeseries corresponding to the selected scenarios are identified in the following table.

Table 9.6: Monthly Selection for Extreme Event Scenarios

Month	Wet Scenario (1 in 100 years)	Dry Scenario (1 in 100 years)
Jan	1989	1987
Feb	2022	1995
Mar	2020	2000
Apr	2002	1987
May	1981	1980
Jun	1998	1990
Jul	2013	2011
Aug	2016	1985

Month	Wet Scenario (1 in 100 years)	Dry Scenario (1 in 100 years)
Sep	1985	1985
Oct	2006	1986
Nov	2001	2001
Dec	2013	2016

Chapter 10

Output

Output of this code has been backed up and saved as an rds file in the **/01_Data/rds** project folder.

References

Gelaro, Ronald, Will McCarty, Max J. Suárez, Ricardo Todling, Andrea Molod, Lawrence Takacs, Cynthia A. Randles, et al. 2017. "The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2)." *Journal of Climate* 30 (14): 5419–54. https://doi.org/10.1175/jcli-d-16-0758.1.

Hersbach, Hans, Bill Bell, Paul Berrisford, Shoji Hirahara, András Horányi, Joaquín Muñoz-Sabater, Julien Nicolas, et al. 2020. "The ERA5 Global Reanalysis." *Quarterly Journal of the Royal Meteorological Society* 146 (730): 1999–2049. https://doi.org/10.1002/qj.3803.

Muñoz-Sabater, Joaquín, Emanuel Dutra, Anna Agustí-Panareda, Clément Albergel, Gabriele Arduini, Gianpaolo Balsamo, Souhail Boussetta, et al. 2021. "ERA5-Land: A State-of-the-Art Global Reanalysis Dataset for Land Applications." *Earth System Science Data* 13 (9): 4349–83. https://doi.org/10.5194/essd-13-4349-2021.

Thornton, M. M., R. Shrestha, Y. Wei, P. E. Thornton, and S-C. Kao. 2022. "Daymet: Daily Surface Weather Data on a 1-Km Grid for North America, Version 4 R1," November. https://doi.org/10.3334/ORNLDAAC/2129.

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FINAL

Memo

To	Kevin Ducharme	**Client**	Nouveau Monde Graphite Inc.
From	Tony Fedec, EIT (BC), MEng	**Project**	CAPR003306
Cc	Jean-François St-Laurent, ing, PEng (ON), MSc, # OIQ 140 657 Charles Veilleux, ing, # OIQ 5 038 360 Camilo Gllard, ing, PEng (BC), MScEng, # OIQ 6 033 031 Brandon Smith, PEng (ON), MEng	**Date**	September 12, 2025
Subject	GoldSim Water Balance Design Basis Memorandum		

File name: NMG_Matawinie_CAPR003306_Water_Balance_Design_Basis_FINAL_20250912.docx

1 Introduction

Nouveau Monde Graphite Inc. (NMG) aims to be a major contributor to the energy transition from fossil fuels and to be a leader in the mining industry by developing, operating, and restoring the Matawinie graphite project, in accordance with the highest environmental, social, and governance (ESG) standards.

NMG will operate a world-class graphite open pit mine. Ore will be concentrated at the Matawinie plant site before being transported to Bécancour, Québec for further processing, an approach that will result in a high purity graphite concentrate intended for use in the manufacturing of battery anode materials. The planned Life-of-Mine (LoM) for the Matawinie project is 28 years, including construction and pre-mining phases (BBA, 2022).

In addition to the open pit mine and industrial area, a co-disposal facility (CDF) for tailings and waste rock, surface water management infrastructure (i.e., ditches and collection ponds), and an overburden (OVB) stockpile will be constructed on the mine site (the site).

SRK Consulting (Canada) Inc. (SRK) was engaged in 2023 to review and update a previously developed MS Excel-based water balance model (WBM) to support the sizing of storm management ponds (referred to as “BC” for *Bassin collecteur* in French). One of SRK’s recommendations from that work was to transition the model into a GoldSim format to allow for improved forecasting and modelling scenarios to support surface water management planning.

1.1 Project Location

The project is located in the Lanaudière region of Quebec, approximately 5 km southwest of the municipality of Saint-Michel-des-Saints, and 400 m west of Lac aux Pierres (**Figure 1-1**). An unpaved access road (Chemin de la Sagacité) between the project and Road 131/Chemin Brassard (**Figure 1-2**) was constructed by NMG between 2021 and 2022.

1.2 Scope of Work

SRK was retained by NMG to develop an operational WBM that would align with recommendations made during a past water balance modelling scope (SRK, 2024). These recommendations stated:

> *SRK understands that NMG requires an operational water balance tool to inform pond water levels during operations and to test detailed scenarios. The current Microsoft Excel-based WBM is not an optimal tool to achieve this, due to the structural limitations of spreadsheet models. SRK recommends building a new GoldSim-based model using the information from the existing WBM as a starting point. A GoldSim model will provide greater flexibility in testing scenarios and can be calibrated to observed data (pumping rates, pond water levels, temperature, precipitation, etc.) to create a more robust tool for operational decision making. The operational WBM should be developed to assess the response of subsequent events after the design storm.*

This memo provides the design basis for the GoldSim model and is expected to be a living document for NMG to revise and SRK to update as the mine plan and operational design are finalized.

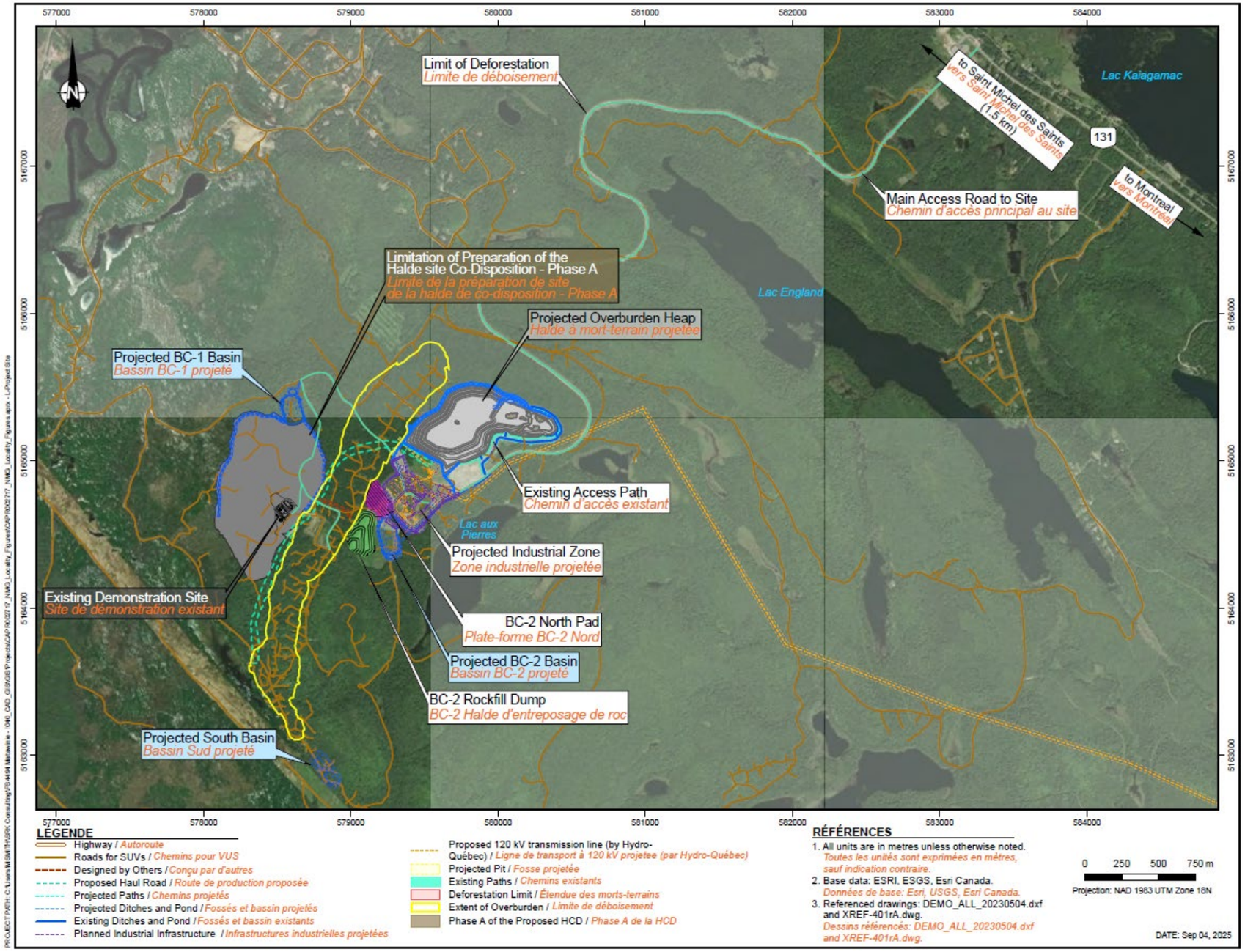
1.3 Memo Content

This memo is intended to summarize and present the WBM that will be used for the engineering of water ponds BC-1, BC-2, and BC-Sud. This memo is divided into the following sections:

- **Section 2**: Basis of Engineering / Modelling
  - Presents the design objectives, criteria, assumptions, parameters, and inputs.
- **Section 3**: Conceptual Model
  - Presents the conceptual water balance model and process flow diagram (PFD).
- **Section 4**: Water Management Objectives
  - Details the discharge strategy, concentrator storage requirements, pond operating water levels, operating rules and conditions, and pumping rates.
- **Section 5**: Closure

Figure 1-1: Matawinie Mining Project Location

Figure 1-2: Detailed Location Map



2 Basis of Modelling

2.1 Design Objectives

The main objective of the WBM was to determine how to optimally collect, store, and discharge water throughout the LoM while complying with environmental and operational objectives. Previous modelling efforts (SRK, 2024) were focused on sizing collection basins and associated infrastructure for the LoM. This stage of modelling was completed using the completed infrastructure sizing to support LoM operations and assess the performance of the site water management system under different climatic scenarios (e.g., wet years, dry years, etc.).

Specifically, the objective was to develop a surface water management plan that will:

- Inform collection, storage, treatment, and discharge of water to the environment while respecting discharge limits
- Ensure a supply of water to the concentrator year-round to maintain operations
- Ensure a supply of water for dust suppression to maintain safe operations
- Ensure that all collection basins are operated in compliance with applicable freeboard requirements (e.g., Environmental Design Flood).

2.2 Design Criteria

The main water management design criteria for the project are as follows:

- BCs shall be capable of holding the 24-hour 1:2,000-year rainfall event combined with the 1:100-year 30-day snowmelt, per Directive 019 (D019) (MDDELCC, 2025).
- The concentrator shall be supplied with water at all times of the year.

The WBM was therefore constructed to adhere to these criteria.

2.3 Phasing, Conditions, and Operating Rules

The GoldSim WBM was built to simulate the LoM, from 2028 (Year 0) through 2056 (Year 28) (with the option to model the closure phase as part of a future phase of work).

The project phases and key milestones pertaining to water management are as follows:

- Phase A – 2028 to 2032 (Year 0 – 4)
  - Early operations: the pit is established and in development, the CDF and the concentrator are built and operating, initial water management infrastructure is in place (i.e., BC-1, BC-2), and the first phase of the water treatment plant is operational.
  - Most of the planned mine catchments are contributing to ponds at this time.

- Phase B1 – 2033 to 2035 (Year 5 – 7)
  - The CDF is expanded towards the south and the impacted catchment area is increased.
  - The pit catchment will be fully developed in this phase.
  - BC-Sud Phase 1 is constructed and operational by 2033 and is collecting runoff in the southern portion of the site.
  - The WTP is doubled in size to reflect the additional runoff from BC-Sud.
- Phase B2 – 2036 to 2056 (Year 8 – 28) (**Figure 2-2**)
  - Catchment areas increase to reflect the expansion of the CDF and the pit. Catchments are now contributing the maximum runoff to site water management in Year 8.
  - BC-Sud Phase 2 is operational in 2036.
  - The pit will continue to increase in depth, but the catchment area will not expand. The CDF will overlap, resulting in in-pit tailings and mine rock disposal later in mining operations.
- Closure – 2057+
  - Closure details are not yet defined in the model.

The focus of the model was the current iteration of Phase A (**Figure 2-1**) to support early operational planning, using available information for relevant infrastructure (e.g., pond stage storage curves, production forecasts, etc.).

The WBM does not account for any progressive reclamation work to be completed on the CDF, which may reduce water collection needs over time.

Figure 2-1: Mining Phase A

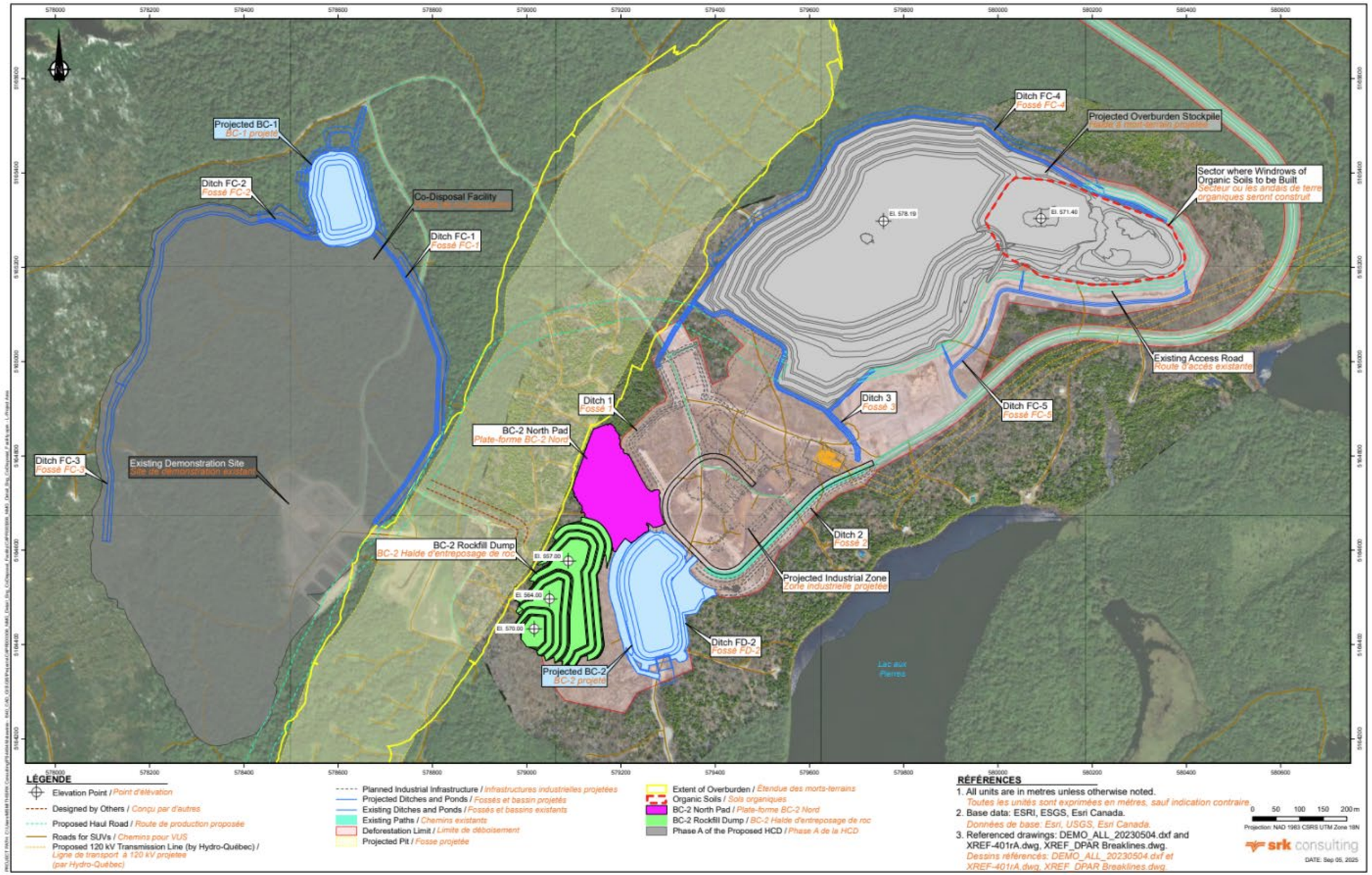


Figure 2-2: Mining Phase B

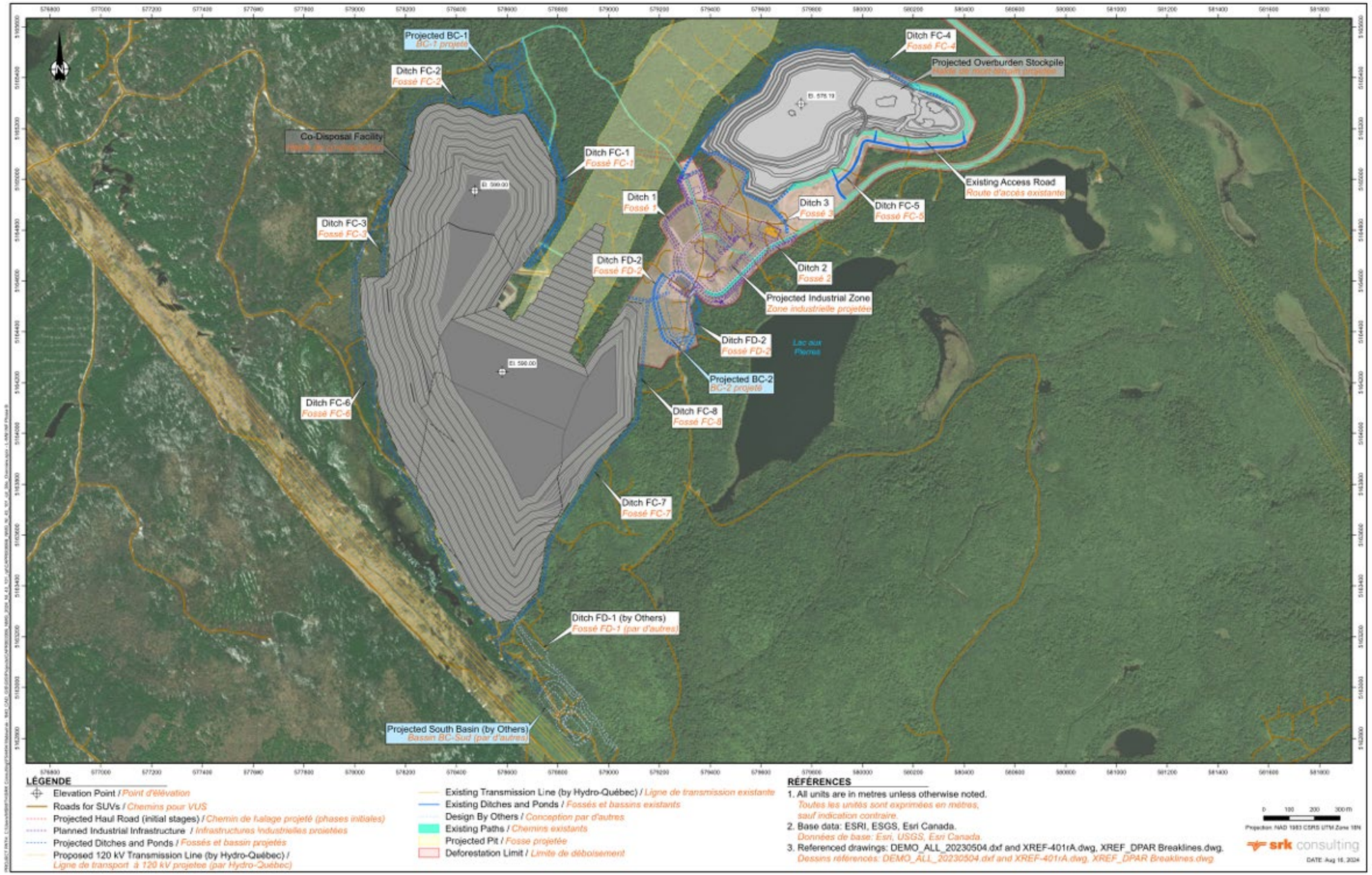


Table 2-1 and **Table 2-2** summarize the operating conditions and rules used to develop the WBM.

Table 2-1: WBM Operating Conditions

Facility	Condition/Rule	Value	Description
WTP	Maximum flow rate (Phase A)	900 m^3/h	Based on criteria established by NMG and Mabarex during a previous engineering phase (SRK, 2024).
	Maximum flow rate (Phase B1, B2)	1,800 m^3/h	Based on criteria established by NMG and Mabarex during a previous engineering phase.
BC-1	Minimum pond volume	2,400 m^3	This pond can be operated empty. Minimum volume established to account for sediment accumulation over time.
	Maximum pond volume	172,000 m^3	Per SRK (2024).
BC-2	Minimum pond volume	10,000 m^3	Minimum water level to be maintained to provide water for the mill and fire suppression.
	Maximum pond volume	170,000	Per SRK (2024).
BC-Sud	Minimum pond volume	2,400 m^3	This pond can be operated empty. Minimum volume established to account for sediment accumulation over time.
	Maximum pond volume	86,000 m^3 / 256,000 m^3	Per SRK (2024).

Source: Compiled in text

Table 2-2: WBM Operating Rules

Flows from	Operating Window	Water Source	Flows to	Description
BC-1	Year-round	Direct precipitation, contributing catchment, pit water	BC-2, Dust Suppression	▪ Collects water throughout the year, majority of runoff occurs between April and December. ▪ Receives pit water and provides settlement capacity. ▪ Operating objective is to strategically store and manage water to supply BC-2 to support concentrator operations during winter months.
Pit	Year-round	Direction precipitation, contributing catchment, groundwater inflow	BC-1, BC-2	▪ Pit receives water from direct precipitation, contributing catchment, and from groundwater inflow, all flows will be captured through pit dewatering. ▪ During winter months, groundwater will be the main inflows pumped from the pit.
Freshwater Tank	Year-round	WTP	Concentrator	▪ Treated water from WTP feeds the Freshwater Tank. ▪ Concentrator sources treated water from tank, as required. ▪ Tank has fixed volume (300 m^3) (Atkin comms, 2025).
Process Water Tank	Year-round	Freshwater Tank	Concentrator	▪ Water is sourced from the Freshwater Tank to the Process Water Tank. ▪ Concentrator sources treated water from tank, as required. ▪ Tank has fixed volume (300 m^3) (Atkin comms, 2025).
Concentrator	Year-round	Freshwater Tank, Process Water Tank	BC-2	▪ Concentrator sources water from the Freshwater Tank and Process Water Tank and discharges water back to BC-2 throughout the year. ▪ Concentrator freshwater demand ranges from 249.8 – 345.5 m^3/hr and returns 214 – 309.7 m^3/hr to BC-2. The concentrator runs a water deficit and requires a constant source to maintain operations throughout the year. ▪ Additional information found in Atkins Réalis (2023).
WTP	Year-round	BC-2	Freshwater Tank, BC-2, Environment	▪ Operating rates are fixed at low or high rates (350 m^3/hr, 900 m^3/hr / 1,800 m^3/hr). ▪ WTP required to support concentrator operations. ▪ Treated water can either be discharged to BC-2, Freshwater Tank, the Environment, or a combination of the three.
BC-Sud	Year-round	Direct precipitation, contributing catchment	BC-2	▪ Collects water throughout the year, majority of runoff occurs between April and December. ▪ Operating objective is to strategically store and manage water to supply BC-2 to support concentrator operations during winter months.
BC-2	Year-round	Direct precipitation, contributing catchment - Pumped water from BC-1, Concentrator return and eventually BC-Sud (+Y4)	WTP & Concentrator	▪ Operates year-round to collect water from contribution catchments and receives pumped water from all other ponds and the open pit. ▪ Provides water source to the concentrator, a portion of the water used is returned. ▪ Acts as a head pond for the WTP. ▪ Minimum operating volume is defined by fire suppression requirement (10,000 m^3)

Source: Compiled in text

2.4 Mine Plan

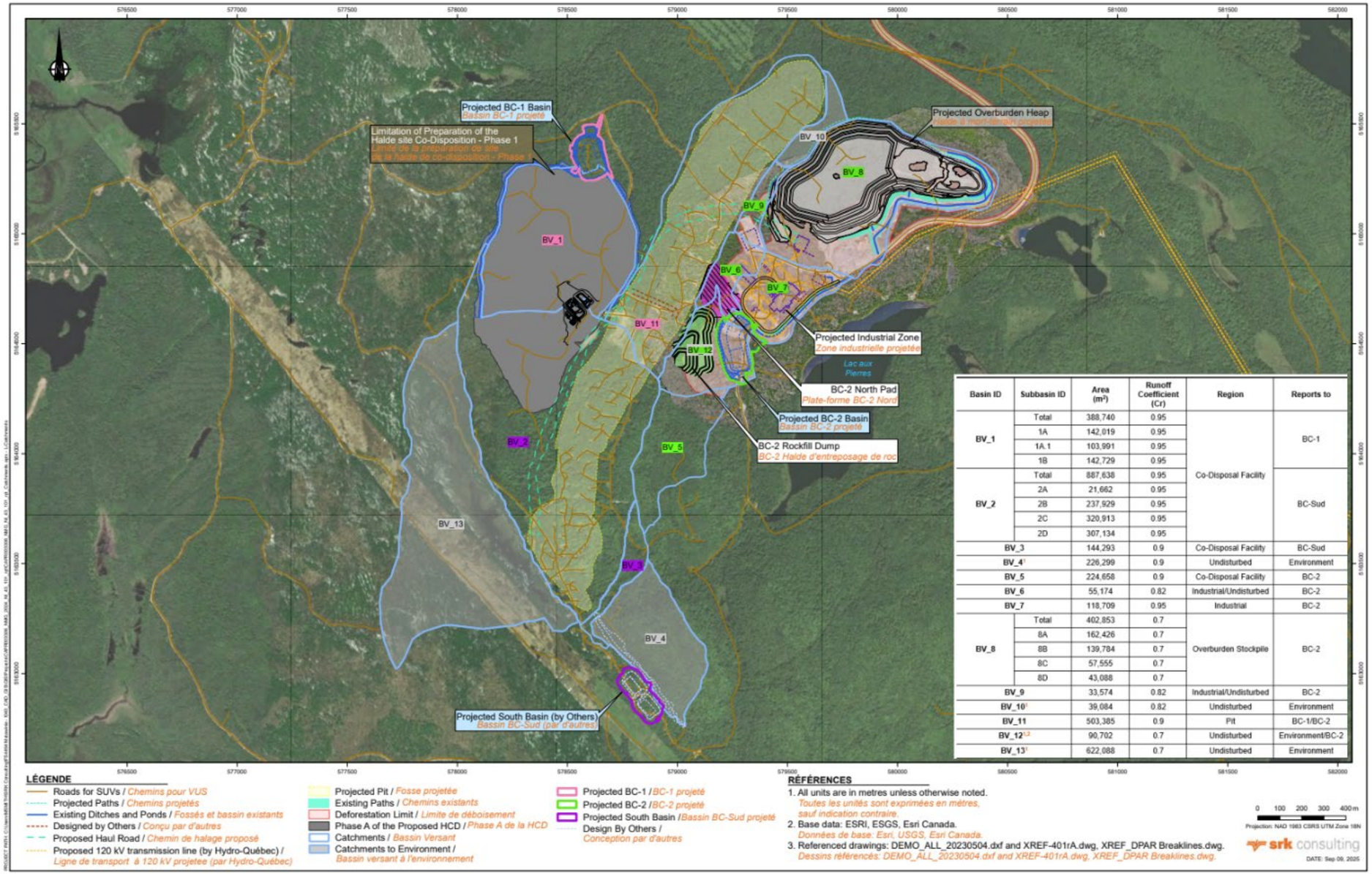
Catchment areas evolve throughout the project LoM, influencing runoff volume and BC storage availability over time. Changes in catchment areas are driven by the development of the pit, and the expansion of the CDF and the OVB stockpile. A detailed monthly breakdown of catchment areas over the LoM is provided as **Attachment 1**.

Catchment areas and sequencing used within the GoldSim model are the same as the Excel model. If catchment areas or deposition planning are updated in the future, the WBM will be updated to reflect the changes.

2.5 Catchment Areas and Runoff Model

Figure 2-3 illustrates the catchment areas used in the WBM. **Table 2-3** presents the catchment area details including area and estimated runoff coefficient (C_r). These runoff coefficients remain the same as the Excel model. During future WBM updates, site-specific studies should be conducted to improve confidence in runoff coefficients.

Figure 2-3: Matawinie Project Catchments



Basin ID	Subbasin ID	Area (m^2)	Runoff Coefficient (Cr)	Region	Reports to
BV_1	Total	388,740	0.95	Co-Disposal Facility	BC-1
	1A	142,019	0.95		
	1A.1	103,991	0.95		
	1B	142,729	0.95		
BV_2	Total	887,638	0.95		BC-Sud
	2A	21,662	0.95		
	2B	237,929	0.95		
	2C	320,913	0.95		
	2D	307,134	0.95		
BV_3		144,293	0.9	Co-Disposal Facility	BC-Sud
BV_4[1]		226,299	0.9	Undisturbed	Environment
BV_5		224,658	0.9	Co-Disposal Facility	BC-2
BV_6		55,174	0.82	Industrial/Undisturbed	BC-2
BV_7		118,709	0.95	Industrial	BC-2
BV_8	Total	402,853	0.7	Overburden Stockpile	BC-2
	8A	162,426	0.7		
	8B	139,784	0.7		
	8C	57,555	0.7		
	8D	43,088	0.7		
BV_9		33,574	0.82	Industrial/Undisturbed	BC-2
BV_10[1]		39,084	0.82	Undisturbed	Environment
BV_11		503,385	0.9	Pit	BC-1/BC-2
BV_12[1,3]		90,702	0.7	Undisturbed	Environment/BC-2
BV_13[1]		622,088	0.7	Undisturbed	Environment

Table 2-3: Catchment Summary (SRK, 2024)

Basin ID	Subbasin ID	Area (m^2)	Runoff Coefficient (Cr)	Region	Reports to
BV_1	Total	388,740	0.95	Co-Disposal Facility	BC-1
	1A	142,019	0.95		
	1A.1	103,991	0.95		
	1B	142,729	0.95		
BV_2	Total	887,638	0.95		BC-Sud
	2A	21,662	0.95		
	2B	237,929	0.95		
	2C	320,913	0.95		
	2D	307,134	0.95		
BV_3		144,293	0.9	Co-Disposal Facility	BC-Sud
BV_4[1]		226,299	0.9	Undisturbed	Environment
BV_5		224,658	0.9	Co-Disposal Facility	BC-2
BV_6		55,174	0.82	Industrial/Undisturbed	BC-2
BV_7		118,709	0.95	Industrial	BC-2
BV_8	Total	402,853	0.7	Overburden Stockpile	BC-2
	8A	162,426	0.7		
	8B	139,784	0.7		
	8C	57,555	0.7		
	8D	43,088	0.7		
BV_9		33,574	0.82	Industrial/Undisturbed	BC-2
BV_10[1]		39,084	0.82	Undisturbed	Environment
BV_11		503,385	0.9	Pit	BC-1/BC-2
BV_12[1,2]		90,702	0.7	Undisturbed	Environment/BC-2
BV_13[1]		622,088	0.7	Undisturbed	Environment

Notes:

1 Does not report to collection pond and is not accounted for in the model

2 BV-12 will be diverted for portions of the LOM to the receiving environment when no material is placed within the catchment. When material is present, runoff will report to BC-2

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

2.6 Ore Production

Mine plan throughputs are presented as tonnes per day from the pit to the concentrator. Throughput is based on estimates presented in **Table 2-4** (more detail is provided in **Attachment 4**). Throughput is expected to be consistent throughout operations, with a ramp-up at the start of operations and a ramp-down at the end.

Table 2-4: Daily Concentrator Throughput

Year	Daily Ore Input (tonnes/d)
2028	7,099
2029 – 2050	9,810
2051 – 2053	9,376
2054 – 2055	8,587
2056	7,491

Note: Reference data is not in sync with project schedule, data was updated to be aligned.

Source: 3936022-000000-4M-ECA-0011-RAA (NMG, 2025)

2.7 Concentrator

The concentrator requires water to process ore into concentrate. Water inputs and outputs are related to the throughput of the operation (**Section 2.6**) . Concentrator values are sourced from the updated feasibility study (BBA, 2025) (**Table 2-5**).

Table 2-5: Concentrator Operational Parameters (BBA, 2025)

Stream	Dry Solids (tpd)	Water (m^3/d)	Ratio (m^3 water /tonne)
Ore to Concentrator	7,764	409	0.053
Final Concentrate	322	1	0.003
Sulphide Filter Cake (PAG)	1,563	276	0.177
Non-Sulphide Filter Cake (NAG)	5,879	1,038	0.177
Evaporation from Dryer	-	56	0.006

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

The maximum design throughput values for estimating concentrator demand are listed in **Table 2-6**. A detailed breakdown of the inflow demands is provided in **Table 2-7**.

Table 2-6: Concentrator Inflow Requirements (NMG, 2025)

Parameter	Value	Unit
Max Freshwater Demand	249.8-345.5	m^3/hr
Max Design Throughput	9,837	tpd

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

Table 2-7: Concentrator Inflow Demand Details (Atkins comms, 2025)

	Constant flow (fresh water)	Nominal (m^3/h)	Max (m^3/h)	Notes
W121	Mill multidrive VFD cooling water	40.5	60	
W122	SAG mill lube system cooling water	2.4	5	
W123	Ball mill lube system cooling water	1.8	3.6	
W124	Polishing mill lube system cooling water	1.8	3.6	
W125	Compressors cooling loop heat exchanger	58.1	58.1	
W503	Water to graphite concentrate cooling screws	27	32.4	
W904	Total gland seal water	15.3	30.6	100% Design Factor vs Estimated Value in 2021
W903	Fresh water to process water tank	98.4	147.7	50% design factor
	Total Constant Flow Demand	**245.3**	**341**	
	Intermittent flow (fresh water)	**Average (m^3/h)**	**Inst. Flow (m^3/h)**	
W810	Fresh Water to Lime mix tank	0.1	0.1	Negligible flow rate. Marked as 0.1 for now (TBC)
W811	Fresh Water to Xanthate mix tank	0.2	10	10 m^3/h for 14 min, 0.6 to 1.3 times per day
W502	Concentrate Filter Press - Cloth wash water (Fresh Water)	1.5	10	10 m^3/h for 8 min, 27 times per day
W800	Fresh water to flocculant mix tank - graphite conc.	0.1	6	6 m^3/h for 5 min, 3 to 6 times per day
W809	Fresh water to flocculant mix tank - PAG, NAG, Tailings	2.6	24	24 m^3/h for 50 min, 3 to 6 times per day
	Total Intermittent Flow Demand	**4.5**	**50.1**	
	Total Concentrator Demand	**249.8**	**345.5**	Max = Max Constant Flow + Average Int Flow

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400- 4%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

Using the values from **Table 2-5** and **Table 2-6**, the forecasted water process inflows and outflows for the concentrator were generated (**Table 2-8**).

Table 2-8: Concentrator Inflow and Outflow Summary

Year	Water In with Ore (m^3/d)	Water Out with Final Concentrate (m^3/d)	Water out with PAG (m^3/d)	Water out with NAG (m^3/d)	Water out with Evaporation (m^3/d)
2028	374	22	252	949	40.4
2029 – 2050	518	31	350	1,315	56.0
2051 – 2053	494	29	333	1,254	53.4
2054 – 2055	452	27	305	1,148	48.9
2056	395	23	266	1,002	42.6

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG %20Input%20Tables%20202520512.xlsm?web=1

2.8 Climate

Climate inputs inform the quantity and timing of water that reports to collection basins at the site. Climate inputs include precipitation, air temperature, and evaporation.

SRK conducted a baseline climate analysis for the Matawinie Mine (SRK, 2025a) to provide site-specific climatic inputs for surface water management and engineering design. The results of this analysis serve as the baseline climate inputs for the WBM. In consultation with NMG, this information was used to select climate conditions for assessing the performance of the water management system. The WBM includes daily climate inputs for long-term average, 1-in-100-year dry year (Dry100), and 1-in-100-year wet year (Wet100) conditions.

The historical year 2018 was determined to be a representative year of average conditions. Representative timeseries of Wet100 and Dry100 years were synthesized using representative months from historical records to create composites. Further information is detailed in **Attachment 5**. These climate data were then used as inputs to model hydrological processes (e.g., evaporation, snowmelt).

Climate change scenarios were evaluated (SRK, 2025b) and the results of the study are included in the model for scenario evaluation.

2.8.1 Precipitation

Monthly precipitation inputs for Average, Dry100, and Wet100 climate regimes are summarized in **Table 2-9**.

Table 2-9: Monthly Precipitation Inputs Summary (mm)

Month	Average	Dry100	Wet100
January	78.7	38.1	63.9
February	66.5	33.5	90.0
March	60.3	68.6	119.3
April	94.1	37.3	105.6
May	70.7	61.2	128.0
June	102.3	114.3	185.2
July	143.7	82.2	98.6
August	91.4	53.8	110.3
September	89.1	142.8	142.8
October	84.1	63.4	122.8
November	118.9	82.1	82.1
December	85.0	84.6	94.8
Total	1084.9	862.0	1343.5

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

2.8.2 Environmental Design Flood

Directive 019, issued by Quebec's Ministry of the Environment, sets out environmental requirements for the mining industry, including criteria for the design and sizing of water management infrastructure such as sedimentation ponds, polishing ponds, and water retention structures.

Directive 019 designates that the environmental design flood (EDF) ponds must contain the 1-in-2,000-year 24-hour rainfall event combined with the average 30-day snowmelt from the 1:100-year snowpack (MDDELCC, 2025).

Design storms can vary in intensity between spring and summer (**Table 2-10**).

Table 2-10: Spring and Annual Design 24h Storms (SRK, 2025)

Return Period (Years)	Spring Daily Precipitation (mm)	Summer Daily Precipitation (mm)
2	32	56
2.3	34	60
5	45	76
10	55	89
20	66	102
25	70	107
50	83	120
100	96	134
200	111	148
500	133	168
1,000	151	183
2,000	171	199
10,000	224	239

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

- The D019 conditions, defined as a 1-in-2,000-year 24-hour rain event combined with the average 30-day snowmelt derived from the 1:100-year snowpack, were assessed based on the framework and assumptions outlined in the guidance provided by NMG.
- Spring rain-on-snow event modelling approach:
  - Two consecutive 1-in-100 wet years are modelled to ensure that a 1-in-100-year snowpack (snowpack is expected to accumulate between November and April) is developed for testing the design event. This ensures that the full hydrologic year is captured for the snowpack depth. 171 mm of rainfall attributable to the 1-in-2000-year 24-hour spring rainfall (SRK, 2025; Attachment 5). The rainfall event will occur at the end of the snowpack melt, when the remaining snowpack depth equals the snowmelt potential of the rainfall design event.
- Summer/Fall rainfall event:
  - The design summer/fall flood (i.e., 1-in-2,000-year 24-hour rainfall event) corresponds to a storm depth of 199 mm with no snowpack or snowmelt involved.

This information was used to determine EDF volumes as part of the operating water level assignment (**Section 4.3**).

2.8.3 Air Temperature

Air temperature inputs from the NMG Baseline Climate Analysis (SRK, 2025) were reviewed and updated by SRK for use in the WBM. Results from SRK (2025) were used to generate temperatures associated with three chosen climatic scenarios (i.e., long-term average, Dry100, Wet100).

Further details on rationale for these scenarios are presented in SRK (2025). The range is intended to present suitably variable conditions that could occur during the LoM (28 years). Monthly averaged air temperatures are summarized in **Table 2-11**.

Table 2-11: Monthly Averaged Air Temperature

Month	Average			Dry100			Wet100		
	Tmax	Tmin	Tavg	Tmax	Tmin	Tavg	Tmax	Tmin	Tavg
January	-8.2	-20.2	-14.2	-7.4	-20.0	-13.7	-5.2	-20.1	-12.7
February	-2.9	-16.7	-9.8	-7.9	-22.5	-15.2	-6.2	-21.0	-13.6
March	0.1	-8.9	-4.4	3.7	-8.2	-2.2	2.0	-11.0	-4.5
April	4.0	-7.6	-1.8	13.2	-1.2	6.0	8.0	-4.0	2.0
May	18.6	2.0	10.3	16.1	1.5	8.8	15.3	2.7	9.0
June	21.4	7.0	14.2	20.4	8.7	14.5	20.6	9.7	15.1
July	25.5	12.4	18.9	25.0	11.6	18.3	24.1	11.0	17.5
August	24.2	12.7	18.5	20.8	7.7	14.3	23.3	11.9	17.6
September	18.8	6.7	12.8	18.0	4.8	11.4	18.0	4.8	11.4
October	6.7	-1.1	2.8	9.0	-0.8	4.1	7.8	-0.1	3.8
November	-2.0	-9.2	-5.6	3.8	-4.5	-0.4	3.8	-4.5	-0.4
December	-5.2	-16.4	-10.8	-4.4	-13.1	-8.7	-8.6	-19.4	-14.0
Annual	**8.4**	**-3.3**	**2.6**	**9.2**	**-3.0**	**3.1**	**8.6**	**-3.3**	**2.6**

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG %20Input%20Tables%20202520512.xlsm?web=1

2.8.4 Evaporation

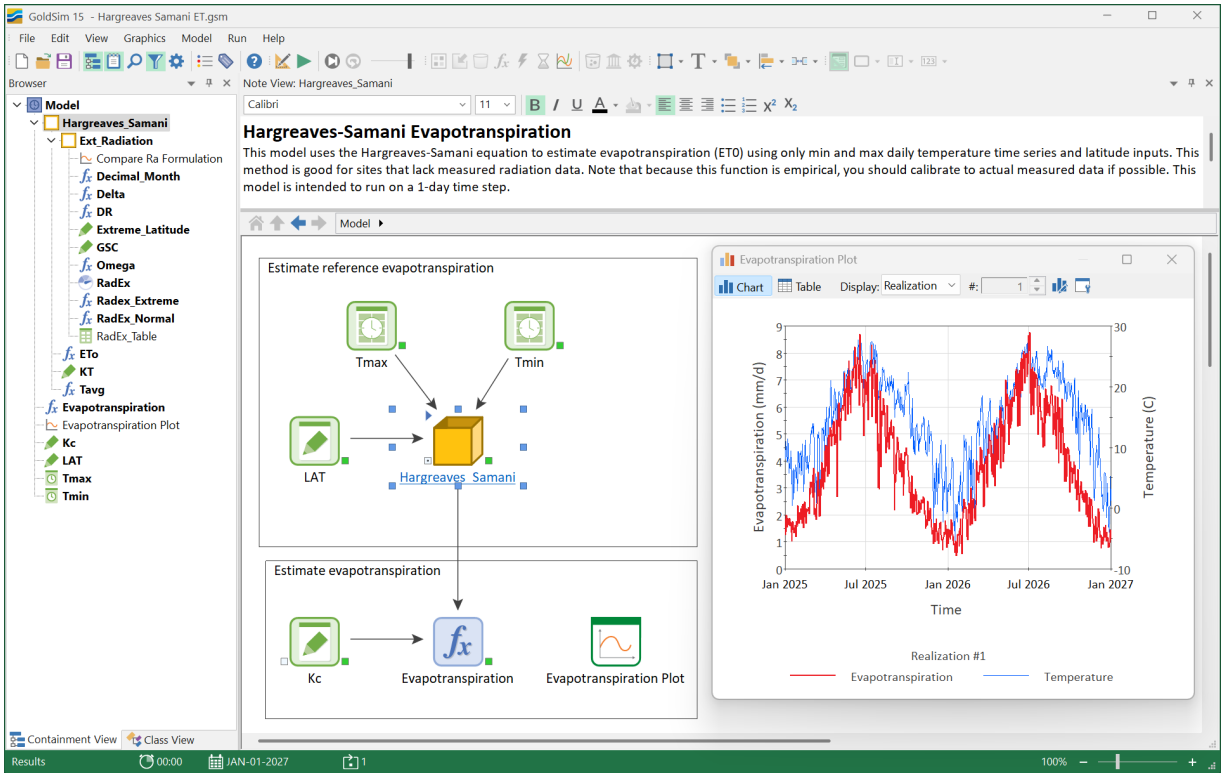
The Hargreaves-Samani evapotranspiration (ET) model is an empirical method used to estimate reference ET based on temperature data (Hargreaves & Samani,1985). It simplifies the more complex Penman-Monteith equation by relying primarily on daily maximum and minimum temperatures, along with extraterrestrial solar radiation. The model is expressed as:

$$ET_0 = 0.0023 \times (T_mean + 17.8) \times (T_max - T_min)^{0.5} \times R_a$$

where T_mean is the average temperature, T_max and T_min are the daily maximum and minimum temperatures, and R_a is the extraterrestrial radiation. Due to its minimal data requirements, it is widely used in areas where detailed meteorological data (e.g., humidity, wind speed) are unavailable.

The Hargraves-Samani method was used to estimate potential evapotranspiration (PET) using maximum and minimum air temperature data (**Section 2.8.3**), and extraterrestrial radiation estimated from site latitude. PET was estimated within the NMG model using the GoldSim Hargreaves-Samani package (**Figure 2-4**) with air temperature data series from the Average, Dry100, and Wet100 datasets (**Table 2-11**). The results are three evaporation ranges available for running scenarios, Average, Dry100, and Wet100 evaporation data series (**Table 2-12**). The model assumes that PET is equal to actual evapotranspiration (AET).

Figure 2-4: GoldSim Hargreaves-Samani ET Model



Source: https://support.goldsim.com/hc/en-us/articles/360000991667-Hargreaves-Samani-Evapotranspiration

Table 2-12: Monthly Evaporation Rates (mm/d)

Month	Average	Dry100	Wet100
January	0.2	0.2	0.3
February	0.6	0.3	0.4
March	1.1	1.5	1.3
April	2.1	3.6	2.7
May	5.4	4.8	4.4
June	6.1	5.5	5.4
July	6.4	6.4	6.2
August	5.2	4.8	5.0
September	3.5	3.4	3.4
October	1.3	1.5	1.4
November	0.4	0.7	0.7
December	0.2	0.3	0.2

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400 04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

2.8.5 Snow Accumulation and Snowmelt Model

The Snow-17 model (Anderson, 2006), developed by the U.S. National Weather Service, is a conceptual tool designed to simulate snow accumulation and ablation processes. It primarily requires two inputs: air temperature and precipitation. By using air temperature as an index for energy exchange at the snow-air interface, the model estimates snowpack dynamics, including accumulation, melt, heat storage, and liquid water retention or transmission. This simplicity makes Snow-17 useful in data limited scenarios.

In the WBM, snow accumulation and snowmelt are estimated using the Snow-17 module for Goldsim[1]. which uses daily temperature, daily precipitation, and site latitude to model the state (i.e., rain or snow) of precipitation, the storage of the snow pack (in millimeters Snow Water Equivalent, mm SWE), and snowmelt processes (**Figure 2-5**). The model operates on a daily time step and reports snowmelt as runoff (in mm).

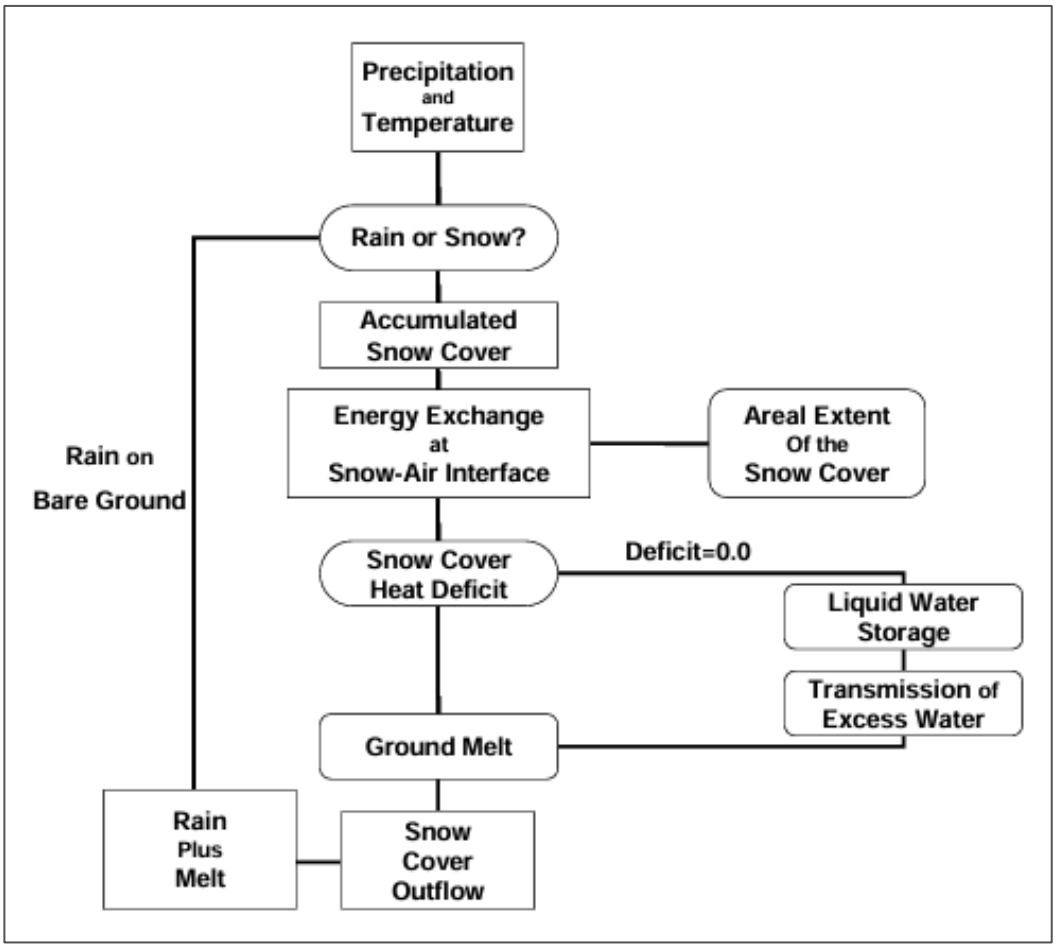
Key processes simulated by Snow-17 include:

- Precipitation Division: Determines whether precipitation falls as rain or snow based on temperature thresholds.
- Snow Accumulation: Adjusts new snowfall amounts and computes the density and depth of the snowpack.

[1] Documentation for the Snow-17 model can be found at https://support.goldsim.com/hc/en-us/articles/360001100167-Snow-Accumulation-and-Ablation-Model-Snow-17.

- Energy Exchange: Calculates net radiation, latent and sensible heat transfer, and heat from precipitation at the snow-air interface.
- Heat Deficit: Tracks the heat deficit within the snowpack, which affects the ripeness and melt potential of the snow.
- Ground Melt: Accounts for melt at the snow-soil interface based on a constant daily melt rate.
- Outflow Calculation: Computes the outflow from the snowpack into the catchment area, considering the snowpack ripeness and liquid water content.

Figure 2-5: Snow-17 Model



Source: Anderson (2006)

The Snow-17 model tracks snow accumulation and melt by dynamically adjusting snowpack properties based on incoming precipitation and energy fluxes (temperature). When precipitation occurs, the model determines whether it falls as rain or snow using a temperature threshold. Snowfall increases the SWE, while rain can percolate into the snowpack or contribute directly to runoff. The model tracks changes in snow density, affecting the snow depth over time. Snowmelt is primarily controlled by energy exchanges, including net radiation, latent and sensible heat fluxes, and heat from precipitation. A crucial component of Snow-17 is its treatment of the heat deficit, which represents the cold content of the snowpack; a higher heat deficit means more energy is required before melting can begin. Once the heat deficit is overcome, the snowpack reaches a state wherein further energy input leads directly to meltwater production.

2.8.6 Climate Change

Estimates of climate change impacts on precipitation, air temperature, and evaporation were developed and reported on in SRK's Climate Change Analysis for NMG (SRK, 2025). These values present the average of the Highest Density Intervals for Shared Socioeconomic Pathway (SSP) climate change scenarios SSP2-4.5 and SSP5-8.5, for each period (i.e., 2015 – 2040, 2041 – 2071, 2071 – 2100). These scenarios were selected as they provide a range of possible climatic scenarios in the future (SRK, 2025). Because the future is uncertain, there is no consensus in the literature on the criteria for the selection of a specific emission scenario or a specific global circulation model (GCM).

Climate change adjustments for Mean Annual Precipitation (MAP), Mean Annual Air Temperature (MAAT), Evaporation, and Design Storms are found in **Table 2-13** through **Table 2-16**. The values are used to adjust the climate inputs (precipitation, temperature, and evaporation) within each period and are constant throughout a given year (i.e. the values do not fluctuate monthly).

Table 2-13: Mean Annual Precipitation Climate Change Adjustments

Time Frame	MAP Median (%)
2015-2040	5
2041-2071	9
2071-2100	13

Source: SRK (2025)

Table 2-14: Mean Annual Average Temperature Climate Change Adjustments

Time Frame	MAAT Median (°C)
2015-2040	1.4
2041-2071	3.0
2071-2100	4.9

Source: SRK (2025)

Table 2-15: Evaporation Climate Change Adjustments

Time Frame	Evaporation Increase (%)
2015-2040	5
2041-2070	12
2071-2100	19

Source: SRK (2025)

Table 2-16: Climate Change Adjustment for 1-in-2000 Year Return Period Design Storm

Time Frame	IDF Median Rate of Change
2015-2040	6%
2041-2071	14%
2071-2100	25%

Source: SRK (2025)

Climate change adjustments are included to assess the impacts of changes to precipitation, temperature and evaporation on the water balance over time. Regardless of scenario, climate change is currently expected to result in increased precipitation at site, resulting in more runoff. Temperature changes are also expected to increase, which may result in changes to timing, depth, and melt rate of the snowpack. Similarly, evaporation is expected to increase which will impact the amount of stored water in ponds over time.

2.9 Dust Suppression Demands

Dust suppression will be required to manage environmental and operational standards. No data was available from site to estimate demand; therefore, assumptions were made based on data available from a regionally similar location to develop a unit rate (m^3/ha/d) for expected dust suppression usage. The model was constructed under the assumption that dust suppression water would be required from May through October, annually.

To estimate future dust suppression usage, SRK estimated the total service area as follows:

- SRK assumed that haul and access roads would be 10 m in width.
- Period maps were used to estimate the total length of active roadways in each year.
- SRK also assumed that the entire CDF footprint would require dust water to be applied each day during the dust suppression window.
- A dust suppression usage of 50 m^3/ha/d was estimated by SRK from experience at a regionally comparable mining operation.

The estimated annual dust suppression daily requirements are shown in **Table 2-17**. **Attachment 2** contains figures outlining the areas used to develop these inputs.

Table 2-17: Estimated Daily Dust Suppression

Year	Total Dust Suppression Area (ha)	Daily Dust Suppression Water (m^3/d)
2028 - 2030	41	2,052
2031 - 2033	71	3,560
2034 - 2056	115	5,769
2056	115	5,769

Note: 2030, 2033, 2042 development figures were used to estimate dust suppression areas. Volumes are carried over life of mine to estimate demand.

Source: Compiled in text

During operations, SRK recommends that dust suppression water usage be measured to verify these estimates.

2.10 Hydrogeology Inputs

Table 2-18 presents estimates of groundwater flows to the open-pit during development and active phases, as estimated by Richelieu Hydrogéologie Inc. (PH00-PH05) (Richelieu Hydrogéologie Inc., 2022).

Table 2-18: Groundwater Inflow Results per Pit Phase

Phase of work	Cumulative area (m^2)	Groundwater input (m^3/day)	Precipitation input (m^3/day)	Total infiltration rate (m^3/day)
PH-00	114239	289	169	458
PH-01	243727	659	360	1019
PH-02	360705	714	533	1247
PH-03	450813	798	666	1465
PH-04	622247	1075	920	1995
PH-05	784591	1144	1160	2304

Source: Richelieu Hydrogéologie (2022)

These inflows would be collected in sumps and pumped to either BC-1 or BC-2. The ponds and system were designed for pit water to be sent to BC-1, however pit water may be sent to BC-2 during periods of the year if the site determines it to be efficient.

The open pit development schedule was applied to the WBM.

A breakdown of groundwater inflow rates and open pit progression is presented in **Attachment 3**.

SRK understands that these groundwater estimates are being revised. Once new information is available, the WBM can be updated to reflect the most recent information.

2.11 Groundwater Supply Wells

There are three existing groundwater supply wells (HG-21-03, HG-17-05, HG-17-02) that have undergone pump testing investigations to determine long term pumping rates available. The results of the study (Richelieu, 2023) indicate that two pumping wells (HG-17-05 and HG-17-02) can provide meaningful amounts of water to support operations (446 m^3/d and 288 m^3/d, respectively). The model accounts for this additional water to be pumped to BC-2 for concentrator supply.

Additional supplemental groundwater supply wells are being considered as a contingency measure for water supply during dry periods. Pumping from groundwater wells would be triggered by a minimum operational water level target in BC-2. These pumps were assumed to convey groundwater at a rate of 100 m^3/hr.

This pumping logic and estimated rates for the wells are subject to change based on future scenario modelling. Where possible, the water management plan will be optimized to minimize or eliminate the need for supplemental groundwater.

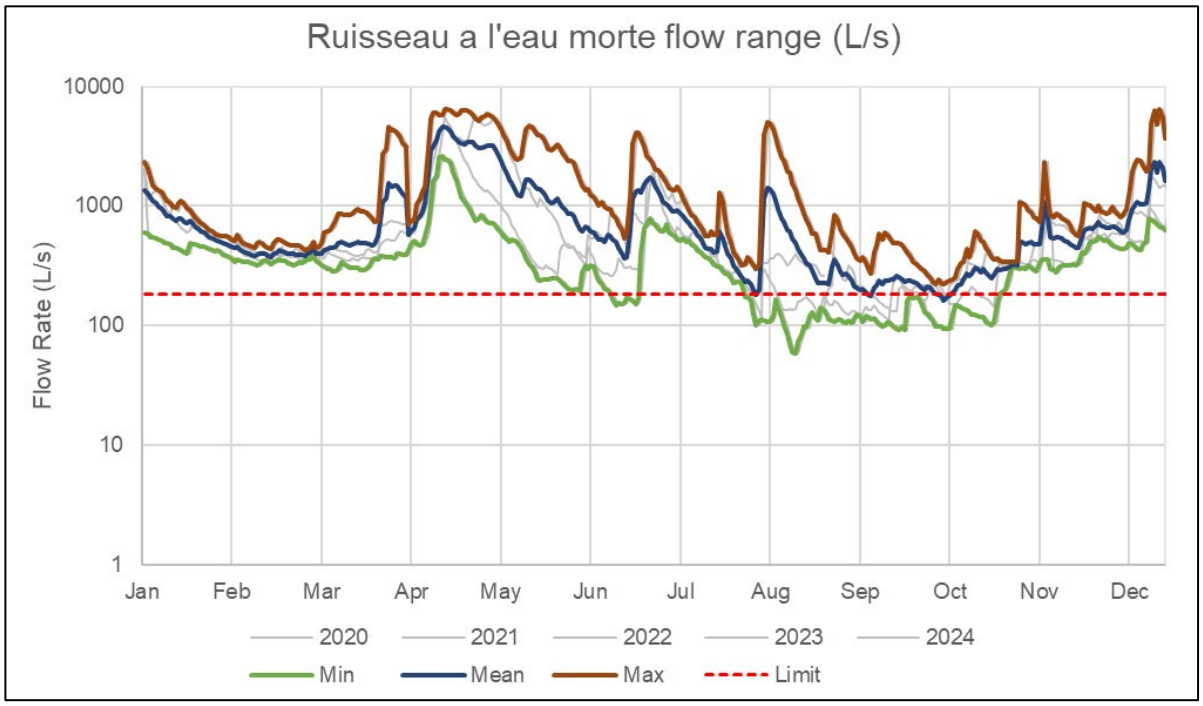
2.12 Discharge Limit at Ruisseau à l'Eau Morte

The receiving environment for discharge from the project will be Ruisseau à l'Eau Morte. Discharge from site will be required to comply with requirements for annual treated volume and minimum flow thresholds. The annual maximum discharge of treated water from site is set at 2,800,000 m^3 for the LoM (NMG comms, 2025). NMG established a hydrometric station within Ruisseau à l'Eau Morte, and flow data is collected by Atkins-Realis (Atkins, 2024a) to support baseline flow for estimating minimum creek flows and associated discharge permissions. The monitoring results are provided by source and summarized in **Figure 2-6**.

The project has established a minimum creek flow of 182 L/s, below which the site cannot discharge to Ruisseau à l'Eau Morte (Atkins, 2024b). Based on flow data collected, annual low flows appear to occur between the summer and fall months, typically between late July and early October (based on mean observed flow rates).

These flow rate data and discharge limits will be used to inform the water management objectives and discharge strategy (**Section 4**).

Figure 2-6: Ruisseau à l'Eau Morte Hydrometric Data



Note: The red hatched line denotes the minimum creek flow of 182 L/s.

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/Site%20Files/Environmental%20Flows/REM_novembre2024.xlsx?web=1

3 Conceptual Model

3.1 Model Overview

Table 3-1 summarizes the conceptual model for the overall site water balance.

Table 3-1: Site Water Balance Conceptual Model

Parameter	Model Input	Comments	Source
		MODEL STAGING	
Model Start Date	2028	Start of mining (Y1)	NMG
Model End Date	2056	End of mining (Y28)	NMG
Model Time Step	Daily		SRK
Model Results	Daily/Summarized by Year or Phase		SRK
Year Start Date	January 1st		SRK
Year End Date	December 31st		SRK
Environmental Discharge Window	March 16th – June 30th October 1st – December 31st	Treated water can be discharged to the receiving environment during these periods	NMG
No Environmental Discharge	January 1st – March 15th July 1st – September 30th	Treated water cannot be discharged to the receiving environment during these periods. Treated water must be sent back to BC-2 and stored.	NMG
Phase A	2028 - 2032	**Section 2.3**	NMG
Phase B1	2033 - 2035	**Section 2.3**	NMG
Phase B2	2036 - 2056	**Section 2.3**	NMG
		CLIMATE INPUTS	
Precipitation		**Section 2.8.1**	**SRK**
Air Temperature		**Section 2.8.3**	**SRK**
Evaporation		**Section 2.8.4**	**SRK**
		CONCENTRATOR INPUTS	
Mill Daily Ore Throughput	7,099 – 9,810 tonnes/d	**Section 2.6**	NMG
Treated Water Demand	Up to 345.5 m^3/hr	**Section 2.7**	NMG

Source: Compiled in text

3.2 GoldSim Structure

The Matawinie WBM is constructed using GoldSim. GoldSim is a graphical, object-oriented computer simulation program used for carrying out dynamic, probabilistic simulations (GoldSim, 2018). In GoldSim, users can create, document, and present model components by manipulating graphical objects that represent the various components of a system. In a sense, GoldSim can be interpreted as a "visual spreadsheet" that allows users to visually create and manipulate data and equations (GoldSim, 2018).

The components that make up the GoldSim visual interface and that are used to construct the model, are categorized as either "Elements" or "Containers". Elements represent the building blocks of the GoldSim model; they can be used to represent data inputs (e.g., scalar, vector, matrices, or probability distributions), mathematical functions or expressions, indications of status (i.e., true/false), or conditional statements leading to one of a selection of decisions (using if/then logic). In GoldSim, Elements are identified by their individual icons, while the exchange of information between communicating Elements (i.e., linkages) are indicated by arrows.

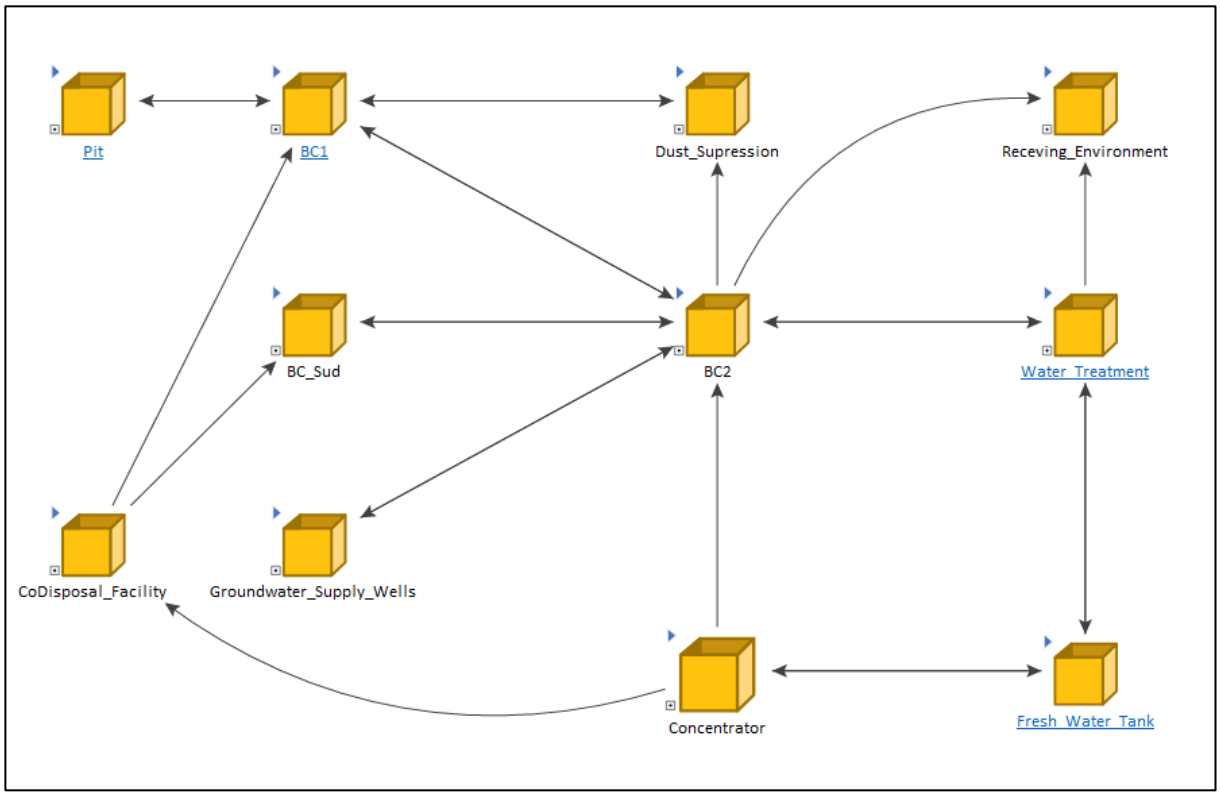
Containers are used to construct complex, multi-layered models often with numerous Elements connected by dozens, or even hundreds, of linkages across a model domain. Containers, which by default are illustrated as boxes within GoldSim (though icons can be changed by the modeller), provide a means of organizing and categorizing larger models. For a project like a mine site WBM, Containers are an effective way to represent a subsystem within the larger overall system (e.g., an open pit, a tailings cell, or a stockpile).

3.3 Model Layout

Each Matawinie facility relevant to the WBM has been assigned a Container within GoldSim, like those shown in **Figure 3-1**. Within each Container, Elements have been used to characterize how water will be generated, stored, and/or directed. Flow exchanges expected to occur during the operations phase of the mine life, for each facility, are summarized in **Table 3-2**. Further detail regarding the current and future water management objectives at Matawinie Mine, and flows between these structures, is provided in the following sections.

Figure 3-1 and **Figure 3-2** present the GoldSim flow network and PFD between the BCs, open pit, processing plant, and WTP, while **Table 3-2** provides an overview of the inflows, outflows, and BC storage capacities considered within the WBM.

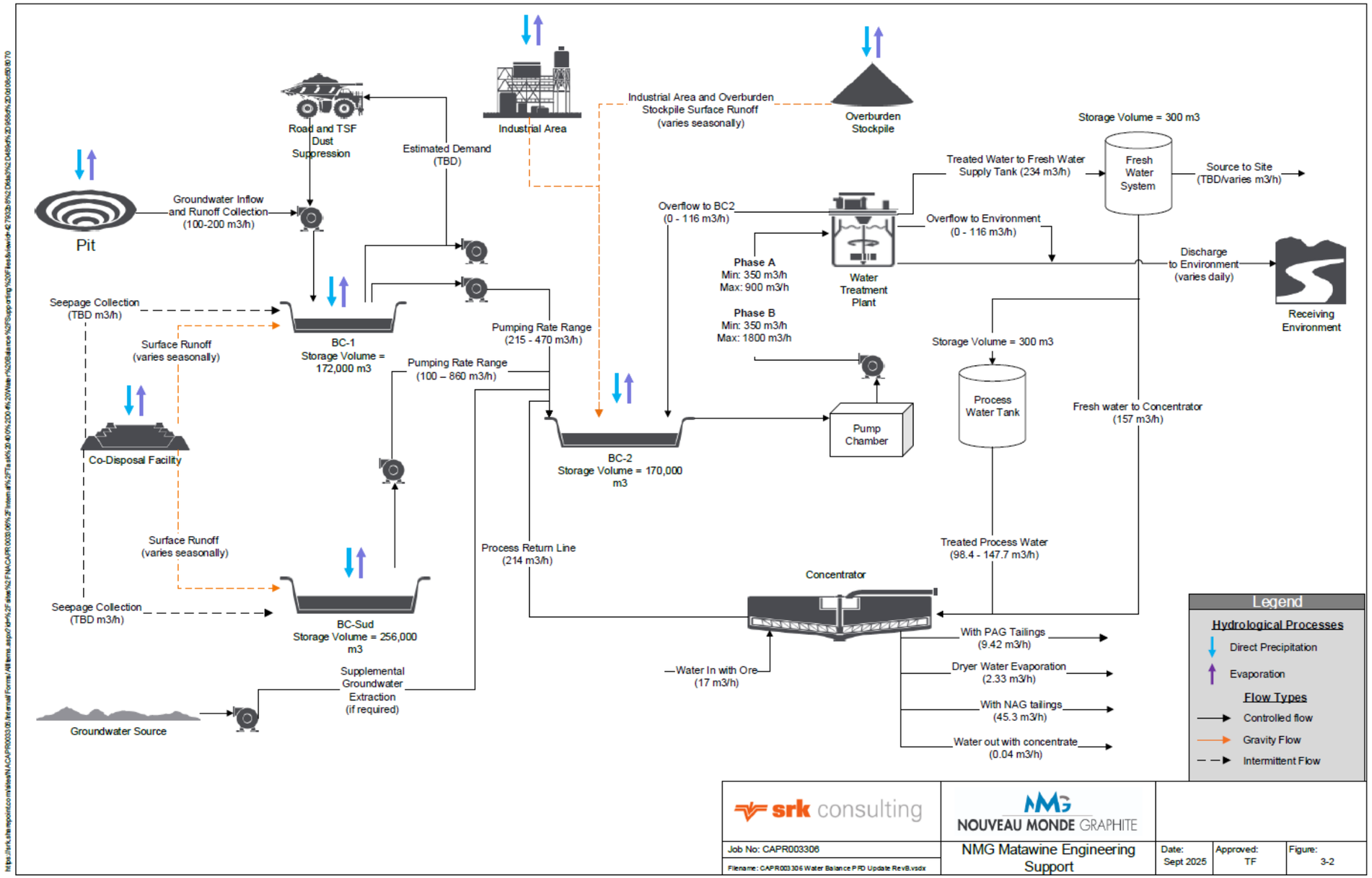
Figure 3-1: GoldSim Containers Used Within the Matawinie WBM



Source: CAPR003306_NMG Water Balance RevA.gsm

The water management plan (**Section 2.3**) will continuously evolve throughout the LoM of the project.

Figure 3-2: WBM Conceptual Framework



Source: CAPR003306_Water_Balance_PFD_Update_RevC.vsdx

Table 3-2: Water Flows and Volumes Modelled

Facility	Inflows	Outflows	Storage
Open-Pit	▪ Direct precipitation ▪ Groundwater inflows	▪ Water pumped directly to BC-1 ▪ Evaporation	▪ Water temporarily held in inventory
BC-1	▪ Direct precipitation ▪ Upstream runoff ▪ Water pumped from Pit	▪ Water pumped directly to BC-2 ▪ Evaporation ▪ Dust Suppression Supply	▪ Water temporarily held in inventory
BC-2	▪ Direct precipitation ▪ Upstream runoff ▪ Water pumped from BC-1 ▪ Water pumped from BC-Sud ▪ Water pumped from Pit ▪ Water from Mill ▪ Supplemental groundwater wells	▪ Water treatment facility ▪ Evaporation	▪ Water temporarily held in inventory ▪ Maintain target amount for fire suppression
BC-Sud	▪ Direct precipitation ▪ Upstream runoff	▪ Water pumped directly to BC-2 ▪ Evaporation	▪ Water temporarily held in inventory
WTP	▪ BC-2	▪ Freshwater Tank ▪ BC-2 Return	▪ N/A
Freshwater Tank	▪ BC-2	▪ Site ▪ Concentrator	▪ N/A
Concentrator	▪ Freshwater Tank ▪ Ore	▪ BC-2 ▪ Concentrate ▪ Tailings	▪ N/A

Source: Compiled in text

4 Water Management Objectives

4.1 Discharge Strategy

The overall discharge strategy for the site is described as:

- Collect, treat, and discharge water to the receiving environment during the discharge window.
- Provide treated water for the concentrator to maintain production throughout the year.
- Respect the operating water levels of the ponds while storing enough water to supply the concentrator through the winter months while not exceeding operating water levels.
- Respect applicable discharge restrictions (i.e., no discharge when flow in Ruisseau à l'Eau Morte is below 182 L/s, and annual discharge limit of 2,800,000 m^3).

There are periods of the year where the site cannot discharge to the receiving environment. During these periods, water levels in the ponds will need to be carefully managed to meet storage plans and ensure water levels are maintained to respect EDF requirements. The environmental discharge window (when treated water can be sent to the environment) is presented in **Table 4-1**.

Table 4-1: Environmental Discharge Windows

Window	Description
January 1st – March 15th	▪ No discharge, all water must remain on site
March 16th – June 30th	▪ Treated water can be discharged to the environment as required, discharge limits need to reflect minimum flow requirements at Ruisseau à l'Eau Morte (no discharge when flows are <182 L/s)
July 1st – September 30th	▪ No discharge, all water must remain on site
October 1st – December 31st	▪ Treated water can be discharged to the environment as required, discharge limits need to reflect minimum flow requirements at Ruisseau à l'Eau Morte (no discharge when flows are <182 L/s)

Source: Compiled in text

The discharge strategy needs to consider that winter inventory requirements are met, however too much water storage will pose issues in the event of a wet winter. Summer discharge limits require the ponds to be drawn down before the end of June to ensure the ponds can store summer precipitation events. Excess water needs to be consumed by the concentrator and dust suppression. If the ponds are not drawn down enough by then, it could result in either operating at a reduced capacity or needing to discharge outside of the discharge window.

4.2 Concentrator Storage Requirements

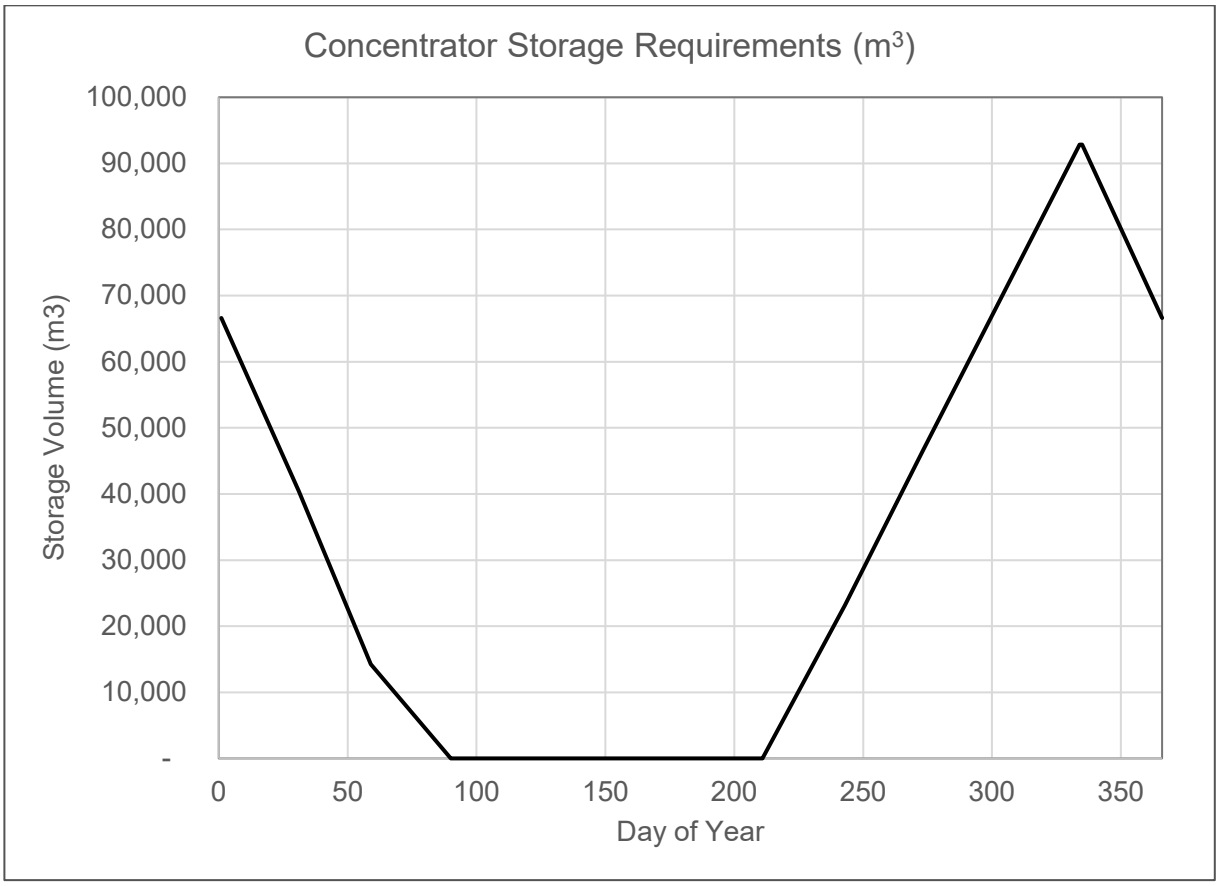
The concentrator is the critical component of mining operations and requires water year-round (planned shutdowns excluded). The concentrator requires treated water sourced the WTP via the Freshwater and Process Water Tanks. During the open water season (i.e., April – November), there is likely to be sufficient water supplied to BC-2 through rainfall and runoff processes. However, during the winter months, when little new runoff is generated, sufficient inventory will need to be stored by the end of wet season to supply the concentrator until the following spring.

The concentrator storage approach is summarized as follows:

- The concentrator sources water from the WTP via the Fresh Water Tank and Process Water Tanks (**Figure 3-2**).
- The concentrator requires up to 345.5 m^3/hr of water to operate, with up to 309.7 m^3/hr being returned to BC-2 and 35.8 m^3/hr lost to concentrator outputs (i.e., tailings, concentrate, and dryer evaporation) (**Section 2.7**).
  - Storage requirements assume the normal concentrator requirements as the maximum values are rated for additional cooling needs during summer periods (**Table 2-7**).
- Additional site water demands for general use (showers, washrooms, etc.) are estimated at 25 m^3/d.
- A storage estimate was developed, equal to the minimum supply to the concentrator for four months, as follows (assuming no new inputs to the system):
  - December 1 through March 15: 105 days at 35.8 m^3/hr + 25 m^3/d = 92,841 m^3 of storage required by December 1, annually.
  - Stored water is expected to be split between BC-1 and BC-2. The proportion of the split will need to include consideration for operational water levels (**Section 4.4**) and will be evaluated during scenario modelling (next stage of work).

Using this logic, a storage plan was developed for the purpose of collecting and storing water to supply the concentrator during the winter period (**Figure 4-1**). This plan provides a timeline to track the amount of water stored in the fall and to manage water levels throughout the winter.

Figure 4-1: Concentrator Winter Storage Plan



Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

4.3 Pond Operating Water Levels

Pond operating water levels refer to the range of water elevations maintained under normal operating conditions. These levels are typically designed to balance storage capacity, water quality, and system functionality while accommodating seasonal variations in inflow and evaporation. These operating levels for the project were established based on site-specific climate conditions, regulatory requirements, and engineering design criteria, and may be adjusted over time based on monitoring data and operational experience.

Currently EDF volumes, operating volumes, and operating levels were established for each pond (**Table 4-2** through **Table 4-4**). These values varied for each pond based on catchment area, additional water sources reporting to the pond, and operational use. Reference water levels are defined as:

- Minimum operating water level (MinOWL): Level which triggers to stop all pumping out of the facility. This level is often selected as the base of the facility or based on a minimum storage requirement for sedimentation purposes or mill reclaim purposes.
- Functional operating water level (FOWL): Level below the MOWL that triggers pumping actions to reduce the risk of exceeding the NOWL. Actions vary per facility, but may include stopping pumped inflows or activating additional dewatering systems.
  - FOWL to be developed as water management strategy advances.
- Normal operating water level (NOWL): Level that initiates emergency action and provides EDF contingency storage below the spillway, where applicable.
  - NOWL to be developed as water management strategy advances.
- Maximum operating water level (MOWL): Level above the NOWL that allows emergency use of the EDF storage before pumping water to other systems. Developed specifically to reduce the likelihood of pumping non-contact water into contact water systems or vice-versa.
  - The EDF volume is based on Directive 019 (**Section 2.8.2**). This volume must be always maintained.
- Maximum Water Level (MAX): Level in which ponds will start to spill to the environment. Dictated by pond spillway inverts.

Table 4-2: EDF Volumes

Pond	Catchment Area (m^2)	Spring (m^3)	Summer (m^3)
BC-1	388,739	81,810	73,491
BC-2	567,115	103,973	89,319
BC-Sud	1,031,931	215,405	165,873

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

Table 4-3: Pond Operating Volumes (m^3)

Pond	Base	Min OWL	FOWL[4]	NOWL[4]	MOWL[3] (Spring/Summer)	MAX
BC-1	0	2,400[1]	TBD	TBD	90,190 / 98,5098	172,000
BC-2	0	10,000[2]	TBD	TBD	66,027 / 80,681	170,000
BC-Sud	0	2,400[1]	TBD	TBD	40,595 / 90,127[5]	256,000

Notes:

1 Assumed that the ponds should be allowed to drop to zero for storm capacity, the ponds do not directly feed the plant and can be emptied

2 Minimum water volume for BC-2 set to 10,000 m^3 for fire suppression system

3 Maximum Operating Level = MAX – Directive 019 Storm (Spring/Summer)

4 FOWL and NOWL volumes to be defined, currently not critical to discharge strategy logic

5 BC-Sud MOWL are temporary values, to be updated once designs are advanced

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

Table 4-4: Pond Operating Levels (m)

Pond	Base	Min OWL	FOWL[4]	NOWL[4]	MOWL[3] (Spring/Summer)	MAX
BC-1	504.0	504.3[1]	TBD	TBD	512.2 / 512.8	517.0
BC-2	532.0	532.8[2]	TBD	TBD	536.3 / 537.1	541.5
BC-Sud	0	0[1]	TBD	TBD	TBC/TBC[5]	TBC[5]

Notes:

1 Assumed that the ponds should be allowed to drop to zero for storm capacity, ponds do not directly the plant and be emptied

2 Minimum water volume for BC-2 set to 10,000 m^3 for fire suppression system

3 Maximum Operating Level = MAX – Directive 019 Storm (Spring/Summer)

4 FOWL and NOWL volumes to be defined, currently not critical to discharge strategy logic

5 BC-Sud pond design not yet developed, stage storage curve not available

Source: https://srk.sharepoint.com/sites/NACAPR003306/Internal/Task%20400-04%20Water%20Balance/GoldSim%20Files/CAPR003306_NMG%20Input%20Tables%20202520512.xlsm?web=1

4.4 Operating Rules and Conditions

Pumping logic are the rules developed to determine when water is pumped from a pond. This logic must reflect the various demands and constraints across the site, including:

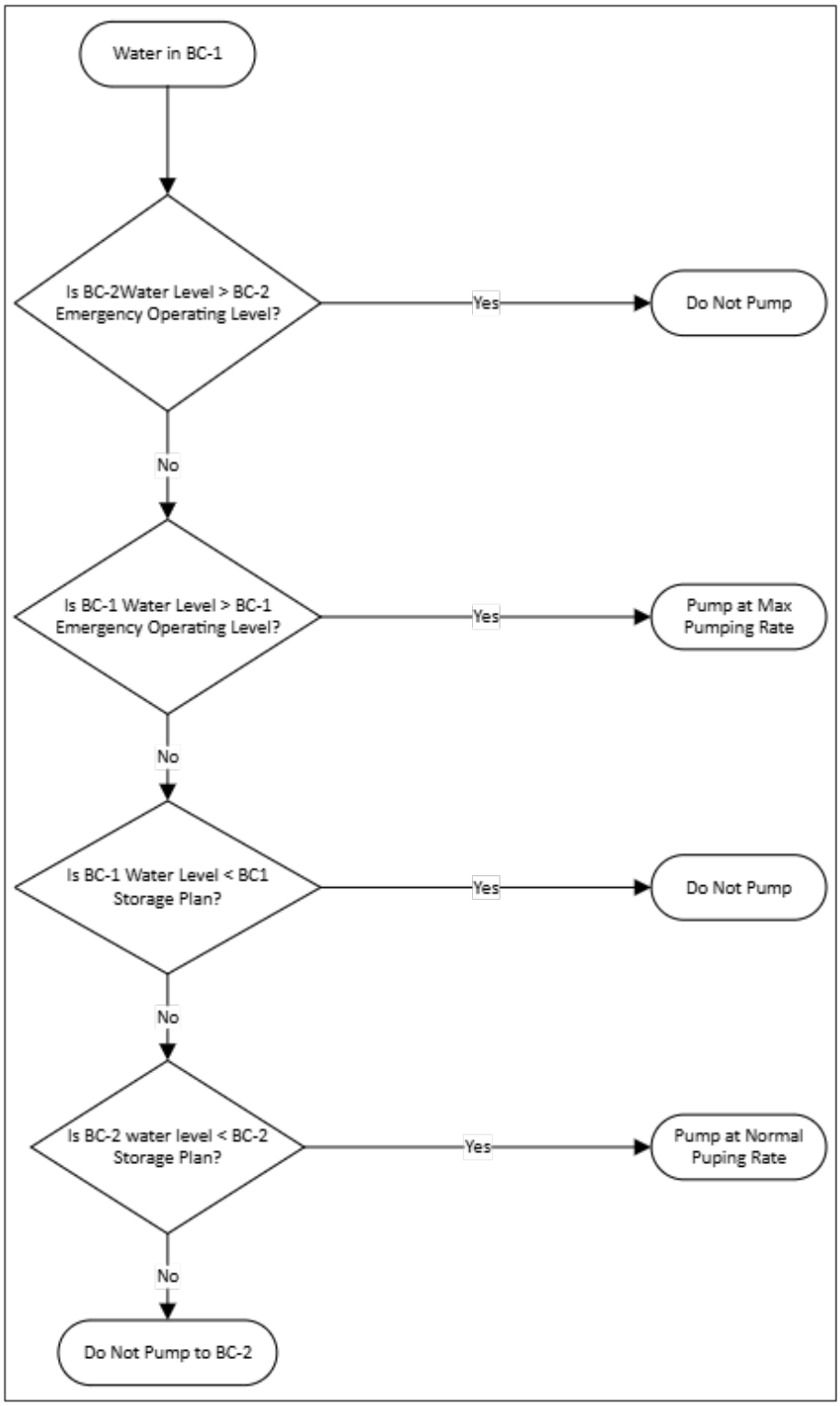
- Concentrator winter storage requirements
- Pond water levels: MOWL and EOL
- Environmental discharge windows
- Operating demands
  - BC-1: Runoff collection, pit water collection, dust suppression source, BC-2 storage offsetting
  - BC-Sud: Runoff collection, BC-2 storage offsetting
  - BC-2: Operational primary runoff collection, concentrator water source, WTP intake point.

Decision trees were developed to determine when and how much water should be pumped. This logic was then translated into logic controls embedded in the GoldSim model. The following sections outline the decision trees for:

- BC-1 (**Figure 4-2**)
- BC-Sud (**Figure 4-3**)
- BC-2 (**Figure 4-4**)
- the WTP (**Figure 4-5**).

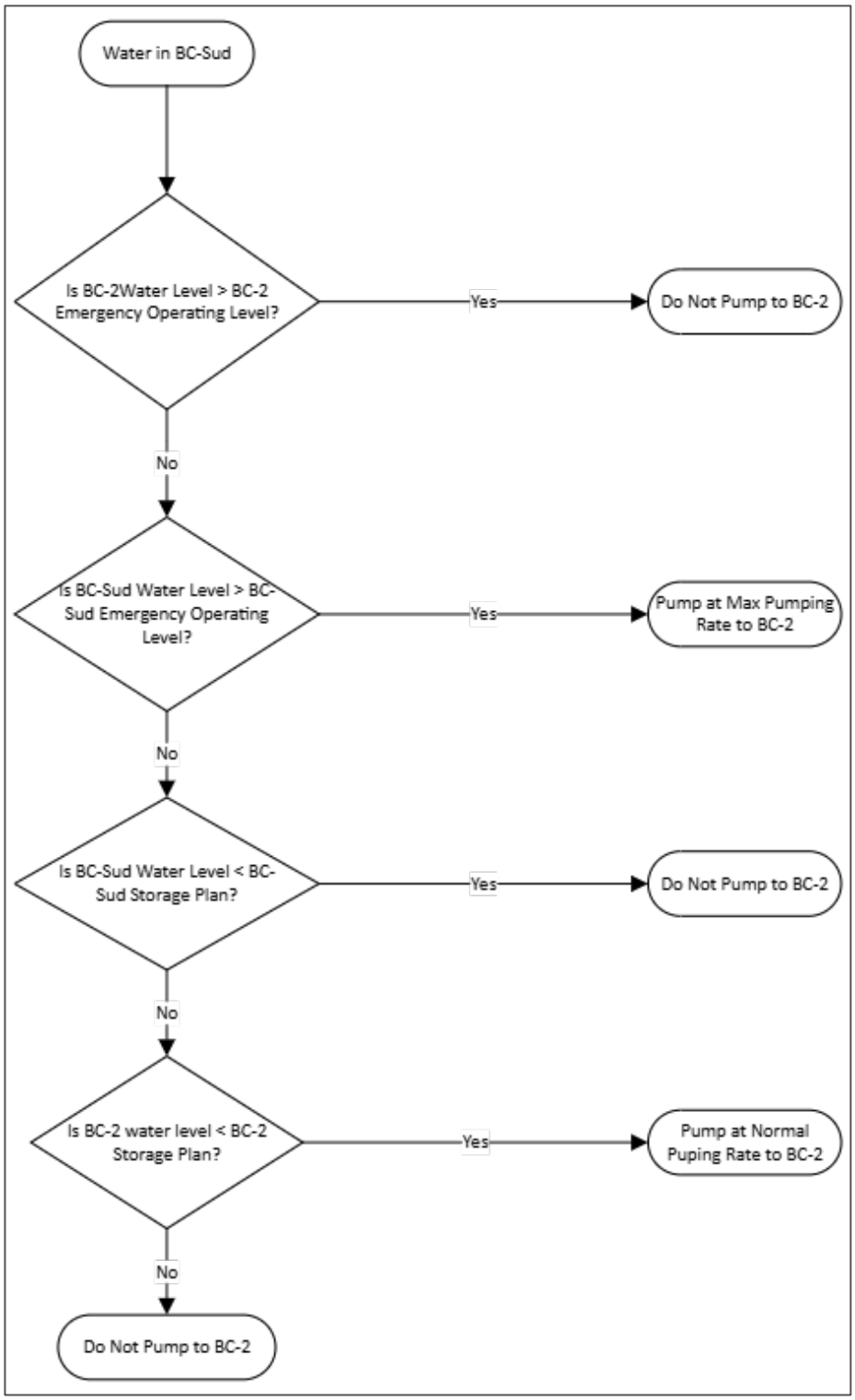
These decision trees will be updated as the modelling scenarios and discharge strategy are advanced.

Figure 4-2: BC-1 Pumping Decision Tree



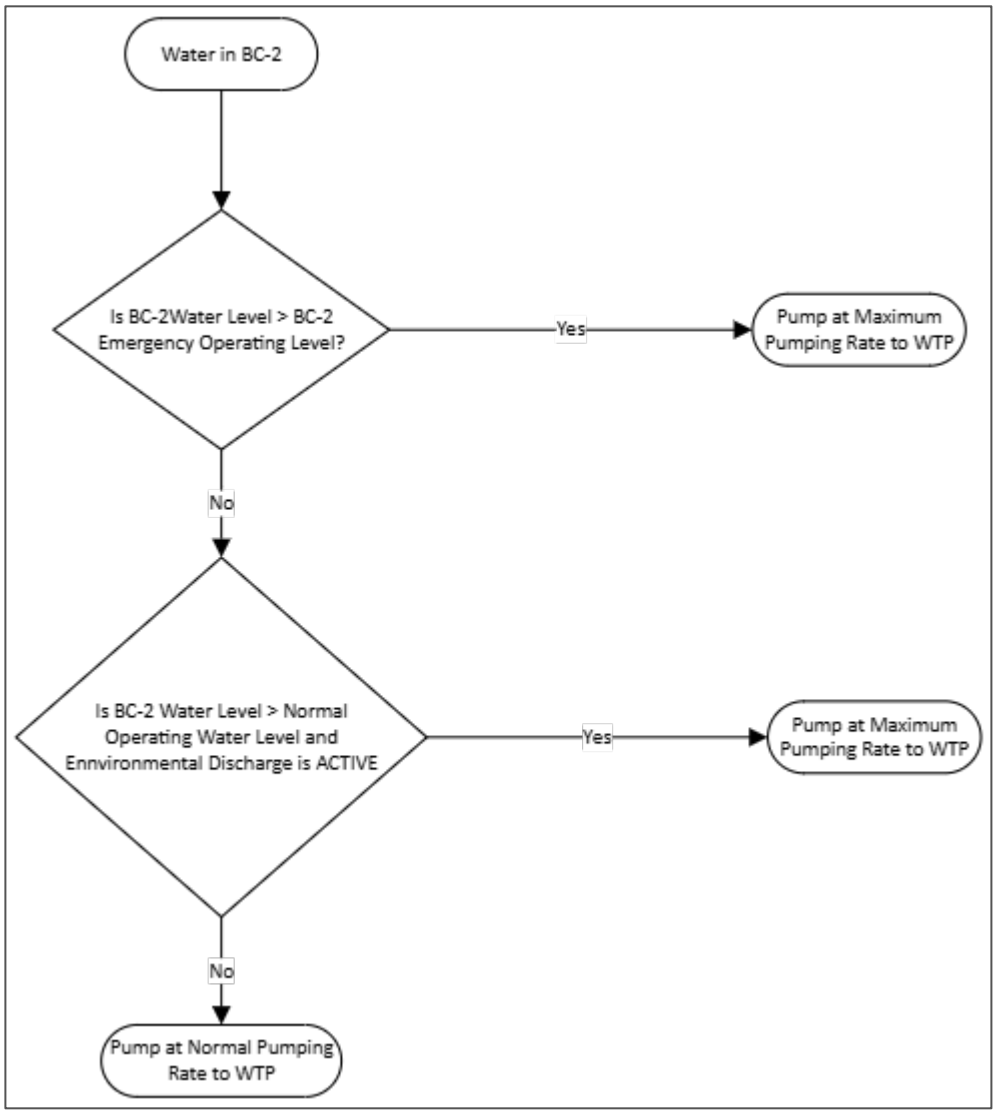
Source: CAPR003306 Pumping Decision Trees RevA.vsdx

Figure 4-3: BC-Sud Pumping Decision Tree



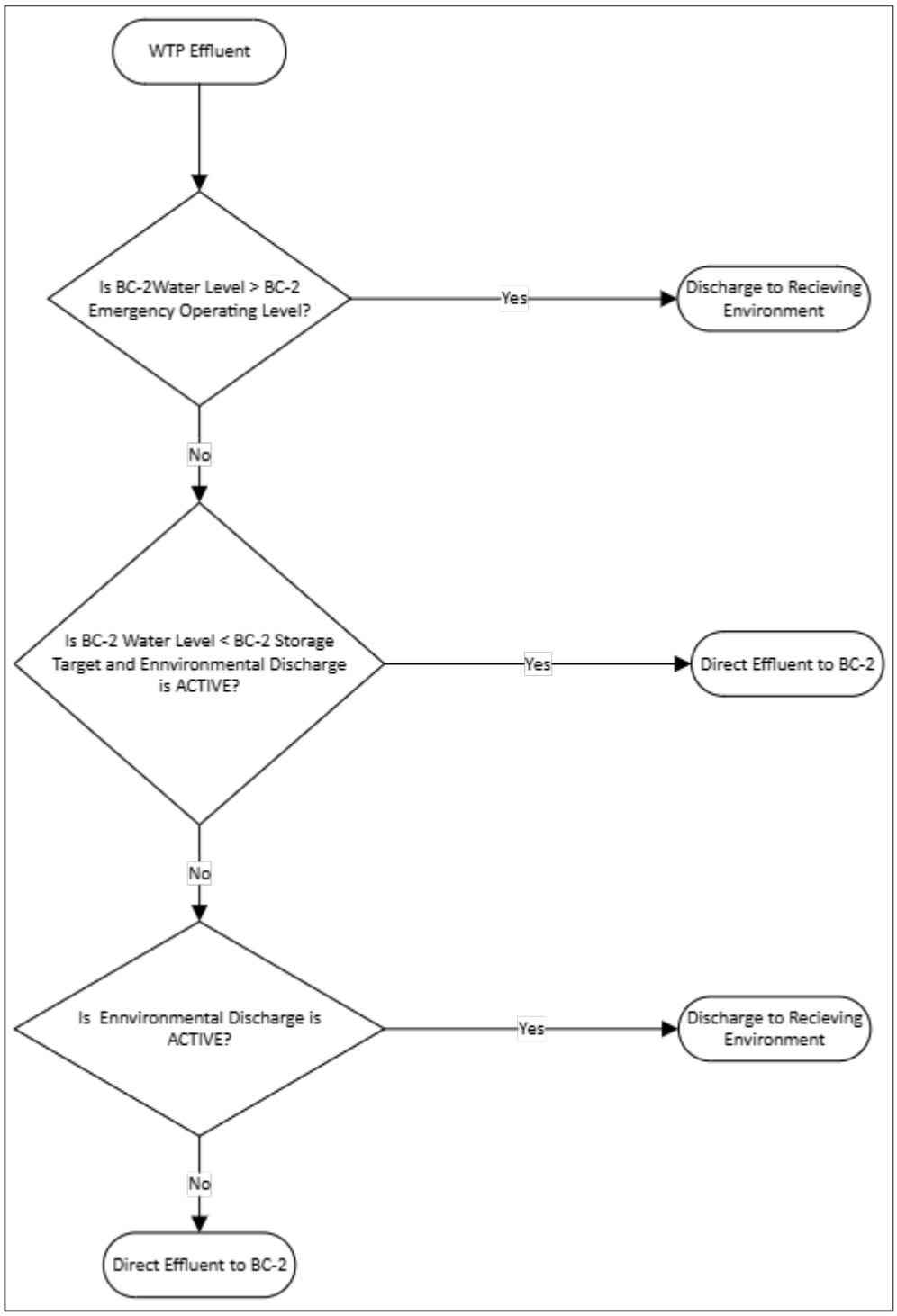
Source: CAPR003306 Pumping Decision Trees RevA.vsdx

Figure 4-4: BC-2 Pumping Decision Tree



Source: CAPR003306 Pumping Decision Trees RevA.vsdx

Figure 4-5: Water Treatment Plant Discharge Decision Tree



Source: CAPR003306 Pumping Decision Trees RevA.vsdx

4.5 Pumping Rates

Pumping between ponds and the WTP can be operated at either normal or maximum rates (there is no control to operate between normal and maximum) or off. Pumping rates (**Table 4-5**) used in the WBM were previously developed by SRK (2024) and remain unchanged.

Table 4-5: Pumping Rate Schedule (m^3/hr)

Year	BC-1 Normal	BC-1 Max	BC-2/WTP Normal	BC-2/WTP Max	BC-Sud Normal	BC-Sud Max
2027	0	0	0	0	0	0
2028 - 2032	255	470	350	900	0	0
2033 - 2035	215	470	350	1800	100	780
2035 - 2056	215	345	350	1800	100	860

Source: SRK (2024)

4.6 Model Calibration

At the time of reporting, there was no operational data to calibrate the model. Once operational data becomes available, the WBM will be calibrated.

5 Closure

Regards,
SRK Consulting (Canada) Inc.

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Attachments:

Attachment 1	Catchment Evolution
Attachment 2	Period Maps for Dust Suppression Estimates
Attachment 3	Hydrogeology Evolution Summary
Attachment 4	Concentrator Inputs
Attachment 5	Precipitation Analysis

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References

Anderson, E. A. (2006). Snow Accumulation and Ablation Model – SNOW-17. NOAA's National Weather Service, Office of Hydrologic Development, Silver Spring, MD.

AtkinsRéalis, 2023. Matawinie Concentrateur de graphite. Process Flowsheet Diagram Ponds and Water Treatment Plan. 669469-0505-49DG02-0004_PC_2023-11-06.

AtkinsRéalis, 2024a. AMP-15 et 19 – QC38. Project 653897.

AtkinsRéalis, 2024b. Données brute débit REM November 2024. AtkinsRéalis, 2025. Email communication via Ducharme, April 2025.

BBA, 2025. NI 43-101 Updated Technical Feasibility Study Report for The Matawinie Mine and the Bécancour Battery Material Plant Integrated Graphite Projects. Bécancour, Québec, Canada. Prepared for: Nouveau Monde Graphite.

GoldSim Technology Group. (2018). GoldSim User's Guide. GoldSim Technology Group LLC, Issaquah, WA, USA.

Hargreaves, G. H., & Samani, Z. A. (1985). Reference crop evapotranspiration from temperature. Applied Engineering in Agriculture, 1(2), 96–99.

MDDELCC, 2012. Directive 019 sur l'industrie minière

NMG, 2025. Email communication via Ducharme. February 18, 2025.

Ouranos, 2015. Vers l'adaptation. Synthèse des connaissances sur les changements climatiques au Québec. Édition 2015. Montréal, Québec : Ouranos. 415 p.

Richelieu Hydrogéologie Inc, 2022. Projet de graphite Mattawinie. Modélisation hydrogéologique des phases de développement

Richelieu Hydrogéologie Inc, 2023. Nouveau monde Graphite. Etude Hydrologique. Alimentation en eau potable – Project Matawinie. September 2023.

SNC-Lavalin, 2020 Rapport 654068-4000-40 ER-0001 (SNC-Lavalin, 2020), Rapport de faisabilité sur la gestion de l'eau, des résidus et stériles miniers.

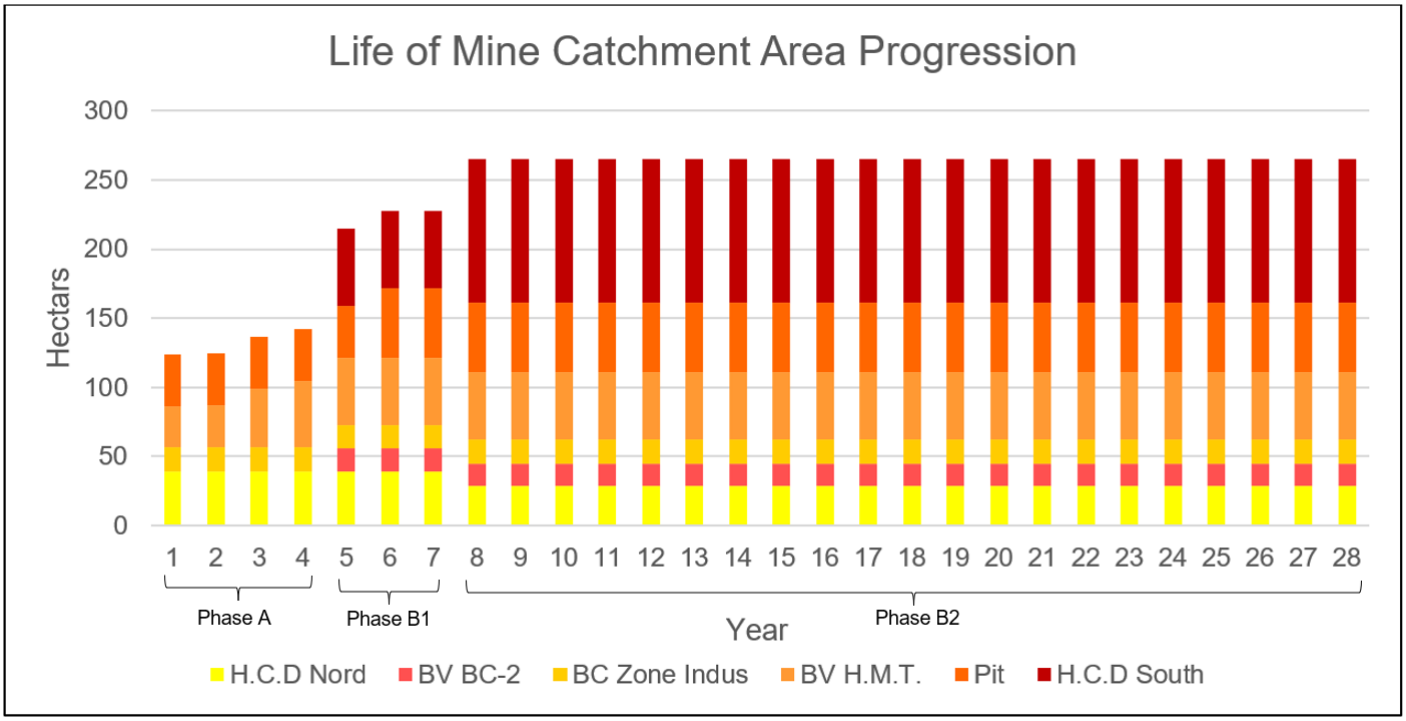
SRK Consulting (Canada) Inc., 2024. Site overall Water Balance for BC1 and BC2 Sizing. Memo. Prepared for Nouveau Monde Graphite – Matawinie Site. Saint-Michel-des-Saints. Québec. Project number: CAPR002717. Issued July 19, 2024

SRK Consulting (Canada) Inc., 2025a.Baseline Climate Analysis. FINAL. Prepared for Nouveau Monde Graphite – Matawinie Site. Saint-Michel-des-Saints. Québec. Project number: CAPR003306. Issued April 8, 2025.

SRK Consulting (Canada) Inc., 2025b Climate Change Analysis. FINAL. . Prepared for Nouveau Monde Graphite – Matawinie Site. Saint-Michel-des-Saints. Québec. Project number: CAPR003306. Issued April 7, 2025.

Wood, 2020. Nouveau Monde Graphite – Projet Matawinie. Ingénierie détaillée - Données de base et critères de conception. TX20035103-02000-NGE-0001-B. 2020-11-25. Wood – Solutions en environnement & infrastructure, une division de Wood Canada limitée.

Attachment 1 Catchment Evolution


Life of Mine Catchment Area Progression
Hectars
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
Phase A
Phase B1
Phase B2
Year
H.C.D Nord
BV BC-2
BC Zone Indus
BV H.M.T.
Pit
H.C.D South

Life of Mine Catchment Progression (Hectares)

Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
1	A	1					37.4	
1	A	2					37.4	
1	A	3					37.4	
1	A	4					37.4	
1	A	5					37.4	
1	A	6		0.0	17.5	30.2	37.4	
1	A	7		0.0	17.5	30.2	37.4	
1	A	8		0.0	17.5	30.2	37.4	
1	A	9		0.0	17.5	30.2	37.4	
1	A	10	38.9	0.0	17.5	30.2	37.4	
1	A	11	38.9	0.0	17.5	30.2	37.4	
1	A	12	38.9	0.0	17.5	30.2	37.4	
2	A	1	38.9	0.0	17.5	30.2	37.4	
2	A	2	38.9	0.0	17.5	30.2	37.4	
2	A	3	38.9	0.0	17.5	30.2	37.4	
2	A	4	38.9	0.0	17.5	30.2	37.4	
2	A	5	38.9	0.0	17.5	30.2	37.4	
2	A	6	38.9	0.0	17.5	30.2	37.4	
2	A	7	38.9	0.0	17.5	30.2	37.4	
2	A	8	38.9	0.0	17.5	30.2	37.4	
2	A	9	38.9	0.0	17.5	30.2	37.4	
2	A	10	38.9	0.0	17.5	30.2	37.4	
2	A	11	38.9	0.0	17.5	31.7	37.4	
2	A	12	38.9	0.0	17.5	33.3	37.4	
3	A	1	38.9	0.0	17.5	34.8	37.4	
3	A	2	38.9	0.0	17.5	36.3	37.4	
3	A	3	38.9	0.0	17.5	37.8	37.4	
3	A	4	38.9	0.0	17.5	39.4	37.4	
3	A	5	38.9	0.0	17.5	40.9	37.4	
3	A	6	38.9	0.0	17.5	42.4	37.4	

Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
3	A	7	38.9	0.0	17.5	43.9	37.4	
3	A	8	38.9	0.0	17.5	45.5	37.4	
3	A	9	38.9	0.0	17.5	47.0	37.4	
3	A	10	38.9	0.0	17.5	48.5	37.4	
3	A	11	38.9	0.0	17.5	48.5	37.4	
3	A	12	38.9	0.0	17.5	48.5	37.4	
4	A	1	38.9	0.0	17.5	48.5	37.4	
4	A	2	38.9	0.0	17.5	48.5	37.4	
4	A	3	38.9	0.0	17.5	48.5	37.4	
4	A	4	38.9	0.0	17.5	48.5	37.4	
4	A	5	38.9	0.0	17.5	48.5	37.4	
4	A	6	38.9	0.0	17.5	48.5	37.4	
4	A	7	38.9	0.0	17.5	48.5	37.4	
4	A	8	38.9	0.0	17.5	48.5	37.4	
4	A	9	38.9	0.0	17.5	48.5	37.4	
4	A	10	38.9	0.0	17.5	48.5	37.4	
4	A	11	38.9	0.0	17.5	48.5	37.4	
4	A	12	38.9	0.0	17.5	48.5	37.4	
5	B	1	38.9	16.7	17.5	48.5	37.4	55.9
5	B	2	38.9	16.7	17.5	48.5	37.4	55.9
5	B	3	38.9	16.7	17.5	48.5	37.4	55.9
5	B	4	38.9	16.7	17.5	48.5	37.4	55.9
5	B	5	38.9	16.7	17.5	48.5	37.4	55.9
5	B	6	38.9	16.7	17.5	48.5	37.4	55.9
5	B	7	38.9	16.7	17.5	48.5	37.4	55.9
5	B	8	38.9	16.7	17.5	48.5	37.4	55.9
5	B	9	38.9	16.7	17.5	48.5	37.4	55.9
5	B	10	38.9	16.7	17.5	48.5	37.4	55.9
5	B	11	38.9	16.7	17.5	48.5	37.4	55.9
5	B	12	38.9	16.7	17.5	48.5	37.4	55.9
6	B	1	38.9	16.7	17.5	48.5	50.3	55.9

Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
6	B	2	38.9	16.7	17.5	48.5	50.3	55.9
6	B	3	38.9	16.7	17.5	48.5	50.3	55.9
6	B	4	38.9	16.7	17.5	48.5	50.3	55.9
6	B	5	38.9	16.7	17.5	48.5	50.3	55.9
6	B	6	38.9	16.7	17.5	48.5	50.3	55.9
6	B	7	38.9	16.7	17.5	48.5	50.3	55.9
6	B	8	38.9	16.7	17.5	48.5	50.3	55.9
6	B	9	38.9	16.7	17.5	48.5	50.3	55.9
6	B	10	38.9	16.7	17.5	48.5	50.3	55.9
6	B	11	38.9	16.7	17.5	48.5	50.3	55.9
6	B	12	38.9	16.7	17.5	48.5	50.3	55.9
7	B	1	38.9	16.7	17.5	48.5	50.3	55.9
7	B	2	38.9	16.7	17.5	48.5	50.3	55.9
7	B	3	38.9	16.7	17.5	48.5	50.3	55.9
7	B	4	38.9	16.7	17.5	48.5	50.3	55.9
7	B	5	38.9	16.7	17.5	48.5	50.3	55.9
7	B	6	38.9	16.7	17.5	48.5	50.3	55.9
7	B	7	38.9	16.7	17.5	48.5	50.3	55.9
7	B	8	38.9	16.7	17.5	48.5	50.3	55.9
7	B	9	38.9	16.7	17.5	48.5	50.3	55.9
7	B	10	38.9	16.7	17.5	48.5	50.3	55.9
7	B	11	38.9	16.7	17.5	48.5	50.3	55.9
7	B	12	38.9	16.7	17.5	48.5	50.3	55.9
8	B	1	28.5	16.7	17.5	48.5	50.3	103.2
8	B	2	28.5	16.7	17.5	48.5	50.3	103.2
8	B	3	28.5	16.7	17.5	48.5	50.3	103.2
8	B	4	28.5	16.7	17.5	48.5	50.3	103.2
8	B	5	28.5	16.7	17.5	48.5	50.3	103.2
8	B	6	28.5	16.7	17.5	48.5	50.3	103.2
8	B	7	28.5	16.7	17.5	48.5	50.3	103.2
8	B	8	28.5	16.7	17.5	48.5	50.3	103.2

Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
8	B	9	28.5	16.7	17.5	48.5	50.3	103.2
8	B	10	28.5	16.7	17.5	48.5	50.3	103.2
8	B	11	28.5	16.7	17.5	48.5	50.3	103.2
8	B	12	28.5	16.7	17.5	48.5	50.3	103.2
9	B	1	28.5	16.7	17.5	48.5	50.3	103.2
9	B	2	28.5	16.7	17.5	48.5	50.3	103.2
9	B	3	28.5	16.7	17.5	48.5	50.3	103.2
9	B	4	28.5	16.7	17.5	48.5	50.3	103.2
9	B	5	28.5	16.7	17.5	48.5	50.3	103.2
9	B	6	28.5	16.7	17.5	48.5	50.3	103.2
9	B	7	28.5	16.7	17.5	48.5	50.3	103.2
9	B	8	28.5	16.7	17.5	48.5	50.3	103.2
9	B	9	28.5	16.7	17.5	48.5	50.3	103.2
9	B	10	28.5	16.7	17.5	48.5	50.3	103.2
9	B	11	28.5	16.7	17.5	48.5	50.3	103.2
9	B	12	28.5	16.7	17.5	48.5	50.3	103.2
10	B	1	28.5	16.7	17.5	48.5	50.3	103.2
10	B	2	28.5	16.7	17.5	48.5	50.3	103.2
10	B	3	28.5	16.7	17.5	48.5	50.3	103.2
10	B	4	28.5	16.7	17.5	48.5	50.3	103.2
10	B	5	28.5	16.7	17.5	48.5	50.3	103.2
10	B	6	28.5	16.7	17.5	48.5	50.3	103.2
10	B	7	28.5	16.7	17.5	48.5	50.3	103.2
10	B	8	28.5	16.7	17.5	48.5	50.3	103.2
10	B	9	28.5	16.7	17.5	48.5	50.3	103.2
10	B	10	28.5	16.7	17.5	48.5	50.3	103.2
10	B	11	28.5	16.7	17.5	48.5	50.3	103.2
10	B	12	28.5	16.7	17.5	48.5	50.3	103.2
11	B	1	28.5	16.7	17.5	48.5	50.3	103.2
11	B	2	28.5	16.7	17.5	48.5	50.3	103.2
11	B	3	28.5	16.7	17.5	48.5	50.3	103.2

Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
11	B	4	28.5	16.7	17.5	48.5	50.3	103.2
11	B	5	28.5	16.7	17.5	48.5	50.3	103.2
11	B	6	28.5	16.7	17.5	48.5	50.3	103.2
11	B	7	28.5	16.7	17.5	48.5	50.3	103.2
11	B	8	28.5	16.7	17.5	48.5	50.3	103.2
11	B	9	28.5	16.7	17.5	48.5	50.3	103.2
11	B	10	28.5	16.7	17.5	48.5	50.3	103.2
11	B	11	28.5	16.7	17.5	48.5	50.3	103.2
11	B	12	28.5	16.7	17.5	48.5	50.3	103.2
12	B	1	28.5	16.7	17.5	48.5	50.3	103.2
12	B	2	28.5	16.7	17.5	48.5	50.3	103.2
12	B	3	28.5	16.7	17.5	48.5	50.3	103.2
12	B	4	28.5	16.7	17.5	48.5	50.3	103.2
12	B	5	28.5	16.7	17.5	48.5	50.3	103.2
12	B	6	28.5	16.7	17.5	48.5	50.3	103.2
12	B	7	28.5	16.7	17.5	48.5	50.3	103.2
12	B	8	28.5	16.7	17.5	48.5	50.3	103.2
12	B	9	28.5	16.7	17.5	48.5	50.3	103.2
12	B	10	28.5	16.7	17.5	48.5	50.3	103.2
12	B	11	28.5	16.7	17.5	48.5	50.3	103.2
12	B	12	28.5	16.7	17.5	48.5	50.3	103.2
13	B	1	28.5	16.7	17.5	48.5	50.3	103.2
13	B	2	28.5	16.7	17.5	48.5	50.3	103.2
13	B	3	28.5	16.7	17.5	48.5	50.3	103.2
13	B	4	28.5	16.7	17.5	48.5	50.3	103.2
13	B	5	28.5	16.7	17.5	48.5	50.3	103.2
13	B	6	28.5	16.7	17.5	48.5	50.3	103.2
13	B	7	28.5	16.7	17.5	48.5	50.3	103.2
13	B	8	28.5	16.7	17.5	48.5	50.3	103.2
13	B	9	28.5	16.7	17.5	48.5	50.3	103.2
13	B	10	28.5	16.7	17.5	48.5	50.3	103.2

Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
13	B	11	28.5	16.7	17.5	48.5	50.3	103.2
13	B	12	28.5	16.7	17.5	48.5	50.3	103.2
14	B	1	28.5	16.7	17.5	48.5	50.3	103.2
14	B	2	28.5	16.7	17.5	48.5	50.3	103.2
14	B	3	28.5	16.7	17.5	48.5	50.3	103.2
14	B	4	28.5	16.7	17.5	48.5	50.3	103.2
14	B	5	28.5	16.7	17.5	48.5	50.3	103.2
14	B	6	28.5	16.7	17.5	48.5	50.3	103.2
14	B	7	28.5	16.7	17.5	48.5	50.3	103.2
14	B	8	28.5	16.7	17.5	48.5	50.3	103.2
14	B	9	28.5	16.7	17.5	48.5	50.3	103.2
14	B	10	28.5	16.7	17.5	48.5	50.3	103.2
14	B	11	28.5	16.7	17.5	48.5	50.3	103.2
14	B	12	28.5	16.7	17.5	48.5	50.3	103.2
15	B	1	28.5	16.7	17.5	48.5	50.3	103.2
15	B	2	28.5	16.7	17.5	48.5	50.3	103.2
15	B	3	28.5	16.7	17.5	48.5	50.3	103.2
15	B	4	28.5	16.7	17.5	48.5	50.3	103.2
15	B	5	28.5	16.7	17.5	48.5	50.3	103.2
15	B	6	28.5	16.7	17.5	48.5	50.3	103.2
15	B	7	28.5	16.7	17.5	48.5	50.3	103.2
15	B	8	28.5	16.7	17.5	48.5	50.3	103.2
15	B	9	28.5	16.7	17.5	48.5	50.3	103.2
15	B	10	28.5	16.7	17.5	48.5	50.3	103.2
15	B	11	28.5	16.7	17.5	48.5	50.3	103.2
15	B	12	28.5	16.7	17.5	48.5	50.3	103.2
16	B	1	28.5	16.7	17.5	48.5	50.3	103.2
16	B	2	28.5	16.7	17.5	48.5	50.3	103.2
16	B	3	28.5	16.7	17.5	48.5	50.3	103.2
16	B	4	28.5	16.7	17.5	48.5	50.3	103.2
16	B	5	28.5	16.7	17.5	48.5	50.3	103.2

Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
16	B	6	28.5	16.7	17.5	48.5	50.3	103.2
16	B	7	28.5	16.7	17.5	48.5	50.3	103.2
16	B	8	28.5	16.7	17.5	48.5	50.3	103.2
16	B	9	28.5	16.7	17.5	48.5	50.3	103.2
16	B	10	28.5	16.7	17.5	48.5	50.3	103.2
16	B	11	28.5	16.7	17.5	48.5	50.3	103.2
16	B	12	28.5	16.7	17.5	48.5	50.3	103.2
17	B	1	28.5	16.7	17.5	48.5	50.3	103.2
17	B	2	28.5	16.7	17.5	48.5	50.3	103.2
17	B	3	28.5	16.7	17.5	48.5	50.3	103.2
17	B	4	28.5	16.7	17.5	48.5	50.3	103.2
17	B	5	28.5	16.7	17.5	48.5	50.3	103.2
17	B	6	28.5	16.7	17.5	48.5	50.3	103.2
17	B	7	28.5	16.7	17.5	48.5	50.3	103.2
17	B	8	28.5	16.7	17.5	48.5	50.3	103.2
17	B	9	28.5	16.7	17.5	48.5	50.3	103.2
17	B	10	28.5	16.7	17.5	48.5	50.3	103.2
17	B	11	28.5	16.7	17.5	48.5	50.3	103.2
17	B	12	28.5	16.7	17.5	48.5	50.3	103.2
18	B	1	28.5	16.7	17.5	48.5	50.3	103.2
18	B	2	28.5	16.7	17.5	48.5	50.3	103.2
18	B	3	28.5	16.7	17.5	48.5	50.3	103.2
18	B	4	28.5	16.7	17.5	48.5	50.3	103.2
18	B	5	28.5	16.7	17.5	48.5	50.3	103.2
18	B	6	28.5	16.7	17.5	48.5	50.3	103.2
18	B	7	28.5	16.7	17.5	48.5	50.3	103.2
18	B	8	28.5	16.7	17.5	48.5	50.3	103.2
18	B	9	28.5	16.7	17.5	48.5	50.3	103.2
18	B	10	28.5	16.7	17.5	48.5	50.3	103.2
18	B	11	28.5	16.7	17.5	48.5	50.3	103.2
18	B	12	28.5	16.7	17.5	48.5	50.3	103.2

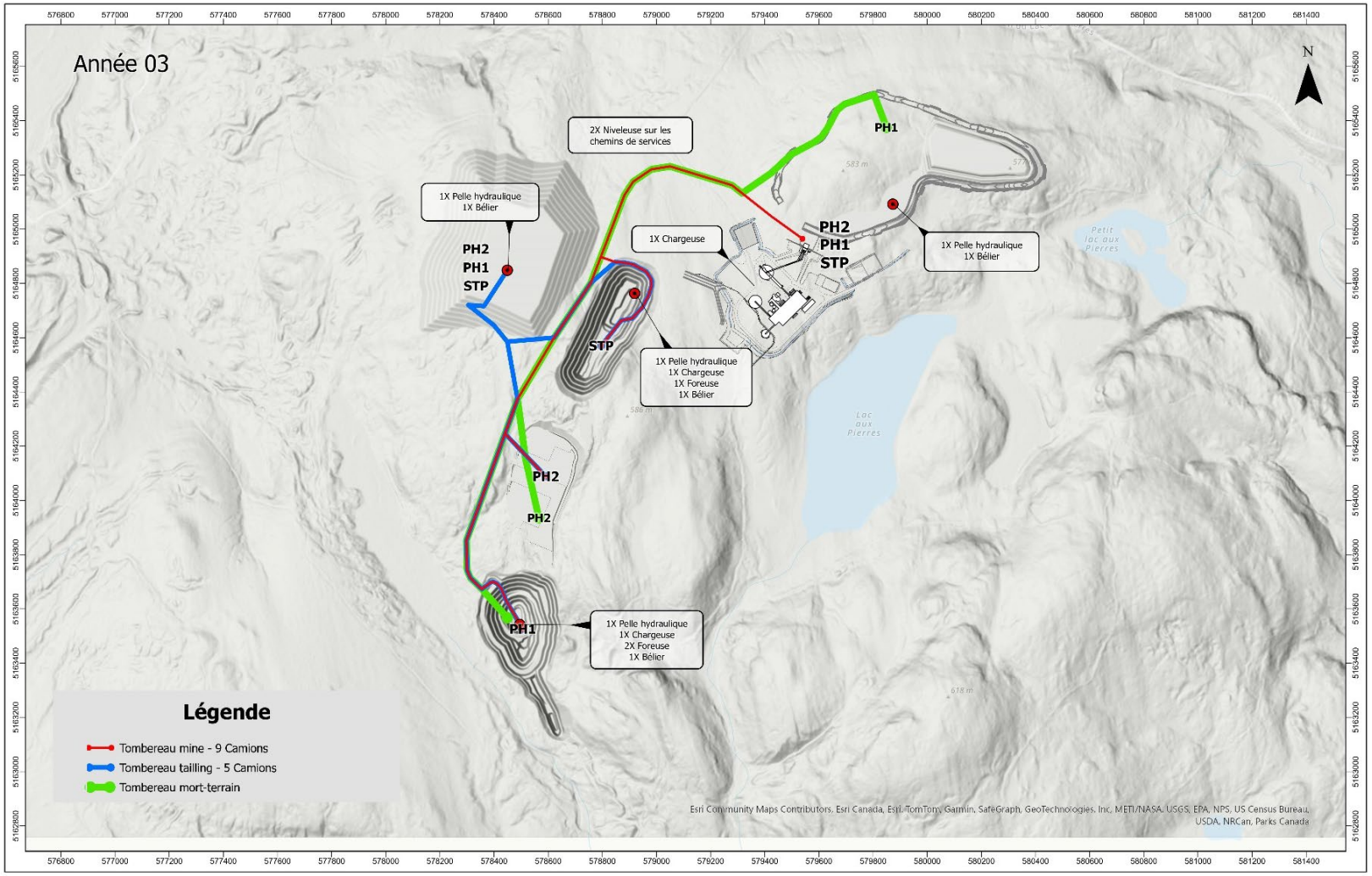
Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
19	B	1	28.5	16.7	17.5	48.5	50.3	103.2
19	B	2	28.5	16.7	17.5	48.5	50.3	103.2
19	B	3	28.5	16.7	17.5	48.5	50.3	103.2
19	B	4	28.5	16.7	17.5	48.5	50.3	103.2
19	B	5	28.5	16.7	17.5	48.5	50.3	103.2
19	B	6	28.5	16.7	17.5	48.5	50.3	103.2
19	B	7	28.5	16.7	17.5	48.5	50.3	103.2
19	B	8	28.5	16.7	17.5	48.5	50.3	103.2
19	B	9	28.5	16.7	17.5	48.5	50.3	103.2
19	B	10	28.5	16.7	17.5	48.5	50.3	103.2
19	B	11	28.5	16.7	17.5	48.5	50.3	103.2
19	B	12	28.5	16.7	17.5	48.5	50.3	103.2
20	B	1	28.5	16.7	17.5	48.5	50.3	103.2
20	B	2	28.5	16.7	17.5	48.5	50.3	103.2
20	B	3	28.5	16.7	17.5	48.5	50.3	103.2
20	B	4	28.5	16.7	17.5	48.5	50.3	103.2
20	B	5	28.5	16.7	17.5	48.5	50.3	103.2
20	B	6	28.5	16.7	17.5	48.5	50.3	103.2
20	B	7	28.5	16.7	17.5	48.5	50.3	103.2
20	B	8	28.5	16.7	17.5	48.5	50.3	103.2
20	B	9	28.5	16.7	17.5	48.5	50.3	103.2
20	B	10	28.5	16.7	17.5	48.5	50.3	103.2
20	B	11	28.5	16.7	17.5	48.5	50.3	103.2
20	B	12	28.5	16.7	17.5	48.5	50.3	103.2
21	B	1	28.5	16.7	17.5	48.5	50.3	103.2
21	B	2	28.5	16.7	17.5	48.5	50.3	103.2
21	B	3	28.5	16.7	17.5	48.5	50.3	103.2
21	B	4	28.5	16.7	17.5	48.5	50.3	103.2
21	B	5	28.5	16.7	17.5	48.5	50.3	103.2
21	B	6	28.5	16.7	17.5	48.5	50.3	103.2
21	B	7	28.5	16.7	17.5	48.5	50.3	103.2

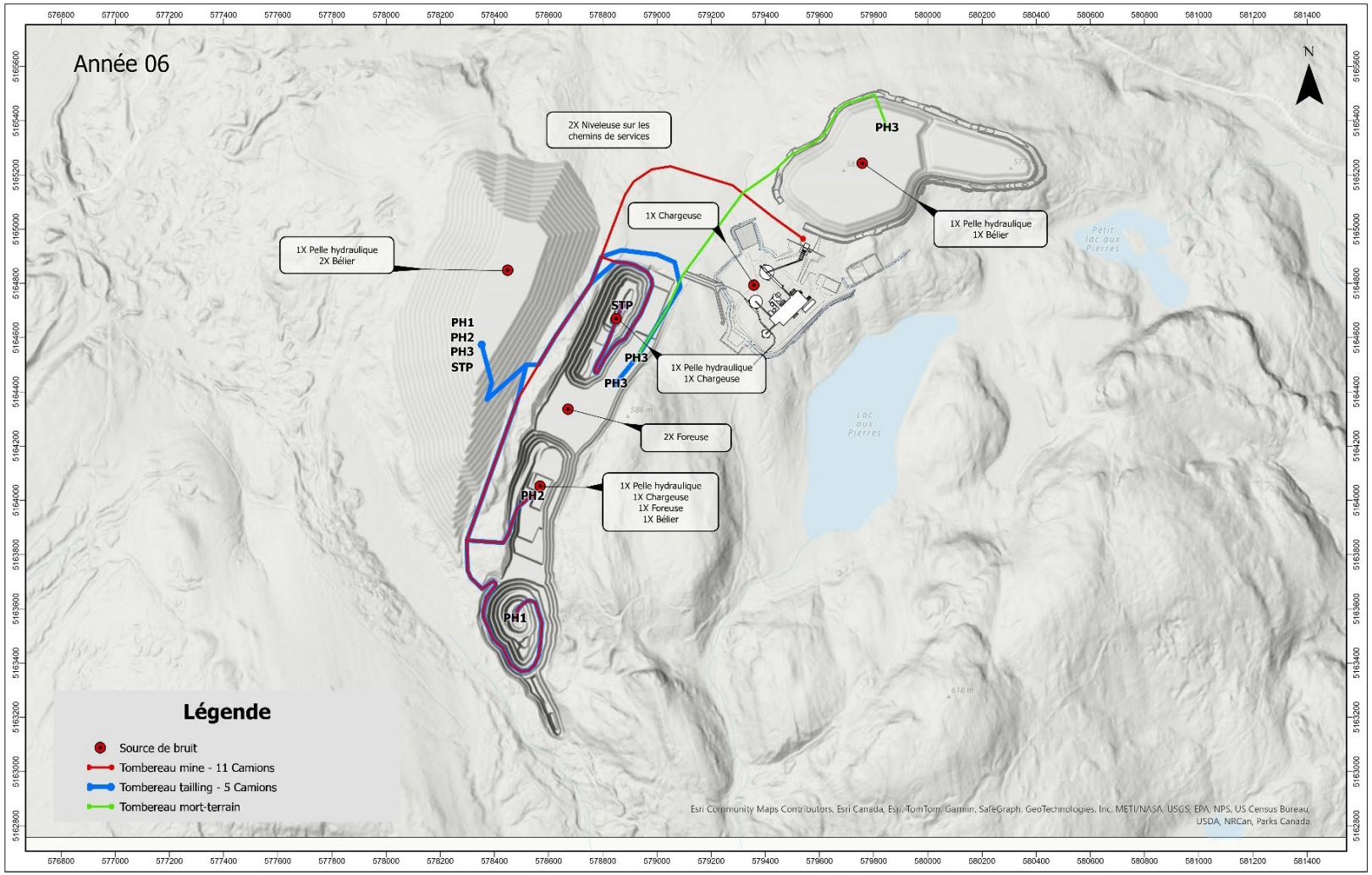
Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
21	B	8	28.5	16.7	17.5	48.5	50.3	103.2
21	B	9	28.5	16.7	17.5	48.5	50.3	103.2
21	B	10	28.5	16.7	17.5	48.5	50.3	103.2
21	B	11	28.5	16.7	17.5	48.5	50.3	103.2
21	B	12	28.5	16.7	17.5	48.5	50.3	103.2
22	B	1	28.5	16.7	17.5	48.5	50.3	103.2
22	B	2	28.5	16.7	17.5	48.5	50.3	103.2
22	B	3	28.5	16.7	17.5	48.5	50.3	103.2
22	B	4	28.5	16.7	17.5	48.5	50.3	103.2
22	B	5	28.5	16.7	17.5	48.5	50.3	103.2
22	B	6	28.5	16.7	17.5	48.5	50.3	103.2
22	B	7	28.5	16.7	17.5	48.5	50.3	103.2
22	B	8	28.5	16.7	17.5	48.5	50.3	103.2
22	B	9	28.5	16.7	17.5	48.5	50.3	103.2
22	B	10	28.5	16.7	17.5	48.5	50.3	103.2
22	B	11	28.5	16.7	17.5	48.5	50.3	103.2
22	B	12	28.5	16.7	17.5	48.5	50.3	103.2
23	B	1	28.5	16.7	17.5	48.5	50.3	103.2
23	B	2	28.5	16.7	17.5	48.5	50.3	103.2
23	B	3	28.5	16.7	17.5	48.5	50.3	103.2
23	B	4	28.5	16.7	17.5	48.5	50.3	103.2
23	B	5	28.5	16.7	17.5	48.5	50.3	103.2
23	B	6	28.5	16.7	17.5	48.5	50.3	103.2
23	B	7	28.5	16.7	17.5	48.5	50.3	103.2
23	B	8	28.5	16.7	17.5	48.5	50.3	103.2
23	B	9	28.5	16.7	17.5	48.5	50.3	103.2
23	B	10	28.5	16.7	17.5	48.5	50.3	103.2
23	B	11	28.5	16.7	17.5	48.5	50.3	103.2
23	B	12	28.5	16.7	17.5	48.5	50.3	103.2
24	B	1	28.5	16.7	17.5	48.5	50.3	103.2
24	B	2	28.5	16.7	17.5	48.5	50.3	103.2

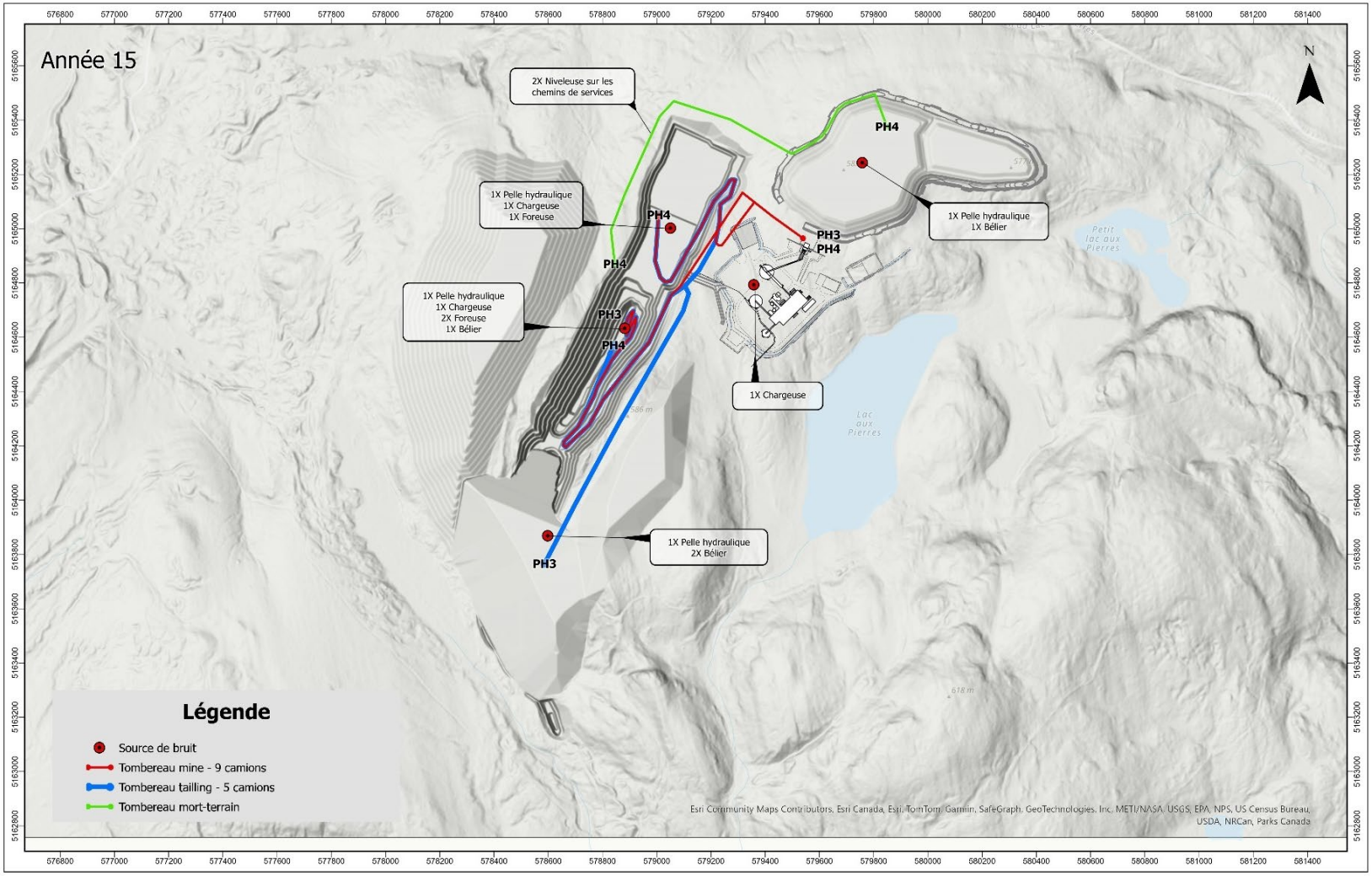
Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
24	B	3	28.5	16.7	17.5	48.5	50.3	103.2
24	B	4	28.5	16.7	17.5	48.5	50.3	103.2
24	B	5	28.5	16.7	17.5	48.5	50.3	103.2
24	B	6	28.5	16.7	17.5	48.5	50.3	103.2
24	B	7	28.5	16.7	17.5	48.5	50.3	103.2
24	B	8	28.5	16.7	17.5	48.5	50.3	103.2
24	B	9	28.5	16.7	17.5	48.5	50.3	103.2
24	B	10	28.5	16.7	17.5	48.5	50.3	103.2
24	B	11	28.5	16.7	17.5	48.5	50.3	103.2
24	B	12	28.5	16.7	17.5	48.5	50.3	103.2
25	B	1	28.5	16.7	17.5	48.5	50.3	103.2
25	B	2	28.5	16.7	17.5	48.5	50.3	103.2
25	B	3	28.5	16.7	17.5	48.5	50.3	103.2
25	B	4	28.5	16.7	17.5	48.5	50.3	103.2
25	B	5	28.5	16.7	17.5	48.5	50.3	103.2
25	B	6	28.5	16.7	17.5	48.5	50.3	103.2
25	B	7	28.5	16.7	17.5	48.5	50.3	103.2
25	B	8	28.5	16.7	17.5	48.5	50.3	103.2
25	B	9	28.5	16.7	17.5	48.5	50.3	103.2
25	B	10	28.5	16.7	17.5	48.5	50.3	103.2
25	B	11	28.5	16.7	17.5	48.5	50.3	103.2
25	B	12	28.5	16.7	17.5	48.5	50.3	103.2
26	B	1	28.5	16.7	17.5	48.5	50.3	103.2
26	B	2	28.5	16.7	17.5	48.5	50.3	103.2
26	B	3	28.5	16.7	17.5	48.5	50.3	103.2
26	B	4	28.5	16.7	17.5	48.5	50.3	103.2
26	B	5	28.5	16.7	17.5	48.5	50.3	103.2
26	B	6	28.5	16.7	17.5	48.5	50.3	103.2
26	B	7	28.5	16.7	17.5	48.5	50.3	103.2
26	B	8	28.5	16.7	17.5	48.5	50.3	103.2
26	B	9	28.5	16.7	17.5	48.5	50.3	103.2

Year of Operation	Phase	Month	BC-1	BC-2				BC-Sud
			H.C.D North	BV BC-2	BC Zone Indus	BV H.M.T.	Pit	H.C.D South
26	B	10	28.5	16.7	17.5	48.5	50.3	103.2
26	B	11	28.5	16.7	17.5	48.5	50.3	103.2
26	B	12	28.5	16.7	17.5	48.5	50.3	103.2
27	B	1	28.5	16.7	17.5	48.5	50.3	103.2
27	B	2	28.5	16.7	17.5	48.5	50.3	103.2
27	B	3	28.5	16.7	17.5	48.5	50.3	103.2
27	B	4	28.5	16.7	17.5	48.5	50.3	103.2
27	B	5	28.5	16.7	17.5	48.5	50.3	103.2
27	B	6	28.5	16.7	17.5	48.5	50.3	103.2
27	B	7	28.5	16.7	17.5	48.5	50.3	103.2
27	B	8	28.5	16.7	17.5	48.5	50.3	103.2
27	B	9	28.5	16.7	17.5	48.5	50.3	103.2
27	B	10	28.5	16.7	17.5	48.5	50.3	103.2
27	B	11	28.5	16.7	17.5	48.5	50.3	103.2
27	B	12	28.5	16.7	17.5	48.5	50.3	103.2
28	B	1	28.5	16.7	17.5	48.5	50.3	103.2
28	B	2	28.5	16.7	17.5	48.5	50.3	103.2
28	B	3	28.5	16.7	17.5	48.5	50.3	103.2
28	B	4	28.5	16.7	17.5	48.5	50.3	103.2
28	B	5	28.5	16.7	17.5	48.5	50.3	103.2
28	B	6	28.5	16.7	17.5	48.5	50.3	103.2
28	B	7	28.5	16.7	17.5	48.5	50.3	103.2
28	B	8	28.5	16.7	17.5	48.5	50.3	103.2
28	B	9	28.5	16.7	17.5	48.5	50.3	103.2
28	B	10	28.5	16.7	17.5	48.5	50.3	103.2
28	B	11	28.5	16.7	17.5	48.5	50.3	103.2
28	B	12	28.5	16.7	17.5	48.5	50.3	103.2

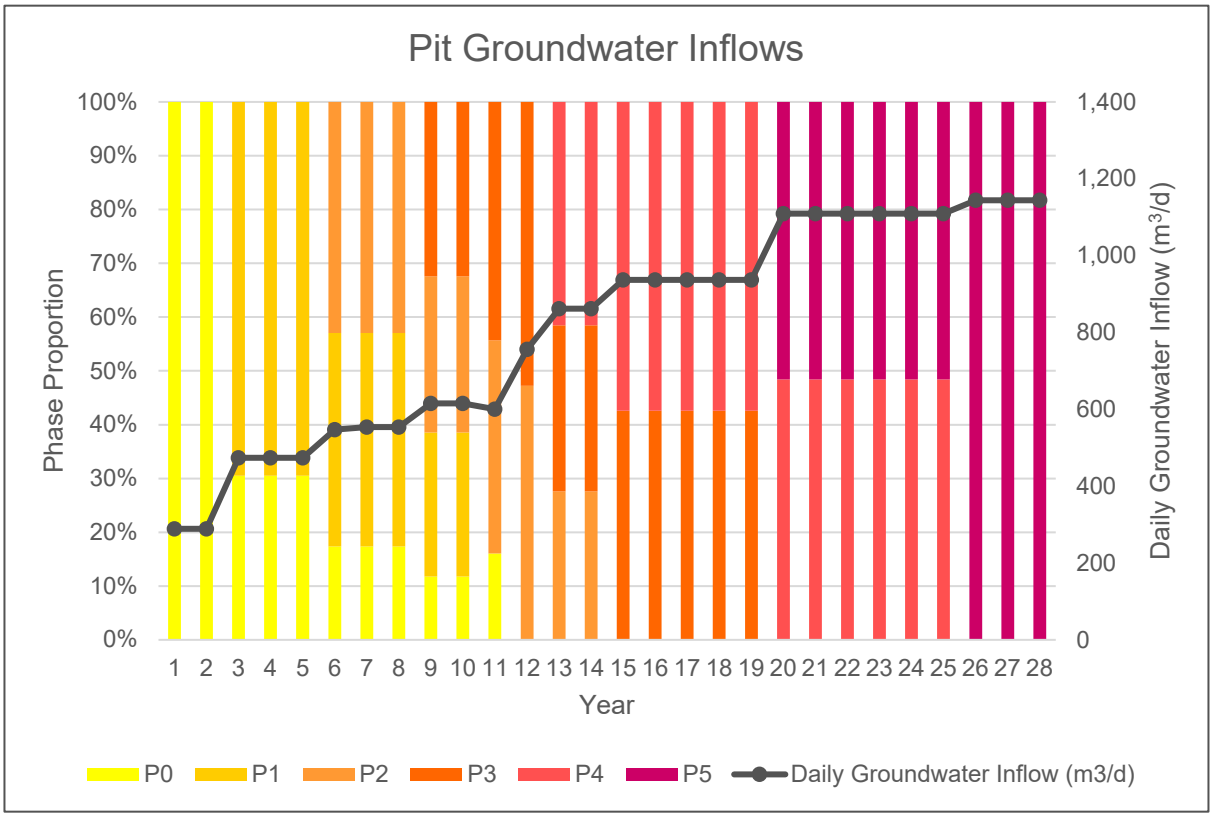
Attachment 2 Period Maps for Dust Suppression Estimates


Année 03
N
2X Niveleuse sur les chemins de services
1X Pelle hydraulique
1X Bélier
PH2
PH1
STP
1X Chargeuse
1X Pelle hydraulique
1X Chargeuse
1X Foreuse
1X Bélier
PH2
PH1
STP
1X Pelle hydraulique
1X Bélier
PH1
STP
PH2
PH2
PH1
1X Pelle hydraulique
1X Chargeuse
2X Foreuse
1X Bélier
Petit lac aux Pierres
Lac aux Pierres
Légende
Tombereau mine - 9 Camions
Tombereau tailling - 5 Camions
Tombereau mort-terrain
Esri Community Maps Contributors, Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, NRCan, Parks Canada


Année 06
N
2X Niveleuse sur les chemins de services
1X Chargeuse
1X Pelle hydraulique 1X Bélier
1X Pelle hydraulique 2X Bélier
1X Pelle hydraulique 1X Chargeuse
2X Foreuse
1X Pelle hydraulique 1X Chargeuse 1X Foreuse 1X Bélier
PH1
PH2
PH3
STP
Petit lac aux Pierres
Lac aux Pierres
Légende
Source de bruit
Tombereau mine - 11 Camions
Tombereau tailling - 5 Camions
Tombereau mort-terrain
Esri Community Maps Contributors, Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, NRCan, Parks Canada


Année 15
N
2X Niveleuse sur les chemins de services
1X Pelle hydraulique
1X Chargeuse
1X Foreuse
1X Pelle hydraulique
1X Chargeuse
2X Foreuse
1X Bélier
1X Pelle hydraulique
1X Bélier
1X Chargeuse
1X Pelle hydraulique
2X Bélier
PH4
PH3
Petit lac aux Pierres
Lac aux Pierres
Légende
Source de bruit
Tombereau mine - 9 camions
Tombereau tailling - 5 camions
Tombereau mort-terrain
Esri Community Maps Contributors, Esri Canada, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, NRCan, Parks Canada

Attachment 3 Hydrogeology Evolution Summary


Pit Groundwater Inflows
Phase Proportion
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1,400
1,200
1,000
800
600
400
200
0
Daily Groundwater Inflow (m3/d)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
Year
P0
P1
P2
P3
P4
P5
Daily Groundwater Inflow (m3/d)

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
1	1	289	289					
1	2	289	289					
1	3	289	289					
1	4	289	289					
1	5	289	289					
1	6	289	289					
1	7	289	289					
1	8	289	289					
1	9	289	289					
1	10	289	289					
1	11	289	289					
1	12	289	289					
2	1	289	289					
2	2	289	289					
2	3	289	289					
2	4	289	289					
2	5	289	289					
2	6	289	289					
2	7	289	289					
2	8	289	289					
2	9	289	289					
2	10	289	289					
2	11	289	289					
2	12	289	289					
3	1	474	289	659				
3	2	474	289	659				
3	3	474	289	659				
3	4	474	289	659				
3	5	474	289	659				
3	6	474	289	659				
3	7	474	289	659				
3	8	474	289	659				
3	9	474	289	659				
3	10	474	289	659				

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
3	11	474	289	659				
3	12	474	289	659				
4	1	474	289	659				
4	2	474	289	659				
4	3	474	289	659				
4	4	474	289	659				
4	5	474	289	659				
4	6	474	289	659				
4	7	474	289	659				
4	8	474	289	659				
4	9	474	289	659				
4	10	474	289	659				
4	11	474	289	659				
4	12	474	289	659				
5	1	474	289	659				
5	2	474	289	659				
5	3	474	289	659				
5	4	474	289	659				
5	5	474	289	659				
5	6	474	289	659				
5	7	474	289	659				
5	8	474	289	659				
5	9	474	289	659				
5	10	474	289	659				
5	11	474	289	659				
5	12	474	289	659				
6	1	474	289	659				
6	2	554	289	659	714			
6	3	554	289	659	714			
6	4	554	289	659	714			
6	5	554	289	659	714			
6	6	554	289	659	714			
6	7	554	289	659	714			
6	8	554	289	659	714			

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
6	9	554	289	659	714			
6	10	554	289	659	714			
6	11	554	289	659	714			
6	12	554	289	659	714			
7	1	554	289	659	714			
7	2	554	289	659	714			
7	3	554	289	659	714			
7	4	554	289	659	714			
7	5	554	289	659	714			
7	6	554	289	659	714			
7	7	554	289	659	714			
7	8	554	289	659	714			
7	9	554	289	659	714			
7	10	554	289	659	714			
7	11	554	289	659	714			
7	12	554	289	659	714			
8	1	554	289	659	714			
8	2	554	289	659	714			
8	3	554	289	659	714			
8	4	554	289	659	714			
8	5	554	289	659	714			
8	6	554	289	659	714			
8	7	554	289	659	714			
8	8	554	289	659	714			
8	9	554	289	659	714			
8	10	554	289	659	714			
8	11	554	289	659	714			
8	12	554	289	659	714			
9	1	615	289	659	714	798		
9	2	615	289	659	714	798		
9	3	615	289	659	714	798		
9	4	615	289	659	714	798		
9	5	615	289	659	714	798		
9	6	615	289	659	714	798		

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
9	7	615	289	659	714	798		
9	8	615	289	659	714	798		
9	9	615	289	659	714	798		
9	10	615	289	659	714	798		
9	11	615	289	659	714	798		
9	12	615	289	659	714	798		
10	1	615	289	659	714	798		
10	2	615	289	659	714	798		
10	3	615	289	659	714	798		
10	4	615	289	659	714	798		
10	5	615	289	659	714	798		
10	6	615	289	659	714	798		
10	7	615	289	659	714	798		
10	8	615	289	659	714	798		
10	9	615	289	659	714	798		
10	10	615	289	659	714	798		
10	11	615	289	659	714	798		
10	12	615	289	659	714	798		
11	1	600	289		714	798		
11	2	600	289		714	798		
11	3	600	289		714	798		
11	4	600	289		714	798		
11	5	600	289		714	798		
11	6	600	289		714	798		
11	7	600	289		714	798		
11	8	600	289		714	798		
11	9	600	289		714	798		
11	10	600	289		714	798		
11	11	600	289		714	798		
11	12	600	289		714	798		
12	1	756			714	798		
12	2	756			714	798		
12	3	756			714	798		
12	4	756			714	798		

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
12	5	756			714	798		
12	6	756			714	798		
12	7	756			714	798		
12	8	756			714	798		
12	9	756			714	798		
12	10	756			714	798		
12	11	756			714	798		
12	12	756			714	798		
13	1	862			714	798	1075	
13	2	862			714	798	1075	
13	3	862			714	798	1075	
13	4	862			714	798	1075	
13	5	862			714	798	1075	
13	6	862			714	798	1075	
13	7	862			714	798	1075	
13	8	862			714	798	1075	
13	9	862			714	798	1075	
13	10	862			714	798	1075	
13	11	862			714	798	1075	
13	12	862			714	798	1075	
14	1	862			714	798	1075	
14	2	862			714	798	1075	
14	3	862			714	798	1075	
14	4	862			714	798	1075	
14	5	862			714	798	1075	
14	6	862			714	798	1075	
14	7	862			714	798	1075	
14	8	862			714	798	1075	
14	9	862			714	798	1075	
14	10	862			714	798	1075	
14	11	862			714	798	1075	
14	12	862			714	798	1075	
15	1	937				798	1075	
15	2	937				798	1075	

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
15	3	937				798	1075	
15	4	937				798	1075	
15	5	937				798	1075	
15	6	937				798	1075	
15	7	937				798	1075	
15	8	937				798	1075	
15	9	937				798	1075	
15	10	937				798	1075	
15	11	937				798	1075	
15	12	937				798	1075	
16	1	937				798	1075	
16	2	937				798	1075	
16	3	937				798	1075	
16	4	937				798	1075	
16	5	937				798	1075	
16	6	937				798	1075	
16	7	937				798	1075	
16	8	937				798	1075	
16	9	937				798	1075	
16	10	937				798	1075	
16	11	937				798	1075	
16	12	937				798	1075	
17	1	937				798	1075	
17	2	937				798	1075	
17	3	937				798	1075	
17	4	937				798	1075	
17	5	937				798	1075	
17	6	937				798	1075	
17	7	937				798	1075	
17	8	937				798	1075	
17	9	937				798	1075	
17	10	937				798	1075	
17	11	937				798	1075	
17	12	937				798	1075	

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
18	1	937				798	1075	
18	2	937				798	1075	
18	3	937				798	1075	
18	4	937				798	1075	
18	5	937				798	1075	
18	6	937				798	1075	
18	7	937				798	1075	
18	8	937				798	1075	
18	9	937				798	1075	
18	10	937				798	1075	
18	11	937				798	1075	
18	12	937				798	1075	
19	1	937				798	1075	
19	2	937				798	1075	
19	3	937				798	1075	
19	4	937				798	1075	
19	5	937				798	1075	
19	6	937				798	1075	
19	7	937				798	1075	
19	8	937				798	1075	
19	9	937				798	1075	
19	10	937				798	1075	
19	11	937				798	1075	
19	12	937				798	1075	
20	1	1110					1075	1144
20	2	1110					1075	1144
20	3	1110					1075	1144
20	4	1110					1075	1144
20	5	1110					1075	1144
20	6	1110					1075	1144
20	7	1110					1075	1144
20	8	1110					1075	1144
20	9	1110					1075	1144
20	10	1110					1075	1144

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
20	11	1110					1075	1144
20	12	1110					1075	1144
21	1	1110					1075	1144
21	2	1110					1075	1144
21	3	1110					1075	1144
21	4	1110					1075	1144
21	5	1110					1075	1144
21	6	1110					1075	1144
21	7	1110					1075	1144
21	8	1110					1075	1144
21	9	1110					1075	1144
21	10	1110					1075	1144
21	11	1110					1075	1144
21	12	1110					1075	1144
22	1	1110					1075	1144
22	2	1110					1075	1144
22	3	1110					1075	1144
22	4	1110					1075	1144
22	5	1110					1075	1144
22	6	1110					1075	1144
22	7	1110					1075	1144
22	8	1110					1075	1144
22	9	1110					1075	1144
22	10	1110					1075	1144
22	11	1110					1075	1144
22	12	1110					1075	1144
23	1	1110					1075	1144
23	2	1110					1075	1144
23	3	1110					1075	1144
23	4	1110					1075	1144
23	5	1110					1075	1144
23	6	1110					1075	1144
23	7	1110					1075	1144
23	8	1110					1075	1144

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
23	9	1110					1075	1144
23	10	1110					1075	1144
23	11	1110					1075	1144
23	12	1110					1075	1144
24	1	1110					1075	1144
24	2	1110					1075	1144
24	3	1110					1075	1144
24	4	1110					1075	1144
24	5	1110					1075	1144
24	6	1110					1075	1144
24	7	1110					1075	1144
24	8	1110					1075	1144
24	9	1110					1075	1144
24	10	1110					1075	1144
24	11	1110					1075	1144
24	12	1110					1075	1144
25	1	1110					1075	1144
25	2	1110					1075	1144
25	3	1110					1075	1144
25	4	1110					1075	1144
25	5	1110					1075	1144
25	6	1110					1075	1144
25	7	1110					1075	1144
25	8	1110					1075	1144
25	9	1110					1075	1144
25	10	1110					1075	1144
25	11	1110					1075	1144
25	12	1110					1075	1144
26	1	1144						1144
26	2	1144						1144
26	3	1144						1144
26	4	1144						1144
26	5	1144						1144
26	6	1144						1144

Date		Pit dewatering water (m^3/j)						
		Combined	P0	P1	P2	P3	P4	P5
26	7	1144						1144
26	8	1144						1144
26	9	1144						1144
26	10	1144						1144
26	11	1144						1144
26	12	1144						1144
27	1	1144						1144
27	2	1144						1144
27	3	1144						1144
27	4	1144						1144
27	5	1144						1144
27	6	1144						1144
27	7	1144						1144
27	8	1144						1144
27	9	1144						1144
27	10	1144						1144
27	11	1144						1144
27	12	1144						1144
28	1	1144						1144
28	2	1144						1144
28	3	1144						1144
28	4	1144						1144
28	5	1144						1144
28	6	1144						1144
28	7	1144						1144
28	8	1144						1144
28	9	1144						1144
28	10	1144						1144
28	11	1144						1144
28	12	1144						1144

Source: https://srk.sharepoint.com/sites/NACAPR002717/Internal/!020_Project_Data/010_SRK/Water%20Balance/CAPR002717%2520NMG-WaterBlanaceModel_DRAFT_2023-12-19_SRK_REV_C.xlsx?web=1

Attachment 4 Concentrator Inputs

MOYENNES QUOTIDIENNES TRANSPORTÉES

Description	Unité	PP	Y01	Y02	Y03	Y04	Y05	Y06	Y07	Y08	Y09	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23	Y24	Y25
De la fosse au concentrateur	tpj	0	7,099	9,810	9,810	9,810	9,837	9,810	9,810	9,810	9,837	9,810	9,810	9,810	9,810	9,810	9,810	9,810	9,810	9,810	9,810	9,376	9,376	9,376	8,587	8,587	7,491
De la fosse à la pile de minerai	tpj	903	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
De la pile de minerai au concasseur	tpj	0	903	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mort-terrain	tpj	1,203	3,731	2,490	3,623	853	534	1,348	2,018	2,304	65	1,855	3,177	4,189	3,872	534	534	534	4,132	4,132	4,132	4,790	4,790	4,790	0	0	0
Stériles	tpj	779	5,764	7,956	10,328	8,276	9,317	11,919	11,249	10,963	13,175	11,412	10,090	9,079	9,396	9,793	9,793	9,793	7,079	7,079	7,079	8,801	8,801	8,801	4,523	4,523	788
Matériaux deplacés	tpj	2,885	17,498	20,255	23,761	18,939	19,688	23,077	23,077	23,077	23,077	23,077	23,077	23,077	23,077	20,136	20,136	20,136	21,021	21,021	21,021	22,966	22,966	22,966	13,110	13,110	8,279

Attachment 5 Precipitation Analysis

3. NMG - Matawinie Precipitation Analysis

CAPR003306

Camilo Gallard

February 12, 2025

Abstract

This report compiles the precipitation anlaysis that was carried out by SRK Consulting (Canada) Inc. for the Nouveau Monde Graphite Matawinie Site in 2024 to support Engineering Design. The data compilation and subsequent analysis was conducted in the R Software environment.

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Chapter 1

Glossary

- **AMS**: Annual Maximum Series.
- **Daymet**: Reanalysis tool developed by the Oak Ridge National Laboratory and supported by NASA (Thornton et al. 2022).
- **ECCC**: Environment and Climate Change Canada.
- **ERA5**: Reanalysis tool developed by the European Centre for Medium-Range Weather Forecasts (Hersbach et al. 2020).
- **ERA5-Land**: Reanalysis tool based on ERA5 but for Land surfaces and a smaller grid, and developed by the European Centre for Medium-Range Weather Forecasts (Muñoz-Sabater et al. 2021).
- **ET**: Evapotranspiration
- **ET0**: Reference Evapotranspiration
- **IDF**: Intensity-Duration-Frequency (IDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
- **KST**: Kolmogorov–Smirnov Test.
- **MAAT**: Mean Annual Air Temperature.
- **MAP**: Mean Annual Precipitation.
- **MERRA2**: Modern-Era Retrospective analysis from Research and Applications, Version 2, is a global climate reanalysis model from the U.S. National Aeronautics and Space Administration (Gelaro et al. 2017).
- **NMG**: Nouveau Monde Graphite.
- **PCC**: Pearson Correlation Coefficient.
- **PDF**: Precipitation-Duration-Frequency (PDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
- **PMP**: Probable Maximum Precipitation.
- **RH**: Relative Humidity.

- **SRAD**: Shortwave (solar) radiation. Incident shortwave radiation flux density in watts per square meter.
- **SRK**: SRK Consulting (Canada) Inc.
- **SSR**: Surface net shortwave (solar) radiation. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth (both direct and diffuse) minus the amount reflected by the Earth's surface (which is governed by the albedo).
- **SSRD**: Surface short-wave (solar) radiation downwards. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth. This parameter comprises both direct and diffuse solar radiation.
- **Tavg**: Mean or Average Air Temperature over a given temporal unit (day, month, year…).
- **Tdew**: Mean or Average Dew Point Temperature over a given temporal unit (day, month, year…).
- **Tmax**: Maximum Air Temperature over a given temporal unit (day, month, year…).
- **Tmin**: Minimum Air Temperature over a given temporal unit (day, month, year…).

Chapter 2

General Parameters

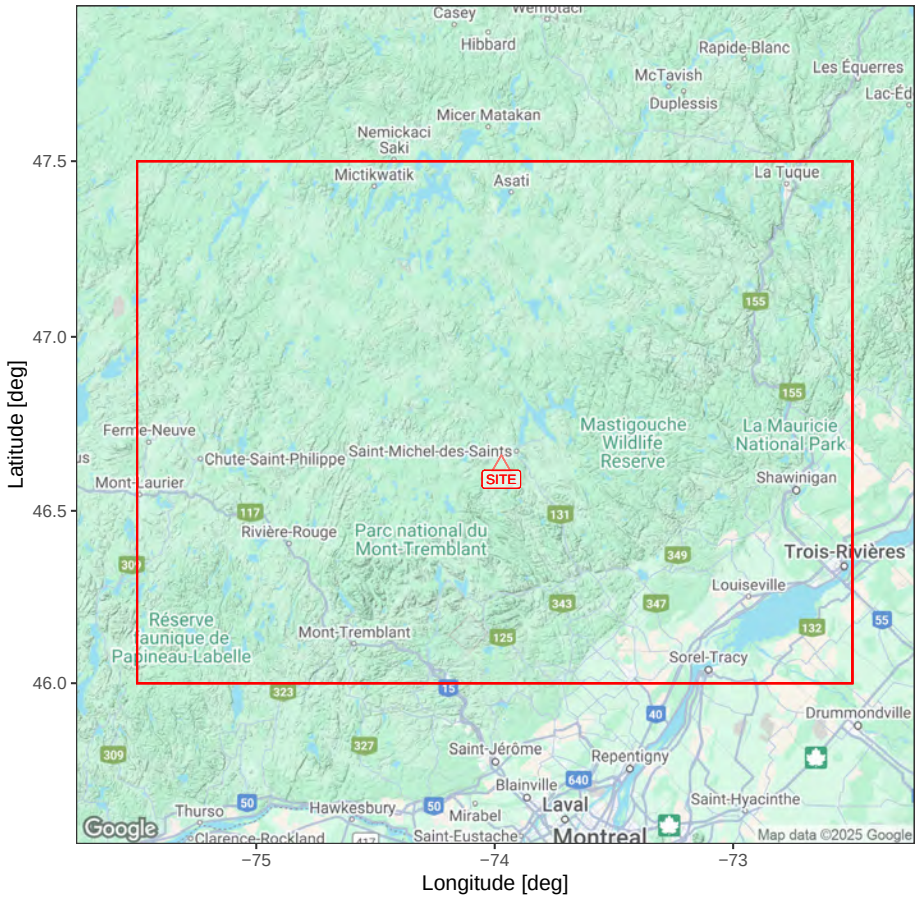
The NMG Matawinie site is located in southern Quebec, 125 km north of Montreal. Site latitude is 46.63 degrees, and longitude is -73.97 degrees, at an elevation of 562 masl. These coordinates were selected to match the location of the meteorological station on site.

For the purpose of this meteorological analysis, an area of interest was defined around site to capture regional data and climate trends, and was defined as the region between:

- 46° and 47.5° Latitude
- -75.5° and -72.5° Longitude

Site Location and Area of Interest for this Study

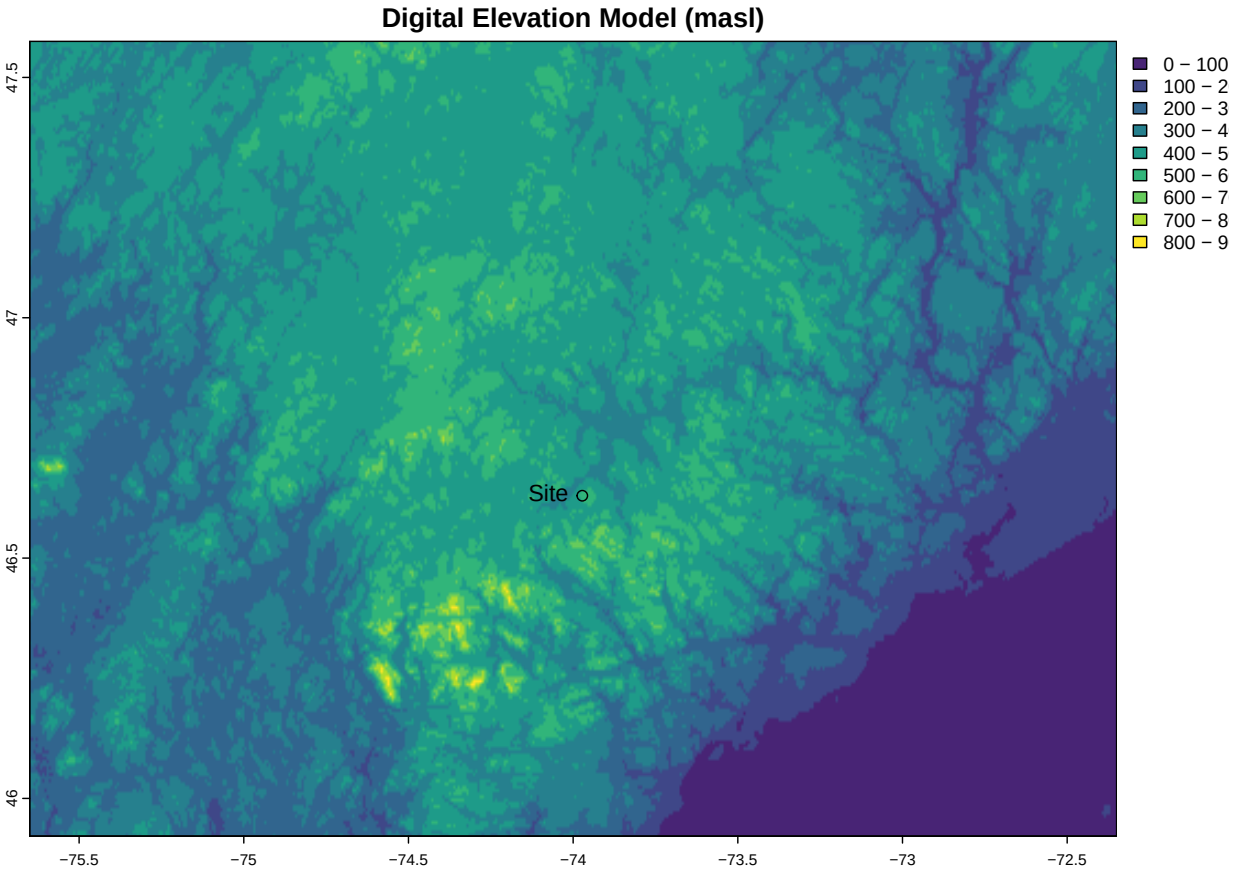
Area of interest covers a distance of up to 125km from Site



Chapter 3

Digital Elevation Model

Digital elevation model from the region was downloaded from the Shuttle Radar Topography Mission (SRTM) dataset. The SRTM database contains global elevation data with 3 arc-second (90 m) spatial resolution, which is deemed sufficient for climate analysis.



Chapter 4

NMG Precipitation Data

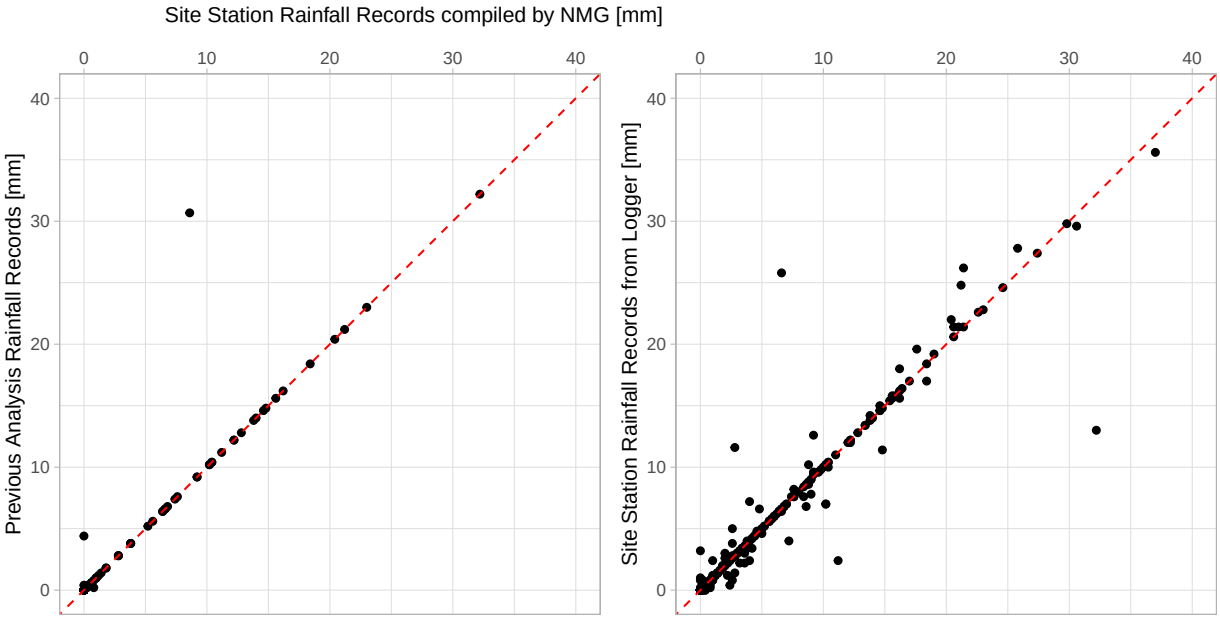
Site data is collected by NMG from two meteorological stations. The first station is located on Site, and the second station, called SoftdB, is located 1.5 km north at the following address: 200 Chemin des Hauteurs, Saint-Michel-des-Saints. Both records appear to only collect rainfall data.

Multiple data files were available for site. In the following section these were compiled and compared. Site records are consistent and the source file compiled by NMG has the longest records and is therefore selected for further analysis.

Note: SoftdB data is different from ECCC station 48188 data, so both records were kept.

NMG Stations Records and Missing Data
NMG Site Station
NMG SoftdB Station
Previous Analysis Site
Site Logger data
Daily Rainfall [mm]
0
50
100
2021
2022
2023
2024

Comparison between all the Site Station data files for Precipitation



Chapter 5

Regional Precipitation Analysis

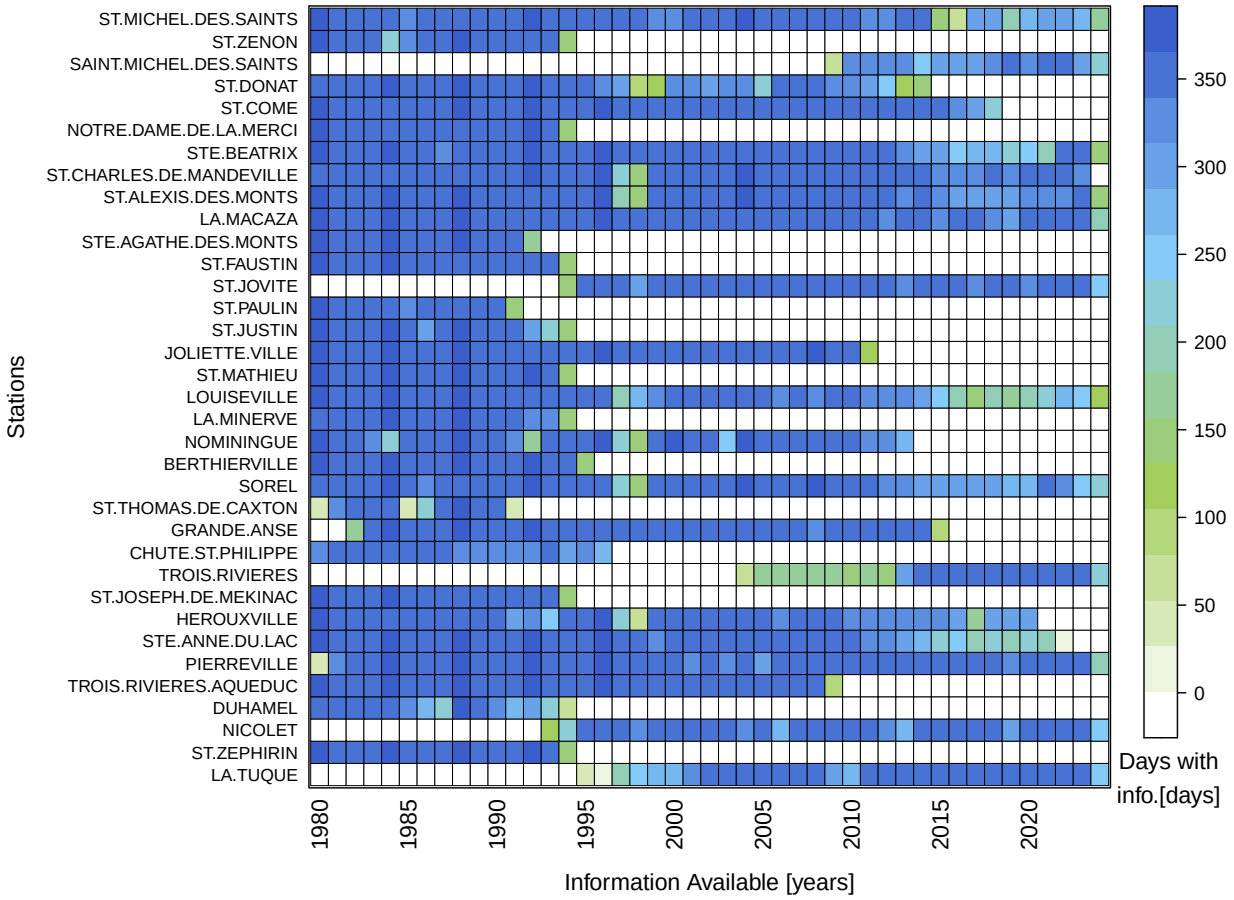
5.1 ECCC Precipitation Data

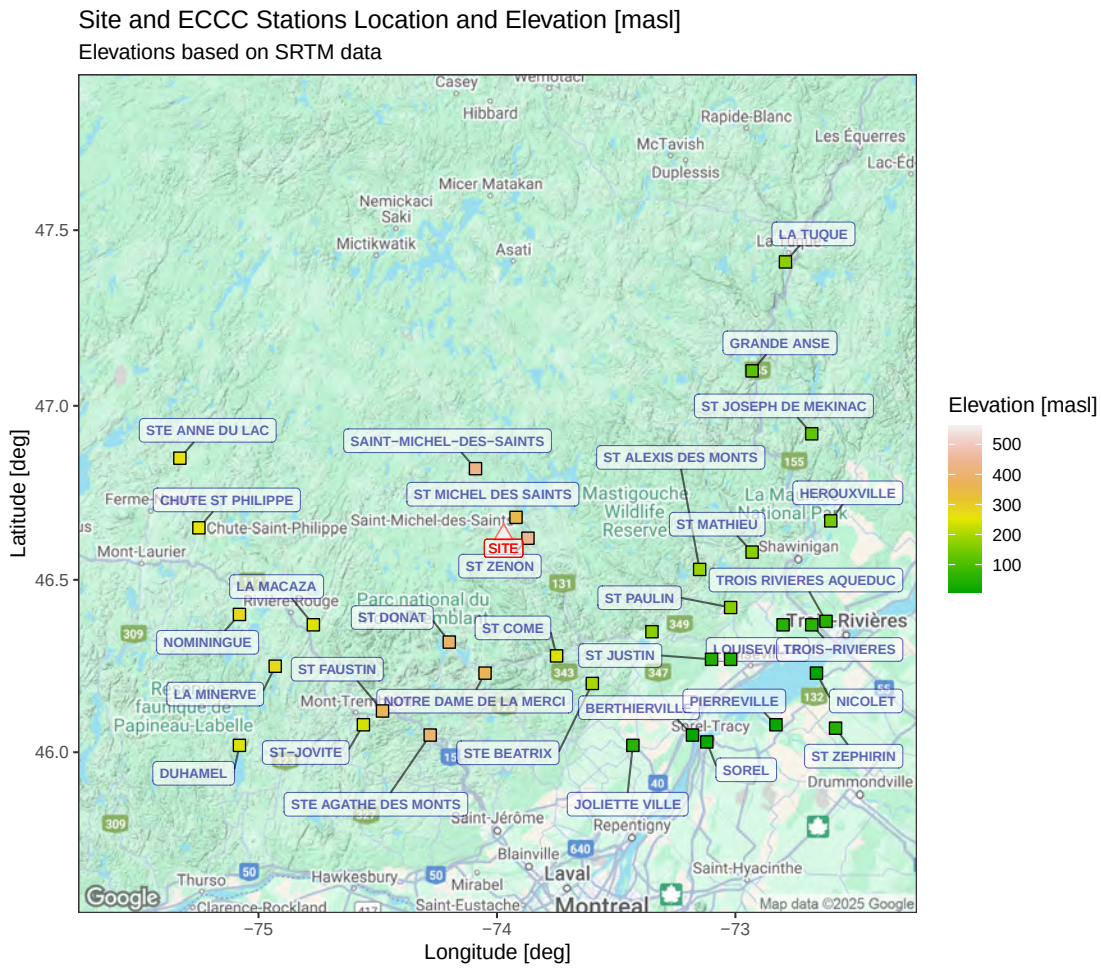
Environment and Climate Change Canada (ECCC) data was downloaded and prepared for analysis. The information is captured on a daily or hourly timestep when available. No complementary/redundant stations were detected so patching was not required for stations within the area of interest.

The following figures show:

1. Data availability over time at each station (only records from 1980 to 2023 were considered for this analysis).
2. Selected ECCC stations location and elevation.

Refer to the "eccc_read.r" for pre-processing details.


ST.MICHEL.DES.SAINTS
ST.ZENON
SAINT.MICHEL.DES.SAINTS
ST.DONAT
ST.COME
NOTRE.DAME.DE.LA.MERCI
STE.BEATRIX
ST.CHARLES.DE.MANDEVILLE
ST.ALEXIS.DES.MONTS
LA.MACAZA
STE.AGATHE.DES.MONTS
ST.FAUSTIN
ST.JOVITE
ST.PAULIN
ST.JUSTIN
JOLIETTE.VILLE
ST.MATHIEU
LOUISEVILLE
LA.MINERVE
NOMININGUE
BERTHIERVILLE
SOREL
ST.THOMAS.DE.CAXTON
GRANDE.ANSE
CHUTE.ST.PHILIPPE
TROIS.RIVIERES
ST.JOSEPH.DE.MEKINAC
HEROUXVILLE
STE.ANNE.DU.LAC
PIERREVILLE
TROIS.RIVIERES.AQUEDUC
DUHAMEL
NICOLET
ST.ZEPHIRIN
LA.TUQUE
Stations
1980
1985
1990
1995
2000
2005
2010
2015
2020
Information Available [years]
350
300
250
200
150
100
50
0
Days with
info.[days]



5.2 Reanalysis Regional Overview

Climate reanalysis combines gridded global models with observed historical data to produce historical climate and to incorporate adjustments based on developed relationships. Multiple reanalysis datasets are available in different spatio-temporal resolutions.

For this project four reanalysis datasets were evaluated. These are presented as gridded climate models and cover an area of interest defined between

5.2.1 Gridded Dataset Analysis Function

A general function is created to review each selected gridded dataset and compare it to station records. Four graphs are presented as outputs including:

- Graph 1: Mean annual precipitation (MAP) as a gridded map over the analysis extents, compared to station results. This aims to help visualize any regional trends in mean precipitation.
- Graph 2: Mean Annual Precipitation Elevation gradient over the analysis extents and regression, compared to station results.
- Graph 3: Mean Monthly Precipitation Elevation gradient over the analysis extents, compared to station results. Results and regressions split by month.

- Graph 4: Mean Annual Precipitation Elevation gradient and regression, compared to station results, split by location by latitude and longitude increments of 0.5 degrees. This graph offers a visualization of any local trends that might be more significant than regional trends.

5.2.2 Daymet

Daymet is a reanalysis tool developed by the Oak Ridge National Laboratory and supported by NASA, Daymet provides long-term, continuous, gridded estimates of daily weather and climatology in North America (Thornton et al. 2022) including variables such as daily maximum and minimum temperatures, precipitation, and shortwave radiation.

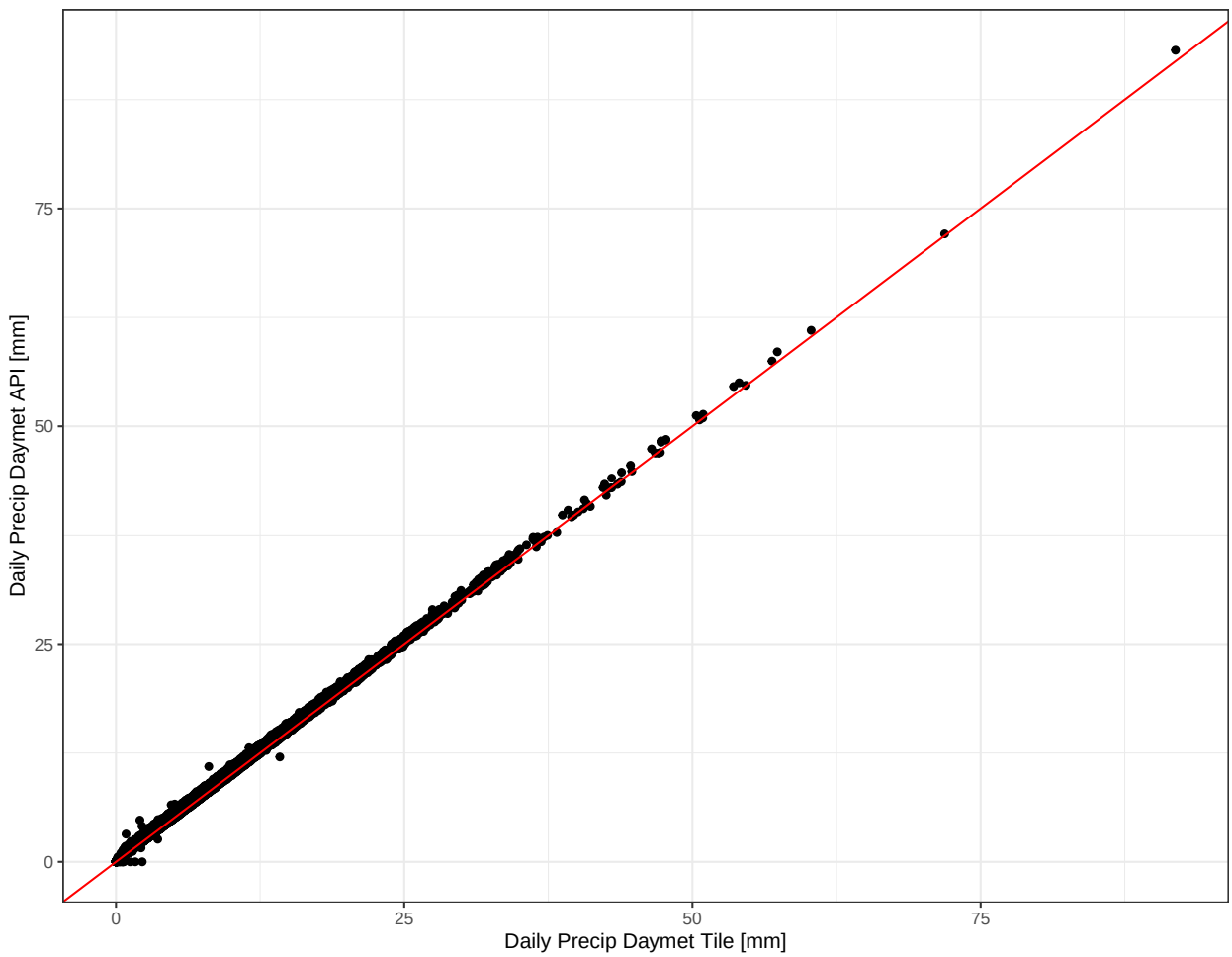
Daymet uses a set of spatial interpolation algorithms to estimate weather and climate patterns at a 1 km spatial resolution. Daymet is particularly useful for ecological and hydrological modeling. It offers high spatial resolution data covering an extended time period, making it suitable for analyzing long-term climate trends and their impacts on various environmental processes.

5.2.2.1 Daymet Source Selection

Two Daymet sources are compared:

1. API: data retrieved directly for a location from the Daymet site (interpolation function used)
2. Tiles: data extracted from the raster dataset

Both are mostly equivalent although slight differences are observed, likely due to interpolation/re-projection methods.

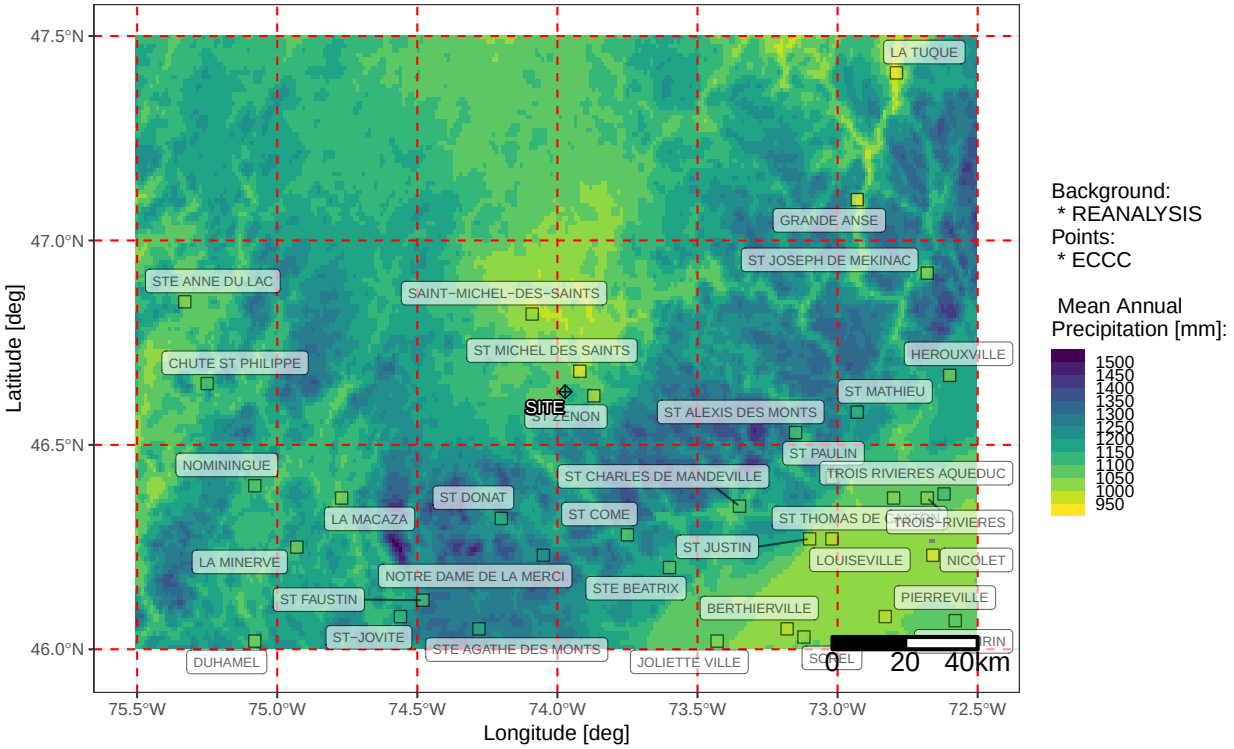


5.2.2.2 Daymet Regional Overview for Precipitation

The main findings of the Daymet regional overview are listed below (the corresponding figures follow):

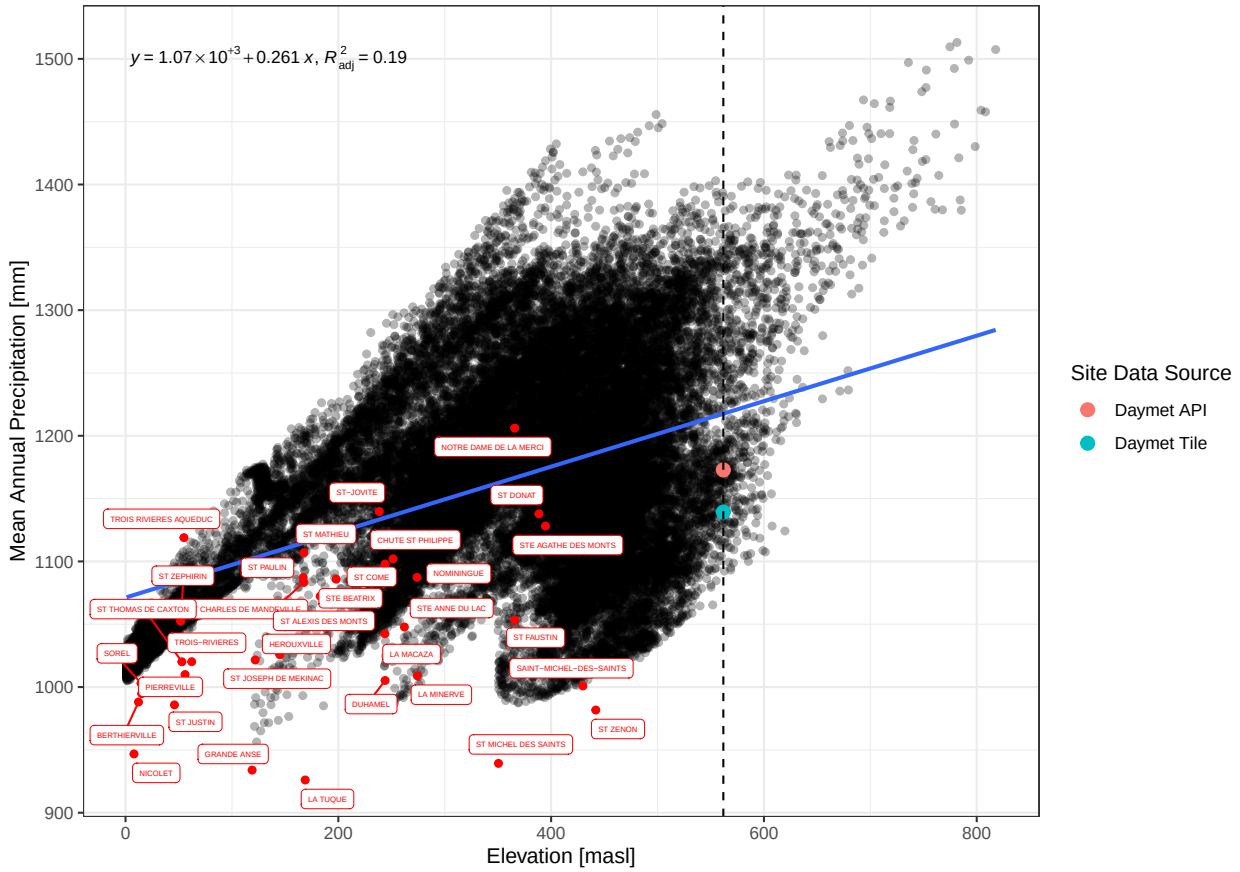
- On a regional scale, Daymet is consistent with ECCC in terms of spatial trends on MAP (Graph 1).
- The MAP versus Elevation gradient (Graph 2) shows a slight overprediction of MAP for Daymet on a regional scale. This observation is generally consistent with the monthly breakdown of this data (Graph 3).
- The localized breakdown of MAP vs Elevation (Graph 4) shows signifantly improved correlations between elevation and MAP, suggesting the existence of localized orthographic effects that don't follow a regional trend. Daymet overprediction of MAP appears to be consistent across the smaller areas.

Graph 1: Mean Annual Precipitation [mm]:
(1980 − 2023)



Graph 2: Regional Elevation Gradient

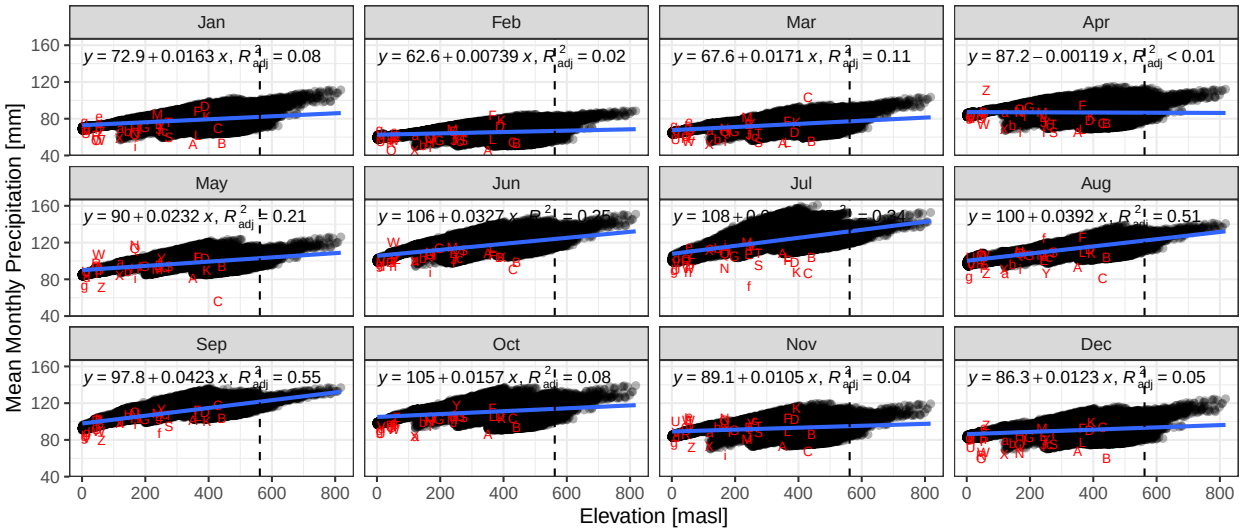
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

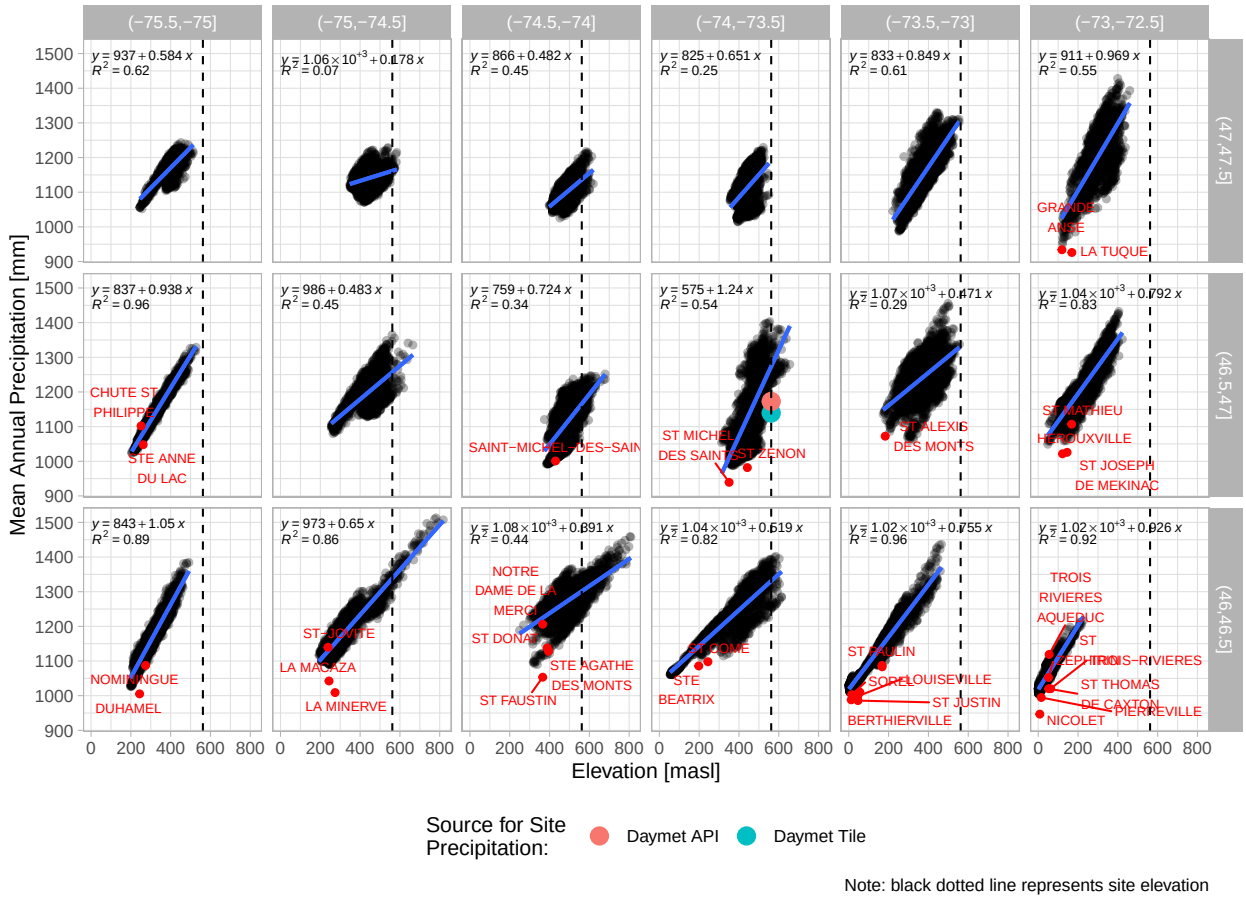
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



A	ST MICHEL DES SAINTS	H	ST CHARLES DE MANDEVILLE	O	ST JUSTIN	V	SOREL	c	STE ANNE DU
B	ST ZENON	I	ST ALEXIS DES MONTS	P	JOLIETTE VILLE	W	ST THOMAS DE CAXTON	d	PIERREVILLE
C	SAINT−MICHEL−DES−SAINTS	J	LA MACAZA	Q	ST MATHIEU	X	GRANDE ANSE	e	TROIS RIVIERE
D	ST DONAT	K	STE AGATHE DES MONTS	R	LOUISEVILLE	Y	CHUTE ST PHILIPPE	f	DUHAMEL
E	ST COME	L	ST FAUSTIN	S	LA MINERVE	Z	TROIS−RIVIERES	g	NICOLET
F	NOTRE DAME DE LA MERCI	M	ST−JOVITE	T	NOMININGUE	a	ST JOSEPH DE MEKINAC	h	ST ZEPHIRIN
G	STE BEATRIX	N	ST PAULIN	U	BERTHIERVILLE	b	HEROUXVILLE	i	LA TUQUE

Note: black dotted line represents site elevation

Graph 4: Mean Annual Precipitation [mm] versus Elevation [masl] (1980 − 2023)
Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



5.2.3 ERA5 Regional Overview for Precipitation

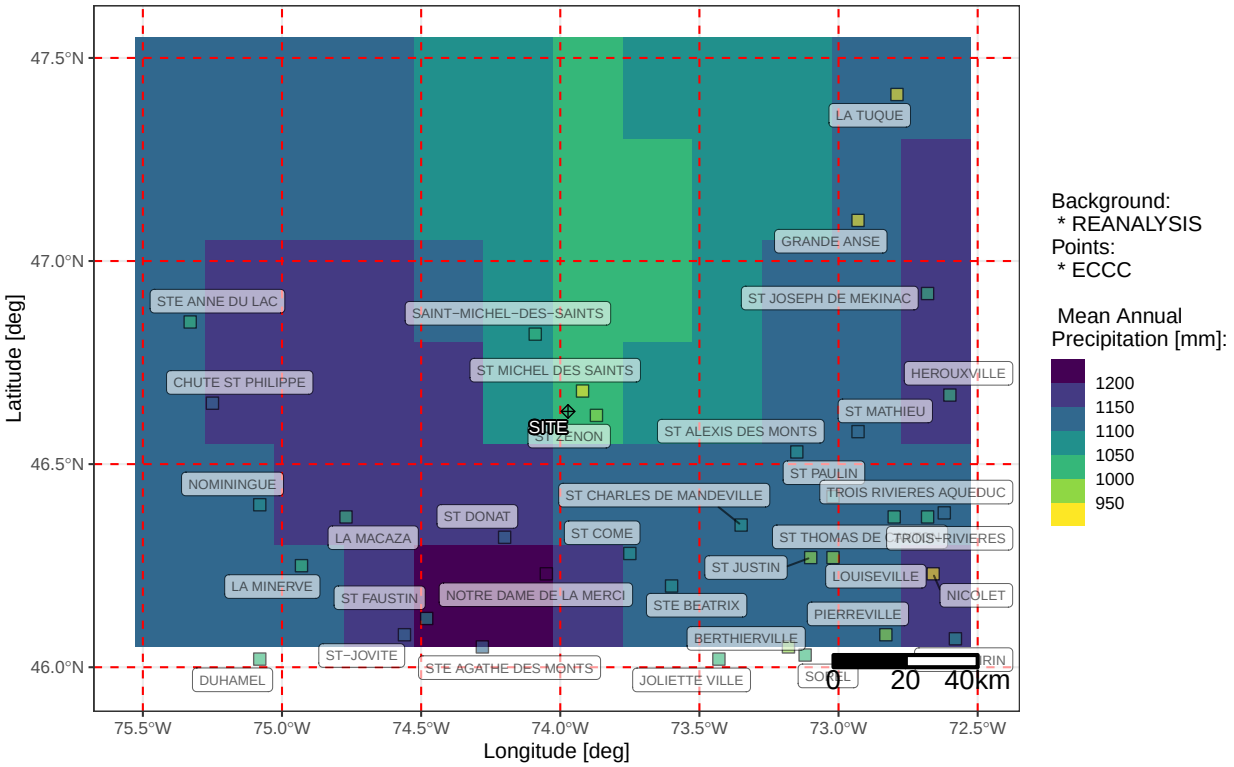
ERA5 is the fifth generation ECMWF atmospheric reanalysis of the global climate covering the period from January 1940 to present (Hersbach et al. 2020). ERA5 is produced by the Copernicus Climate Change Service (C3S) at the European Centre for Medium-Range Weather Forecasts (ECMWF). It offers information about multiple meteorological parameters.

ERA5 provides hourly estimates of a large number of atmospheric, land and oceanic climate variables. The data cover the Earth on a 31km grid and resolve the atmosphere using 137 levels from the surface up to a height of 80km. Surface level parameters were evaluated in this analysis.

The main findings of the ERA5 regional overview are listed below (the corresponding figures follow):

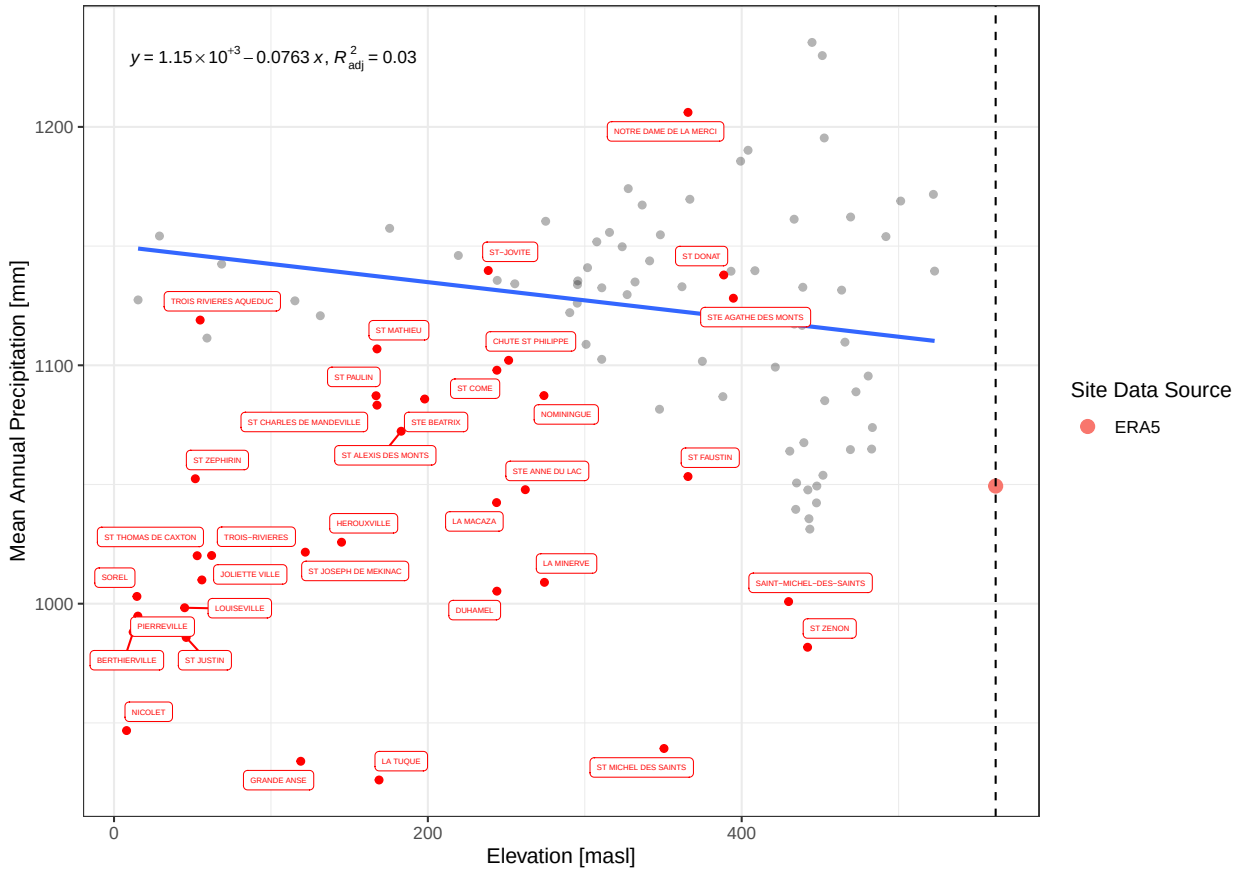
- On a regional scale, ERA5 is consistent with ECCC in terms of spatial trends on MAP (Graph 1).
- The MAP versus Elevation gradient (Graph 2) shows a slight overprediction of MAP for ERA5 on a regional scale. This observation is generally consistent with the monthly breakdown of this data (Graph 3). Mean grid elevation is generally higher than the stations elevation due to the mountainous nature of the region.
- The localized breakdown of MAP vs Elevation (Graph 4) is not relevant for precipitation analysis due to the lower resolution of the ERA5 dataset. Note that mean grid elevation is generally higher than the stations elevation due to the mountainous nature of the region.

Graph 1: Mean Annual Precipitation [mm]:
(1980 – 2023)



Graph 2: Regional Elevation Gradient

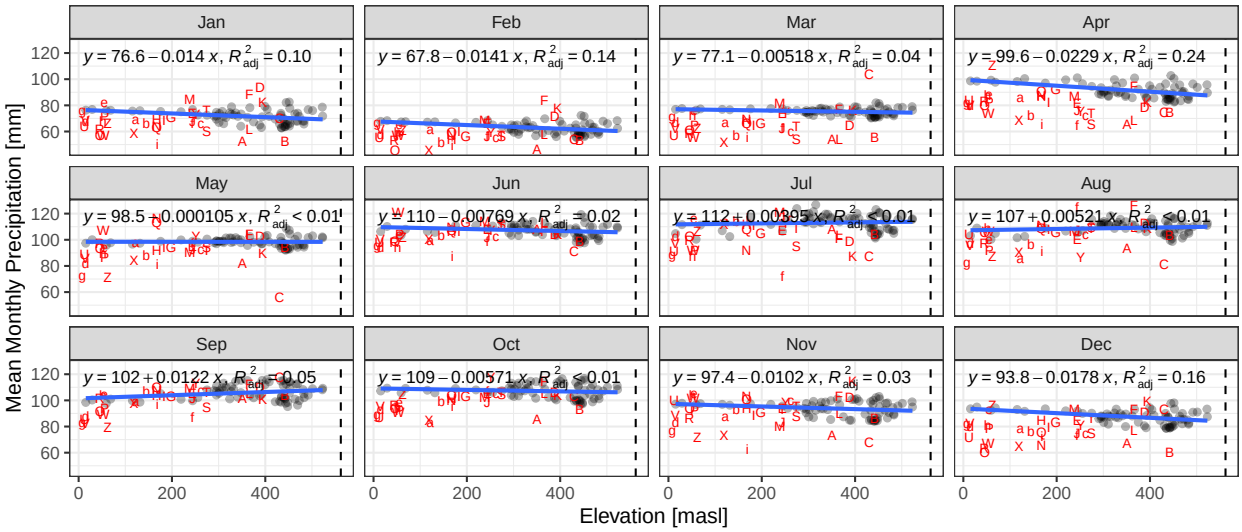
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

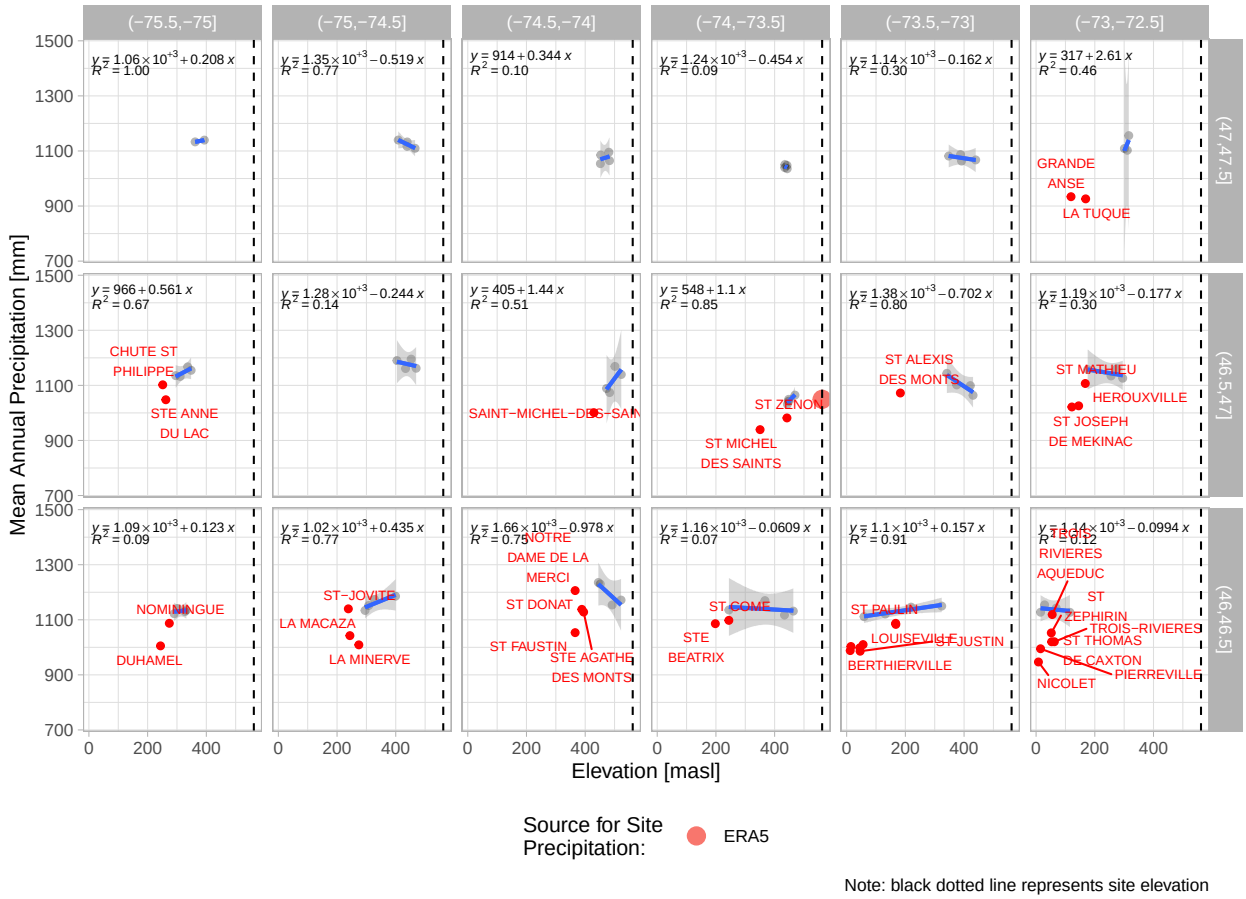
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



A	ST MICHEL DES SAINTS	H	ST CHARLES DE MANDEVILLE	O	ST JUSTIN	V	SOREL	c	STE ANNE DU
B	ST ZENON	I	ST ALEXIS DES MONTS	P	JOLIETTE VILLE	W	ST THOMAS DE CAXTON	d	PIERREVILLE
C	SAINT−MICHEL−DES−SAINTS	J	LA MACAZA	Q	ST MATHIEU	X	GRANDE ANSE	e	TROIS RIVIERE
D	ST DONAT	K	STE AGATHE DES MONTS	R	LOUISEVILLE	Y	CHUTE ST PHILIPPE	f	DUHAMEL
E	ST COME	L	ST FAUSTIN	S	LA MINERVE	Z	TROIS−RIVIERES	g	NICOLET
F	NOTRE DAME DE LA MERCI	M	ST−JOVITE	T	NOMININGUE	a	ST JOSEPH DE MEKINAC	h	ST ZEPHIRIN
G	STE BEATRIX	N	ST PAULIN	U	BERTHIERVILLE	b	HEROUXVILLE	i	LA TUQUE

Note: black dotted line represents site elevation

Graph 4: Mean Annual Precipitation [mm] versus Elevation [masl] (1980 − 2023)
Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



Note: black dotted line represents site elevation

5.2.4 ERA5-Land Regional Overview for Precipitation

ERA5-Land is a higher spatial and temporal resolution reanalysis dataset produced by the European Centre for Medium-Range Weather Forecasts (ECMWF) (Muñoz-Sabater et al. 2021). It offers detailed information about a large number of atmospheric, land and oceanic climate variables.

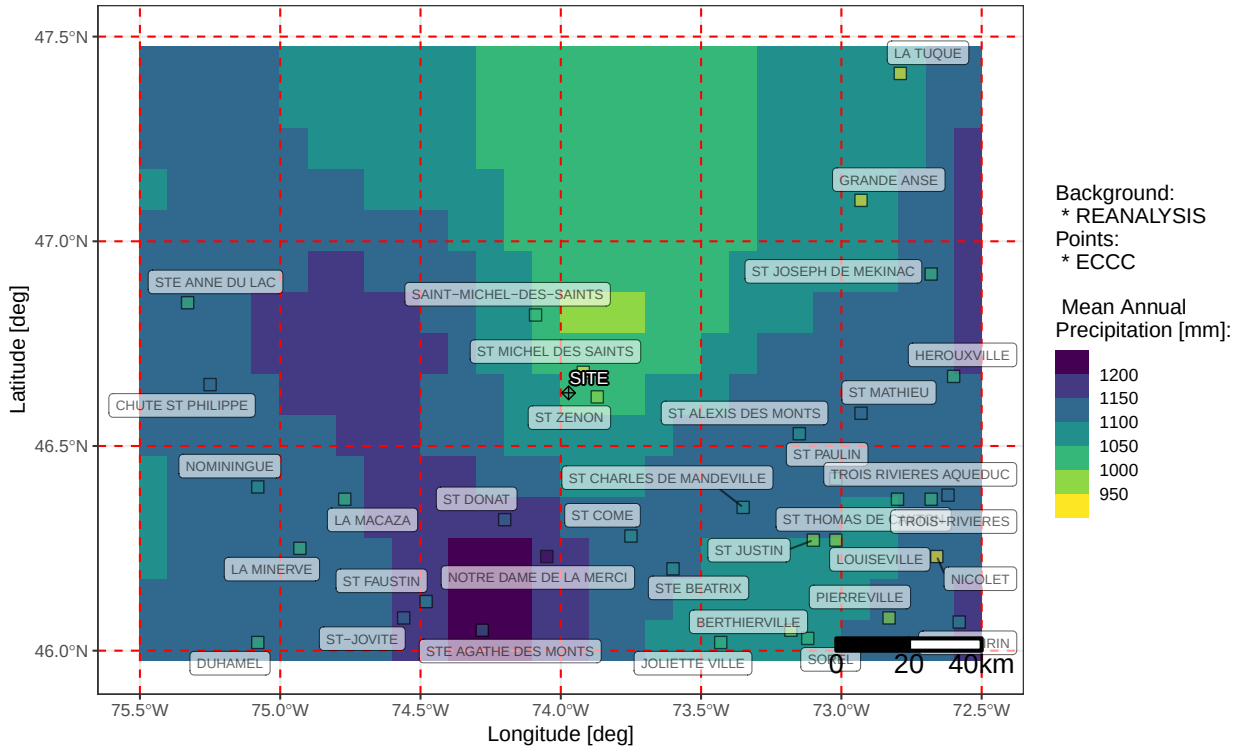
ERA5-Land operates at a spatial resolution of approximately 9 km and provides data at hourly intervals, making it particularly useful for hydrological and environmental studies. This dataset is widely used in research and operational applications due to its comprehensive coverage and high accuracy in representing land-surface conditions.

The main findings of the Era5-Land regional overview are listed below (the corresponding figures follow):

- On a regional scale, Era5-Land is consistent with ECCC in terms of spatial trends on MAP (Graph 1).
- Similarly to ERA5, the MAP versus Elevation gradient (Graph 2) shows a slight overprediction of MAP for Era5-Land on a regional scale. This observation is generally consistent with the monthly breakdown of this data (Graph 3).
- The localized breakdown of MAP vs Elevation (Graph 4) shows slightly improved correlations between elevation and MAP in some areas, suggesting the existence of some localized orthographic effects. Era5-Land overprediction of MAP appears to be consistent across the smaller

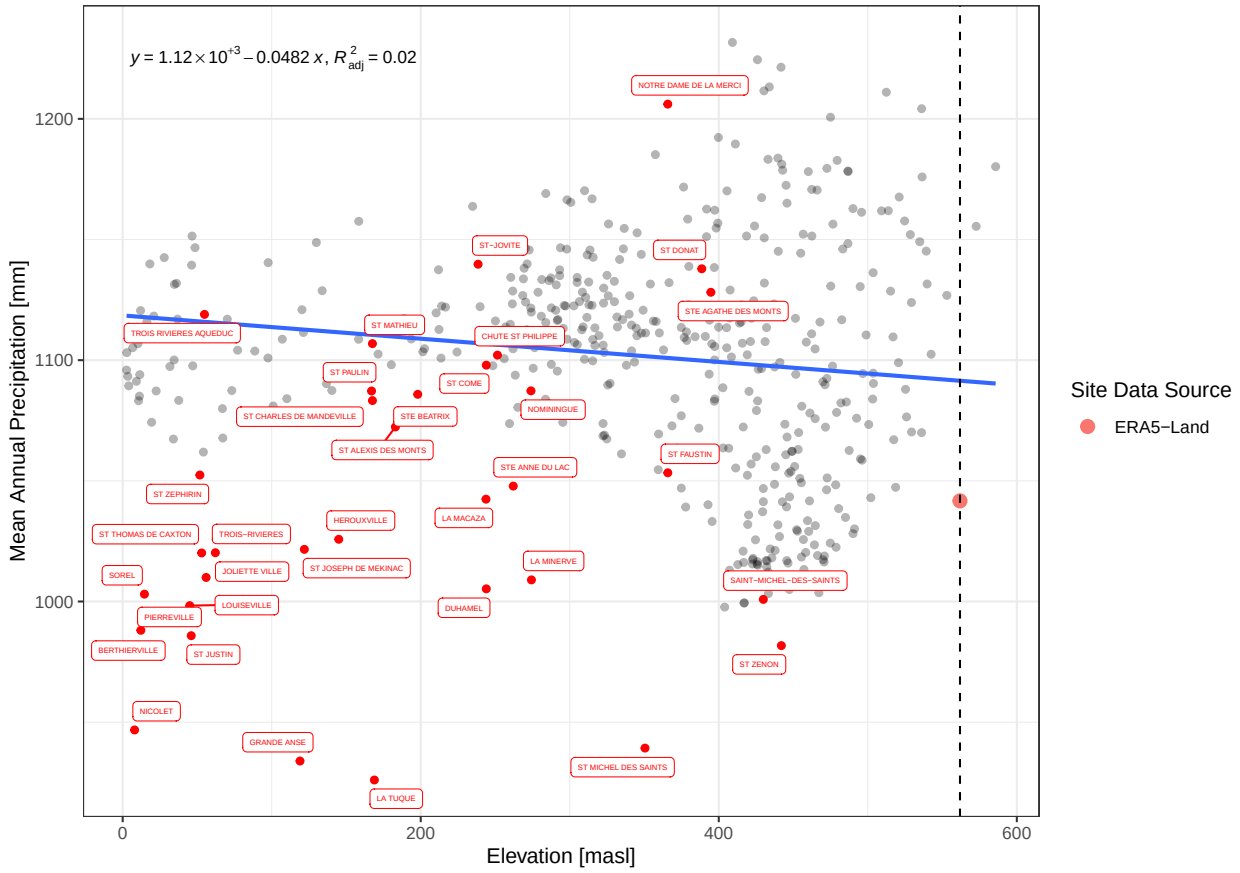
areas.

Graph 1: Mean Annual Precipitation [mm]:
(1980 − 2023)



Graph 2: Regional Elevation Gradient

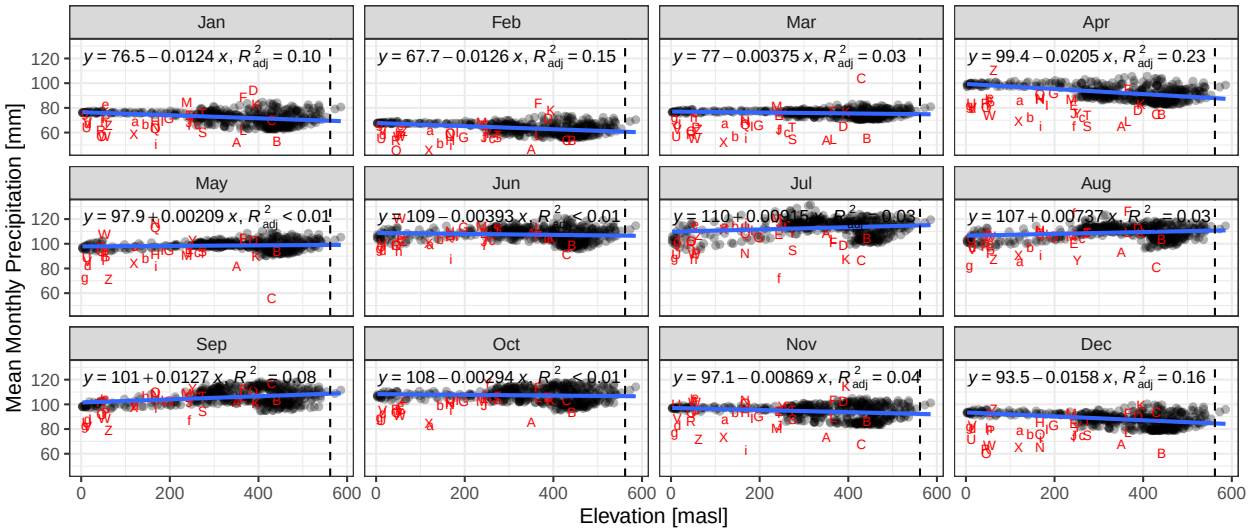
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

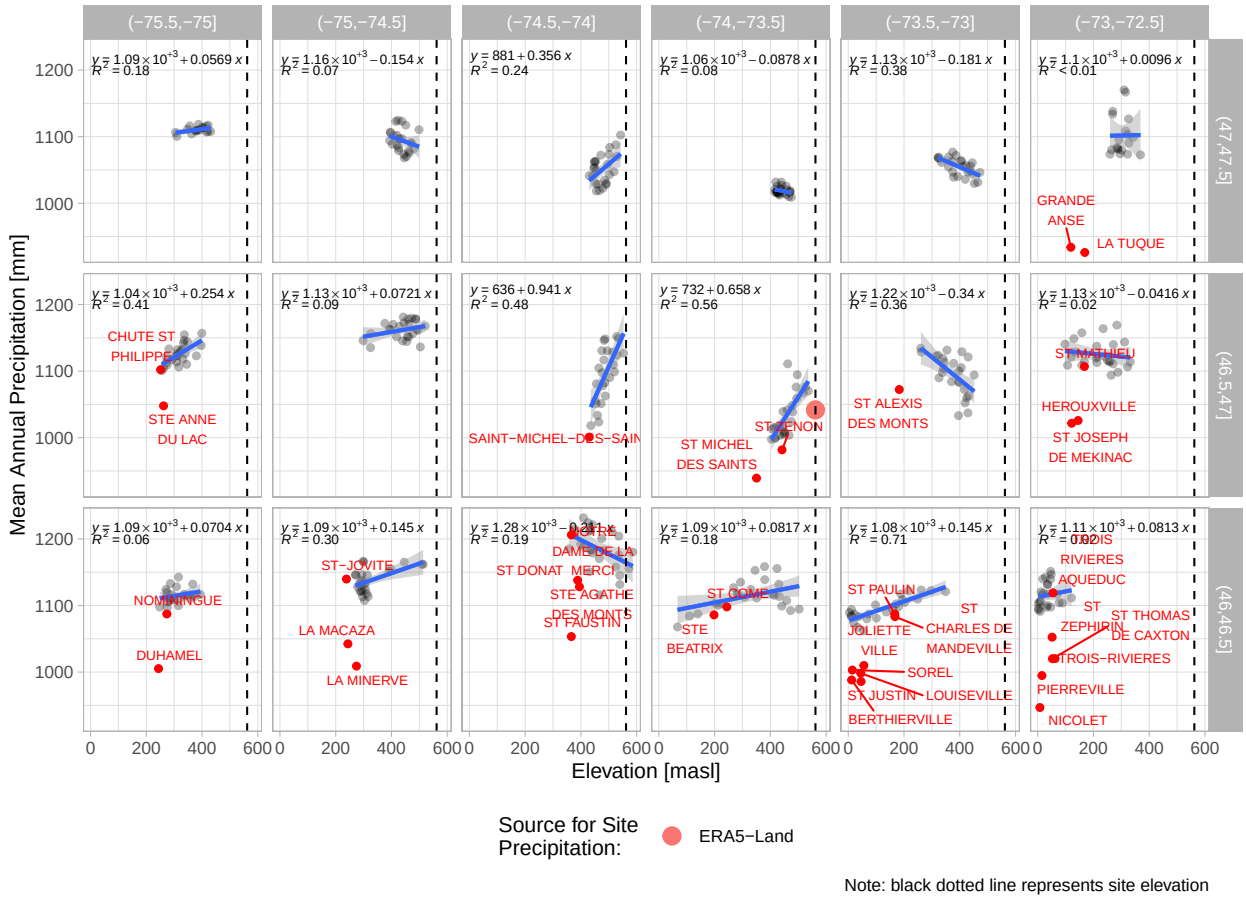
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



A ST MICHEL DES SAINTS	H ST CHARLES DE MANDEVILLE	O ST JUSTIN	V SOREL	c STE ANNE DU
B ST ZENON	I ST ALEXIS DES MONTS	P JOLIETTE VILLE	W ST THOMAS DE CAXTON	d PIERREVILLE
C SAINT−MICHEL−DES−SAINTS	J LA MACAZA	Q ST MATHIEU	X GRANDE ANSE	e TROIS RIVIERE
D ST DONAT	K STE AGATHE DES MONTS	R LOUISEVILLE	Y CHUTE ST PHILIPPE	f DUHAMEL
E ST COME	L ST FAUSTIN	S LA MINERVE	Z TROIS−RIVIERES	g NICOLET
F NOTRE DAME DE LA MERCI	M ST−JOVITE	T NOMININGUE	a ST JOSEPH DE MEKINAC	h ST ZEPHIRIN
G STE BEATRIX	N ST PAULIN	U BERTHIERVILLE	b HEROUXVILLE	i LA TUQUE

Note: black dotted line represents site elevation

Graph 4: Mean Annual Precipitation [mm] versus Elevation [masl] (1980 − 2023)
Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



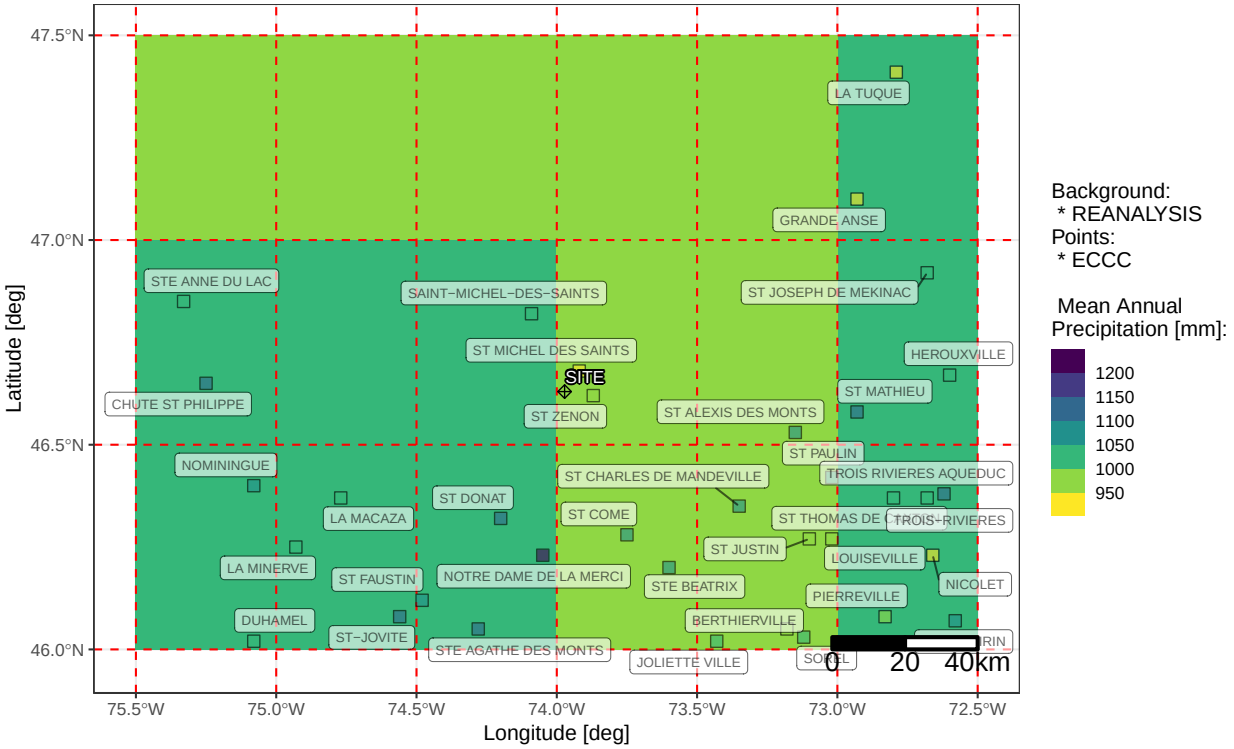
5.2.5 MERRA2 Regional Overview for Precipitation

MERRA2 (Modern-Era Retrospective analysis from Research and Applications, Version 2) is a global climate reanalysis model from the U.S. National Aeronautics and Space Administration (NASA) (Gelaro et al. 2017). MERRA2 offers daily data from 1981 to present (2024) on a grid of 0.5 degrees latitude by 0.5 degrees longitude covering the entire globe.

The main findings of the MERRA2 regional overview are listed below (the corresponding figures follow):

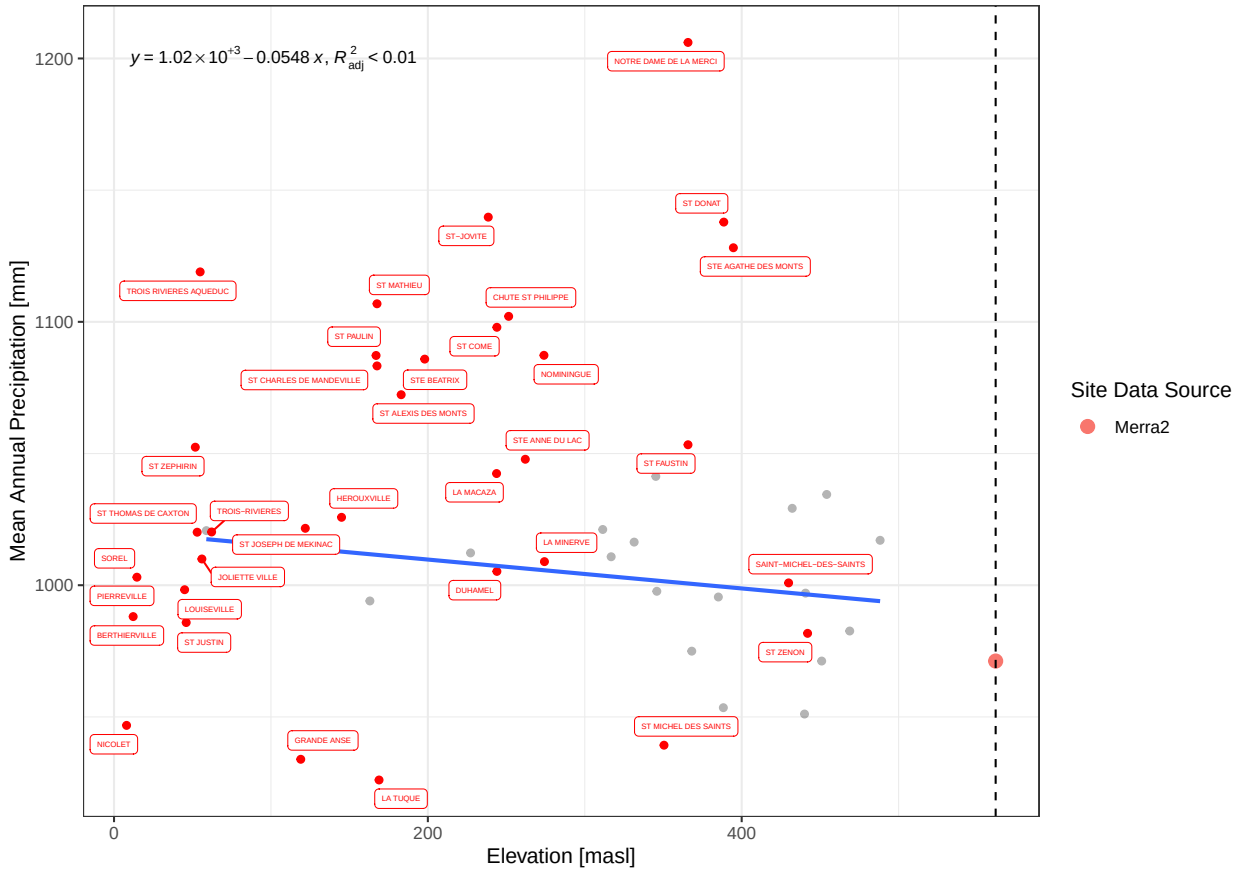
- On a regional scale, MERRA2 appears to be somewhat consistent with ECCC in terms of spatial trends on MAP (Graph 1).
- The MAP versus Elevation gradient (Graph 2) shows MAP predictions below the range of station data for MERRA2 on a regional scale, although mean grid elevation is generally higher than the stations elevation . This observation is generally consistent with the monthly breakdown of this data (Graph 3).
- The localized breakdown of MAP vs Elevation (Graph 4) is not relevant for precipitation analysis due to the lower resolution of the MERRA2 dataset. Note that mean grid elevation is generally higher than the stations elevation due to the mountainous nature of the region.

Graph 1: Mean Annual Precipitation [mm]:
(1980 – 2023)



Graph 2: Regional Elevation Gradient

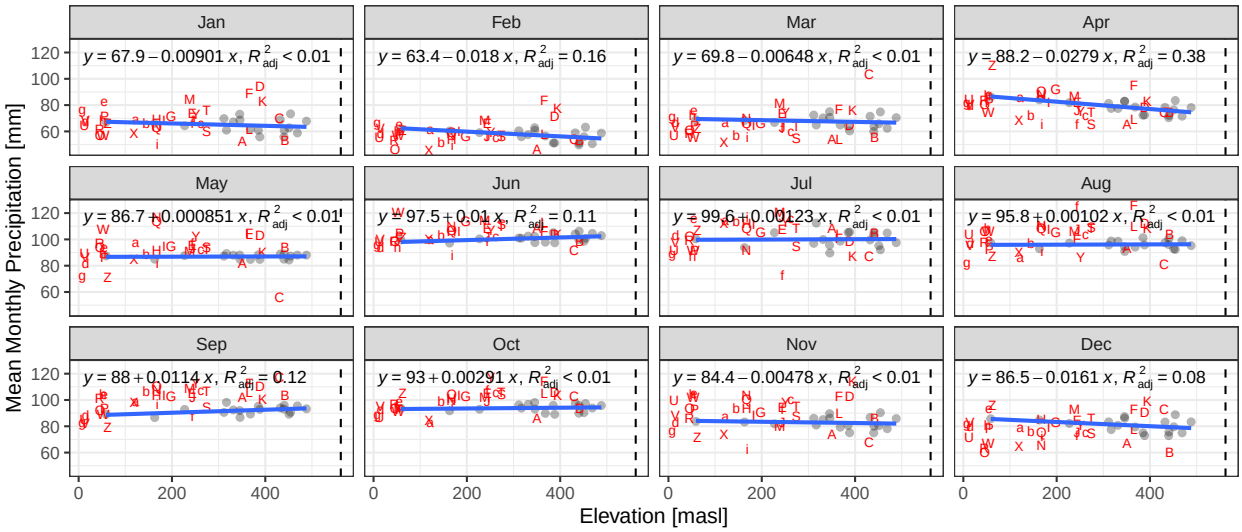
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

Reanalsis source as background: 1980 to 2023 (distance 125 km from site)

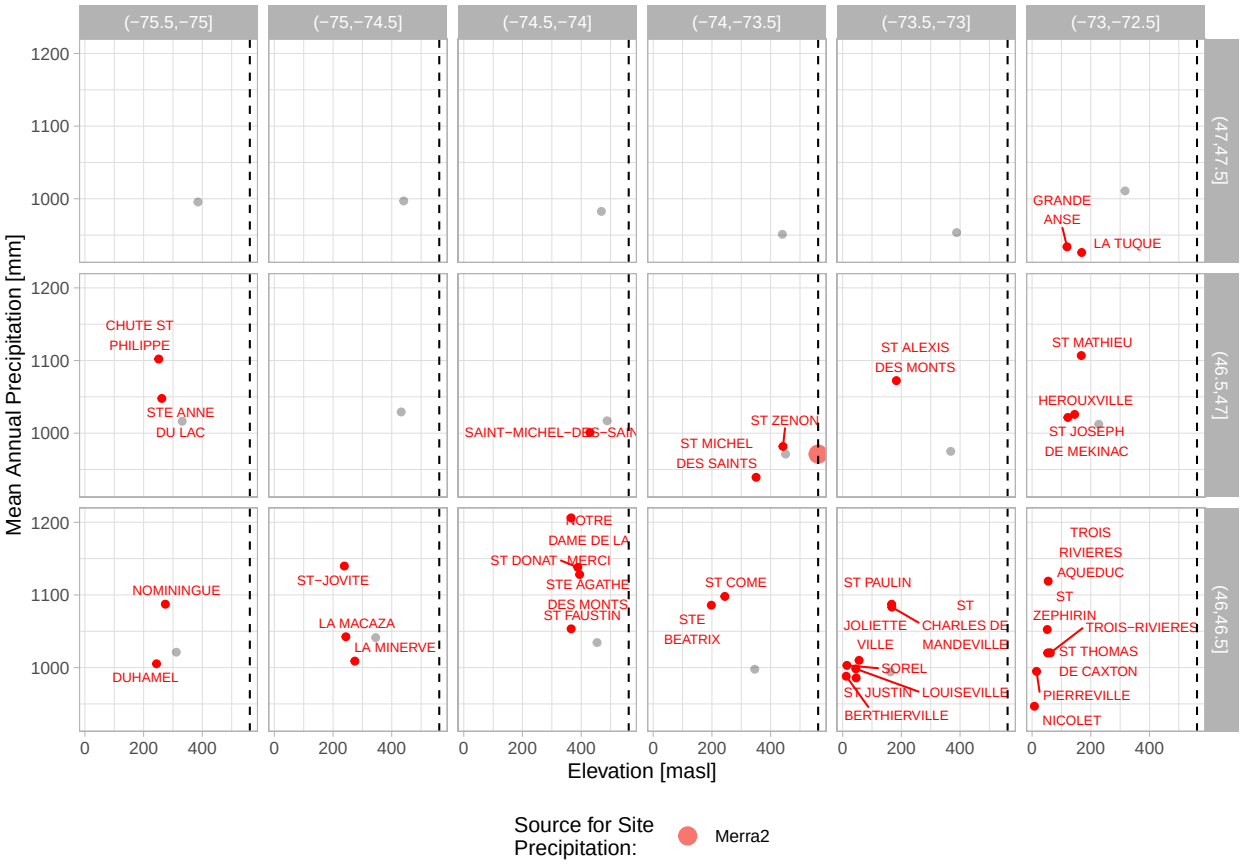


A ST MICHEL DES SAINTS	H ST CHARLES DE MANDEVILLE	O ST JUSTIN	V SOREL	c STE ANNE DU
B ST ZENON	I ST ALEXIS DES MONTS	P JOLIETTE VILLE	W ST THOMAS DE CAXTON	d PIERREVILLE
C SAINT−MICHEL−DES−SAINTS	J LA MACAZA	Q ST MATHIEU	X GRANDE ANSE	e TROIS RIVIERE
D ST DONAT	K STE AGATHE DES MONTS	R LOUISEVILLE	Y CHUTE ST PHILIPPE	f DUHAMEL
E ST COME	L ST FAUSTIN	S LA MINERVE	Z TROIS−RIVIERES	g NICOLET
F NOTRE DAME DE LA MERCI	M ST−JOVITE	T NOMININGUE	a ST JOSEPH DE MEKINAC	h ST ZEPHIRIN
G STE BEATRIX	N ST PAULIN	U BERTHIERVILLE	b HEROUXVILLE	i LA TUQUE

Note: black dotted line represents site elevation

Graph 4: Mean Annual Precipitation [mm] versus Elevation [masl] (1980 − 2023)

Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



Note: black dotted line represents site elevation

Chapter 6

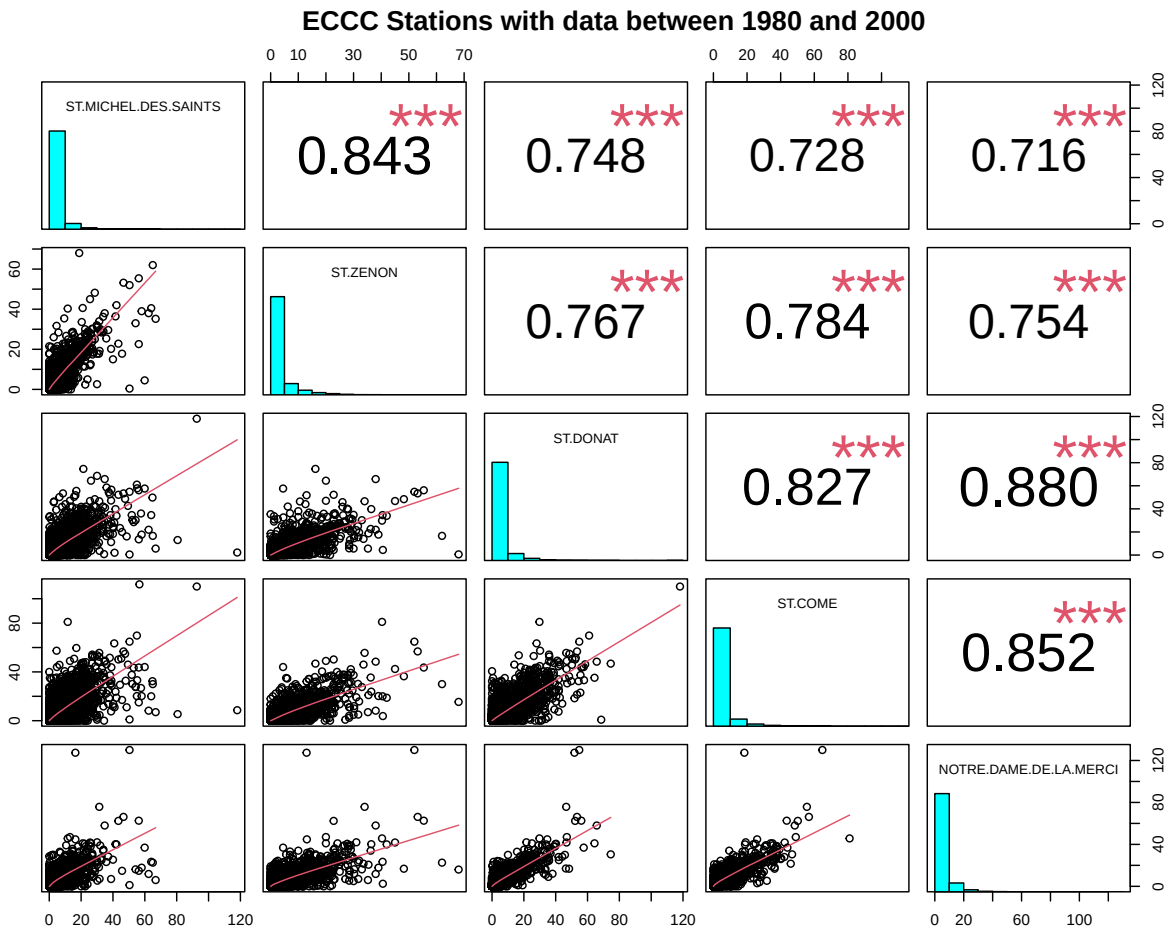
Local Analysis

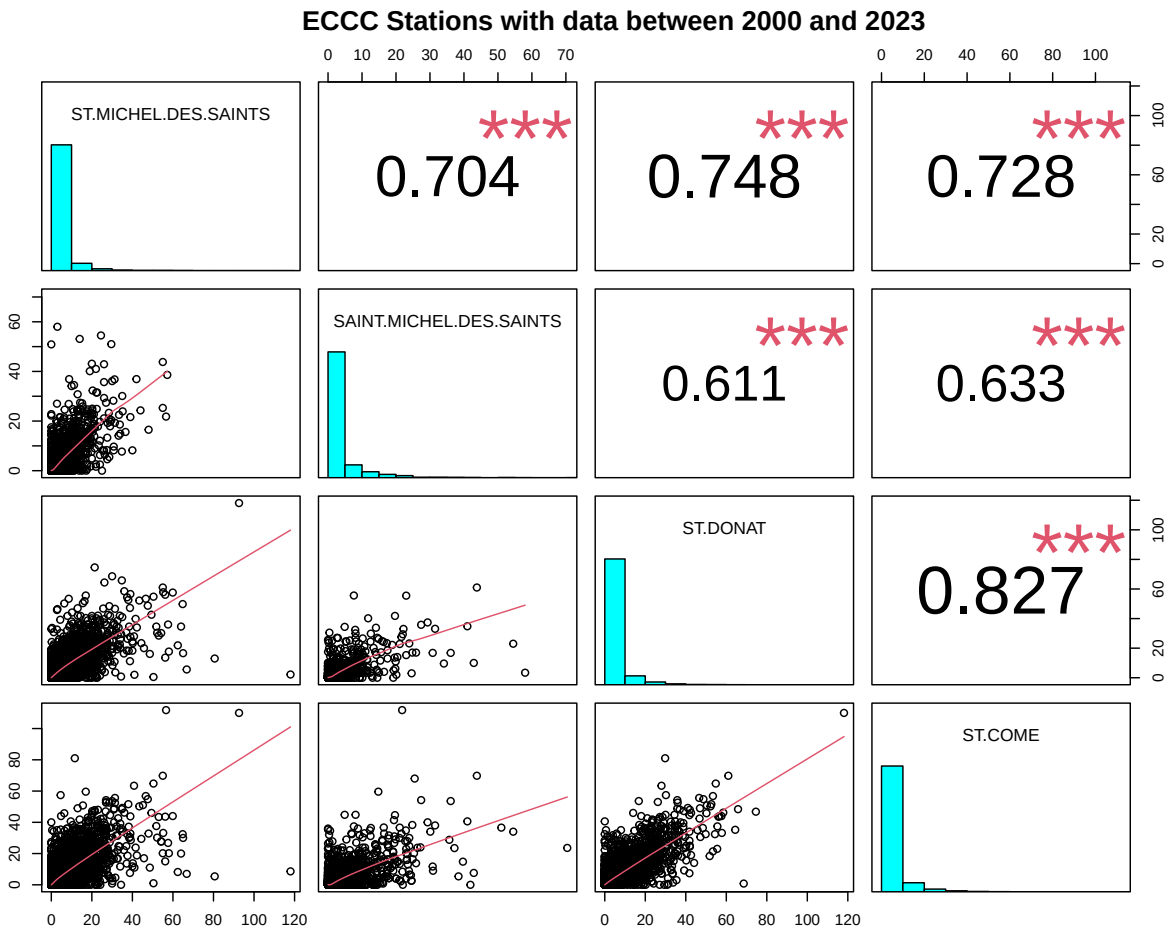
The regional analysis shows that local orographic effects are prominent and variable in the region, therefore a smaller area around Site should be more representative of its climate. The following analysis only considers data within 50km of the Matawinie Site.

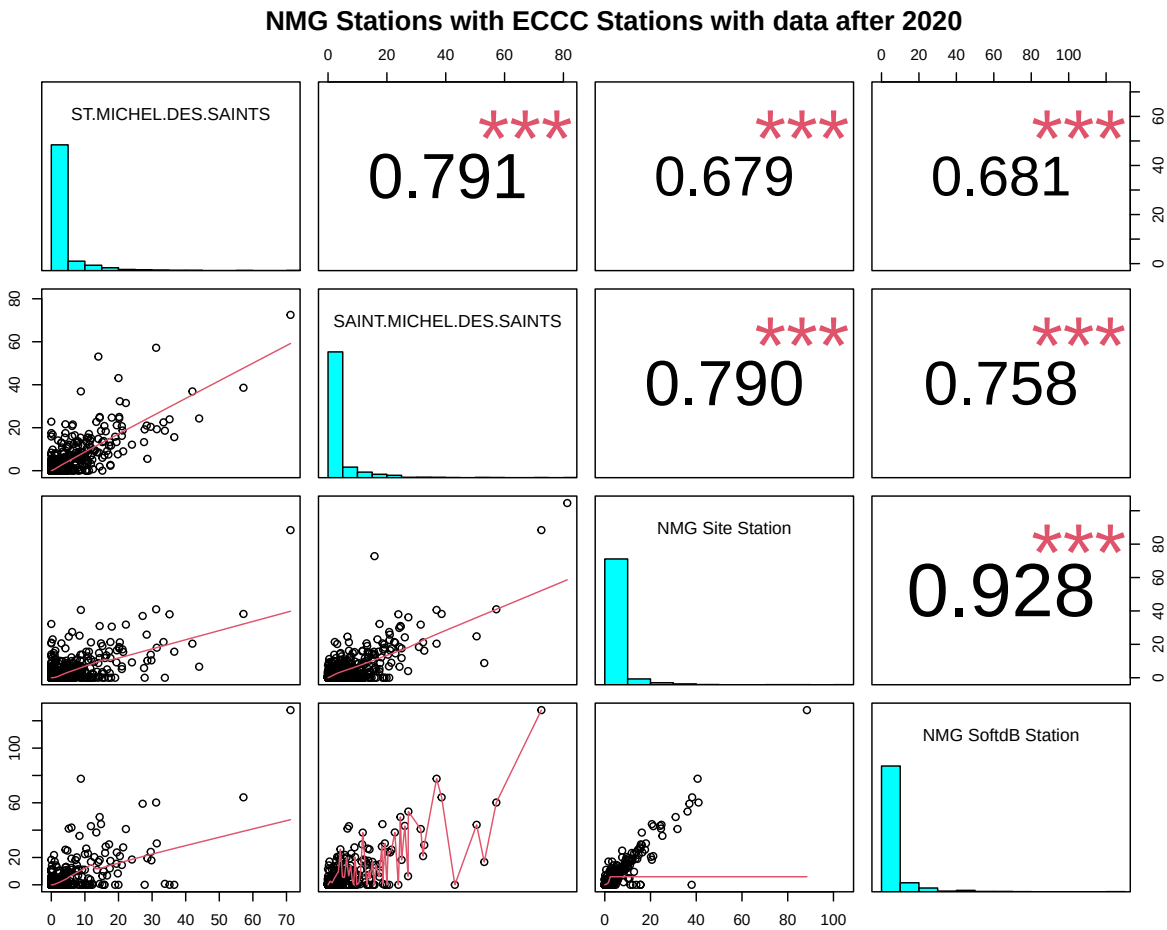
6.1 ECCC and NMG Stations data correlations

The following visualization is a correlation matrix between daily precipitation records from stations close to site. On the top right quadrant, the (absolute) value of the correlation is presented together with the result of the Pearson's product moment correlation coefficient as stars. On bottom-left quadrant the bivariate scatterplots, with a fitted line are presented. On the diagonal there is an histogram of each variable.

Precipitation from the ECCC stations close to site correlate well between each other. Similarly, NMG station records correlate well with both ECCC Saint Michel des Saints stations, but the best correlation is found between both NMG stations.


ECCC Stations with data between 1980 and 2000
ST.MICHEL.DES.SAINTS
ST.ZENON
ST.DONAT
ST.COME
NOTRE.DAME.DE.LA.MERCI
0.843 ***
0.748 ***
0.728 ***
0.716 ***
0.767 ***
0.784 ***
0.754 ***
0.827 ***
0.880 ***
0.852 ***


ECCC Stations with data between 2000 and 2023
ST.MICHEL.DES.SAINTS
0.704
0.748
0.728
SAINT.MICHEL.DES.SAINTS
0.611
0.633
ST.DONAT
0.827
ST.COME
***



6.2 Reanalysis Evaluation Against Station Records

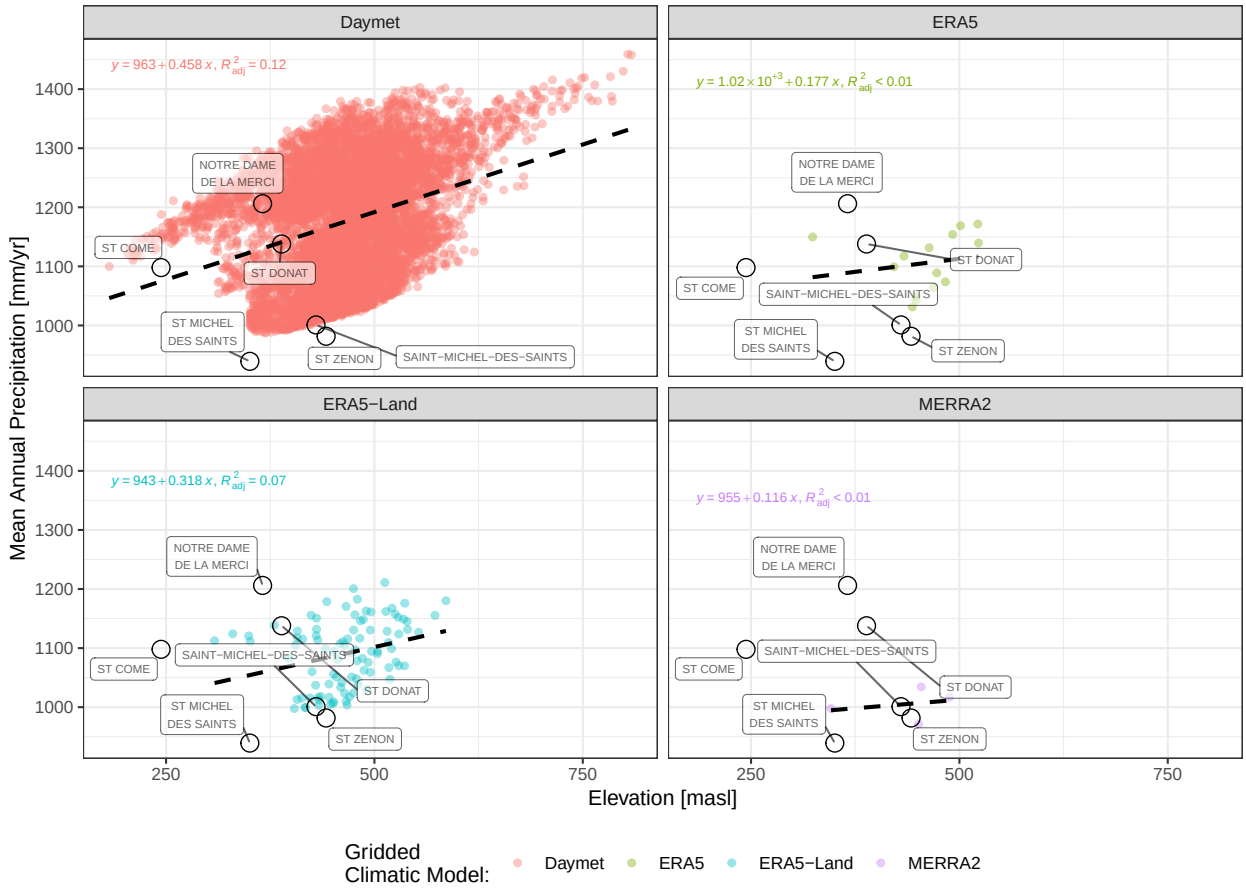
6.2.1 Local MAP Elevation Gradient Comparison

A local MAP to elevation regression is generated with data available within 50km, 30km and 10km from site. NMG stations were excluded for this graph due to only consisting of rainfall data. All the gridded climate models from the previous analysis were kept for reference.

- At an analysis distance of 50km, MAP correlations to elevation for all climate models are poor (R^2 0.2). Similarly no clear relation between MAP and Elevation is evident from the six ECCC stations records within this range.
- At an analysis distance of 30km, MAP correlations to elevation increase (0.4 R^2 0.6). This improvement is significant for Daymet. ERA5, and to a lesser extent ERA5-Land have their data population considerably reduced at this distance so the correlation improvement might not be significant. MERRA2 variability at this scale is not relevant due to it's larger grid size. Only three selected ECCC stations exist within this range.
- At an analysis distance of 10km, Daymet is the only climate model with a data population large enough (i.e. grid size small enough) to be relevant. Daymet shows a clear MAP to Elevation gradient at this scale. Only two selected ECCC stations exist within this range.

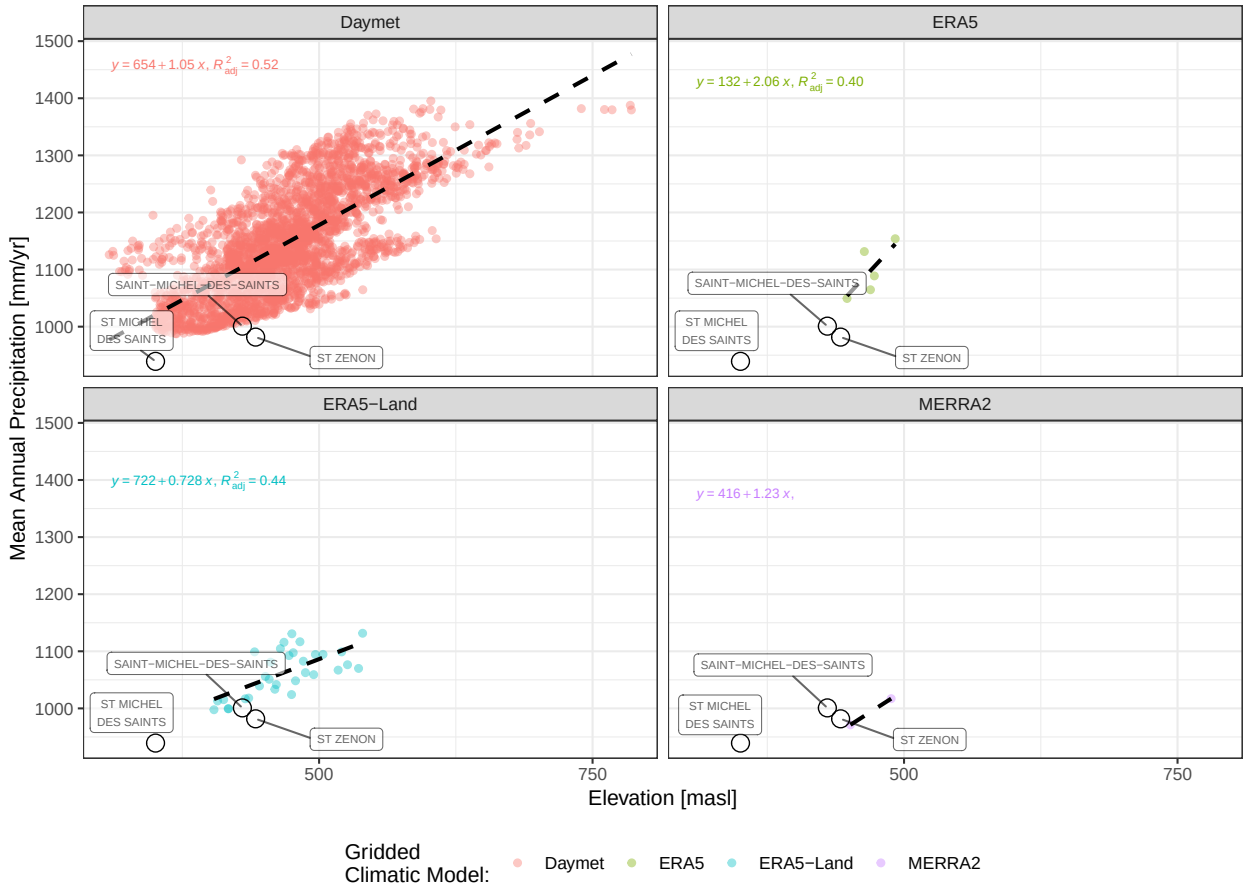
Graph 1: Elevation Gradient for MAP within 50km of Site (1980 to 2023)

Near site comparison of Gridded Climatic Models and ECCC Stations

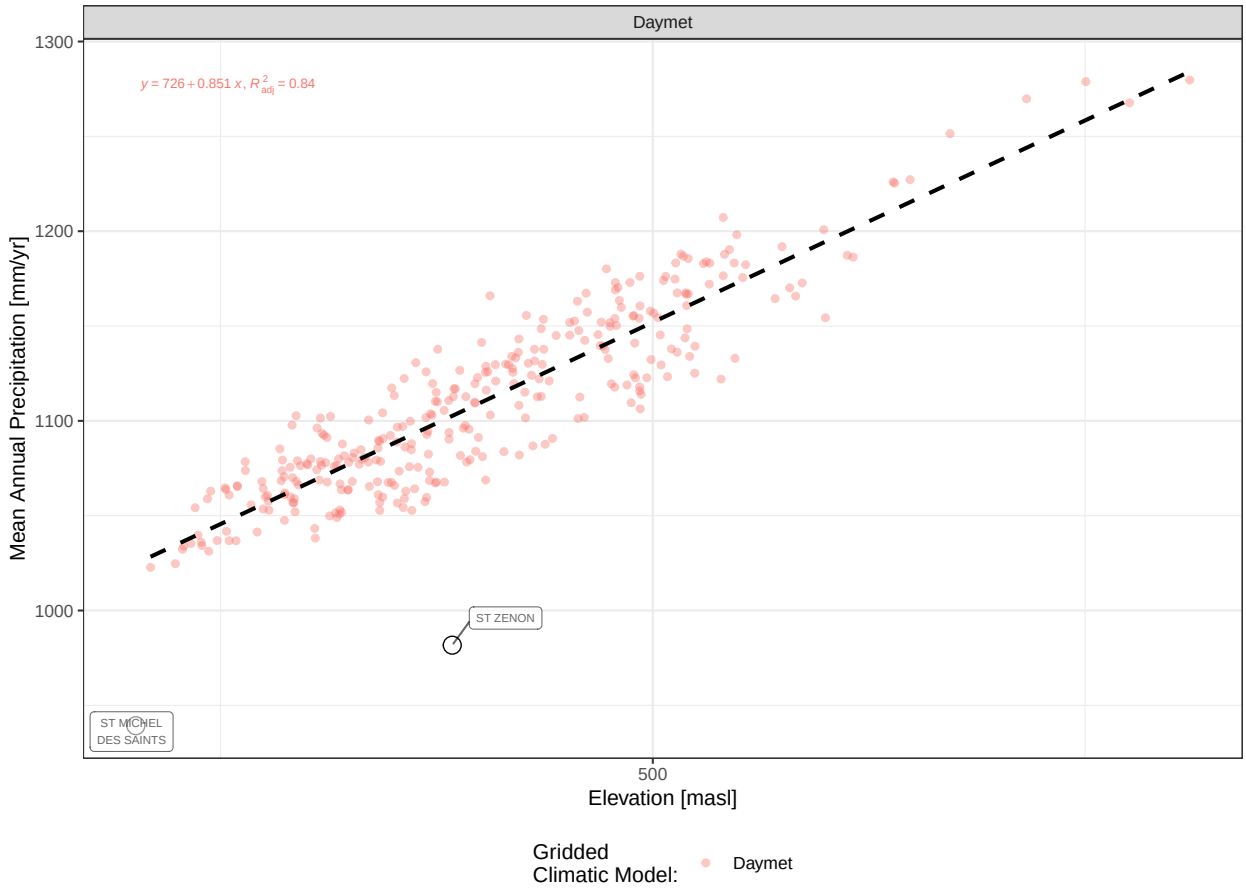


Graph 2: Elevation Gradient for MAP within 30km of Site (1980 to 2023)

Near site comparison of Gridded Climatic Models and ECCC Stations



Graph 3: Elevation Gradient for MAP within 10km of Site (1980 to 2023)
Near site comparison of Daymet and ECCC Stations



6.2.2 Station to Climate Model - Monthly Correlations

Monthly correlations between station and climate model data at each location help comparing model coherence with measured data and highlight seasonal bias. Monthly analysis allows inclusion of the NMG stations records that only collect rainfall. The ECCC stations within 50km of site were kept for this analysis.

The main findings of this section are summarized below:

- All the climate models present good correlation with ECCC station data. Daymet shows the strongest correlation with all ECCC stations for monthly precipitation.
- NMG station records are too short for the results of this test to be significant, although good correlation with all the climate models can be inferred. Site station records span four years only, but all climate models except MERRA2 appear to overestimate precipitation compared to NMG records (only considering May to Oct).

6.2.2.1 Functions Definition

A function is defined to compare monthly station records against data produced for the same location by all four climate models included in this study.

- Monthly precipitation results are summarized in a table comparing climate model results to station records for the same overlapping record period. Only May to October are presented

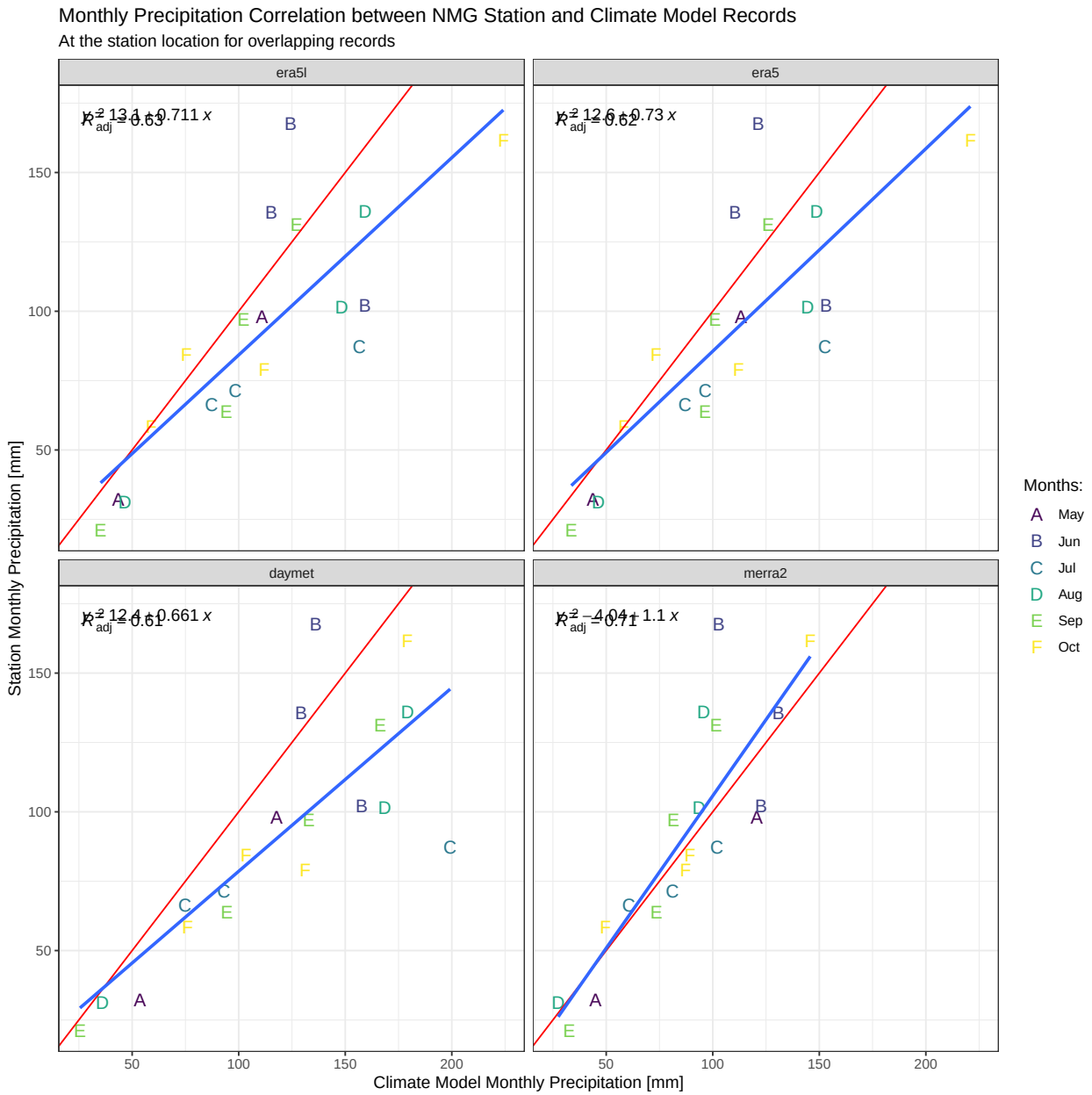
for NMG stations to remove bias related to unmeasured snowfall.

- The plot shows correlation between each station monthly data and all four climate models for the same overlapping record period.

6.2.2.2 Monthly Correlations for NMG Site

Table 6.1: Monthly Summary of Reanalysis Data matching Observed Data at NMG Site

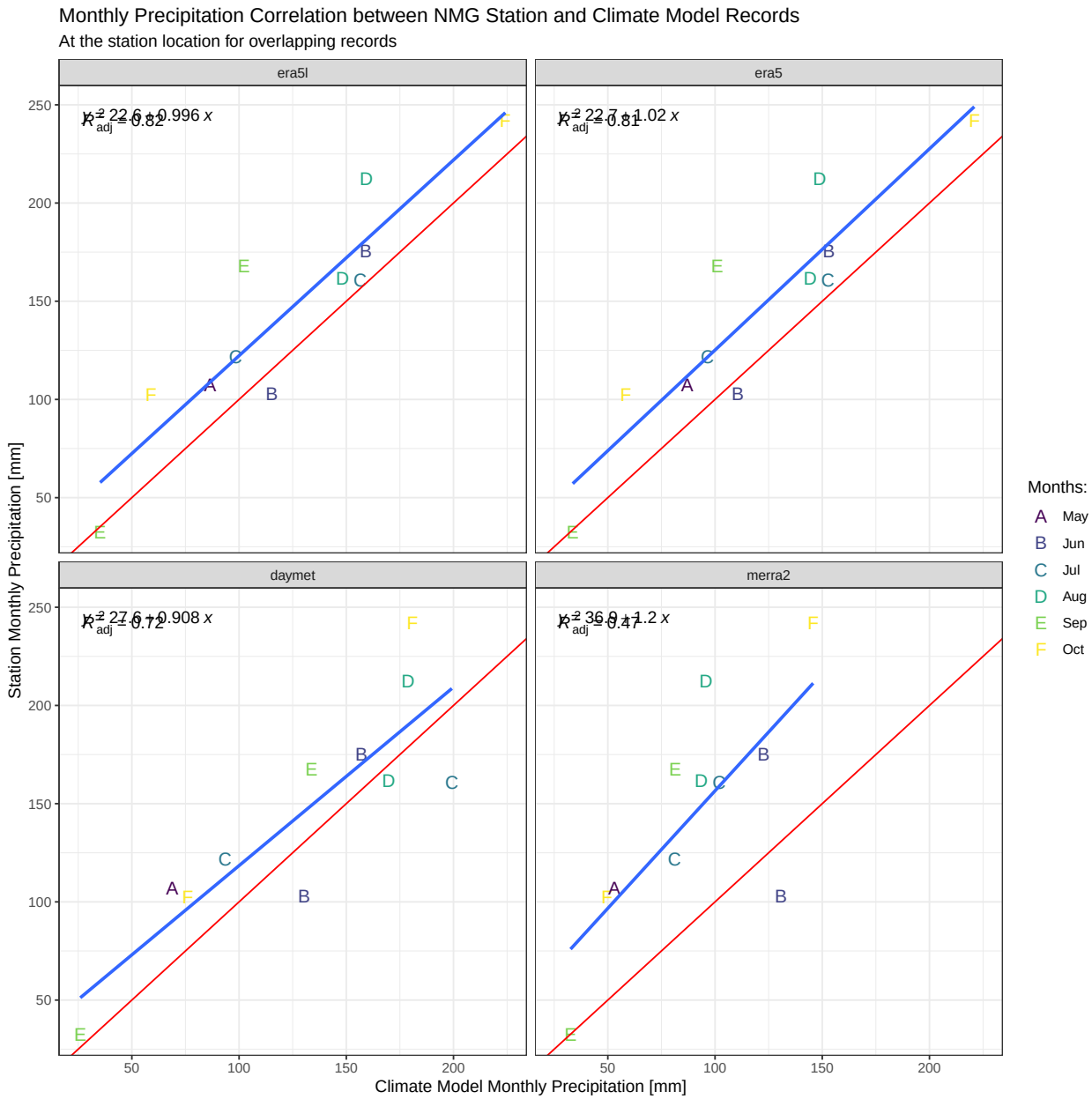
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	NA	NA	NA	NA	77.2	133	114.1	118.1	89.7	117.6	NA	NA	NA
era5	NA	NA	NA	NA	78.5	128.3	112	113.2	89.3	116.1	NA	NA	NA
daymet	NA	NA	NA	NA	85.7	141.1	122.4	128	104.8	122.4	NA	NA	NA
merra2	NA	NA	NA	NA	82.8	118.8	81.2	72.3	72.3	92.9	NA	NA	NA
station	NA	NA	NA	NA	71.7	144.6	76.2	89.6	78.4	96	NA	NA	NA



6.2.2.3 Monthly Correlations for NMG SoftdB

Table 6.2: Monthly Summary of Reanalysis Data matching Observed Data at NMG SoftdB

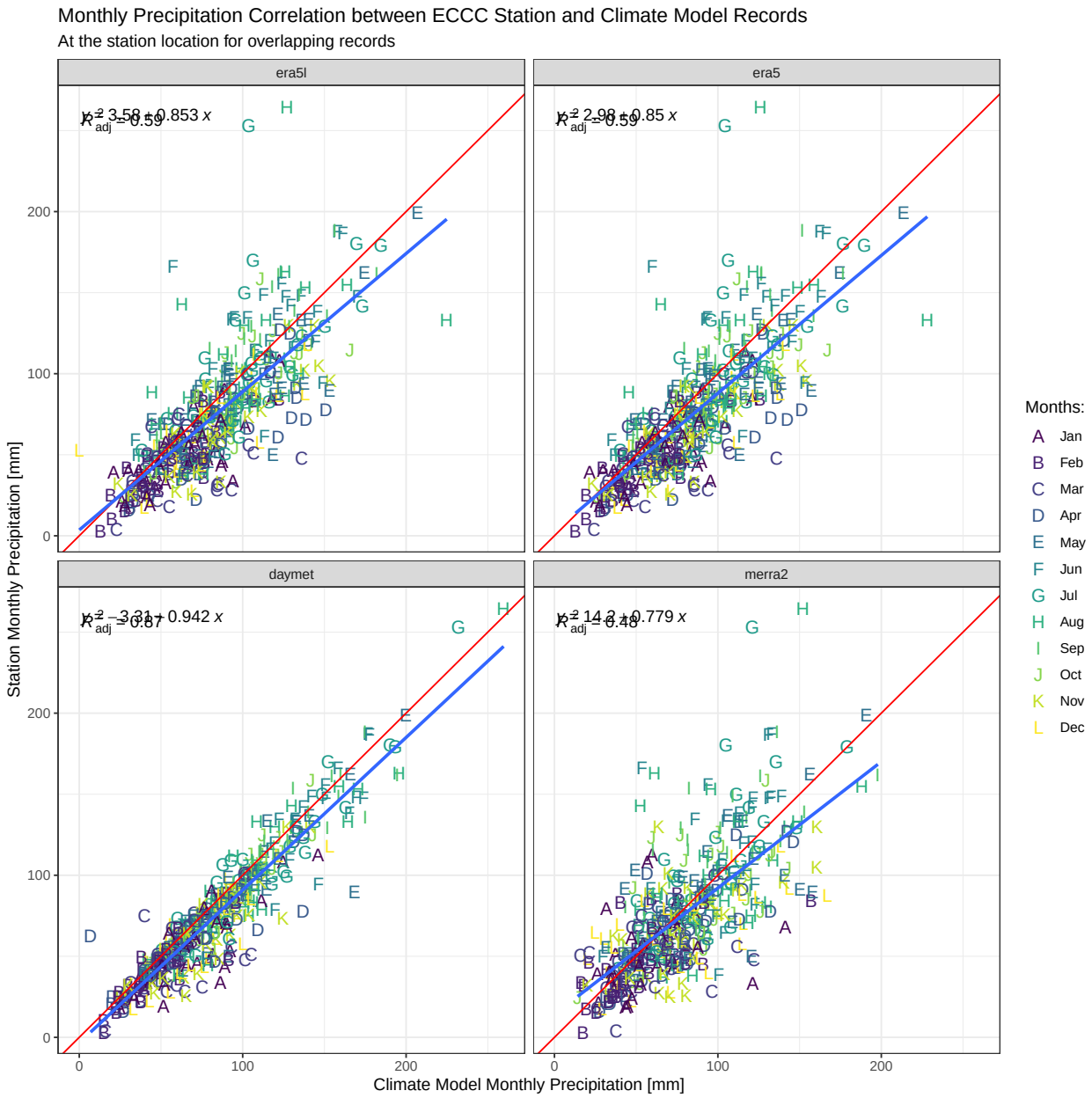
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	NA	NA	NA	NA	86.6	137.2	127.5	153.8	68.7	141.6	NA	NA	NA
era5	NA	NA	NA	NA	87	131.9	124.5	146.6	67.3	139.6	NA	NA	NA
daymet	NA	NA	NA	NA	68.8	143.8	146.3	174.3	79.9	128.4	NA	NA	NA
merra2	NA	NA	NA	NA	53.1	126.7	91.5	94.7	57	97.6	NA	NA	NA
station	NA	NA	NA	NA	108	174.6	141.4	187.2	100.2	172.4	NA	NA	NA



6.2.2.4 Monthly Correlations for ST MICHEL DES SAINTS

Table 6.3: Monthly Summary of Reanalysis Data matching Observed Data at ST MICHEL DES SAINTS

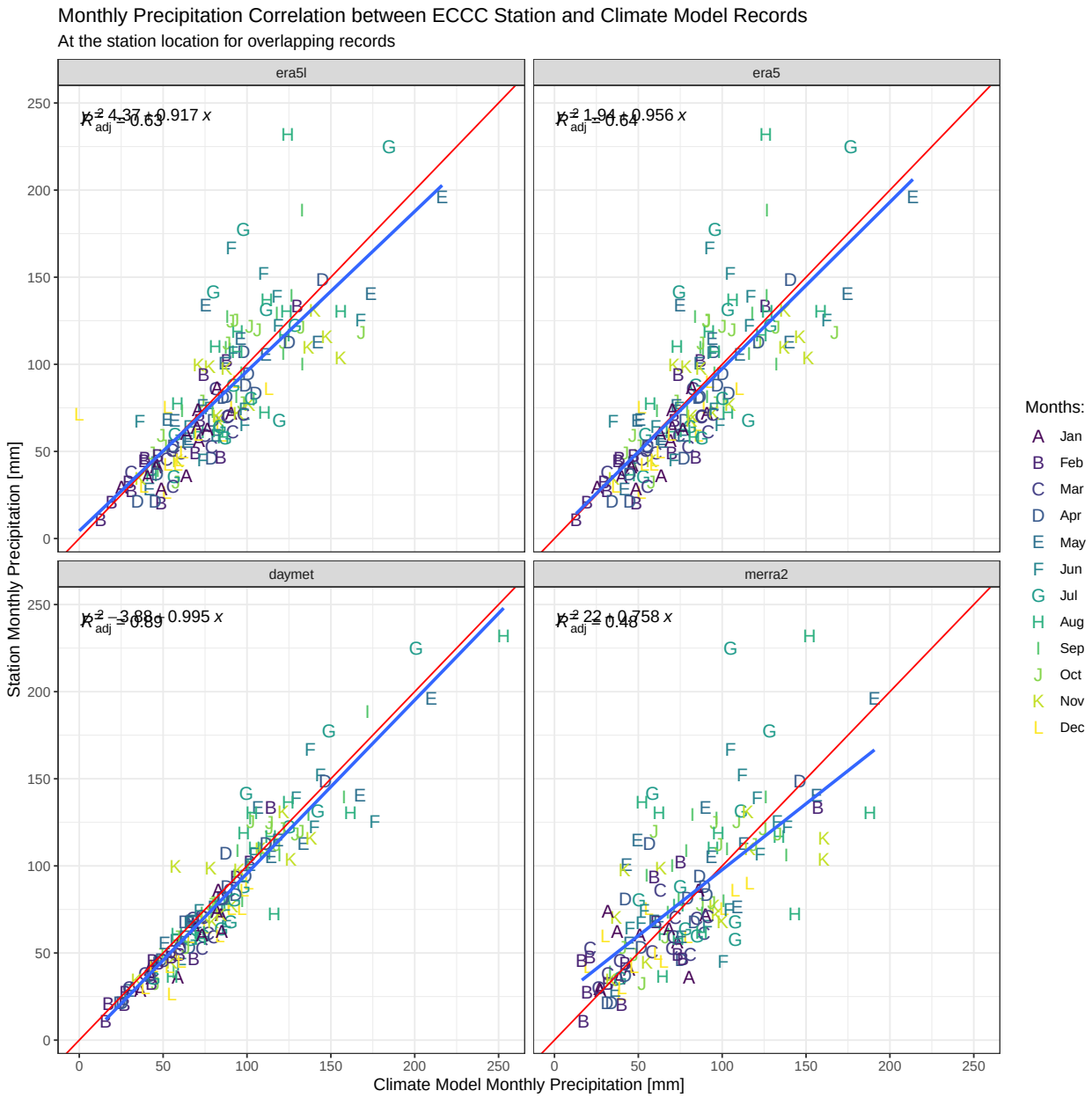
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	65.6	56.2	69.1	88.4	93.9	100.4	102.6	96	97.4	91.3	86.7	77.5	1025
era5	66.1	56.7	69.6	89.4	95.3	101.9	104.2	97	97.7	92.2	87.4	80.4	1038
daymet	66.1	51.3	61	74.4	90.3	112.8	109.7	102.5	105.4	90.1	79.9	76.3	1020
merra2	59.6	53.2	62.8	76.2	86	99.5	94.8	94.3	90.4	87	80.1	77.4	961.3
station	55.9	46.8	55.2	65.7	82.4	103.7	99.9	95.6	99.9	83.1	69.9	68.6	926.5



6.2.2.5 Monthly Correlations for ST ZENON

Table 6.4: Monthly Summary of Reanalysis Data matching Observed Data at ST ZENON

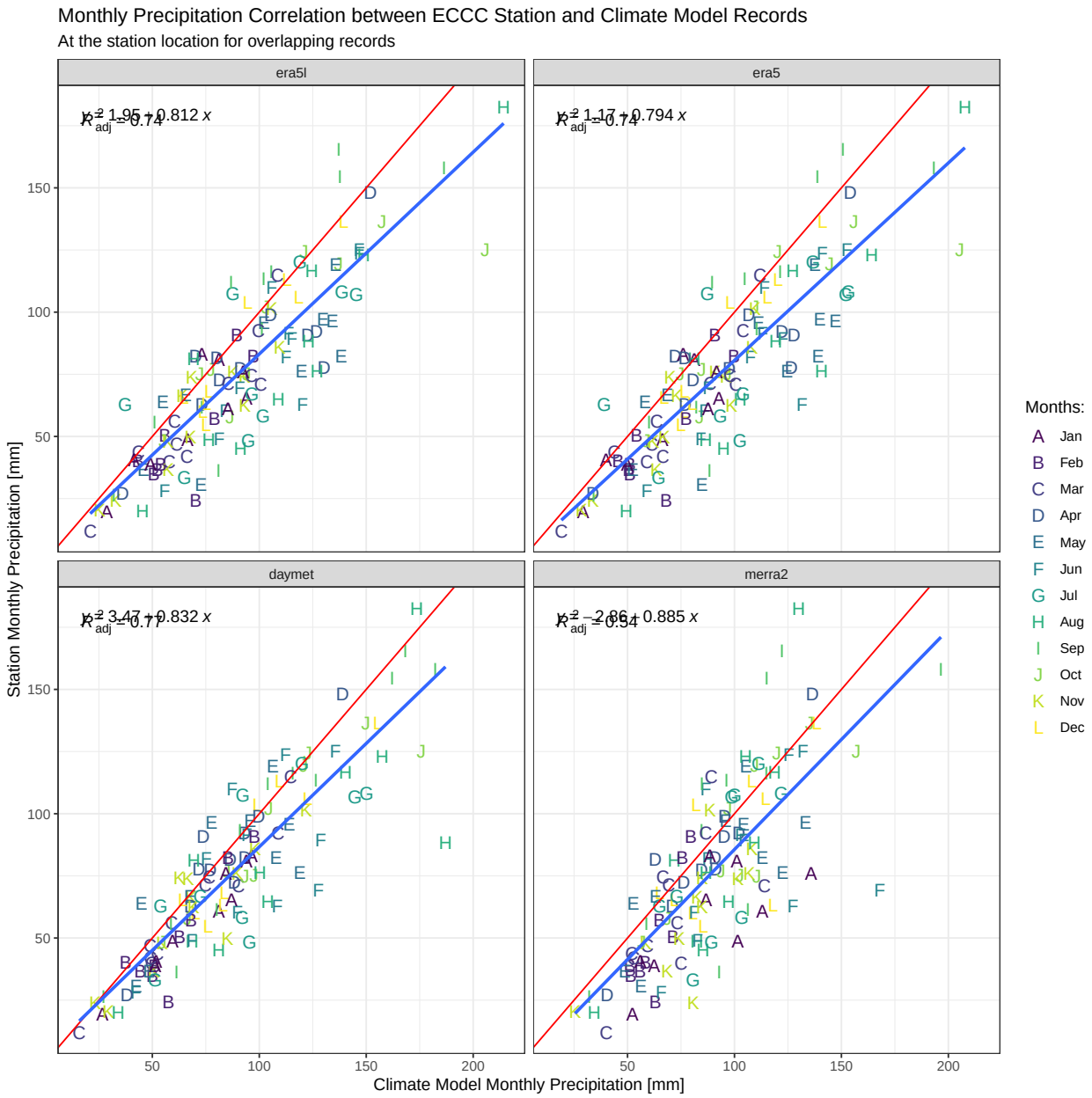
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	61.3	56	68.2	84.9	95.6	91.7	100.1	97.2	98.6	90.8	98.1	65.5	1008
era5	61	55.6	67.7	83.3	93.8	89.8	96.3	95.6	96.8	89.9	97.3	70.1	997.1
daymet	60.9	55.7	62.1	76.2	97.8	101.6	105.6	109.2	105.5	93.9	88.2	71.3	1028
merra2	54.6	53.1	61.4	70	86.4	98.2	86.1	99.2	85.7	86.6	89.7	63.9	935
station	65.6	52.6	62.1	75.2	89	100.5	92.3	105.6	104.7	94.4	88.1	71.6	1002



6.2.2.6 Monthly Correlations for SAINT-MICHEL-DES-SAINTS

Table 6.5: Monthly Summary of Reanalysis Data matching Observed Data at SAINT-MICHEL-DES-SAINTS

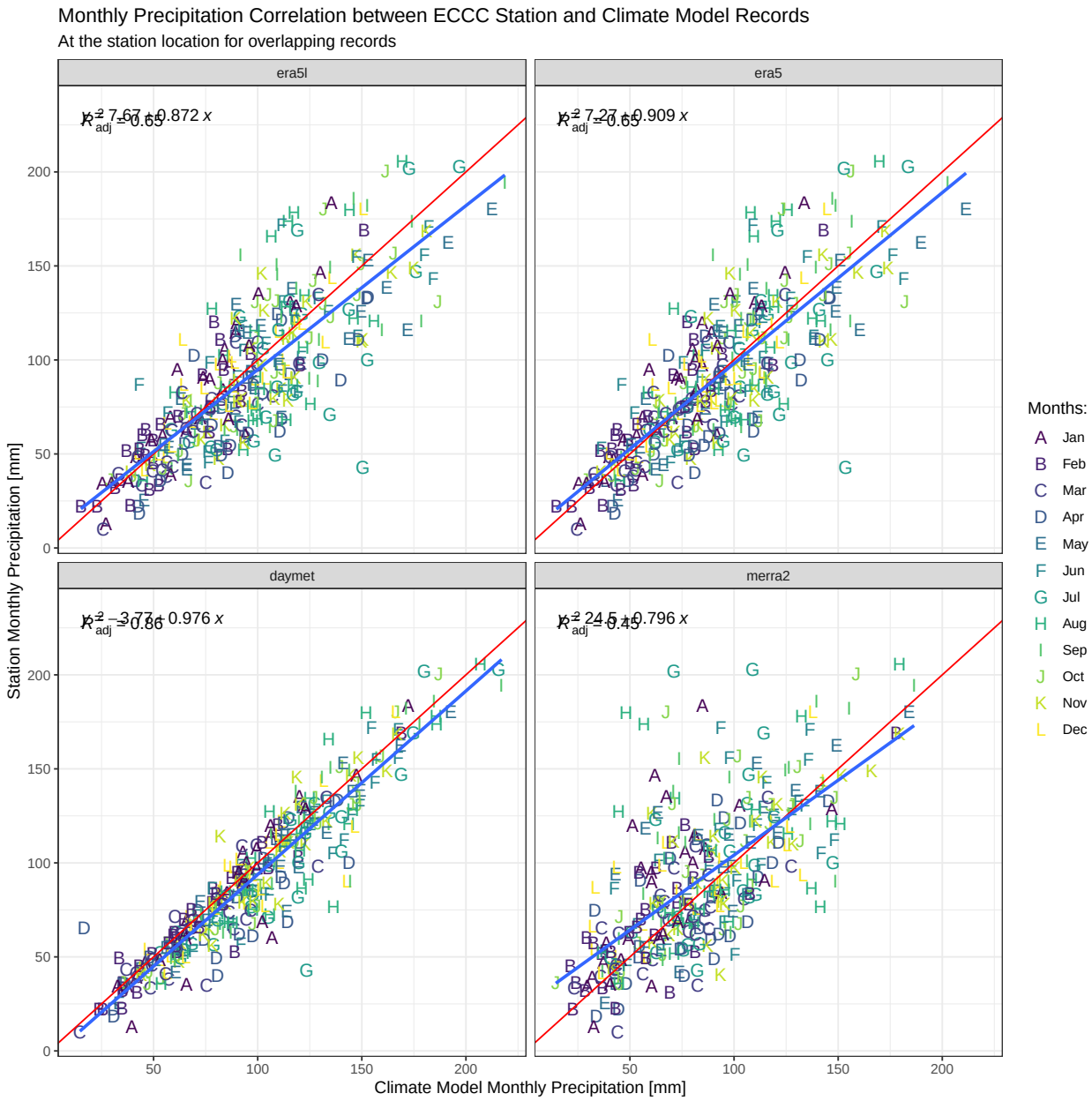
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	68	65.8	72.8	97.2	99.9	106.7	98.5	112.9	99.5	110.9	71.9	92.2	1096
era5	68.3	65.4	74.2	97.8	106.4	109.1	103.7	117.4	106.7	113.4	75.1	94.4	1132
daymet	70.3	61.6	67.3	84.4	82.4	97.3	96.9	111.6	107	107	68.3	95.9	1050
merra2	88.6	63.5	70.8	86.1	89.5	105.8	93.7	92.2	100.4	105	80.4	96	1072
station	57.1	48.6	58.6	82	78.3	87	82.2	84.8	99.5	94.2	60	85.7	918.1



6.2.2.7 Monthly Correlations for ST DONAT

Table 6.6: Monthly Summary of Reanalysis Data matching Observed Data at ST DONAT

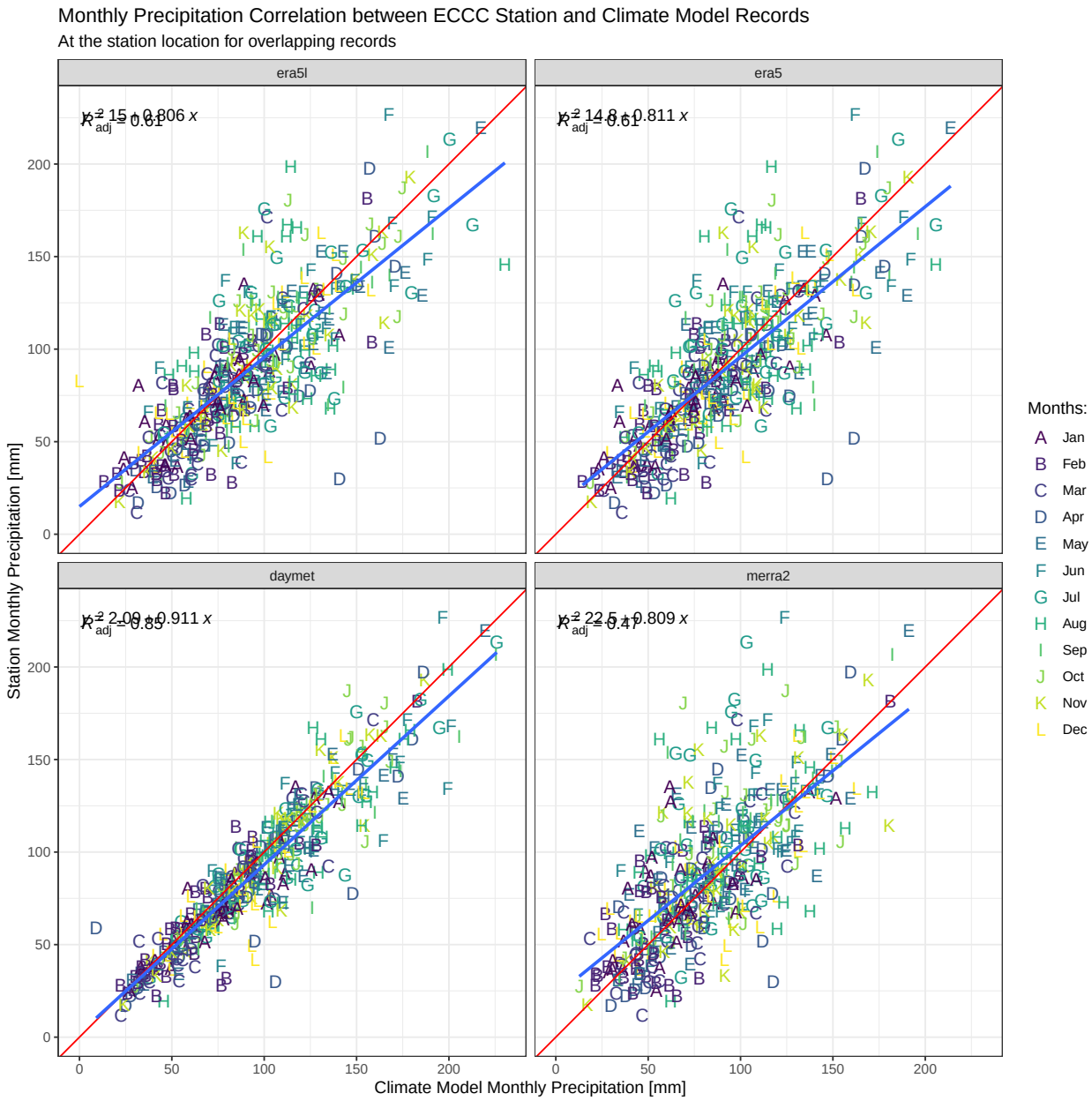
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	74.8	65.2	73.9	94.3	108.7	106.8	117.6	104.6	111.9	105.2	107	88.7	1159
era5	72.5	63.4	71.4	91.4	105.2	102.2	112.9	101.1	106.6	101.4	103.3	85.7	1117
daymet	86.3	68.5	73.2	85	106.1	112.3	114.2	115.1	112.2	107.6	101.7	93.7	1176
merra2	66.8	60.1	70.4	80.8	92.5	98.1	89.4	93.4	92.1	92.9	95.6	81.8	1014
station	84.6	66.4	69.5	72.3	95.7	105.9	102.9	102.9	105.2	101.2	95	96	1098



6.2.2.8 Monthly Correlations for ST COME

Table 6.7: Monthly Summary of Reanalysis Data matching Observed Data at ST COME

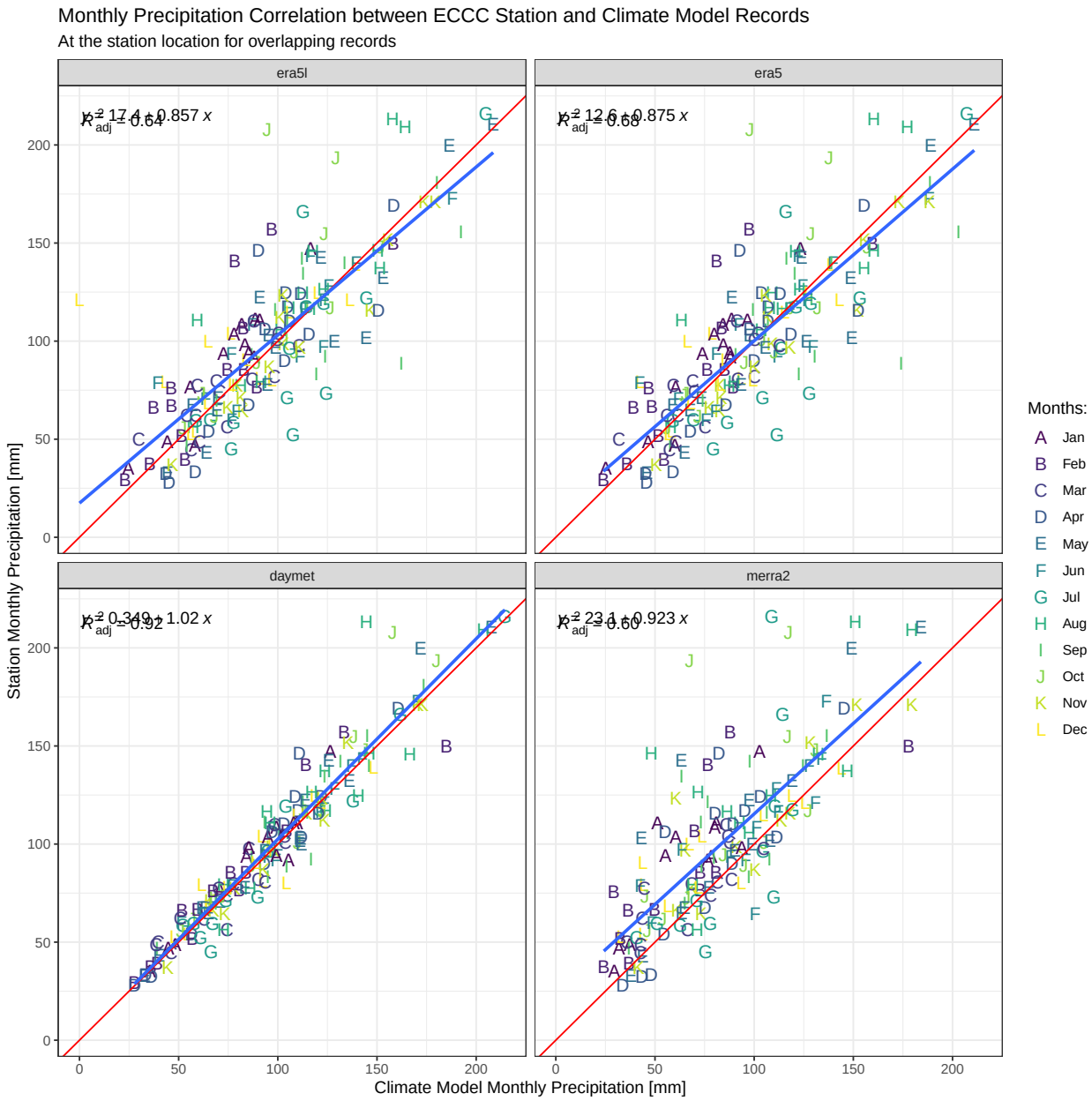
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	73.9	64.6	75.1	95.1	103.4	108	111.3	104.8	105	103	95	85.6	1125
era5	75.6	65.8	75.5	97.6	101.5	105.1	104.2	100.9	104	103.7	96.8	89.9	1120
daymet	80.8	66.5	75.4	90.5	100.1	116.6	114	112.2	111.3	109	97.4	92	1166
merra2	68.2	60.9	72	82.2	87.9	99.4	91	93.8	89.6	93.1	88	86.9	1013
station	74	64.9	71.3	72.9	87.7	102.7	100.1	98.9	103.7	95.1	91.6	89.1	1052



6.2.2.9 Monthly Correlations for NOTRE DAME DE LA MERCI

Table 6.8: Monthly Summary of Reanalysis Data matching Observed Data at NOTRE DAME DE LA MERCI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	74.5	68.3	74.5	95.8	108.5	104.6	109.4	113.7	119.6	98.7	109.6	81	1158
era5	76.9	69.5	75.9	96.8	109.7	106.8	113.7	116.4	125.2	102.9	113.4	89.8	1197
daymet	85.6	79.7	73.9	90.4	102.5	105.3	100.2	120.8	110.8	106.7	104	91.1	1171
merra2	64.9	65.2	68.4	79	88.7	99.5	87.2	101.8	87.6	87.8	96.4	78.6	1005
station	93.7	76	80.7	89.7	103.4	110.3	97.6	114.8	109	110.4	99.3	103	1188

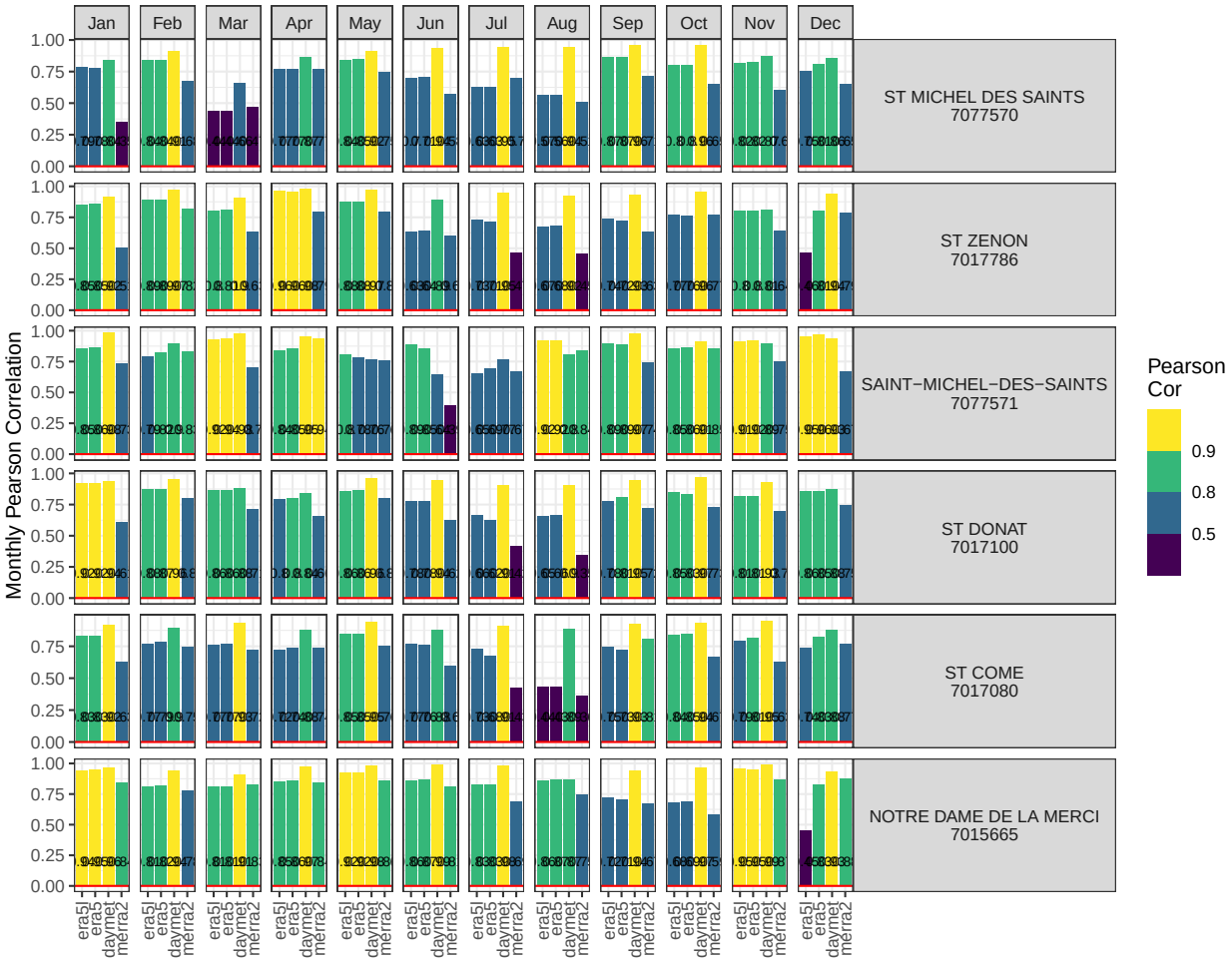


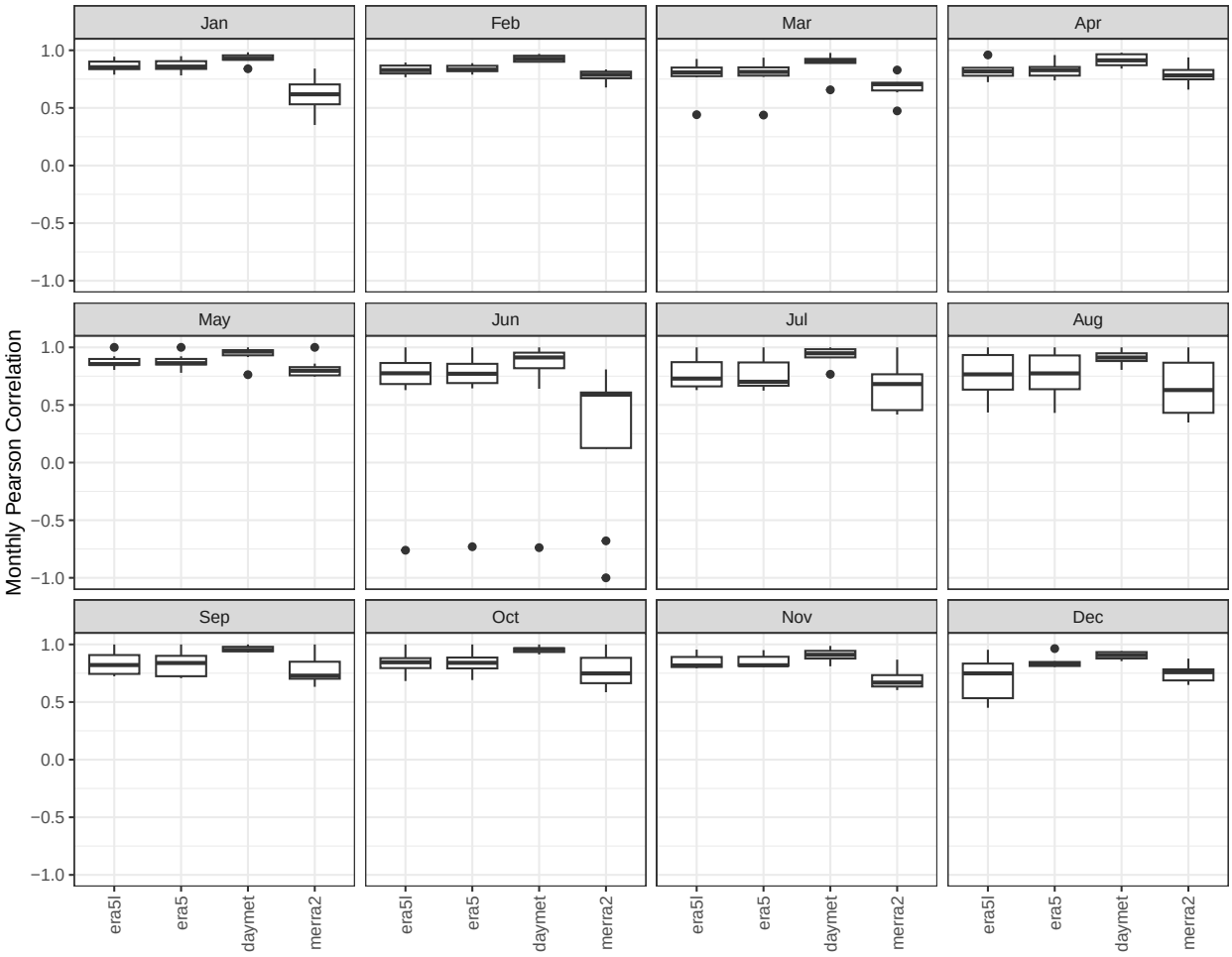
6.2.3 Monthly Pearson Correlation Coefficient

The Pearson correlation coefficient (PCC) is a correlation coefficient that measures linear correlation (and linear only) between two sets of data. It represents a normalized measurement of the covariance, such that the result always has a value between −1 and 1. A value of 0 represents no linear correlation between both datasets. A value of 1 represents perfect positive linear correlation, and a value of -1 perfect negative linear correlation.

Monthly data reviewed in the previous section is summarized in the following figures that represent PCC monthly for ECCC stations versus climate models comparisons.

Daymet generally presents the better linear correlations with station data year round.


Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
ST MICHEL DES SAINTS
7077570
ST ZENON
7017786
SAINT−MICHEL−DES−SAINTS
7077571
ST DONAT
7017100
ST COME
7017080
NOTRE DAME DE LA MERCI
7015665
Monthly Pearson Correlation
1.00
0.75
0.50
0.25
0.00
era5l
era5
daymet
merra2
Pearson
Cor
0.9
0.8
0.5


Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Monthly Pearson Correlation
1.0
0.5
0.0
−0.5
−1.0
era5l
era5
daymet
merra2

Chapter 7

Rainfall and Snowfall Analysis

Total precipitation relationships across stations and areas can be better interpreted by dividing precipitation records into components of rainfall and snowfall.

Given regional trends, the analysis was completed at a local scale (50 km) using all available ECCC records and four reanalysis products: Daymet, ERA5, ERA5-Land, and MERRA2.

The division of rainfall and snowfall for reanalysis products was directly based on zero degrees. Different methods for partitioning total precipitation for local stations and outcomes are evaluated and summarized in a subsequent review.

- Rainfall = total precipitation when Tavg>0
- Snowfall = total precipitation when Tavg 0

Main findings of this section are:

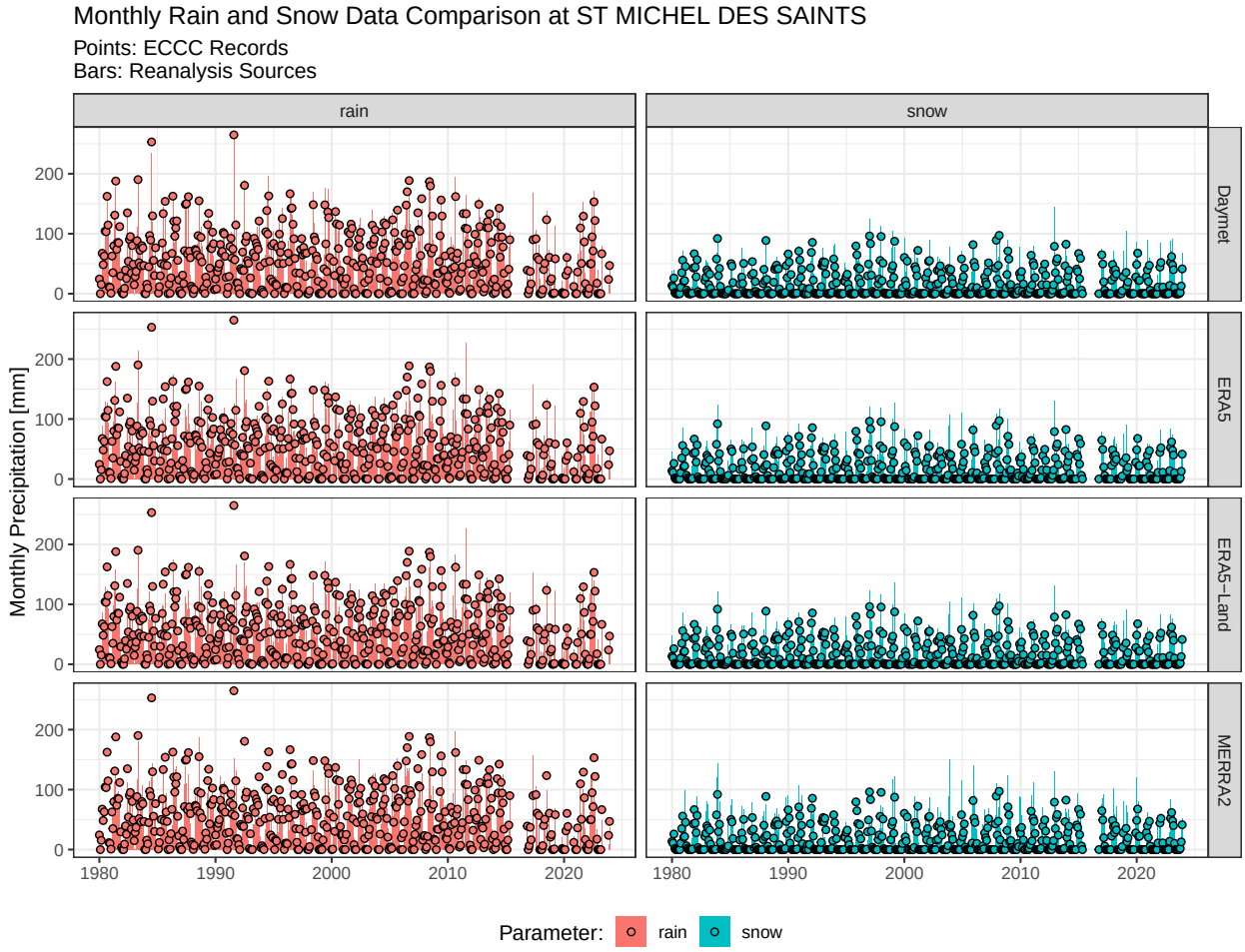
- Daymet is the reanalysis tool that best correlates with ECCC rain and snow data in the project region.
- Reanalysis tools (including Daymet) present bias compared to ECCC measured data. Generally, precipitation, rain and/or snow values presented by the reanalysis tools are greater than measured values reported by ECCC.
- Reanalysis snow records generally present more bias than reanalysis rainfall records when compared to ECCC measured data.

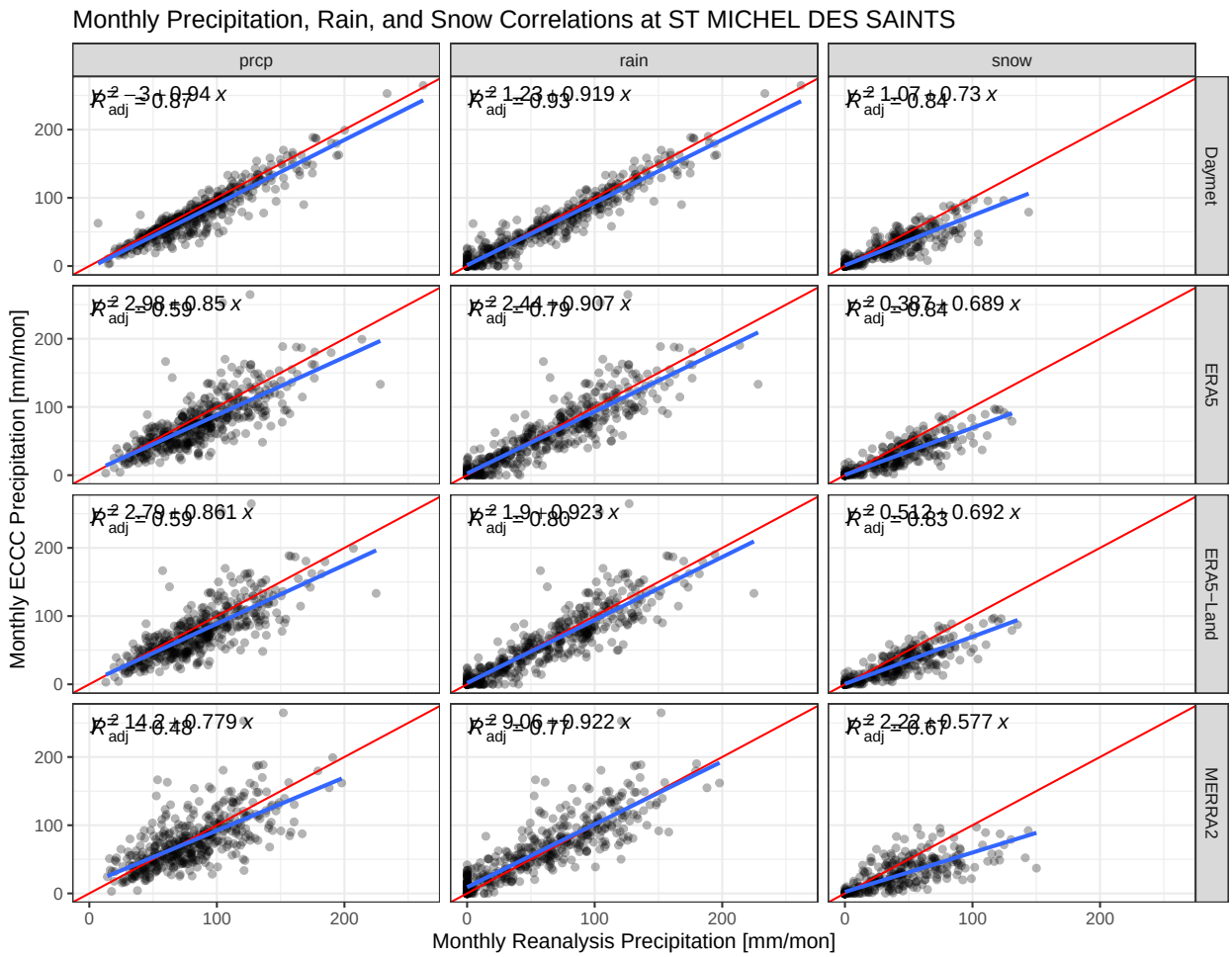
7.1 Rain/Snow ST MICHEL DES SAINTS

Table 7.1: Mean Rain and Snow Monthly Values at ST MICHEL DES SAINTS

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
prcp	ECCC	52	45	52	66	83	106	103	95	101	84	68	64	921
prcp	Daymet	66	51	61	74	90	113	110	102	105	90	80	76	1018
prcp	ERA5	66	57	70	89	95	102	104	97	98	92	87	80	1038
prcp	ERA5-Land	66	56	69	88	94	100	103	96	97	91	87	80	1027
prcp	MERRA2	60	53	63	76	86	100	95	94	90	87	80	77	961
rain	ECCC	10	6	19	52	83	106	103	95	101	81	42	12	709
rain	Daymet	7	6	19	61	90	113	110	102	105	86	44	12	756

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
rain	ERA5	7	7	22	70	95	102	104	97	98	86	45	13	746
rain	ERA5-Land	7	7	22	69	94	100	103	96	97	87	45	13	740
rain	MERRA2	2	2	8	49	86	100	95	94	90	80	37	6	649
snow	ECCC	43	39	35	13	0	0	0	0	0	3	25	50	208
snow	Daymet	60	48	42	12	0	0	0	0	0	4	36	66	268
snow	ERA5	60	52	48	19	0	0	0	0	0	6	42	68	295
snow	ERA5-Land	59	52	48	20	0	0	0	0	0	4	41	67	291
snow	MERRA2	60	52	55	27	0	0	0	0	0	7	43	70	315



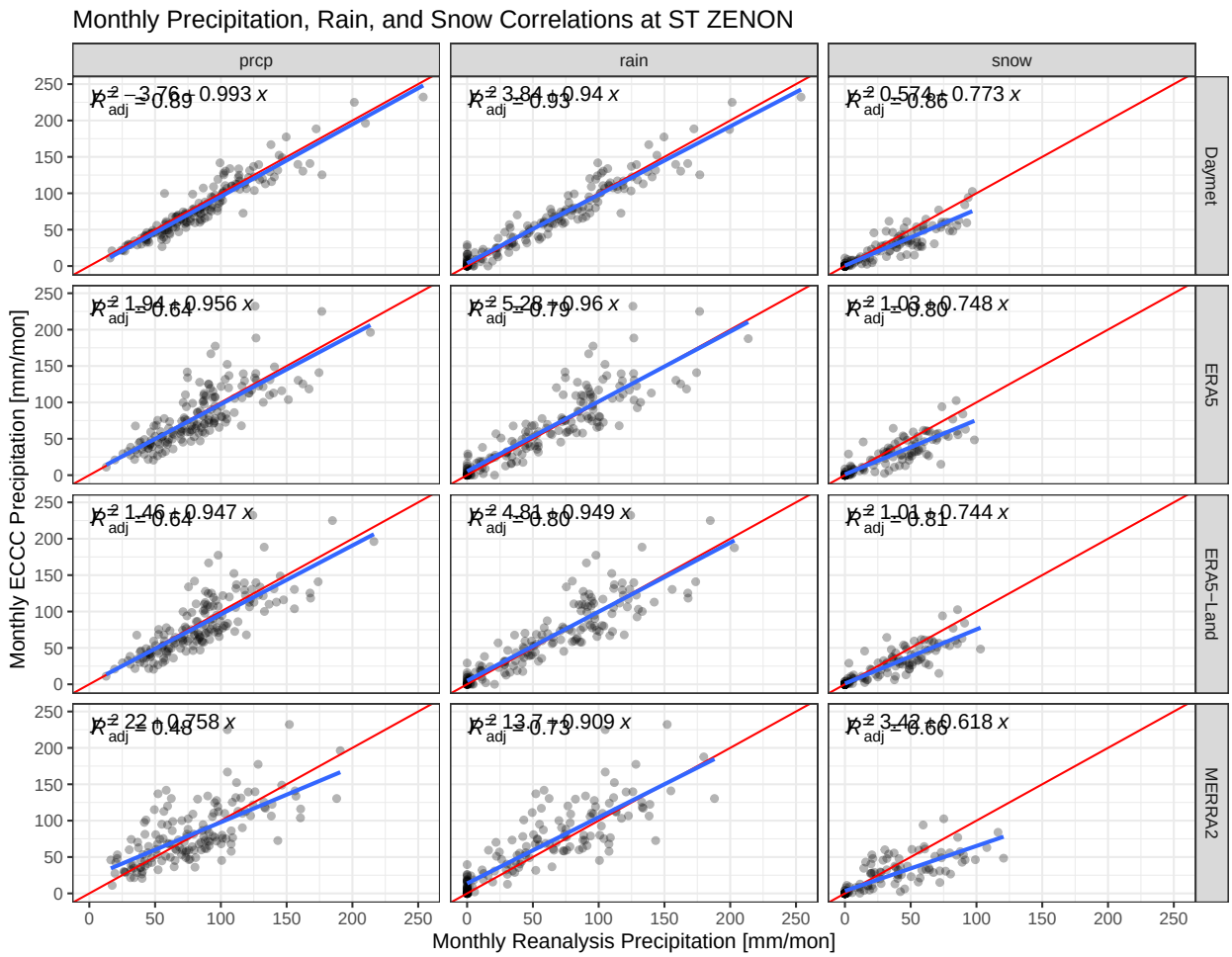


7.2 Rain/Snow ST ZENON

Table 7.2: Mean Rain and Snow Monthly Values at ST ZENON

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
prcp	ECCC	53	53	56	75	94	96	104	104	104	93	86	58	976
prcp	Daymet	61	56	62	76	98	102	106	109	106	94	88	72	1030
prcp	ERA5	61	56	68	83	94	90	96	96	97	90	97	70	997
prcp	ERA5-Land	61	56	68	85	96	92	100	97	99	91	98	71	1013
prcp	MERRA2	55	53	61	70	86	98	86	99	86	87	90	64	935
rain	ECCC	9	9	22	59	93	96	104	104	104	90	56	10	755
rain	Daymet	3	7	22	60	97	102	106	109	106	88	46	6	753
rain	ERA5	3	10	26	67	94	90	96	96	97	86	48	6	719
rain	ERA5-Land	3	8	26	67	95	92	100	97	99	89	52	6	733
rain	MERRA2	0	5	10	50	85	98	86	99	86	81	38	3	642
snow	ECCC	44	45	34	16	1	0	0	0	0	4	31	47	220
snow	Daymet	59	48	40	16	1	0	0	0	0	6	43	65	277
snow	ERA5	59	46	41	16	0	0	0	0	0	4	49	64	279
snow	ERA5-Land	60	48	42	18	1	0	0	0	0	2	46	64	281
snow	MERRA2	54	49	51	20	1	0	0	0	0	5	52	61	292

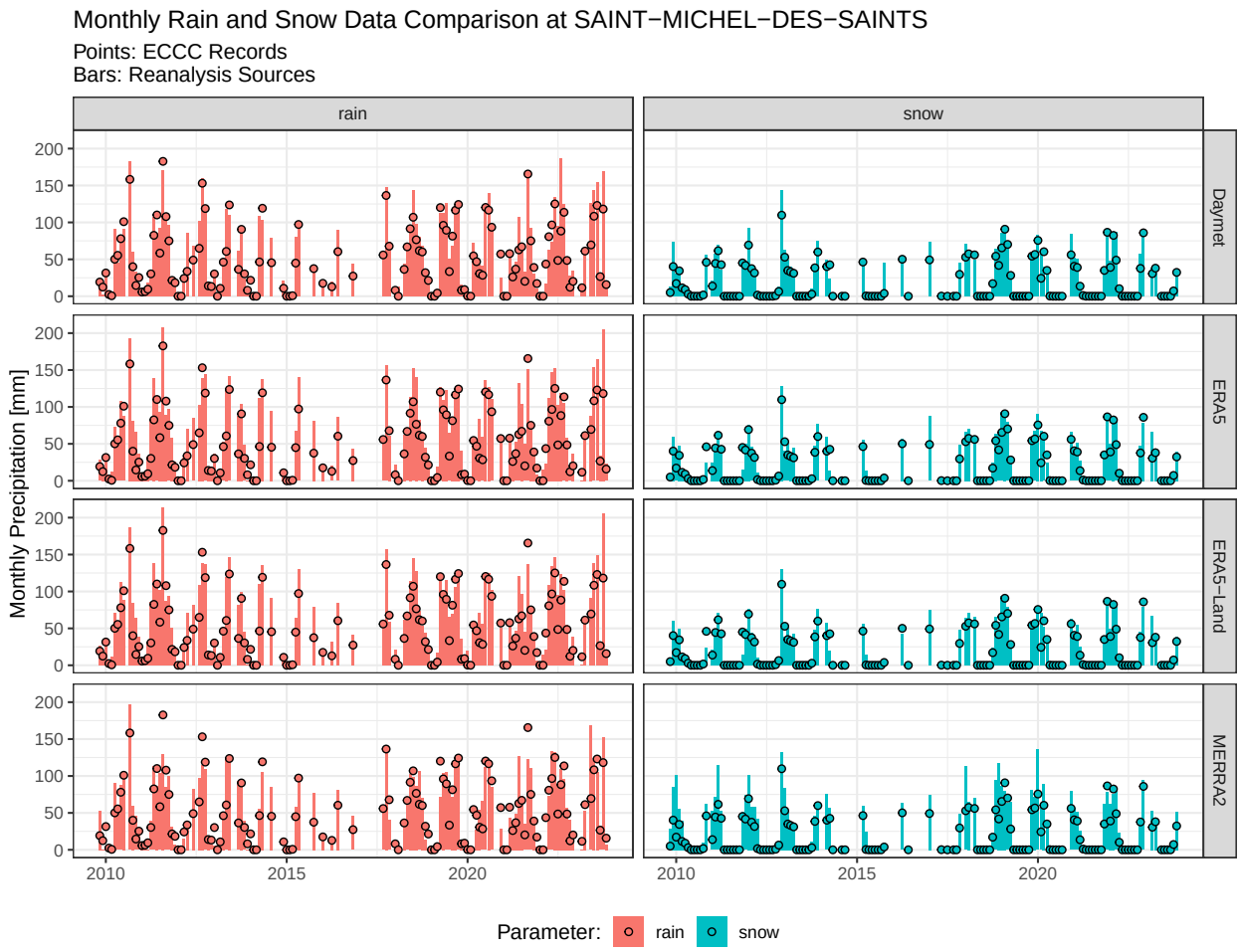
Monthly Rain and Snow Data Comparison at ST ZENON
Points: ECCC Records
Bars: Reanalysis Sources
rain
snow
Daymet
ERA5
ERA5−Land
MERRA2
Monthly Precipitation [mm]
0
50
100
150
200
250
1980
1985
1990
1995
Parameter:
rain
snow

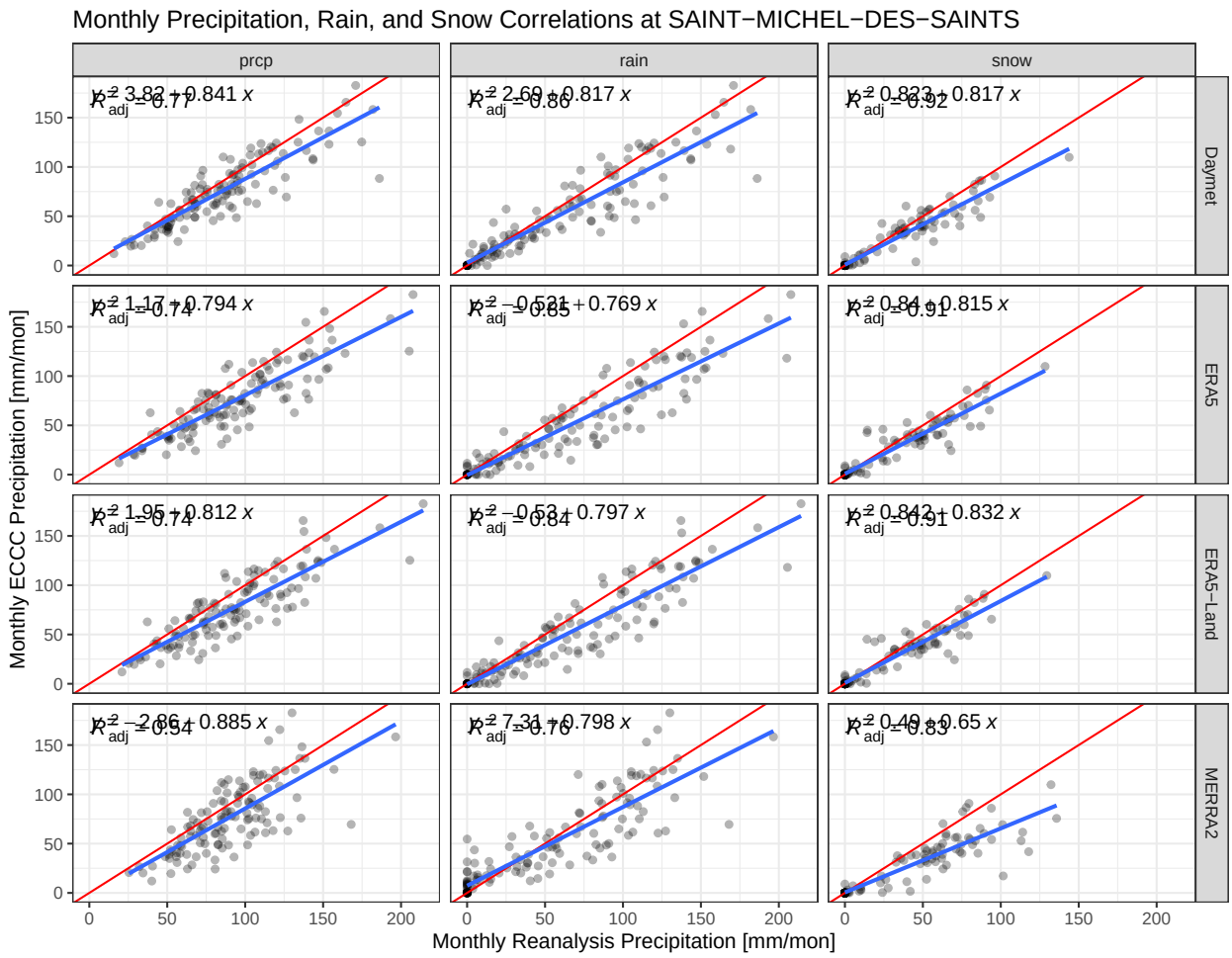


7.3 Rain/Snow SAINT-MICHEL-DES-SAINTS

Table 7.3: Mean Rain and Snow Monthly Values at SAINT-MICHEL-DES-SAINTS

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
prcp	ECCC	57	51	60	83	77	81	79	85	100	94	60	86	913
prcp	Daymet	69	61	66	83	81	96	95	110	106	105	67	95	1033
prcp	ERA5	68	65	74	98	106	109	104	117	107	113	75	94	1132
prcp	ERA5-Land	68	66	73	97	100	107	98	113	99	111	72	92	1096
prcp	MERRA2	89	63	71	86	90	106	94	92	100	105	80	96	1072
rain	ECCC	10	1	20	49	74	81	80	89	99	84	25	19	631
rain	Daymet	8	2	21	64	81	96	100	114	106	96	29	16	734
rain	ERA5	10	3	23	71	105	109	112	121	107	107	41	20	830
rain	ERA5-Land	12	3	22	71	99	107	106	117	99	105	38	20	800
rain	MERRA2	1	0	7	48	89	106	97	93	100	98	31	8	681
snow	ECCC	48	49	41	27	0	0	0	0	0	3	35	64	267
snow	Daymet	62	58	45	23	0	0	0	0	0	8	41	80	316
snow	ERA5	60	62	51	27	1	0	0	0	0	3	36	75	316
snow	ERA5-Land	57	62	51	27	0	0	0	0	0	3	35	74	309
snow	MERRA2	87	63	63	39	0	0	0	0	0	6	52	89	399

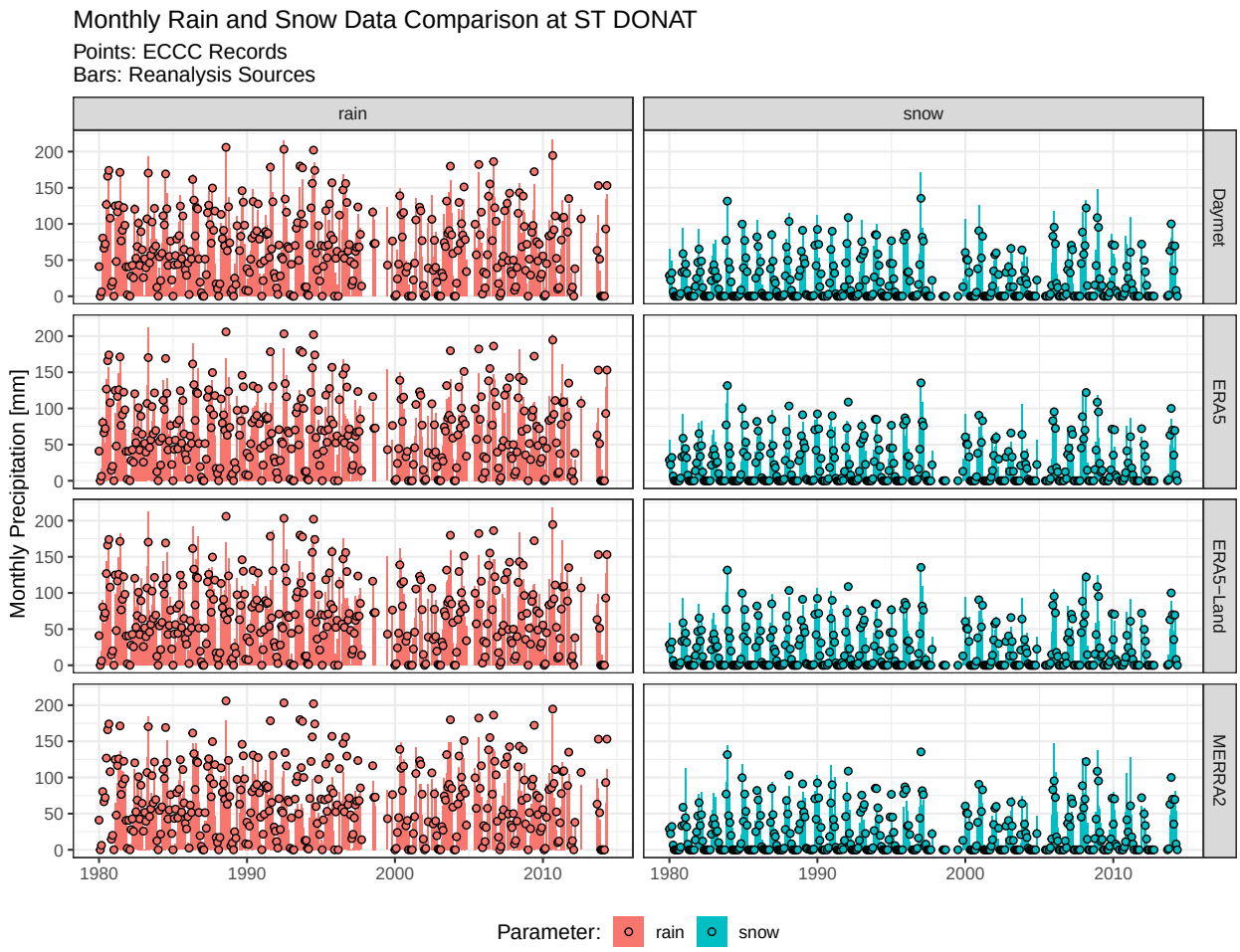

Monthly Rain and Snow Data Comparison at SAINT−MICHEL−DES−SAINTS
Points: ECCC Records
Bars: Reanalysis Sources
rain
snow
Daymet
ERA5
ERA5−Land
MERRA2
Monthly Precipitation [mm]
0
50
100
150
200
2010
2015
2020
Parameter:
rain
snow

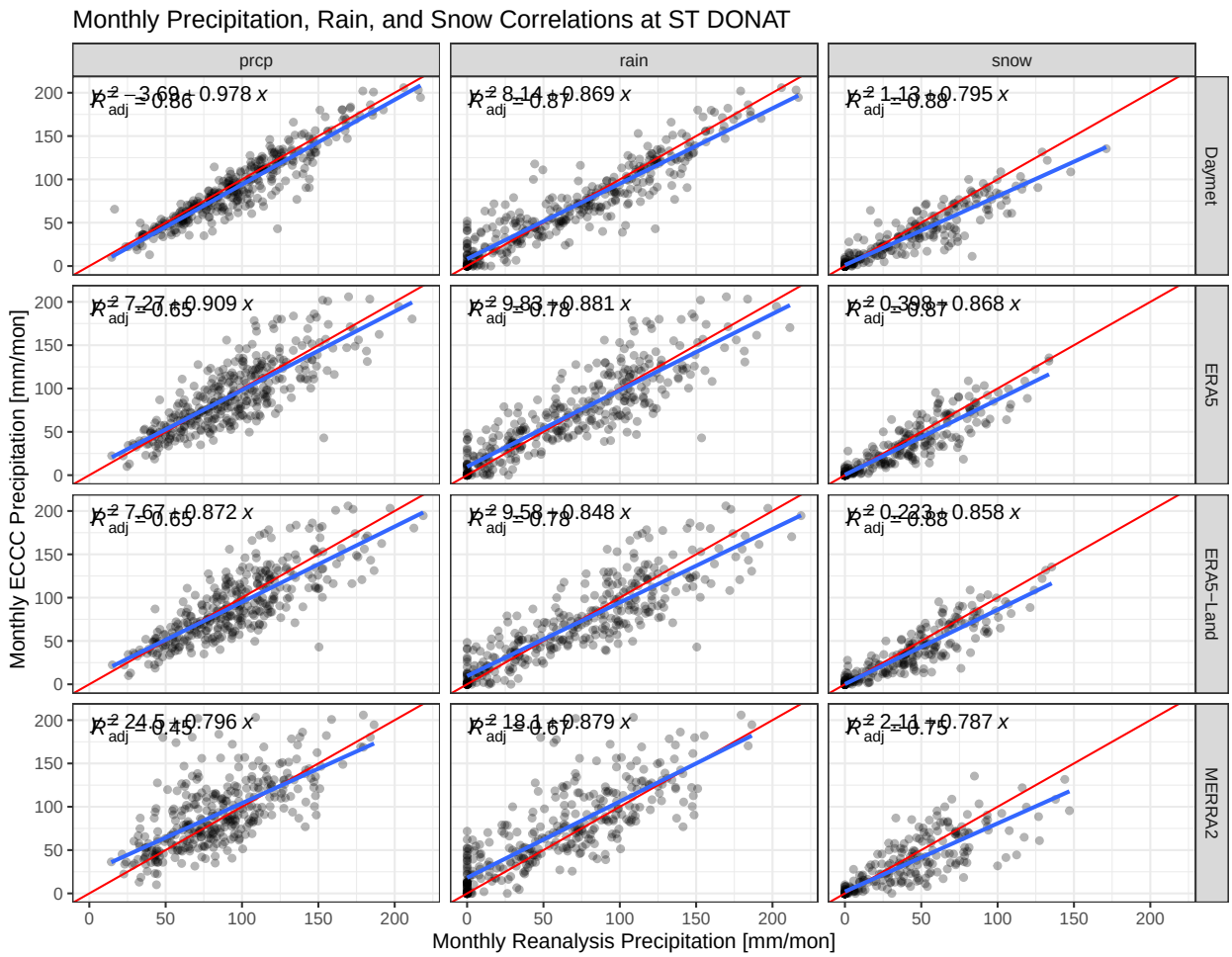


7.4 Rain/Snow ST DONAT

Table 7.4: Mean Rain and Snow Monthly Values at ST DONAT

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
prcp	ECCC	84	68	67	76	100	103	100	105	108	104	98	90	1101
prcp	Daymet	86	68	73	85	106	112	114	115	112	107	101	93	1173
prcp	ERA5	72	63	71	91	105	102	113	101	107	101	103	86	1117
prcp	ERA5-Land	75	65	74	94	109	107	118	105	112	105	107	89	1159
prcp	MERRA2	67	60	70	81	92	98	89	93	92	93	96	82	1014
rain	ECCC	21	15	27	63	99	103	100	105	108	99	65	23	828
rain	Daymet	9	9	22	71	106	112	114	115	112	102	58	12	841
rain	ERA5	8	10	23	76	105	102	113	101	107	95	55	12	807
rain	ERA5-Land	8	10	25	77	108	107	118	105	112	100	59	13	842
rain	MERRA2	4	3	14	60	92	98	89	93	92	87	50	9	691
snow	ECCC	63	52	41	15	1	0	0	0	0	6	31	68	276
snow	Daymet	77	59	51	14	0	0	0	0	0	6	42	82	331
snow	ERA5	65	53	48	18	0	0	0	0	0	7	48	74	313
snow	ERA5-Land	67	56	49	20	1	0	0	0	0	5	46	76	319
snow	MERRA2	63	57	57	21	0	0	0	0	0	6	44	73	322

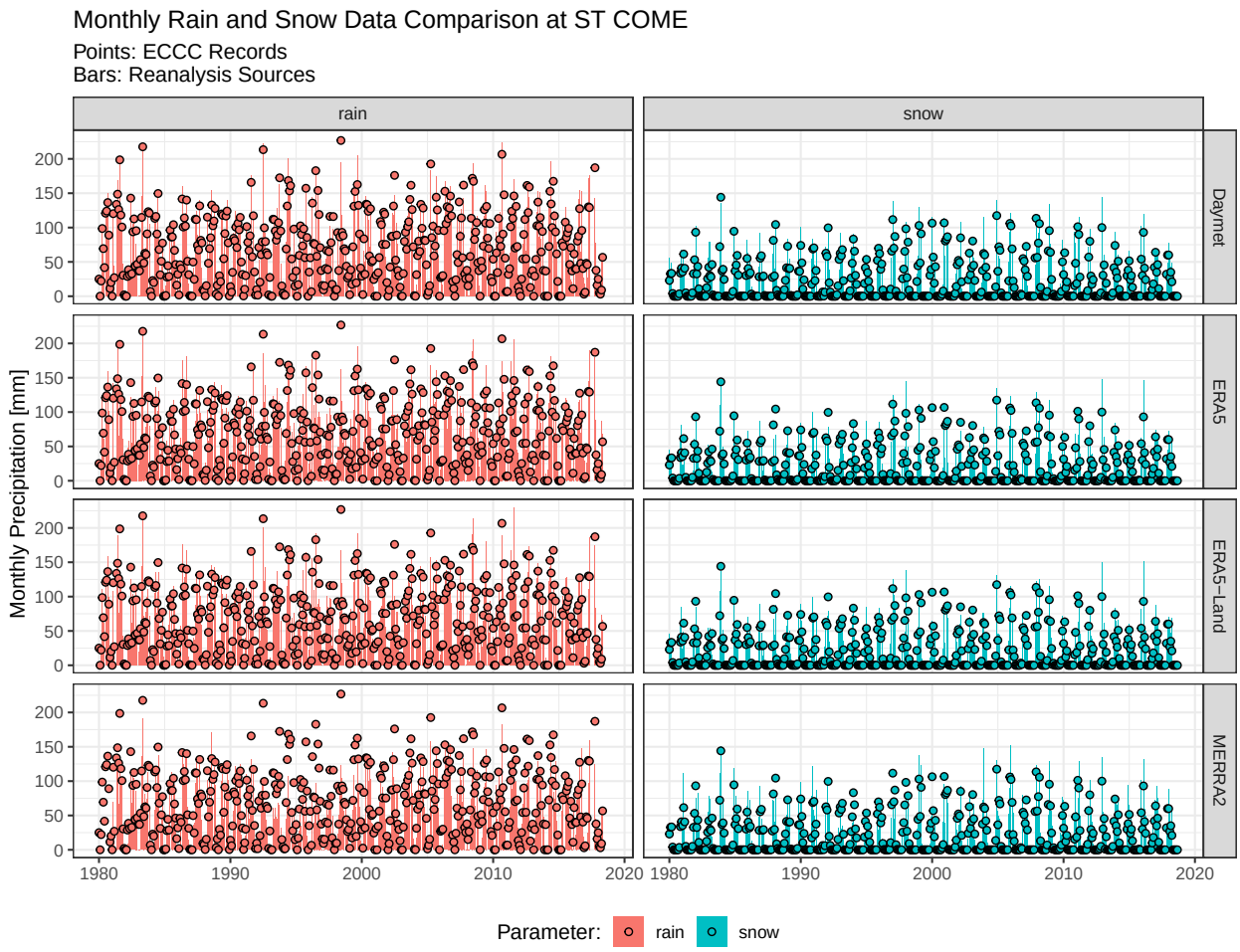

Monthly Rain and Snow Data Comparison at ST DONAT
Points: ECCC Records
Bars: Reanalysis Sources
rain
snow
Daymet
ERA5
ERA5−Land
MERRA2
Monthly Precipitation [mm]
0
50
100
150
200
1980
1990
2000
2010
Parameter:
rain
snow

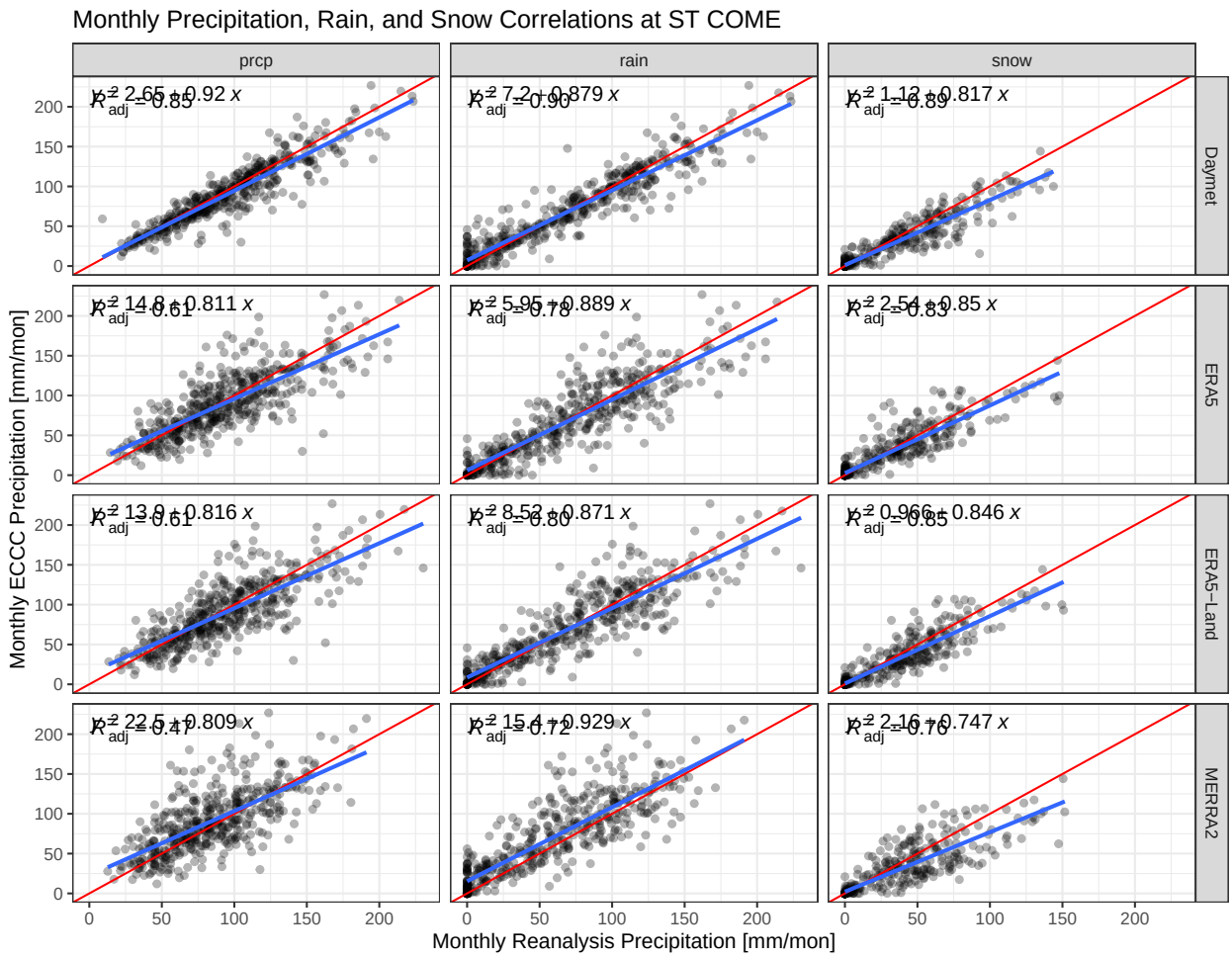


7.5 Rain/Snow ST COME

Table 7.5: Mean Rain and Snow Monthly Values at ST COME

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
prcp	ECCC	74	63	73	81	93	108	107	102	103	105	94	84	1087
prcp	Daymet	79	65	74	89	99	115	112	110	110	107	96	90	1147
prcp	ERA5	76	66	75	98	101	105	104	101	104	104	97	90	1121
prcp	ERA5-Land	74	65	75	95	103	108	111	105	105	103	95	88	1127
prcp	MERRA2	68	61	72	82	88	99	91	94	90	93	88	87	1013
rain	ECCC	16	13	30	68	93	108	107	102	103	102	68	20	829
rain	Daymet	9	9	24	79	99	115	112	110	110	104	61	12	845
rain	ERA5	12	15	33	87	101	105	104	101	104	102	67	19	850
rain	ERA5-Land	10	11	27	79	103	108	111	105	105	100	58	15	833
rain	MERRA2	4	3	15	63	88	99	91	94	90	90	49	10	695
snow	ECCC	59	51	43	14	0	0	0	0	0	3	26	64	261
snow	Daymet	70	56	50	11	0	0	0	0	0	3	35	78	303
snow	ERA5	64	51	42	12	0	0	0	0	0	2	30	71	271
snow	ERA5-Land	64	54	48	17	0	0	0	0	0	3	37	73	295
snow	MERRA2	64	58	57	20	0	0	0	0	0	4	39	76	317

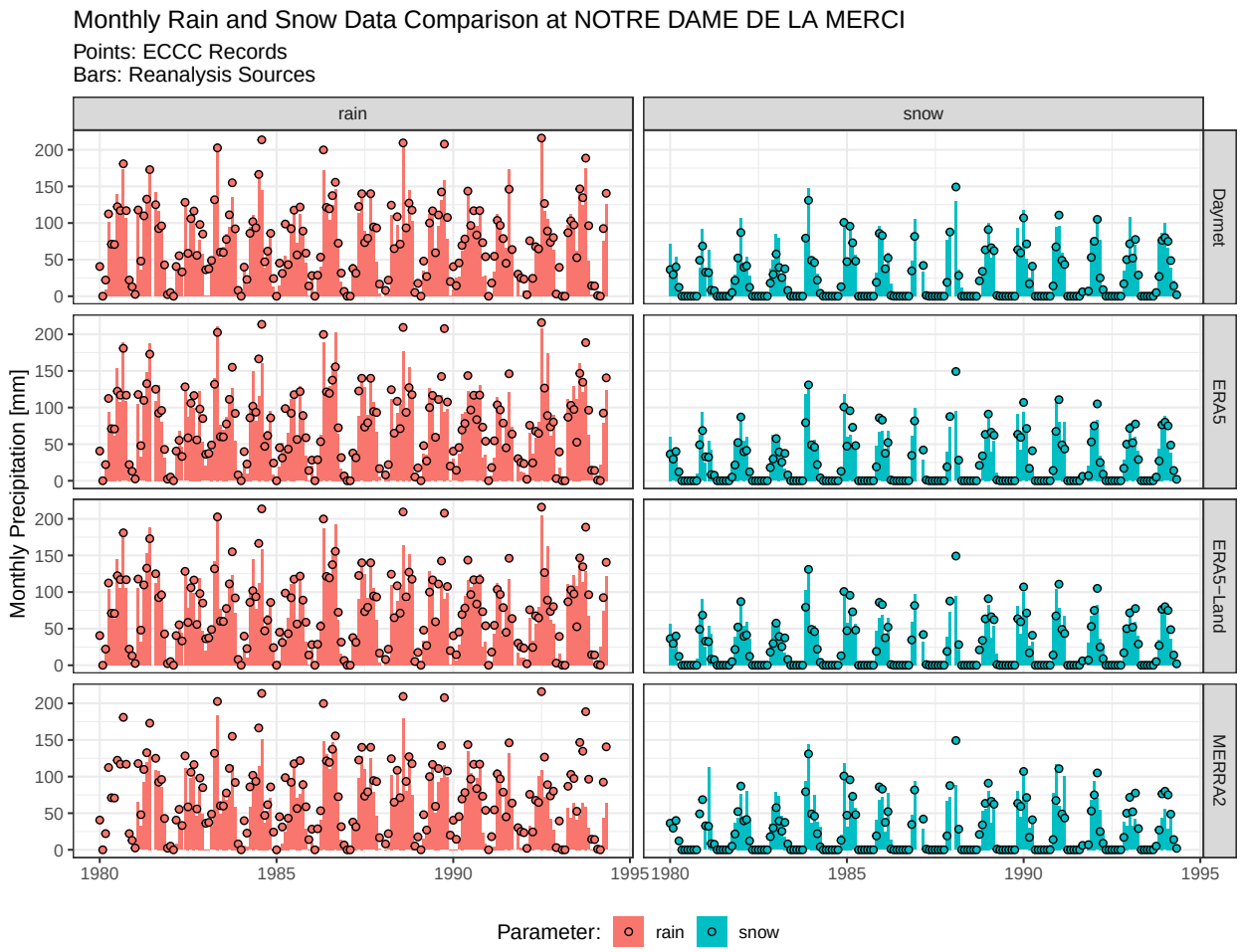

Monthly Rain and Snow Data Comparison at ST COME
Points: ECCC Records
Bars: Reanalysis Sources
rain
snow
Daymet
ERA5
ERA5−Land
MERRA2
Monthly Precipitation [mm]
0
50
100
150
200
1980
1990
2000
2010
2020
Parameter:
rain
snow

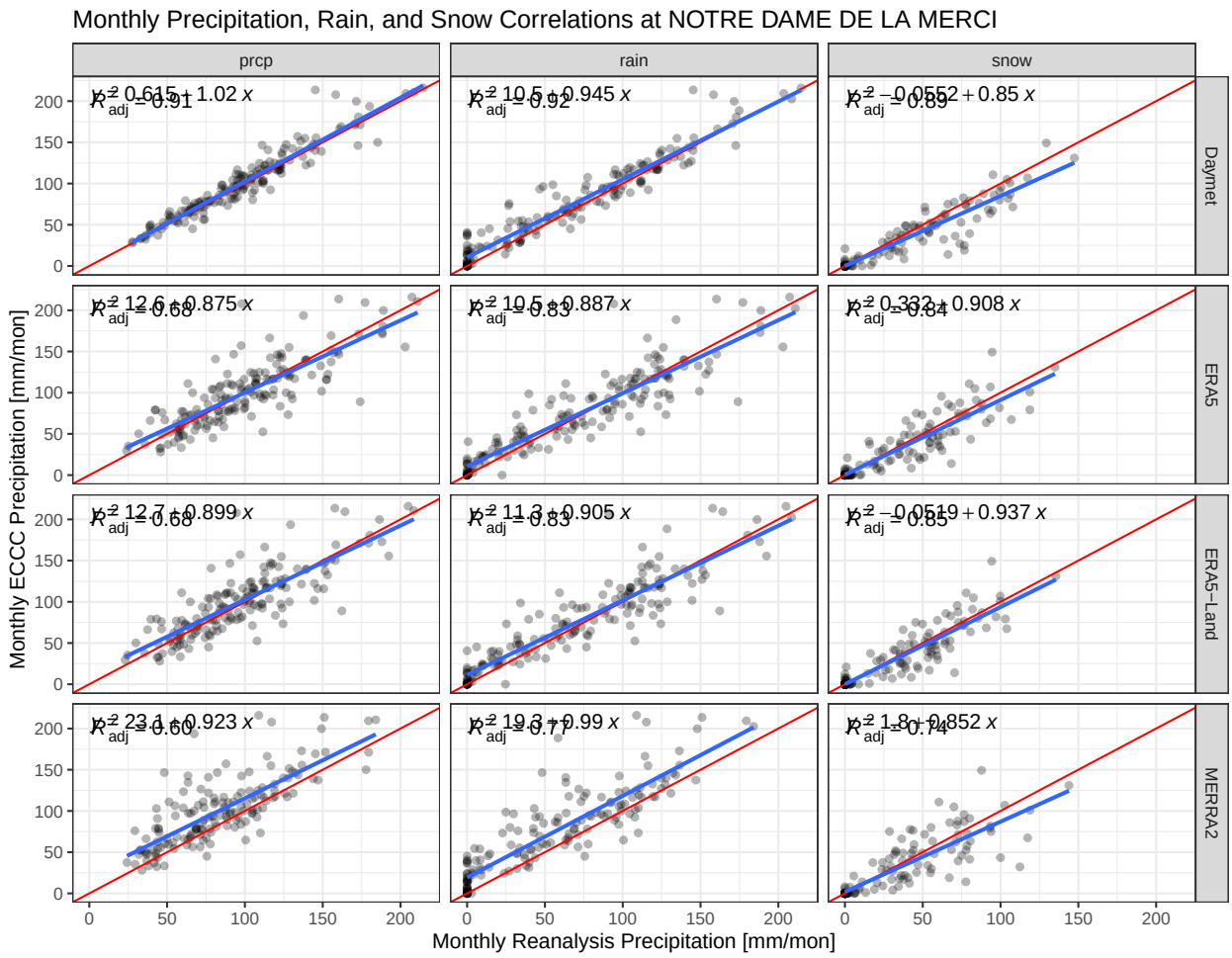


7.6 Rain/Snow NOTRE DAME DE LA MERCI

Table 7.6: Mean Rain and Snow Monthly Values at NOTRE DAME DE LA MERCI

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
prcp	ECCC	90	84	75	95	105	106	97	126	113	114	103	92	1200
prcp	Daymet	86	80	74	91	102	105	100	121	111	107	104	91	1172
prcp	ERA5	77	70	76	97	110	107	114	116	125	103	113	90	1197
prcp	ERA5-Land	75	68	74	96	109	105	109	114	120	99	110	87	1164
prcp	MERRA2	65	65	68	79	89	99	87	102	88	88	96	79	1005
rain	ECCC	18	19	35	80	104	106	97	126	112	112	74	21	904
rain	Daymet	4	14	25	74	102	105	100	121	111	104	56	8	823
rain	ERA5	7	13	31	82	110	107	114	116	125	99	62	9	876
rain	ERA5-Land	6	12	30	79	109	105	109	114	120	97	60	9	848
rain	MERRA2	1	5	15	59	89	99	87	102	88	84	48	5	681
snow	ECCC	71	63	40	14	1	0	0	0	0	2	30	72	295
snow	Daymet	82	65	49	17	0	0	0	0	0	3	48	83	348
snow	ERA5	69	55	45	15	0	0	0	0	0	4	51	80	320
snow	ERA5-Land	68	55	45	17	0	0	0	0	0	2	50	78	315
snow	MERRA2	64	60	54	20	0	0	0	0	0	4	48	74	324


Monthly Rain and Snow Data Comparison at NOTRE DAME DE LA MERCI
Points: ECCC Records
Bars: Reanalysis Sources
rain
snow
Daymet
ERA5
ERA5−Land
MERRA2
Monthly Precipitation [mm]
0
50
100
150
200
1980
1985
1990
1995
Parameter:
rain
snow


Monthly Precipitation, Rain, and Snow Correlations at NOTRE DAME DE LA MERCI
prcp
rain
snow
Daymet
ERA5
ERA5−Land
MERRA2
$R^2_{adj} = 0.91$ $0.615 + 1.02\,x$
$R^2_{adj} = 0.92$ $10.5 + 0.945\,x$
$R^2_{adj} = 0.89$ $-0.0552 + 0.85\,x$
$R^2_{adj} = 0.68$ $12.6 + 0.875\,x$
$R^2_{adj} = 0.83$ $10.5 + 0.887\,x$
$R^2_{adj} = 0.84$ $0.332 + 0.908\,x$
$R^2_{adj} = 0.68$ $12.7 + 0.899\,x$
$R^2_{adj} = 0.83$ $11.3 + 0.905\,x$
$R^2_{adj} = 0.85$ $-0.0519 + 0.937\,x$
$R^2_{adj} = 0.60$ $23.1 + 0.923\,x$
$R^2_{adj} = 0.77$ $19.3 + 0.99\,x$
$R^2_{adj} = 0.74$ $1.8 + 0.852\,x$
Monthly ECCC Precipitation [mm/mon]
Monthly Reanalysis Precipitation [mm/mon]
0
50
100
150
200

Chapter 8

Snowmelt Validation

To further assess reanalysis model results, a separate regional snowpack and snowmelt validation review was undertaken. Please refer to Report **03a Snowpack Check** for further details.

The main takeaways from this analysis are listed below:

- Overprediction bias in Snowpack model was consistent with review of reanalysis products. Further correction to Daymet to better represent site precipitation is required.
- Precipitation undercatch correction is not required due to general overprediction bias both in the reanalysis products for precipitation and the snowpack model results.

Chapter 9

Site Precipitation Selection and Results

9.1 Daymet Correction Factors for Site

Based on regional analysis, Daymet is the most reliable reanalysis source for precipitation near the project location. However, overprediction bias was generally observed when compared to observed data (See **Section 6.2**). This was consistent with snowpack modelling completed as verification (See report **03a Snowpack Check**). The analysis completed in **Section 7** indicates Daymet precipitation overprediction bias appears to be more significant for snowfall than rainfall.

For these reasons, monthly correction factors are developed to adjust the Daymet dataset, and provide a more likely representation of precipitation at Site.

The following graph shows contours of the best fit coefficients for Daymet to Measured precipitation transformations on a monthly basis, based on values calculated at stations locations by using the loess regression. Loess regression is a nonparametric technique that uses local weighted regression to fit a smooth curve through points in a scatter plot. Loess curves can reveal trends and cycles in data that might be difficult to model with a parametric curve.

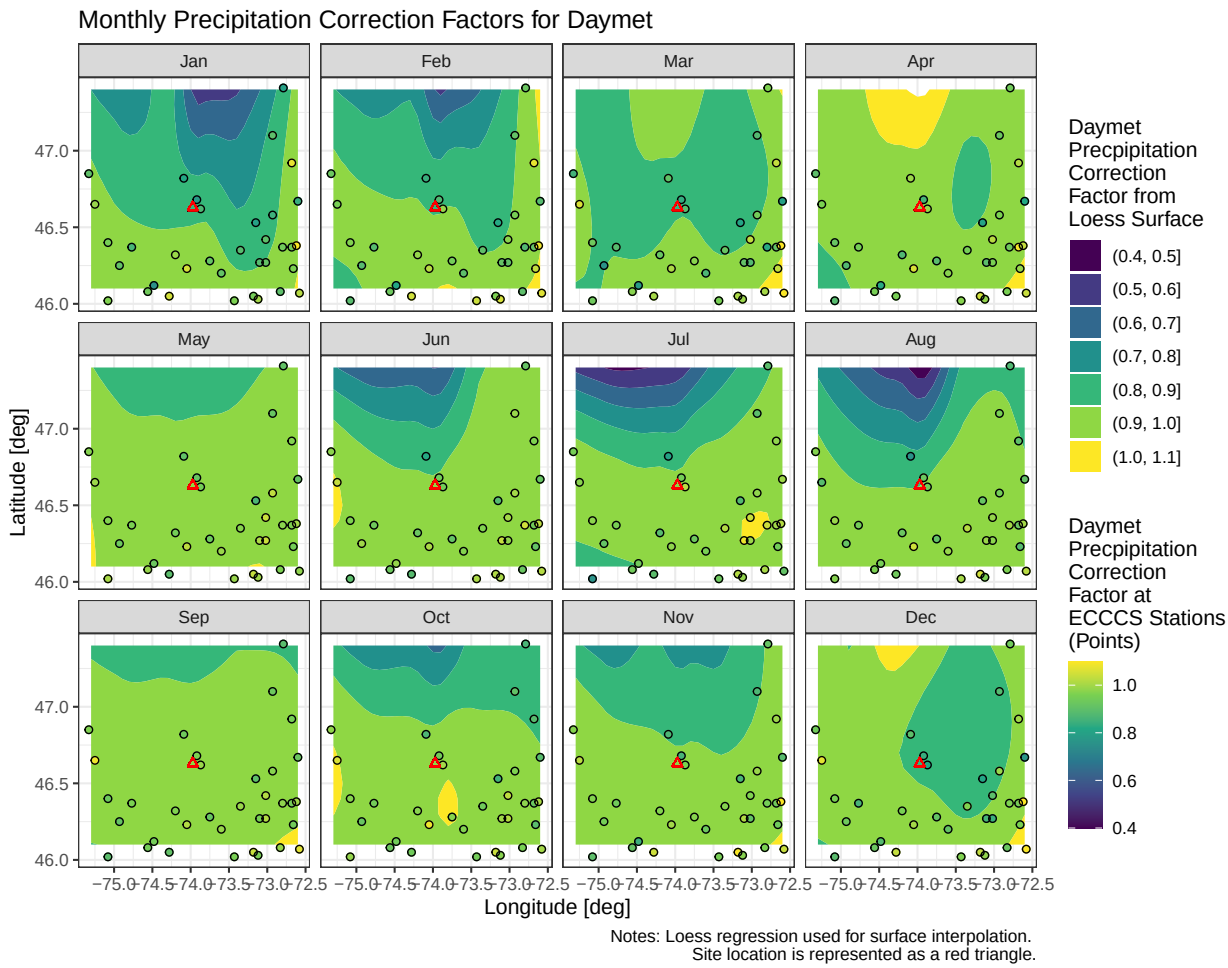
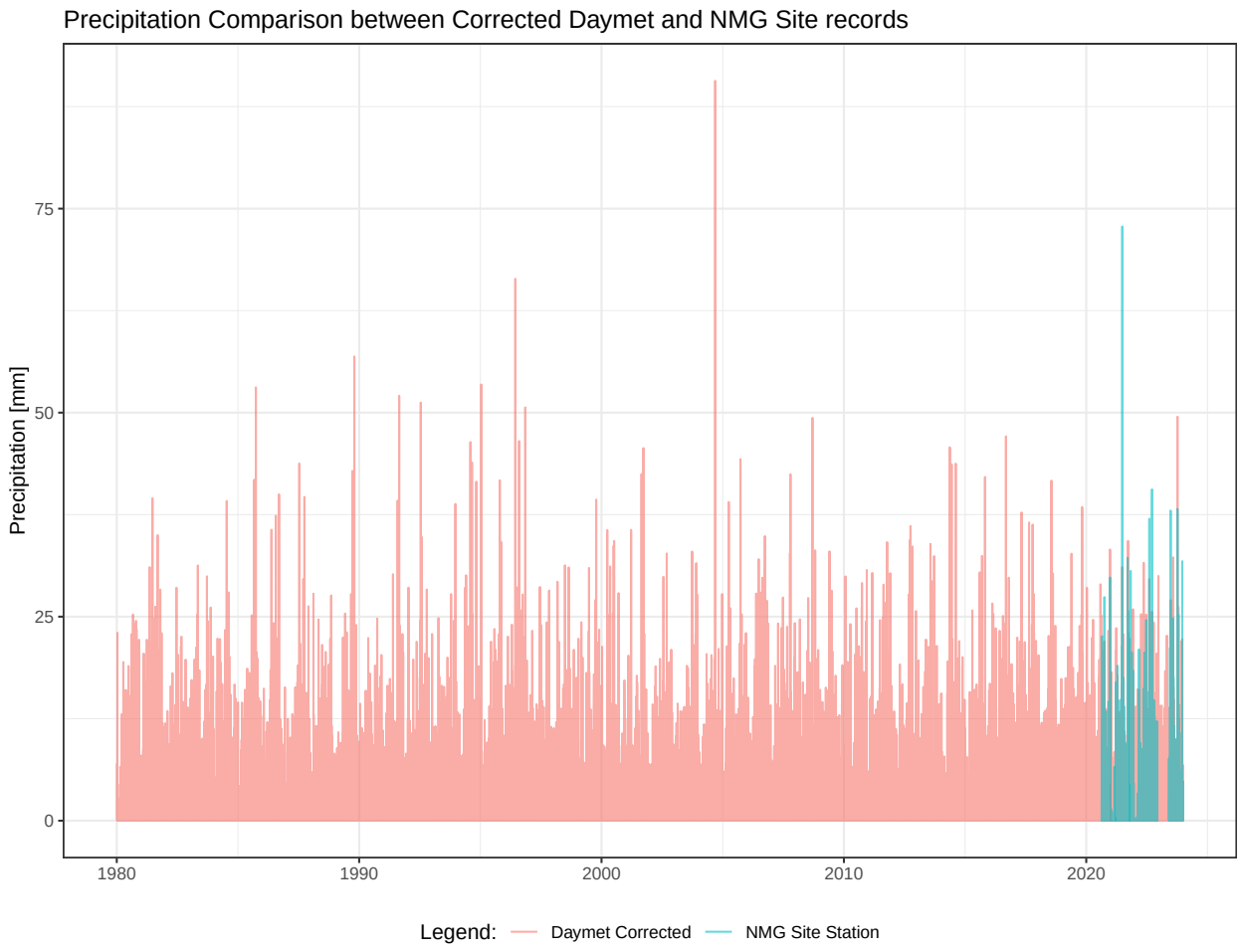


Table 9.1: Daymet Montly Correction Factors for Site

Month	Coef
Jan	0.88
Feb	0.9
Mar	0.9
Apr	0.94
May	0.95
Jun	0.92
Jul	0.93
Aug	0.91
Sep	0.97
Oct	0.97
Nov	0.93
Dec	0.89

9.2 Project Precipitation Timeseries

Coefficients from the previous analysis are applied to the raw Daymet timeseries at the site location to obtain the Project Precipitation Timeseries.



9.3 Climatogram

A climatogram, is a time-based graph that presents a location's average temperature and precipitation on a monthly basis. The following figure was produced for the Project location based on this analysis.

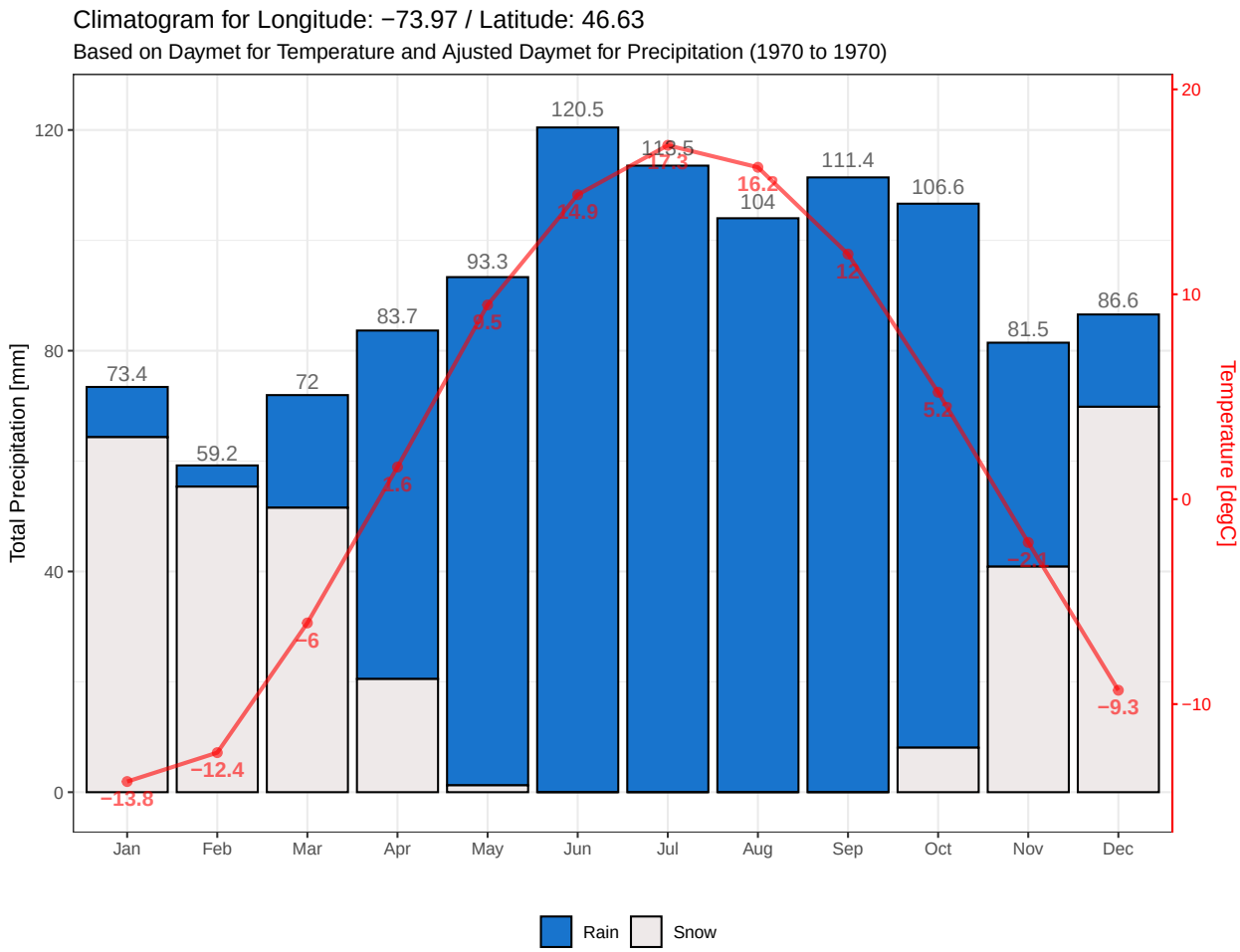


Table 9.2: Mean monthly parameters based on Daymet for Temperature and Ajusted Daymet for Precipitation

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Prcp	73.4	59.2	72	83.7	93.3	120.5	113.5	104	111.4	106.6	81.5	86.6	1106
Rain	9.1	3.8	20.4	63.1	92.1	120.5	113.5	104	111.4	98.6	40.6	16.7	793.9
Snow	64.3	55.4	51.5	20.5	1.2	0	0	0	0	8.1	40.9	69.8	311.8

Table 9.3: Precipitation Normals (1985-2014) for the Project [mm]

Par	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Prcp	73.3	53	66.2	74.6	93.8	116.2	112.7	103	114.1	101	83.5	78	1069
Snow	64.2	50	47.8	18.1	1.2	0	0	0	0.1	7.1	41.8	67.4	297.6
Rain	9.1	3	18.4	56.5	92.7	116.2	112.7	103	113.9	93.9	41.7	10.7	771.9

9.4 Annual Precipitation Frequency Analysis and Monthly Distribution

This section describes the statistical analysis that was completed on yearly precipitation for the Matawinie Site, based on the Project Precipitation Timeseries as defined in Section 9.2. Frequency

analysis were completed on a yearly and monthly basis to estimate precipitation values for typical probabilities of occurrence, or return periods.

Note that the storm event anlysis is included in a separate document. For further information about storm events analysis, please refer to Report **03b Storm Analysis**.

9.4.1 Annual Frequency Analysis

A frequency analysis was completed on yearly precipitation from the Project Precipitation Timeseries. The following results table presents return periods and corresponding monthly and annual precipitation values for the Project.

Tested distributions: [1] NORM LN GEV GUMBEL ———————— Chosen distributions: AIC AICc BIC ADC
LN LN LN LN
whose Maximum-Likelihood parameters are: NORM parameters of log(x): 6.985555 0.09873324

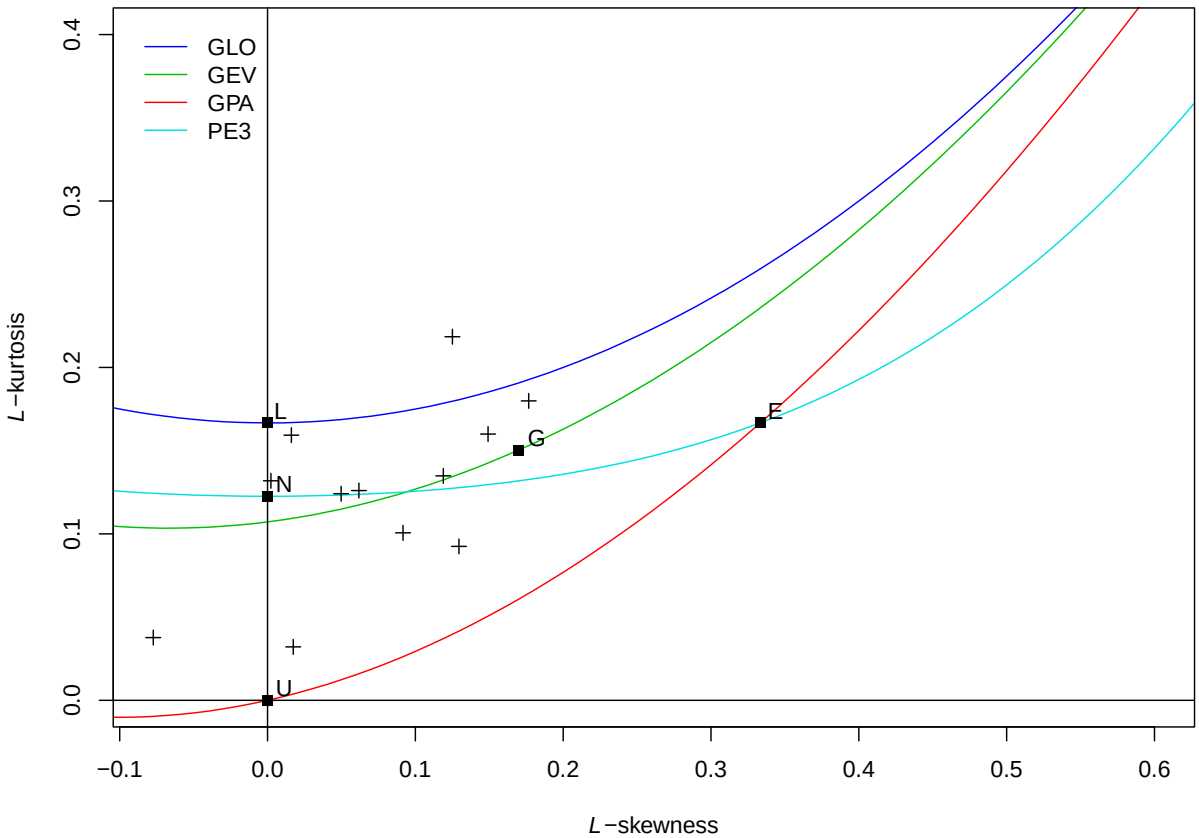
Table 9.4: Annual Precipitation Return Periods [mm]

	Return Period [years]	Annual
1	Wet 10000	1537
2	Wet 2000	1480
3	Wet 1000	1454
4	Wet 500	1426
5	Wet 200	1388
6	Wet 100	1357
7	Wet 50	1323
8	Wet 25	1286
9	Wet 20	1273
10	Wet 10	1230
11	Wet 5	1178
13	Regular 2	1083
15	Dry 5	992
16	Dry 10	946
17	Dry 20	909
18	Dry 25	898
19	Dry 50	868
20	Dry 100	841
21	Dry 200	816
22	Dry 500	787
23	Dry 1000	767
24	Dry 2000	748
25	Dry 10000	709

9.4.2 Monthly Distribution

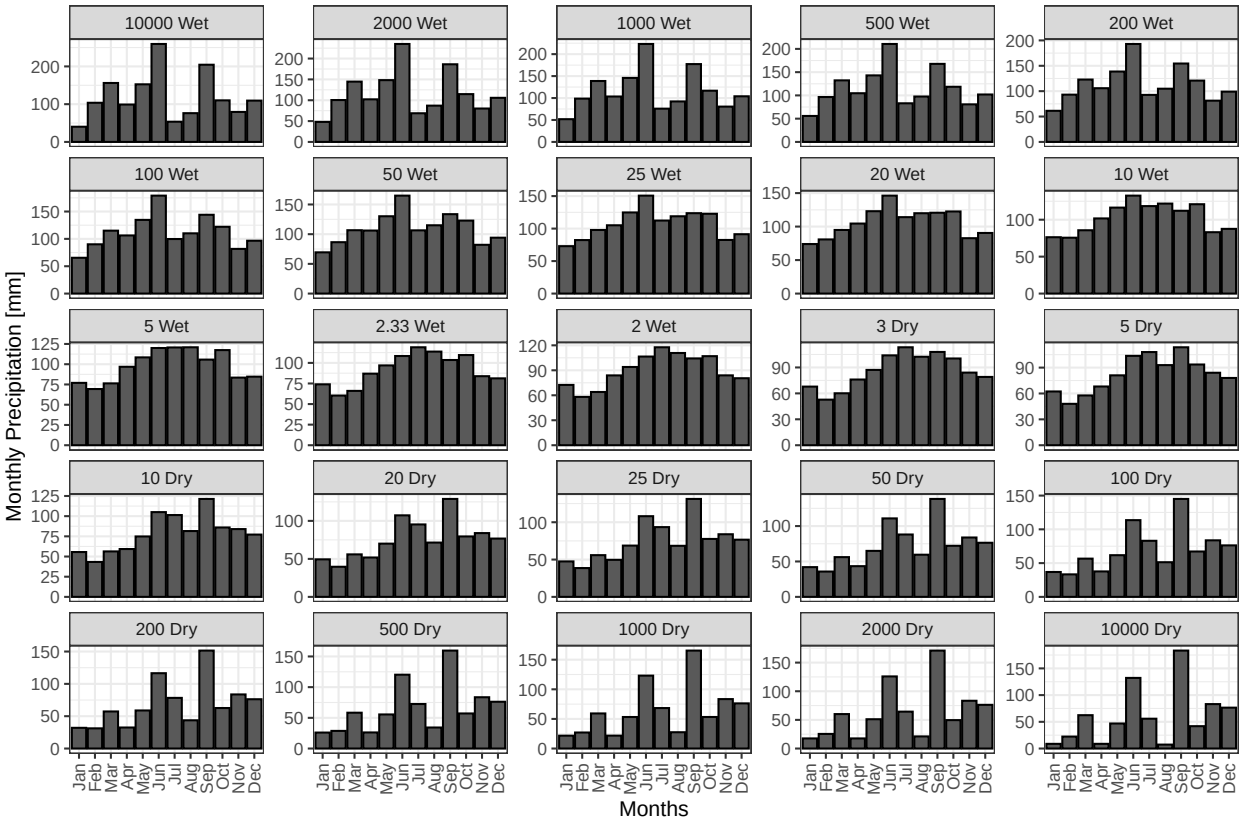
The monthly distribution of precipitation for different return periods might not follow the average distribution of the project precipitation timeseries. An incremental frequency analysis approach was developed and is described below. Note that the monthly distribution of annual precipitation is not equivalent to a monthly precipitation frequency analysis.

First, an L-moments ratio diagram was built to select representative probability distributions to assess data on a monthly basis. The L-moments ratio diagram is the plot of the sample moments on the moment-ratio diagram. The Project Precipitation was summarized monthly and grouped per calendar month. Skewness and kurtosis (L-moments) were computed and plotted in a moment-ratio diagram for each month (black crosses). On the same plot, multiple two parameter (black squares), and three-parameter (colored curves) candidate distributions to model the data are represented. The cluster of L-moments representing the samples are be closer to the distributions that better represent the data.



The generalized extreme value (GEV) distribution, the Pearson Type III (PE3), and the Log-Pearson Type III distributions were selected from this analysis.

The monthly distribution of precipitation was adjusted for each return period by completing an incremental frequency analysis month to month, resulting in the following graphs and table.


10000 Wet
2000 Wet
1000 Wet
500 Wet
200 Wet
100 Wet
50 Wet
25 Wet
20 Wet
10 Wet
5 Wet
2.33 Wet
2 Wet
3 Dry
5 Dry
10 Dry
20 Dry
25 Dry
50 Dry
100 Dry
200 Dry
500 Dry
1000 Dry
2000 Dry
10000 Dry
Monthly Precipitation [mm]
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Months

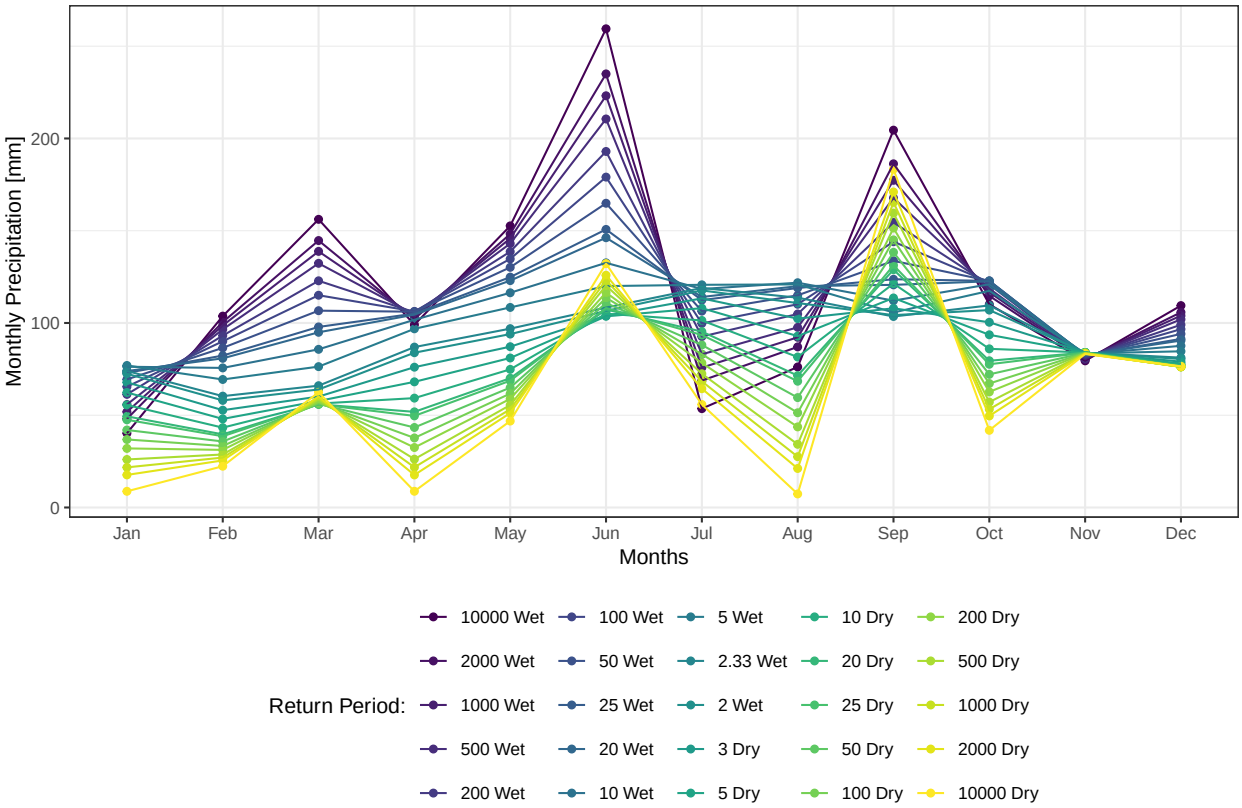

Monthly Precipitation [mm]
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Months
Return Period:
10000 Wet
2000 Wet
1000 Wet
500 Wet
200 Wet
100 Wet
50 Wet
25 Wet
20 Wet
10 Wet
5 Wet
2.33 Wet
2 Wet
3 Dry
5 Dry
10 Dry
20 Dry
25 Dry
50 Dry
100 Dry
200 Dry
500 Dry
1000 Dry
2000 Dry
10000 Dry

Table 9.5: Monthly Distribution of Annual Precipitation [mm]

RP	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
10000 Wet	40	104	156	99	153	259	54	76	205	110	79	109	1444
2000 Wet	48	100	145	102	148	235	69	87	186	115	80	106	1421
1000 Wet	52	99	139	103	146	223	76	92	177	117	80	104	1408
500 Wet	56	97	132	105	143	211	83	98	168	119	81	102	1393
200 Wet	61	93	123	106	139	193	93	105	154	121	81	99	1368
100 Wet	65	90	115	106	135	179	100	110	144	122	82	97	1345
50 Wet	69	87	107	106	130	165	106	115	134	123	82	94	1318
25 Wet	73	82	98	105	125	151	112	119	124	123	83	91	1286
20 Wet	74	81	95	105	123	146	114	120	121	123	83	90	1274
10 Wet	76	76	86	102	116	133	118	122	112	121	83	88	1232
5 Wet	77	69	76	97	108	120	121	121	106	117	83	85	1181
2.33 Wet	74	60	66	87	97	108	119	114	104	110	84	81	1103
2 Wet	72	58	64	84	94	107	118	111	104	107	84	80	1083
3 Dry	68	53	60	76	87	104	113	102	108	100	84	79	1035
5 Dry	62	48	58	68	81	104	108	93	114	94	84	78	991
10 Dry	56	43	56	59	75	105	101	82	121	86	84	77	946
20 Dry	49	40	56	52	70	107	95	71	129	80	84	77	910
25 Dry	48	39	56	50	69	108	93	68	131	78	84	77	900
50 Dry	42	36	56	43	65	111	88	60	138	72	84	76	871
100 Dry	37	33	57	38	62	114	83	51	145	67	84	76	846
200 Dry	32	31	57	32	59	116	78	44	151	63	84	76	824
500 Dry	26	29	58	26	56	120	72	34	160	57	84	76	798
1000 Dry	22	27	59	22	53	123	68	28	165	53	83	76	780
2000 Dry	18	26	60	18	51	126	64	21	171	50	83	76	764
10000 Dry	9	22	62	9	47	132	56	7	183	42	83	76	729

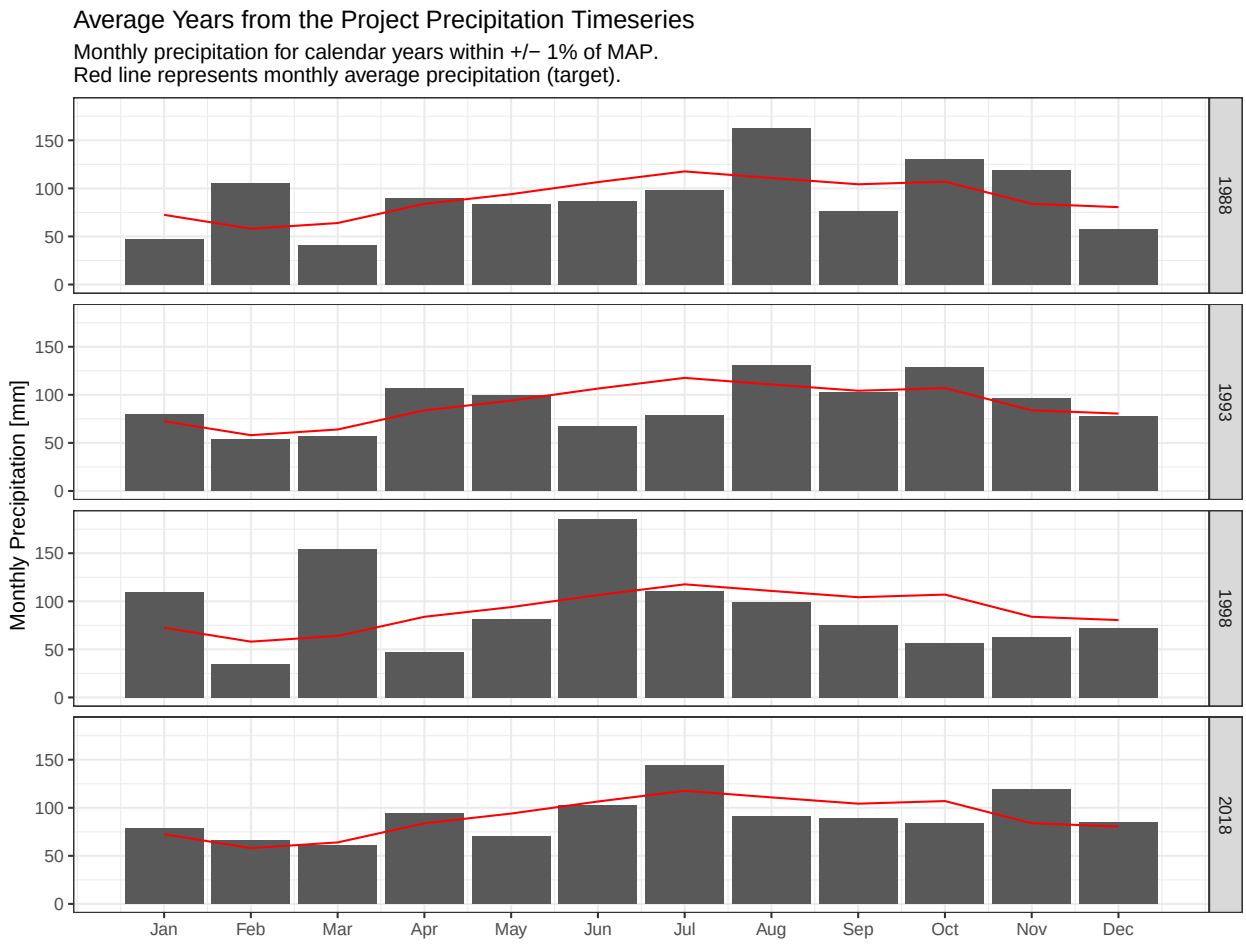
9.5 Representative Years for Water Balance

The site water balance looks to assess different hydrological scenarios. The following scenarios were requested:

- Average year
- 1 in 100 wet year
- 1 in 100 dry year

9.5.1 Average Year

The average year was selected from the project precipitation timeseries as the best matching year to the previous section results.



Based on this analysis, the calendar year 2018 from the project precipitation timeseries is the most representative of an average precipitation year for the Project for historical conditions. 2018 has a total annual precipitation of 1085 mm (target MAP of 1083 mm) and total monthly precipitations that are similar to monthly average precipitation targets.

9.5.2 Extreme Yearly Precipitation Scenarios

The wet and dry scenarios do not have a good 'as is' match within the project precipitation timeseries due to the high return period. Representative months from the project precipitation timeseries corresponding to the selected scenarios are identified in the following table.

Table 9.6: Monthly Selection for Extreme Event Scenarios

Month	Wet Scenario (1 in 100 years)	Dry Scenario (1 in 100 years)
Jan	1989	1987
Feb	2022	1995
Mar	2020	2000
Apr	2002	1987
May	1981	1980
Jun	1998	1990
Jul	2013	2011
Aug	2016	1985

Month	Wet Scenario (1 in 100 years)	Dry Scenario (1 in 100 years)
Sep	1985	1985
Oct	2006	1986
Nov	2001	2001
Dec	2013	2016

Chapter 10

Output

Output of this code has been backed up and saved as an rds file in the **/01_Data/rds** project folder.

References

Gelaro, Ronald, Will McCarty, Max J. Suárez, Ricardo Todling, Andrea Molod, Lawrence Takacs, Cynthia A. Randles, et al. 2017. "The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2)." *Journal of Climate* 30 (14): 5419–54. https://doi.org/10.1175/jcli-d-16-0758.1.

Hersbach, Hans, Bill Bell, Paul Berrisford, Shoji Hirahara, András Horányi, Joaquín Muñoz-Sabater, Julien Nicolas, et al. 2020. "The ERA5 Global Reanalysis." *Quarterly Journal of the Royal Meteorological Society* 146 (730): 1999–2049. https://doi.org/10.1002/qj.3803.

Muñoz-Sabater, Joaquín, Emanuel Dutra, Anna Agustí-Panareda, Clément Albergel, Gabriele Arduini, Gianpaolo Balsamo, Souhail Boussetta, et al. 2021. "ERA5-Land: A State-of-the-Art Global Reanalysis Dataset for Land Applications." *Earth System Science Data* 13 (9): 4349–83. https://doi.org/10.5194/essd-13-4349-2021.

Thornton, M. M., R. Shrestha, Y. Wei, P. E. Thornton, and S-C. Kao. 2022. "Daymet: Daily Surface Weather Data on a 1-Km Grid for North America, Version 4 R1," November. https://doi.org/10.3334/ORNLDAAC/2129.

FINAL

Rapport d'ingénierie des ouvrages de gestion des eaux de surface du projet minier Matawinie

Saint-Michel-des-Saints, Québec, Canada

Nouveau Monde Graphite

SRK Consulting (Canada) Inc. ▪ CAPR002717 ▪ 31 janvier 2025

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FINAL

Rapport d'ingénierie des ouvrages de gestion des eaux de surface du projet minier Matawinie

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Photo du bassin BC-2 en construction, regardant vers le nord

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Résumé

Nouveau Monde Graphite Inc. (NMG) vise d'être l'un des principaux contributeurs à la transition énergétique ainsi qu'un leader de l'industrie minière en développant, exploitant et en restaurant le projet de mine de graphite Matawinie selon les normes environnementales, sociales et de gouvernance (ESG) les plus élevées. La mine Matawinie exploitera un gisement de graphite de classe mondiale à partir d'une fosse à ciel ouvert. Le graphite sera concentré dans l'usine qui sera construite à même la zone industrielle du site minier, avant d'être transportée à Bécancour pour une seconde transformation. En plus de la fosse à ciel ouvert et de la zone industrielle, une halde de co-disposition (HCD), des infrastructures de gestion des eaux de surface ainsi qu'une halde à mort-terrain (HMT) seront présentes sur le site de la mine.

SRK Consulting (Canada) Inc. (SRK) a été retenu par NMG pour réaliser l'ingénierie détaillée des ouvrages de gestion des eaux de surface du site minier Matawinie. La stratégie de gestion des eaux comprend un réseau de fossés collecteurs construits autour de la HMT, de la HCD et de la zone industrielle (ZI), qui achemineront l'eau de ruissellement et de fonte de manière gravitaire vers des bassins d'accumulation ou bassins collecteurs (BC). Des stations de pompage assureront le lien hydraulique entre les différents bassins, la filière de traitement des eaux, l'usine et l'effluent final.

Les fossés seront excavés dans le mort-terrain ou aménagés en remblai par rapport au terrain naturel, lorsqu'une pente longitudinale minimale ne peut être aménagée sans excaver le roc. Étant donnée la qualité d'eau de contact en provenance de la HCD est présumée être en dehors des prescriptions de la Directive 019, les fossés s'y rattachant seront imperméabilisés à l'aide d'une géomembrane. Une géométrie de type trapézoïdale ainsi qu'une pente de talus de 2H : 1V ont été retenus. Les fossés seront construits selon un phasage en fonction du développement de la mine, c'est donc dire que les coûts de construction seront répartis dans le temps.

Les bassins d'accumulation seront eux aussi imperméabilisés au moyen d'une géomembrane polyéthylène de basse densité (PeBD). Une analyse de la stratigraphie sous l'emprise des bassins projetés a permis d'identifier la présence de roc à excaver afin d'atteindre le volume prescrit. Des pentes de talus de 2H : 1V seront appliqués dans le mort terrain ainsi qu'en présence du roc. L'élévation de la nappe phréatique à plus de 8 mètres par rapport au fond projeté des bassins nécessite le rabattement de cette dernière à l'aide de puits en périphérie des ouvrages dans les premières années de vie de la mine. Étant donné la nécessité de construire le Bassin collecteur Sud (BS) à l'année 8 (début de la phase B2), la conception détaillée de ce dernier ne fait pas partie du présent rapport.

En plus du processus de conception, ce rapport présente des directives s'appliquant à la période de construction et d'opération et se conclut avec une série de recommandations.

1 Introduction et mise en contexte

1.1 Contexte

Nouveau Monde Graphite Inc. (NMG) prévoit d'être l'un des principaux contributeurs à la transition énergétique et vise à être un leader dans l'industrie minière en développant, exploitant et restaurant le projet de mine de graphite Matawinie (**Figure 1-1**) selon les normes environnementales, sociales et de gouvernance (ESG) les plus élevées.

NMG exploitera un gisement de graphite de classe mondiale à partir d'une fosse à ciel ouvert. Le graphite sera concentré dans l'usine qui sera construite à même le site minier avant d'être transporté à Bécancour pour une seconde transformation. Cette seconde transformation permettra d'obtenir un concentré de graphite de haute pureté qui sera utilisé dans la fabrication de matériel d'anode de batteries. La durée de vie de la mine telle qu'actuellement anticipée est de 26 ans (BBA, 2022).

En plus de la fosse à ciel ouvert et de la zone industrielle (ZI), une halde de co-disposition[1] (HCD), des infrastructures de gestion des eaux de surface (c.-à-d. : fossés et bassins collecteurs) ainsi qu'une halde à mort-terrain (HMT) seront présentes sur le site de la mine (le site) (**Figure 1-2**).

1.2 Description du mandat

SRK Consulting (Canada) Inc. (SRK) a été retenu par NMG, pour réaliser l'ingénierie détaillée des ouvrages de gestion des eaux de surface, qui comprend un réseau de fossés collecteurs ceinturant les infrastructures minières ainsi que des bassins d'accumulation ou bassins collecteurs (BC) des eaux de contact. Ce mandat fait partie intégrante d'un projet global comprenant également l'ingénierie de la HMT et de la HCD.

1.3 Localisation du site

Le site se situe dans la région de Lanaudière, au Québec et se trouve à environ 5 km au sud-ouest de la municipalité de Saint-Michel-des-Saints, à l'ouest du Lac aux Pierres (Figure 1-1). Une route de type chemin forestier, menant au site à partir de la route 131 (Figure 1-2), a été construite par NMG en 2021 et 2022. Le point central du site se situe approximativement à une latitude de 46,63° et une longitude de -73,96° (en WSG84).

[1] Halde de co-disposition : emplacement où les rejets miniers (c.-à-d. : stériles miniers et résidus miniers) seront mis en pile.

1.4 Contenu du rapport

Ce rapport présente l'ingénierie développée dans le cadre de l'ingénierie des ouvrages de gestion des eaux de surface et se divise en les sections suivantes :

- La **Section 2** décrit le concept général de la gestion des eaux de surface du site de Matawinie.
- La **Section 3** résume les bases de l'ingénierie des ouvrages de gestion des eaux de surface, soit les exigences réglementaires applicables, les bonnes pratiques considérées et les objectifs et critères de conception à respecter.
- La **Section 4** décrit les conditions actuelles du site.
- La **Section 5** résume la conception qui a été réalisée. Elle présente le dimensionnement des divers ouvrages projetés, les phases de construction prévues, les matériaux et conditions piézométriques considérés, les paramètres géotechniques utilisés, les analyses de stabilité réalisées ainsi qu'une analyse de la sensibilité de certains paramètres sur les résultats obtenus.
- La **Section 6** présente quelques directives s'appliquant à la phase de construction et d'opération des ouvrages de gestion des eaux de surface.
- La **Section 7** synthétise les principales conclusions de l'ingénierie, présente des recommandations et identifie des opportunités identifiées lors de l'ingénierie.

Les plans préparés dans le cadre du présent mandat sont insérés à l'Annexe B. La liste des plans se trouve au Tableau 1-1 ci-bas.

Tableau 1-1 : Liste des plans

No. de dessin	Révision	Titre
GE-100	0	Bassin BC-1 vue en plan et section
GE-101	0	Bassin BC-1 sections
GE-110	0	Bassin BC-2 vue en plan et section
GE-111	0	Bassin BC-2 sections et détails
GE-300	0	Détails des bassins
GE-400	0	Chemin d'accès au bassin BC-1 plan et profil et coupe type
GE-401	0	Chemin d'accès au bassin BC-2 0+000 à 0+315 plan et profil
GE-402	0	Chemin d'accès au bassin BC-2 0+315 à 0+588 plan et profil et coupe type
GE-450	0	Fossé FD-2 section ouest plan et profil
GE-451	0	Fossé FD-2 section est plan et profil et coupes types
GE-500	0	Halde d'entreposage temporaire de roc

Figure 1-1 : Localisation du site du projet minier Matawinie

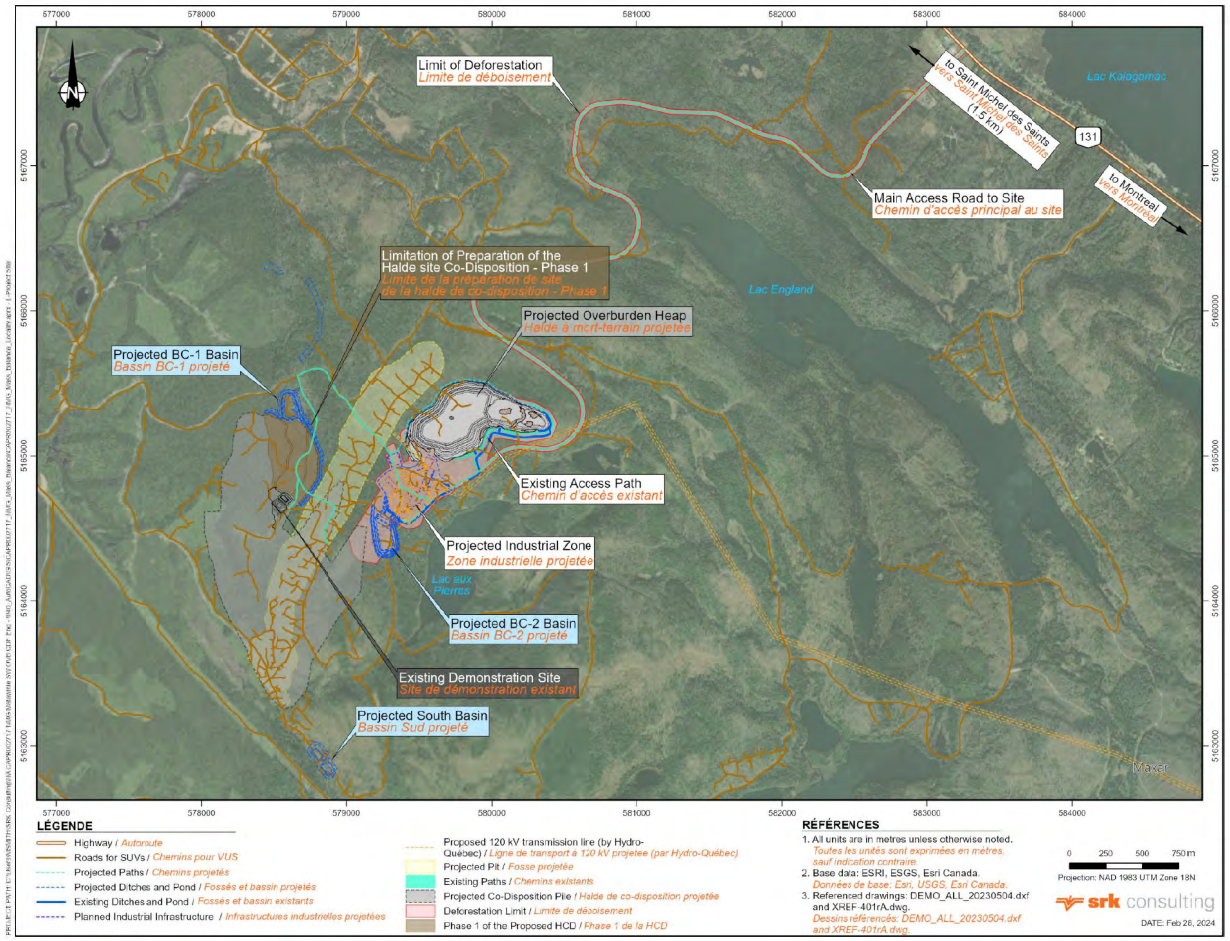

Figure 1-2 : Carte de localisation détaillée

2 Description du site et de la gestion des eaux de surface

2.1 Description de la stratégie de gestion des eaux de surface sur le site

Tel que présenté dans Wood, 2021, la gestion des eaux de surface sur le site se divise en quatre sous-secteurs principaux[2], soient :

- la fosse (F), qui aura une superficie maximale estimée de 78,5 ha ;
- la halde à mort-terrain (HMT), qui aura une superficie maximale estimée de 20,90 ha ;
- la zone industrielle (ZI), qui aura une superficie maximale estimée de 18,60 ha ; et
- la halde de co-disposition (HCD), qui aura une superficie maximale estimée de 148,50 ha (superficie incluant une portion de la fosse).

Trois phases ont été définies pour la gestion de l'eau, basées sur le présent plan minier, sont considérées dans le dimensionnement des ouvrages de gestion des eaux et sont rattachées au bilan des eaux (SRK, 2024a) :

- Phase A* : Années 0 à 4
  *Afin de minimiser les investissements initiaux la phase A comprend 2 sous-secteurs soient A1 et A2 (SRK, 2024c) qui seront construits en séquence en fonction des besoins d'entreposage à l'intérieur de la HCD. …
- Phase B1 : Années 4 à 7
- Phase B2 : Années 8 à 28

Ces quatre sous-secteurs ainsi que le développement du site en fonction du phasage sont présentés à la **Figure 2-1**.

Tel que prévu dans la Directive 019 (D019), les eaux de surface ayant été en contact avec les opérations minières seront collectées et traitées si elles ne respectent pas les critères de rejet de la D019 avant leur rejet à l'effluent final du site puis vers le milieu récepteur. Ainsi, un réseau de fossés collecteurs est prévu afin d'acheminer ces eaux vers les différents BC, ci-après nommés BC-1, BC-2 et le bassin sud (BS). Comme présenté sur la **Figure 2-2**, l'eau de surface en provenance de la HMT, de la ZI et de la fosse seront dirigées vers BC-2. Les eaux de contact provenant de la HCD seront acheminées gravitairement vers BC-1, BC-2 ou BS, conformément à la topographie et au plan minier de 2022[3] (SNC, 2022).

[2] Les superficies et phases ici présentées sont sujettes à modification sur la base des directives de NMG.

[3] SRK comprend qu'une révision du plan minier sera réalisée, par conséquent des modifications à la stratégie de la gestion des eaux pourraient alors être requises.

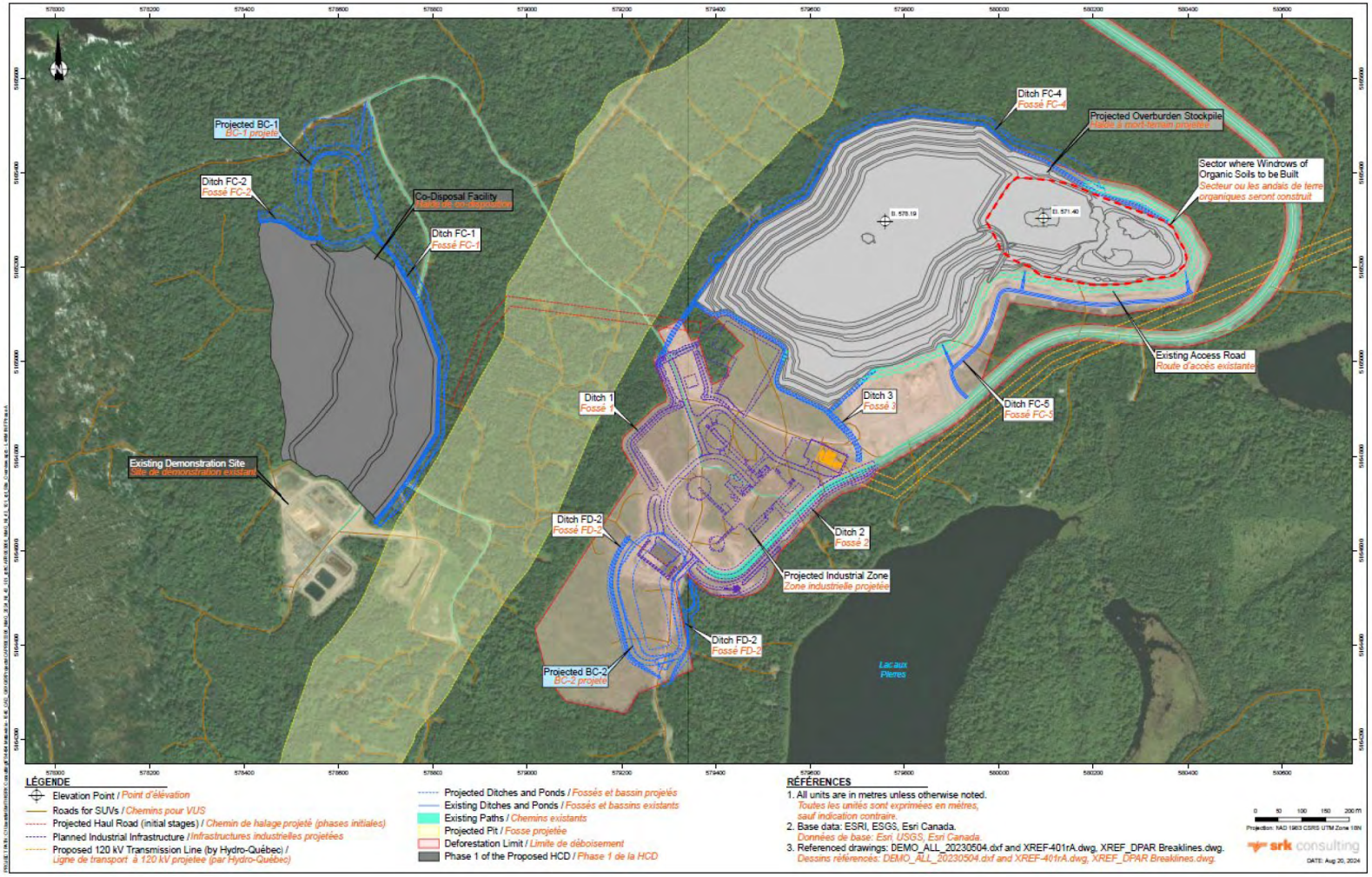

Figure 2-1 : Infrastructures en fonction de la phase A

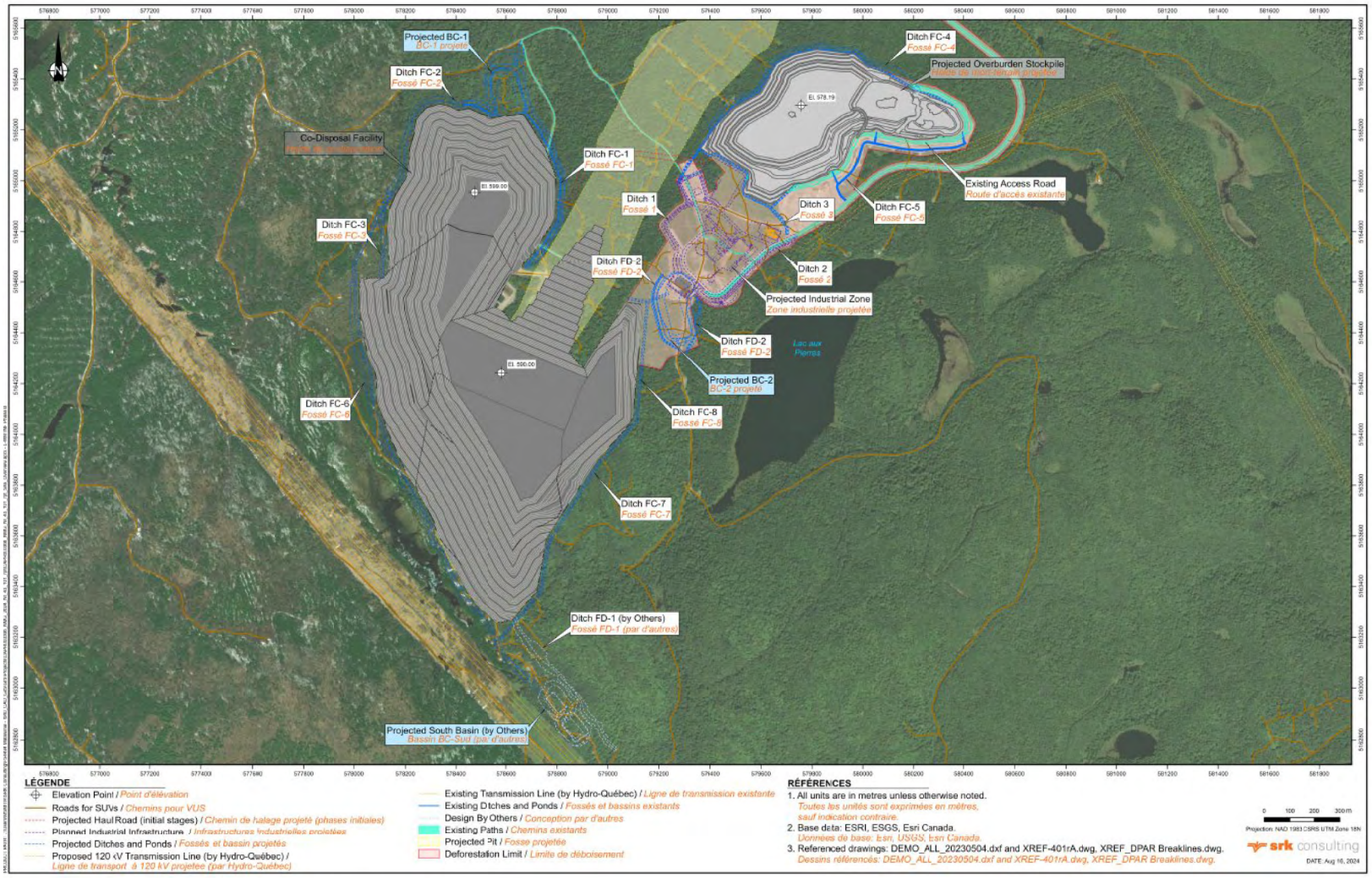

Figure 2-2 : Infrastructures en fonction de la fin de la phase B

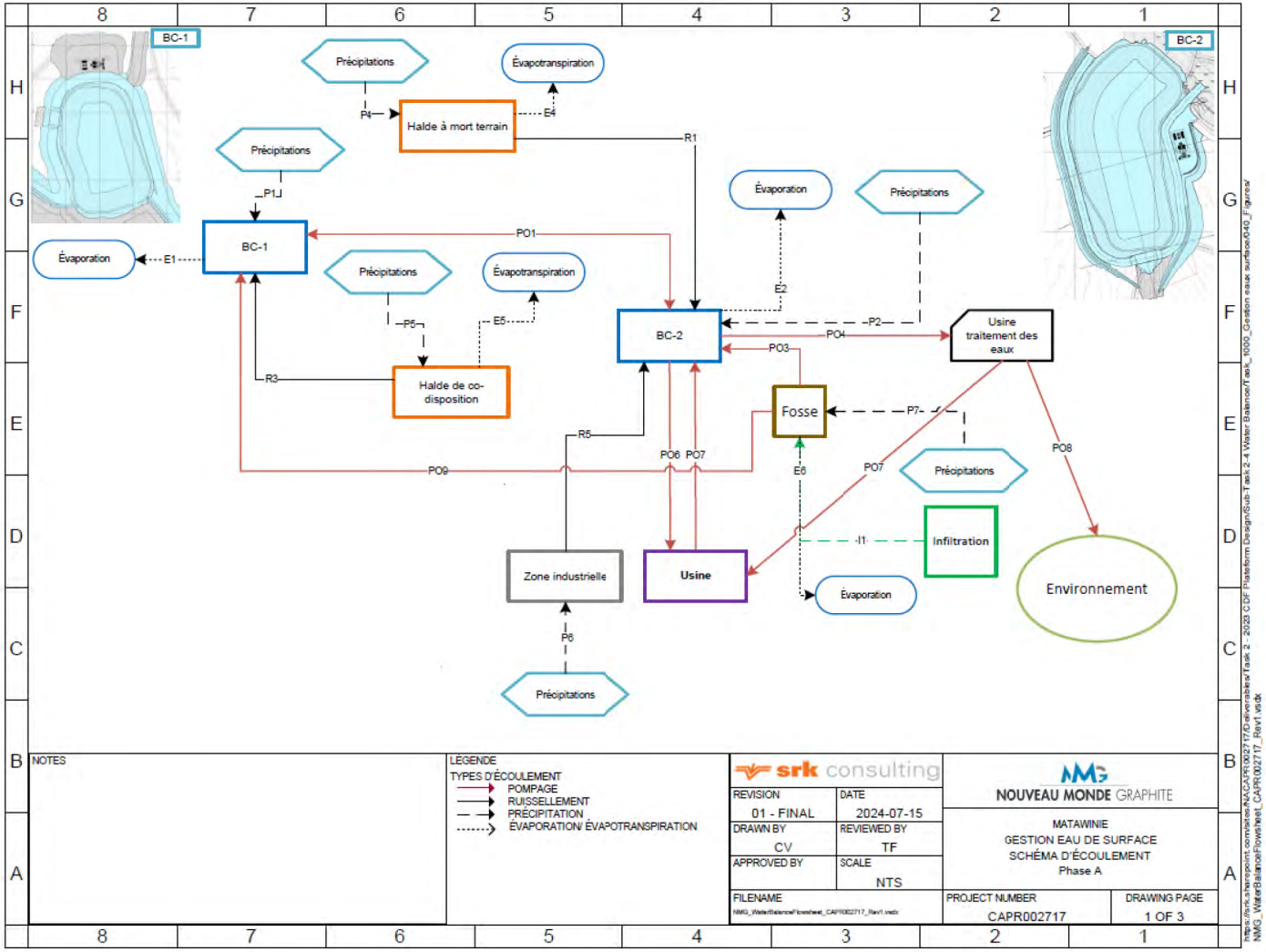

Figure 2-3 : Schéma de gestion des eaux de surface Phase A

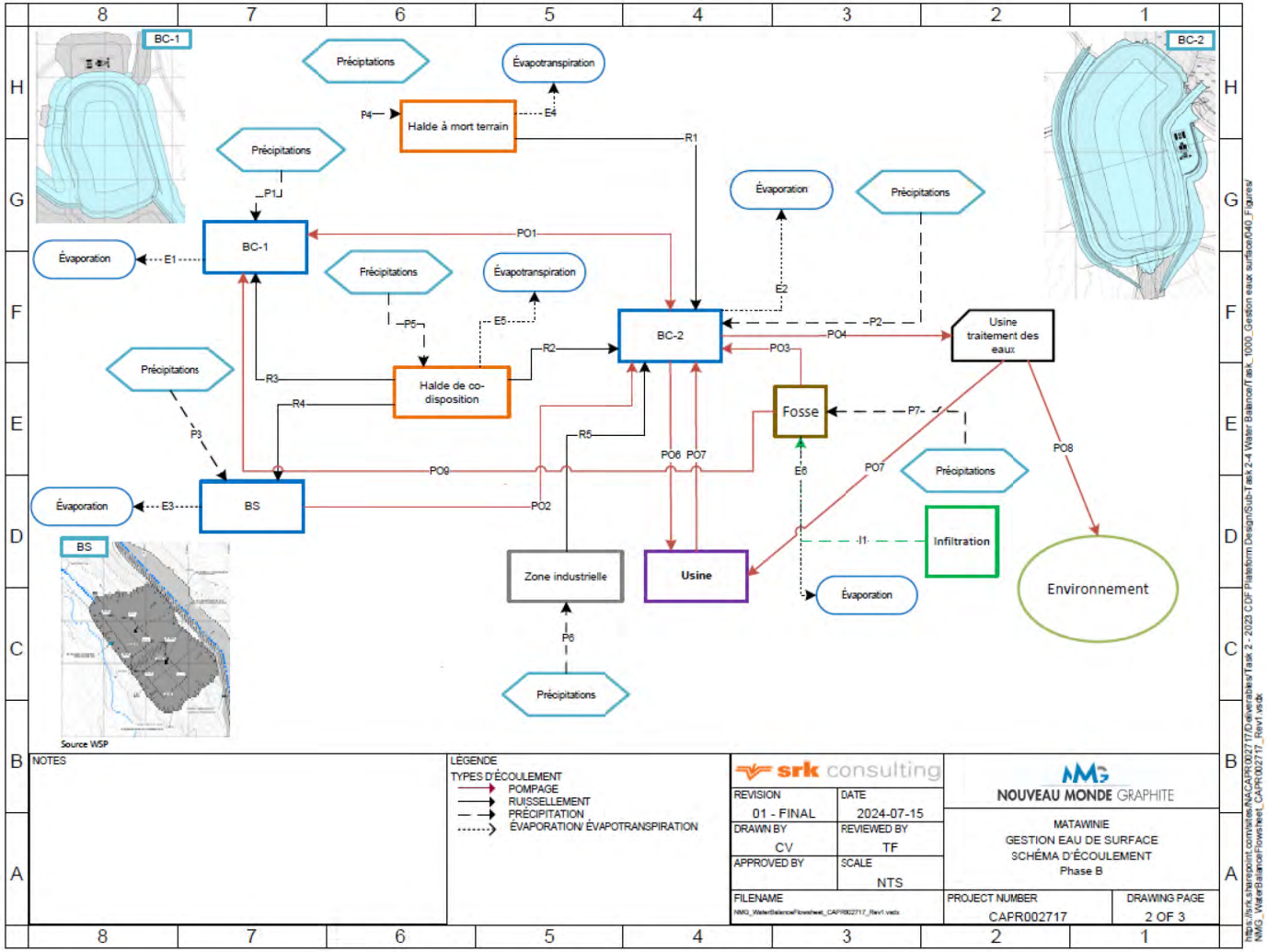

Figure 2-4 : Schéma de gestion des eaux de surface Phase B (Année 5)

Écoulement	De	Vers	Description
E1	BC-1	Atmosphère	Évaporation de l'eau vers l'atmosphère
E2	BC-2	Atmosphère	Évaporation de l'eau vers l'atmosphère
E3	BS	Atmosphère	Évaporation de l'eau vers l'atmosphère
E4	Halde à mort terrain	Atmosphère	Évapotranspiration de l'eau vers l'atmosphère
E5	Halde de co-disposition	Atmosphère	Évapotranspiration de l'eau vers l'atmosphère
E6	Fosse	Atmosphère	Évaporation de l'eau vers l'atmosphère
P1	Atmosphère	BC-1	Précipitations directes sur BC-1
P2	Atmosphère	BC-2	Précipitations directes sur BC-2
P3	Atmosphère	BS	Précipitations directes sur BS
P4	Atmosphère	Halde à mort terrain	Précipitations directes sur la Halde à mort terrain
P5	Atmosphère	Halde de co-disposition	Précipitations directes sur la Halde de co-disposition
P6	Atmosphère	Zone industrielle	Précipitations directes sur la Zone industrielle
P7	Atmosphère	Fosse	Précipitations directes sur la Fosse
I1	Eau souterraine	Fosse	Infiltration des eaux souterraines vers la Fosse
R1	Halde à mort terrain	BC-2	Ruissellement de la Halde à mort terrain vers BC-2
R2	Halde de co-disposition	BC-2	Ruissellement de la Halde à co-disposition vers BC-2
R3	Halde de co-disposition	BC-1	Ruissellement de la Halde à co-disposition vers BC-1
R4	Halde de co-disposition	BS	Ruissellement de la Halde à co-disposition vers BS
R5	Zone industrielle	BC-2	Ruissellement de la Zone industrielle vers BC-2
PO1	BC-1	BC-2	Transfert de BC-1 vers BC-2 via pompage
PO2	BS	BC-2	Transfert de BC-1 vers BC-2 via pompage
PO3	Fosse	BC-2	Transfert de la fosse vers BC-2 via pompage
PO4	BC-2	Usine de traitement des eaux	Transfert de BC-2 vers l'usine de traitement des eaux via pompage
PO5	Usine de traitement des eaux	Usine	Transfert de l'usine de traitement des eaux vers l'usine via pompage
PO6	BC-2	Usine	Transfert de BC-2 vers l'usine via pompage
PO7	Usine	BC-2	Transfert de l'usine vers BC-2 via pompage
PO8	Usine de traitement des eaux	Environnement	Transfert de l'usine de traitement des eaux vers l'environnement via pompage
PO9	Fosse	BC-1	Transfert de la fosse vers BC-1 via pompage

Figure 2-3 : Schéma de gestion des eaux de surface Phases A et B (continue)

Le **Tableau 2-1** identifie les fossés de collecte (FC) qui achemine l'eau de surface vers chacun des BC. Une vue schématique est également disponible aux **Figure 2-1** et **Figure 2-2**.

Tableau 2-1 : Réseau des fossés de collecte en fonction du bassin d'accumulation

BC-1	BC-2	BS
FC-1	FC-4	FC-6
FC-2	FC-5A/B*	FC-7
FC-3	FC-8	
	Fossé 1**	
	Fossé 2**	
	Fossé 3	

* Ce fossé est existant et le mandat de SRK prévoit de la prolonger et de valider la capacité hydraulique totale dans le cadre de cette phase d'ingénierie.

** Ces fossés ne sont pas dimensionnés par SRK, mais leurs capacités hydrauliques seront vérifiées dans le cadre de cette phase d'ingénierie.

Un bilan des eaux global au site de Matawinie a été réalisé par SRK (SRK, 2024a). L'objectif était de mettre à jour le bilan hydrique existant pour soutenir notamment l'ingénierie des BC afin de gérer adéquatement l'eau stockée qui servira aux opérations minières ou, sera traitée avant d'être rejetée dans l'environnement. Le **Tableau 2-2** présente les volumes d'entreposage requis par les bassin (BC et BS) en fonction des différentes phases de développement.

Tableau 2-2 : Volume requis par BC et par Phase du projet

Bassin	Phase A	Phase B-1	Phase B-2
BC-1	172 000 m^3	172 000 m^3	172 000 m^3
BC-2	170 000 m^3	170 000 m^3	170 000 m^3
BS	-	89 000 m^3	256 000 m^3

Il est à noter qu'à partir de l'année 20 du projet, le volume requis du BS sera de 329 000 m^3. Toutefois, ceci ne considère pas de potentiels futurs travaux de restauration progressive qui pourraient réduire la taille du bassin versant à gérer. Puisque ce bassin n'est pas requis dans la première phase du projet, l'ingénierie s'y rattachant n'est pas encore complétée à ce jour.

3 Base de l'ingénierie

3.1 Exigences réglementaires

L'ingénierie des ouvrages de gestion des eaux de surface doit se conformer aux exigences environnementales du Québec ainsi qu'aux engagements décrits dans le Décret 47-2021.

Également, il est considéré que l'exploitation, l'entretien et la surveillance des ouvrages de gestion des eaux du projet de mine de graphite Matawinie doivent être conformes et en accord avec les lois et règlements suivants[4] :

- Réglementation de la province du Québec :
  - Directive 019 sur l'industrie minière (mars 2012)
  - Loi sur la qualité de l'environnement. (Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs)
  - Loi sur les mines (chapitre M-13.1)
- Loi canadienne sur la protection de l'environnement : 1999, c. 33

De plus, les guides et manuels portant sur les meilleures pratiques de conception d'ouvrages hydrauliques sont utilisés dans le cadre de cet exercice :

- Cahier des charges et devis généraux (CCDG), ministère des Transports du Québec (MTQ)
- Manuel de conception des ponceaux, gouvernement du Québec, 2004
- Travaux de génie civil – Granulats (BNQ 2560-114), Devis normalisés techniques (BNQ)
- Guide de gestion des eaux pluviales, ministère du Développement durable, de l'Environnement et des Parcs
- Manuel de calcul et de conception des ouvrages municipaux de gestion des eaux pluviales, avril 2017 (MELCC), Pratiques actuelles de l'industrie minière
- Guide de préparation du plan de réaménagement et de restauration des sites miniers au Québec. Ministère de l'Énergie et des Ressources naturelles (2022)
- Bulletin technique : Application des lignes directrices sur la sécurité des barrages aux barrages miniers. Association Canadienne des barrages (ACB), 2014

3.2 Objectifs

Dans le cadre du présent document, un objectif se définit comme un but ou une cible à atteindre. Les objectifs de l'ingénierie des ouvrages de gestion des eaux de surface sont les suivants :

[4] Cette liste est non exhaustive.

- Permettre l'accumulation et la gestion des eaux de pluie et de fonte des neiges pendant les opérations courantes du site sans débordement au droit des BC.
- Concevoir les ouvrages de gestion des eaux dans l'empreinte déterminée lors de la précédente phase d'ingénierie WOOD, 2021.
- Intégrer les ouvrages projetés à ceux existants, tels que le raccordement des fossés périphériques projetés autour de la HMT aux fossés existants, ou prévus à l'intérieur et autour de la ZI[5].
- Minimiser les distances à parcourir lors des travaux de terrassement et de construction.
- Minimiser la quantité d'enrochements requis lors des travaux de terrassement et de construction. Il est supposé que l'enrochement sera produit sur le site.
- Avoir une géométrie et des méthodes de construction qui limitent les risques d'érosion, tout au long de l'exploitation.

3.3 Critères généraux

Les critères généraux suivants ont été retenus pour l'ingénierie des ouvrages de gestion des eaux de surface :

- Être situé à l'intérieure de l'empreinte au décret 47-2021.
- Contenir les eaux de contact avec les opérations minières au sein du réseau de drainage prévu.
- Rejeter à l'environnement, le cas échéant, une eau de qualité respectant les objectifs de rejet de la D019.
- Utiliser de l'enrochement non générateur d'acide et non lixiviable, selon les définitions de la D019, lors des travaux de construction et de terrassement.

Il est considéré que les équipements et les matériaux de construction énumérés dans le **Tableau 3-1** seront disponibles lors des travaux de terrassement / construction des BC, FC et fossés et pourront être utilisés si jugés nécessaires.

[5] La conception du système de fossé de la zone industrielle ne fait pas partie du présent mandat.

Tableau 3-1 : Équipements et matériels supposés disponibles

Type	Description
Excavatrices	CAT 349 (ou équivalent) CAT 336 (ou équivalent)
Bulldozers	CAT D8 (ou équivalent) CAT D6 (ou équivalent)
Camions de transport	CAT Articulé 735 (ou équivalent) et 775 de la fosse minière
Compacteur	CAT CS64B (ou équivalent)
Chargeurs	CAT 950 et CAT 988
Membranes géosynthétiques	Géotextile non tissé Géotextile 7609 Géotextile 7612 Géotextile 918 Protection ou de filtration (selon les besoins) Géocomposite (ou équivalent) Type à déterminer selon les besoins (épaisseur du grillage et poids du géotextile) Géomembrane Type à déterminer selon les besoins (épaisseur, texturée ou non, couleur, etc.)
Matériau granulaire (NPAG [1] & NLM [2])	Sable propre CG-14 (Matériaux remblai primaire, sable) Roche concassée de diamètre inférieur à 20 mm (MG-20) Roche concassée de diamètre inférieur à 56 mm (MG-56) Roche concassée de diamètre inférieur à 112 mm (MG-112) Empierrement 100-300 mm Empierrement 300-700 mm

1 NPAG = Non potentiellement générateur d'acide
2 NLM = Non lixiviable en métaux

3.4 Critères de la gestion des eaux de surface

3.4.1 BC

Les BC ont :

- Une section de forme trapézoïdale ;
- Les bassins seront construits à même le sol et socle rocheux ;
- Des activités de sautage-dynamitage du socle rocheux seront requises ;
- Permettre l'accumulation et la gestion des eaux issues de la crue de conception, soit une averse de 24 h de récurrence 1 : 2000 ans, combinée à la fonte du couvert de neige de récurrence 1 : 100 ans répartie uniformément sur une période de 30 jours ;
- Les pentes des talus des dépôts meubles seront d'au minimum 2H : 1V (Horizontal : Vertical) ;

- L'imperméabilisation (lorsque nécessaire) sera faite au moyen d'une géomembrane polyéthylène de basse densité (PeBD) exposée d'une épaisseur de 1,5 mm, les ancrages au roc ou dans les dépôts meubles seront considérés dans le dimensionnement ;
- L'inclinaison des talus du socle rocheux sera de 2H : 1V. L'inclinaison des talus du bassin BC-2 déjà excavés sera conservée telle quelle, lorsque possible ;
- Une couche de matériaux granulaires (c.-à-d. sable propre, CG-14 ou MG-20) d'une épaisseur minimum de 300 mm sera mise en place dans le fond et les talus des BC pour agir comme assise pour la géomembrane. Si le roc dynamité présente la pente finale désirée et est libre de tout bloc instable, arrête vive ou tout autre risque d'abimer la géomembrane, la couche de sable pourrait être remplacée par un géocomposite de drainage enrobé d'un géotextile de chaque côté ;
- Un dévers de 4 % minimum vers le bassin pour le chemin périphérique construit au pourtour des BC ;
- Des bermes de sécurité seront mises en place du côté intérieur des bassins, pour prévenir la chute d'un véhicule ou tout équipement de chantier dans ces derniers ;
- Pour des raisons de sécurité, SRK suggère que les BC soient clôturés[6] et munis de bouées ou autres équipements de sauvetage en cas de chute accidentelle ;
- Un déversoir d'urgence[7] devra être construit au droit de BC-1, BC-2 et BS ; et
- Chacun des BC sera muni d'une station de pompage enclavée dans une surexcavation d'une de ses parois[8]. La conception des stations de pompage est effectuée par d'autres, alors que le mandat de SRK est d'intégrer le poste dans l'enceinte de chaque bassin.

Le **Tableau 3-2** résume les paramètres d'ingénierie provenant de WOOD (2021), qui ont été utilisés comme le point de départ de cette ingénierie. SRK comprend qu'une optimisation de la gestion des eaux est en processus de réalisation, par conséquent ces paramètres pourraient être amenés à changer.

Tableau 3-2 : Paramètres de conception des BC selon WOOD 2021

Description	Bassin BC-1	Bassin BC-2	BS
Élévation fond du bassin (masl)	506,0	532,5	446,0
Élévation maximale eau (masl)	517,0	542,0	455,5

3.4.2 Déversoir d'urgence et canaux d'évacuation des BC

La capacité hydraulique des déversoirs d'urgence à BC-1, BC-2 et BS permettra d'évacuer la Crue Maximale Probable (CMP) de 279,0 mm/24 h (SRK, 2023), et ce, sans débordement. Pour fin de

[6] Afin d'empêcher que des animaux ne se noient.

[7] La localisation des déversoirs d'urgence à BC-1 et BS sera établie conjointement avec NMG.

[8] Les critères d'ingénierie des surexcavations devront être établis conjointement avec NMG et l'entreprise qui sera responsable des stations de pompage.

modélisation hydraulique, il sera considéré que les niveaux d'eau dans les bassins seront au seuil des déversoirs d'urgence au début de la pluie de conception. L'utilisation de béton pourrait être requise lors de la construction des seuils des déversoirs d'urgence.

Les déversoirs d'urgence et canaux d'évacuation seront protégés contre l'érosion à l'aide d'un empierrement. Les canaux d'évacuation dirigeront l'eau vers un endroit sécuritaire et limitant les possibles impacts sur l'intégrité des ouvrages et du site.

3.4.3 FC

Les fossés de collecte FC-5A et FC-5B, présentés sur la **Figure 3-1**, ont été construits en 2022, à l'est et au sud de la HMT. Le fossé de collecte FC-4 (**Figure 3-1**) situé au nord-est et nord de la HMT reliera le fossé FC-5B. Le dimensionnement des FC a été réalisé à l'aide d'un modèle hydrologique et hydraulique fait à partir du logiciel PC SWMM comme présenté en **section 5** de ce rapport. Les FC en périphérie de la HCD sont tous à construire et sont présentés à la **Figure 2-2**. Une coupe type du fossé FC-4 est montrée à la **Figure 3-2** alors qu'une coupe du FC-1 se retrouve à la **Figure 3-3**.

Les détails des FC sont présentés au **Tableau 5-4** et leurs caractéristiques peuvent se résumer ainsi :

- Une section de forme trapézoïdale ;
- Une profondeur minimale de 1,0 m ;
- Une largeur au fond minimale de 1,0 m, au-dessus de l'empierrement de protection ;
- Une pente longitudinale minimale de 0,3 % et des pentes de talus de 2H : 1V ;
- Des ponceaux pour faciliter le passage des équipements. Les ponceaux devront être installés au radier des fossés ;
- Les fossés autour de la HMT seront protégés par un enrochement de calibre et d'une épaisseur minimale capable de résister aux vitesses anticipées à l'intérieur de ceux-ci ;
- Les fossés membranés qui seront construits au pourtour de la HCD ne seront pas empierrés, la géomembrane PeBD de 60 mils (1,5 mm) sera exposée et pourrait nécessiter des travaux de réparation, le cas échéant ;
- Une revanche minimale de 300 mm entre le dessus de la lame d'eau, lors de la crue de conception, et la crête des talus des fossés a été appliquée ;
- Un coefficient de Manning de 0,033 pour les fossés membranés a été utilisé pour les calculs dans l'éventualité où de l'empierrement serait ajouté dans la section d'écoulement ; et
- Les fossés sont rattachés au BC et permettre la gestion des eaux de la combinaison d'une pluie de récurrence 1: 2000 ans et de la fonte de neige d'un couvert de récurrence 1: 100 ans s'échelonnant sur 30 jours est le critère retenu pour les fossés autour de la HCD.

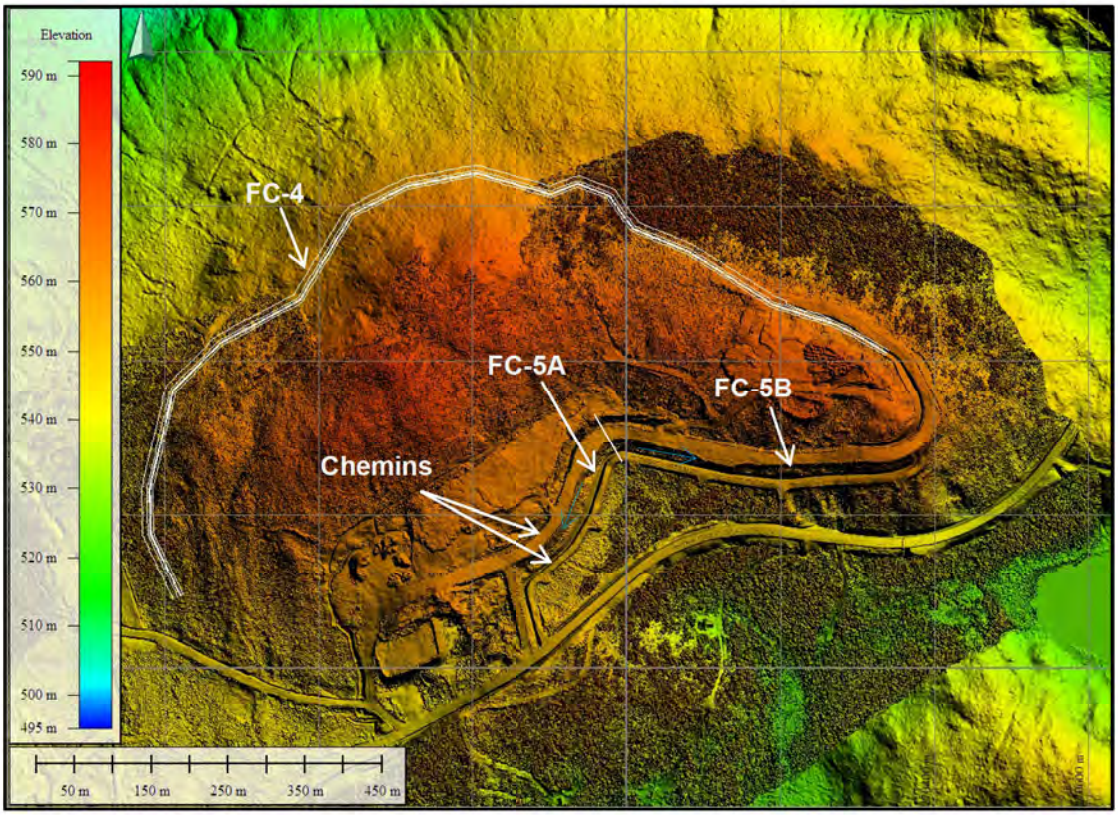

Figure 3-1 : Localisation des fossés de collecte permanents – FC-5A, FC-5B et FC-4

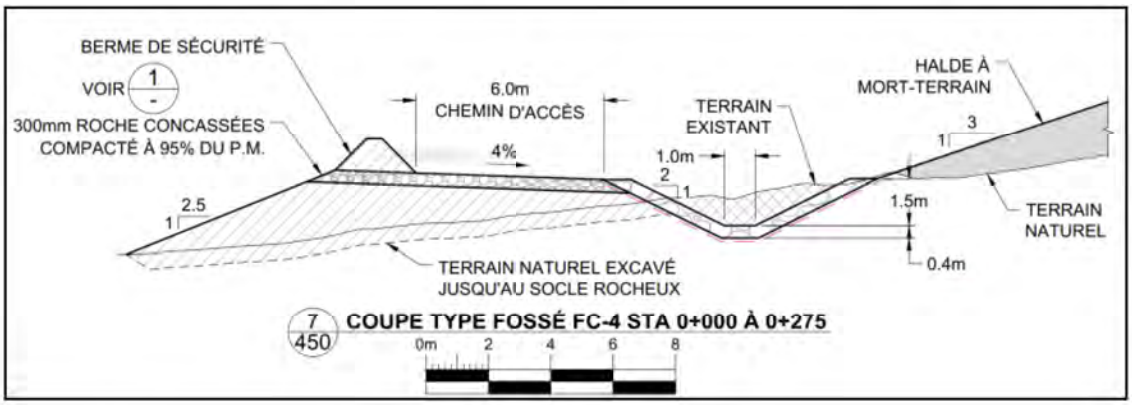

Figure 3-2 : Coupe type d'un FC projeté autour de la HMT

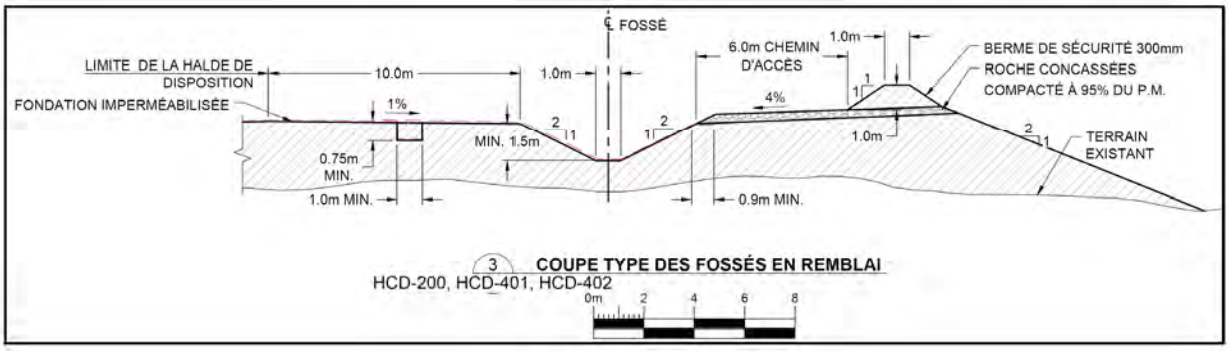

Figure 3-3 : Coupe type d'un FC projeté autour de la HCD

3.4.4 Fossés temporaires et de déviation

La localisation des fossés temporaires a été établie sur la base des conditions topographiques qui prévalent sur le terrain au moment des travaux de construction et sont des ouvrages qui permettent de diriger ou évacuer les eaux d'un secteur pendant les travaux. Aucune analyse hydrologique et hydraulique n'a été réalisée pour la conception des fossés temporaires. La localisation de ces derniers sera déterminée sur le chantier, en concertation entre le concepteur et l'Entrepreneur, en raison de leur statut temporaire. Aucune excavation dans le socle rocheux ne sera permise pour la construction des fossés temporaires et de l'empierrement ou de l'hydroensemencement sera appliqué pour fin de protections hydrauliques et minimiser l'érosion et les matières en suspension, le cas échéant. Les fossés temporaires seront remblayés lors des travaux de terrassement, lorsque le niveau supérieur de la HMT ou de la HCD sera construit.

Les fossés de déviation FD-1 et FD-2 (voir **Figure 2-1** et **Figure 2-2**) ont été positionnés de manière à collecter les eaux propres et à les diriger en dehors de leurs bassins versants respectifs sans affecter la gestion des eaux de contact. L'objectif de ces ouvrages est de minimiser les volumes d'eau devant être acheminés au traitement. Une pluie équivalente à une récurrence 1: 25 ans a été considérée pour le dimensionnement de ces fossés. Tout comme les fossés temporaires, les fossés de déviation pourraient être amenés à être remblayés suivant l'évolution des opérations minières.

Les fossés temporaires ou de déviation auront (voir **Figure 3-4**) :

- Une section de forme trapézoïdale ;
- Une profondeur minimale de 1,0 m ;
- Une largeur au fond minimale de 1,0 m ; et
- Une pente longitudinale minimale de 0,3 %, et des pentes des talus seront de 2H : 1V.

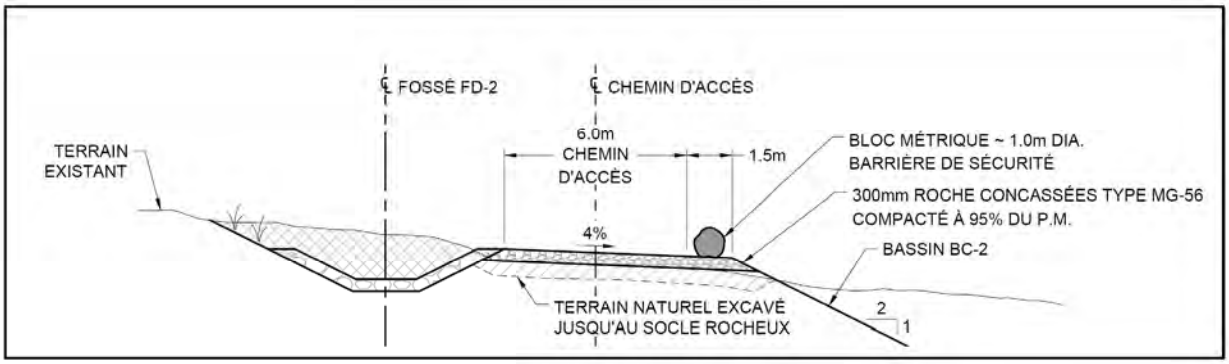

Figure 3-4 : Coupe type d'un fossé de déviation

3.4.5 Ponceaux permanents

Des ponceaux permanents de type tuyaux de tôle ondulée galvanisée (TTOG) seront requis dans l'emprise de la HMT (SRK, 2024b) afin de gérer une crue de conception générée par une averse d'une récurrence 1: 100 ans, et ce, sans débordement sur le chemin qu'il dessert ou du fossé dans lequel il sera déposé.

Les ponceaux permanents auront :

- Un diamètre respectant le dimensionnement préalable ;
- Une pente longitudinale minimale de 0,5 % ou moindre si l'autocurage peut être assuré ;
- Un recouvrement conforme aux recommandations de l'industrie ;
- Les extrémités protégées par l'entremise d'un enrochement de protection ; et
- Un coefficient de Manning de 0,028 a été utilisé pour les calculs.

3.4.6 Ponceaux temporaires

Tout comme les ponceaux permanents, les ponceaux temporaires de type TTOG ou PEHD pourraient être requis et mis en place au sein du réseau de fossés temporaires et auront :

- Un diamètre interne de 1,0 m ;
- Une pente longitudinale minimale de 0,3 % ;
- Un recouvrement conforme aux recommandations de l'industrie ; et
- Les extrémités des ponceaux seront protégées par un enrochement, le cas échéant.

3.4.7 Pompage interbassins

La stratégie de gestion des eaux repose notamment sur l'acheminement des eaux de contact vers le BC-2 pour fin de traitement et de réutilisation ou de retour à l'environnement. Les **Figure 2-3** et **Figure 2-4** indiquent la stratégie de pompage interbassin qui sera mis en œuvre en fonction des phases du projet. Les débits de pompage résumés au **Tableau 3-3** sont extraits de SRK, 2024a.

Tableau 3-3 : Débit de pompage en fonction des phases de la mine

Phasage	Bassin BC-1	Bassin BC-2	BS
Phase A* **(Débit de pompage annuel moyen (m^3/h))**	255	350	N/A
Phase A* **(Débit lors de la crue de conception (m^3/h))**	470	900	100
Phase B **(Débit de pompage annuel moyen (m^3/h))**	215	350	N/A
Phase B **(Débit lors de la crue de conception (m^3/h))**	360	1 800	810

*La phase A inclut les phases A1 et A2 du plan de déposition (SRK, 2024c)

3.5 Plateforme de l'usine de traitement des eaux à BC-2

L'usine de traitement des eaux sera implantée à l'est du bassin BC-2. Une plateforme en till et en type MG-56 sera aménagée pour y accueillir les équipements proposés par Mabarex. Les critères suivants serviront à réaliser la conception de la plateforme :

- Les dimensions minimales requises du système seront fournies par Mabarex.
- L'accès à la plateforme devra se faire par le chemin qui mène à l'usine de traitement des eaux sanitaires.
- Du dégagement supplémentaire sera prévu pour faciliter les déplacements et la livraison des produits chimiques.
- L'empreinte de la plateforme sera optimisée afin d'y aménager des zones d'entreposage des matériaux.
- Il est prévu que le socle rocheux soit excavé à certains endroits pour atteindre l'élévation finale projetée.
- Les détails de la station de pompage seront fournis par d'autres, et au besoin, SRK pourra les intégrer aux plans.

3.6 Plateforme du poste de pompage à BC-1

Un poste de pompage des eaux de contact sera implanté au nord du bassin BC-1. Une plateforme en till et en type MG-56 sera aménagée pour y accueillir les équipements proposés par d'autres. Les critères suivants serviront à réaliser la conception de la plateforme :

- Les dimensions minimales requises du système seront fournies par d'autres.
- L'accès à la plateforme devra se faire par les chemins à proximité de BC-1.
- L'empreinte de la plateforme sera optimisée afin d'y installer une roulotte de chantier ainsi qu'un conteneur marin d'entreposage des matériaux en plus du poste de pompage.
- Il est prévu que la plateforme nécessite du remblai à certains endroits pour atteindre l'élévation finale projetée.

Les détails de la station de pompage seront fournis par d'autres, et au besoin, SRK pourra les intégrer aux plans.

3.7 Stabilité physique

Les bassins décrits en **Annexe B** auront une profondeur de l'ordre de 15 à 18 m selon les secteurs (l'excavation de 18 m comprend les talus du bassin alors que la profondeur d'eau atteindra un maximum de 13 m). Les talus des bassins seront excavés dans le mort-terrain et le socle rocheux. Considérant que i) le talus excavé dans le mort-terrain sera d'une hauteur variable (1 à 5 m) et majoritairement inférieure à 3,0 m, et ii) la nature granulaire du matériau, une inclinaison de 2H:1V est considérée appropriée. Une telle inclinaison correspond à l'inclinaison des talus du mort terrain au pourtour de la fosse tel que recommandé par SNC-Lavalin en 2020 (SNC, 2020a).

Afin d'atteindre les capacités d'emmagasinement requises, des activités de dynamitage seront requises afin d'excaver le socle rocheux sur une profondeur de l'ordre de 10 à 15 m selon les secteurs. Il est considéré que les forages, qui seront réalisés pour fin de dynamitage, permettront d'obtenir une inclinaison des talus de roc dynamité de l'ordre 2H : 1V (26.6°). Cette inclinaison est inférieure à l'inclinaison des paliers variant de 65° à 89° proposée lors de la conception de la fosse et ce pour des paliers d'une hauteur de 20 m (SRK, 2022).

Au moment de l'excavation du roc dynamité, un nettoyage efficace des talus sera réalisé afin de réduire les probabilités de chutes de pierres et maximiser la performance des parois. Pour ce faire l'utilisation d'une excavatrice à longue portée sera nécessaire. De plus, afin d'assurer que l'inclinaison de 2H : 1V soit adéquate sur la totalité du pourtour des bassins, il se pourrait que du remblayage avec des matériaux granulaires soit requis localement.

3.8 Critères spécifiques au choix et à l'installation de la géomembrane

L'hypothèse de base est que la géomembrane qui sera utilisée sera composée de PeBD et aura une épaisseur de 1,5 mm, comme mentionné par NMG dans divers documents déposés aux instances gouvernementales (SNC 2019b, 2019c). Toutefois, s'il est observé lors de l'ingénierie de détails des ouvrages de gestion des eaux de surface qu'une géomembrane plus épaisse pourrait s'avérer plus avantageuse et donc plus performante, cette option pourrait être considérée.

La géomembrane utilisée pour les BC et les fossés devant être imperméabilisés en périphérie de la HCD sera texturée sur 1 des deux côtés, car ce type de géomembrane offre une plus grande résistance au cisaillement avec les matériaux adjacents que les géomembranes lisses. Pour fin de calculs, les paramètres et propriétés d'une géomembrane Texel TM860-ST (Texel, 2017) sont utilisés dans le cadre de l'ingénierie des ouvrages de gestion des eaux de surface (**section 5**). Par souci d'uniformité et de simplification des opérations en chantier, si les calculs pour les BC et les fossés présentent des résultats permettant l'utilisation de la même géomembrane que celle utilisée pour la plateforme de la HCD, cette dernière sera sélectionnée. Si une géomembrane plus épaisse s'avère requise, celle-ci devra être adoptée pour les ouvrages en question.

De plus, la conception de la barrière d'étanchéité des BC devra répondre aux critères suivants, spécifiques à l'installation d'une géomembrane :

- Si la géomembrane présente un risque de soulèvement par le vent et/ou par les poussées hydrostatiques dû à un niveau de la nappe phréatique élevé par rapport au fond du bassin, le dimensionnement des ancrages ou l'utilisation de lests doit permettre de diminuer la tension dans la géomembrane à un niveau acceptable. Le niveau acceptable de déformation dans une géomembrane en PeBD est de 8 à 12 % (Lupo et Morrison, 2007), mais une bonne pratique consiste à ne pas dépasser une déformation de 10 %.
- Le facteur de sécurité minimal (FS_{min}) à atteindre pour la résistance à la rupture en tension est de 1,3 considérant une déformation de 10 %. .
- Le FS_{min} à atteindre pour la résistance à l'arrachement des ancrages de la géomembrane est de 1,3. considérant une déformation de 10 %.

4 Conditions actuelles du site

4.1 Topographie et données de terrain

Dans le cadre du mandat, le système métrique utilisé ainsi que le système de coordonnées sont présentés au **Tableau 4-1**.

Tableau 4-1 : Système de coordonnées devant être utilisé

Datum	NAD83 CSRS (7-PARAM TRANSFORM)
Zone	UTM Zone 18 (78.0W-72.0W)
Système altimétrique	CGVD28
Modèle du géoïde	HT2.0 (1997)
Code EPSG ensemble de données sur les paramètres géodésiques/ellipsoïdes terrestres	2959

Les fichiers suivants, fournis par le client, ont été utilisés comme données topographiques de base :

- Topographie : CMC_ALL_20230714 sous format de modèle numérique de surface (MNS) (14 juillet 2023) et CMC_BC2_20230717.tif (17 juillet 2023) ;
- Limites de la zone déboisée : CMC_ALL_DEBOISEMENT_20220419 sous format de fichier de formes (19 avril 2022).

Les données topographiques de base utilisées pour la HCD sont les modèles numériques de terrain avec une résolution spatiale de 1 m disponibles sur « Forêt ouverte » (portail de diffusion des données écoforestières du Gouvernement du Québec) pour ce secteur. Il s'agit des fichiers MNT_31I1SO.tif et MNT_31I12NO.tif (foret-ouverte-données, 2023). Il est à noter que le modèle de géoïde de référence pour ces fichiers est l'ellipsoïde GRS80. La présence ou non d'une différence d'élévation entre le modèle numérique obtenue sur « Forêt ouverte » et les relevés faits par NMG, utilisant le modèle de géoïde HT2.0 (1997), doit être établie avant la préparation de plans pour construction.

- Les coordonnées centrales approximatives des BC sont :

UTM Zone 18 (NAD83 CSRS)		
Bassin	**Est**	**Nord**
BC-1	578 601.63	5 165 367.07
BC-2	579 257.97	5 164 525.34
BS	578 834.54	5 162 899.43
Degré décimal (pour information seulement)		
Bassin	**Latitude**	**Longitude**
BC-1	46.637256	73.973043
BC-2	46.629604	73.964613
BS	46.615025	73.970421

- Les coordonnées approximatives de l'effluent final projeté sont :
  - Est : 578 784.94
  - Nord : 5 162 201.77

4.2 Stratigraphie sous les bassins d'accumulation des eaux

L'information stratigraphique présentée dans les rapports de SNC-Lavalin (2019) et de WSP (2022) a été utilisée afin d'établir les unités stratigraphiques sous BC-1, BC-2 et BS (**Figure 4-1** à la **Figure 4-6**). L'interprétation préliminaire des données géotechniques disponibles a permis d'établir les stratigraphies suivantes.

4.2.1 Bassin BC-1

La stratigraphie des dépôts de surface dans l'empreinte du bassin BC-1 est composée d'une couche de sable et de silt en proportion variable (sable silteux à silt et sable) et d'épaisseur variant (± 2,9 m à 4,0 m dans la partie nord-est et supérieure à 5,0 m dans le secteur sud-ouest) telle que présentée sur la **Figure 4-2**. Le sable et silt est recouvert d'un horizon de sol organique d'une épaisseur moyenne de 0,30 m. Le dépôt de sable et silt repose sur le socle rocheux.

4.2.2 Bassin BC-2

L'épaisseur du dépôt organique dans le secteur du bassin BC-2 varie entre 0,15 m et 0,30 m. Sous l'horizon de sol organique, l'épaisseur de la couche de sable et silt varie entre 1,0 m aux extrémités nord et sud du bassin pour atteindre près de 7,0 m au centre du futur bassin. Le dépôt de sable et silt repose également sur le socle rocheux (**Figure 4-4**). Il est à noter qu'un secteur au nord du bassin a été excavé en 2022 et le socle rocheux se retrouve à moins de 1,0 m par endroit, ce qui confirme le profil du roc anticipé.

4.2.3 Bassin BS

Un dépôt de sable et silt se retrouve sous la matière organique sur une épaisseur allant fortement variable entre 6,0 m dans le secteur nord du bassin, centimétrique dans la partie centrale de ce dernier et de l'ordre de 2,0 m dans le secteur sud du futur bassin (**Figure 4-6**). Le dépôt de sable et silt repose sur le socle rocheux.

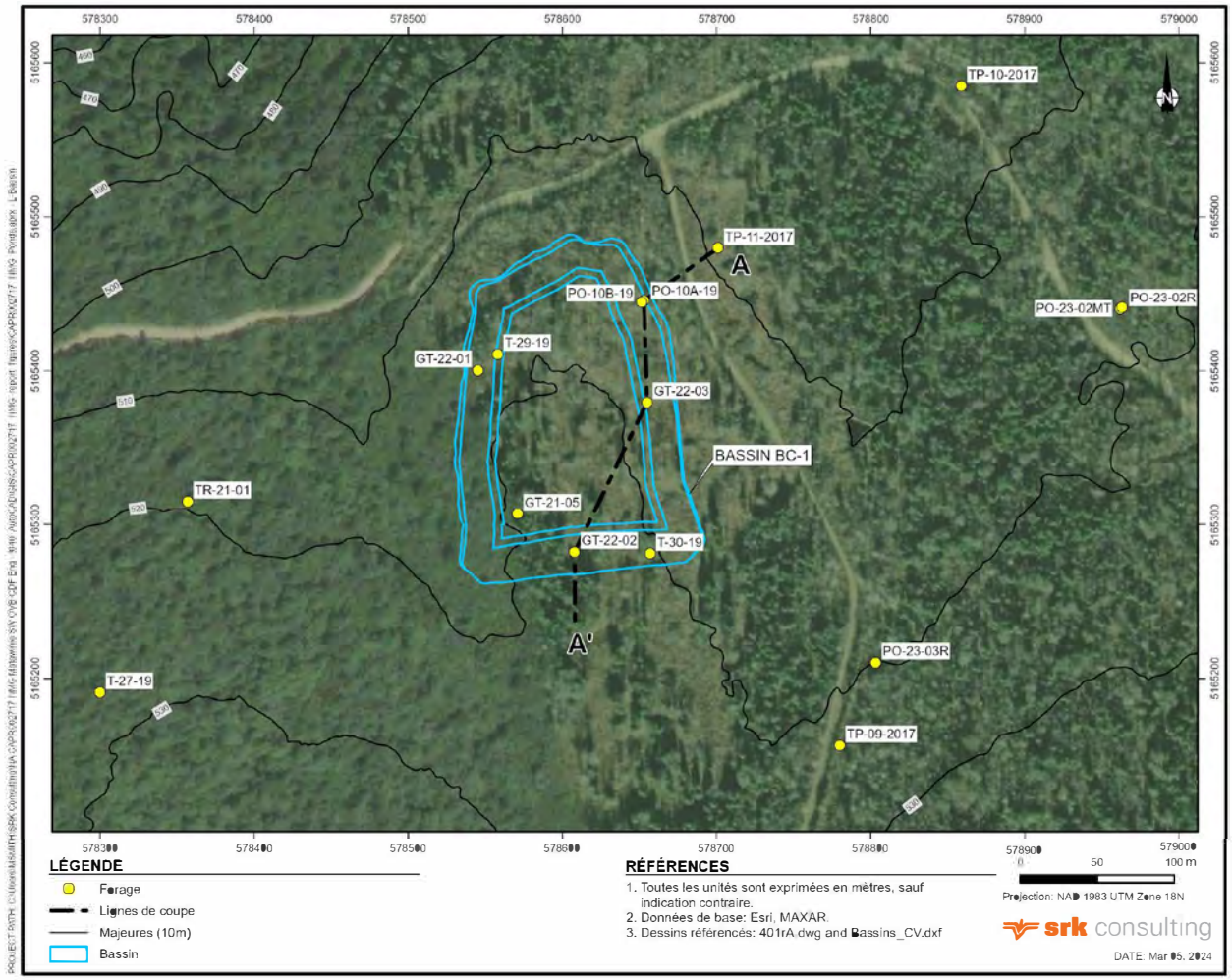

Figure 4-1 : Position des sondages géotechniques disponibles en date du 05 octobre 2023, Bassin BC-1

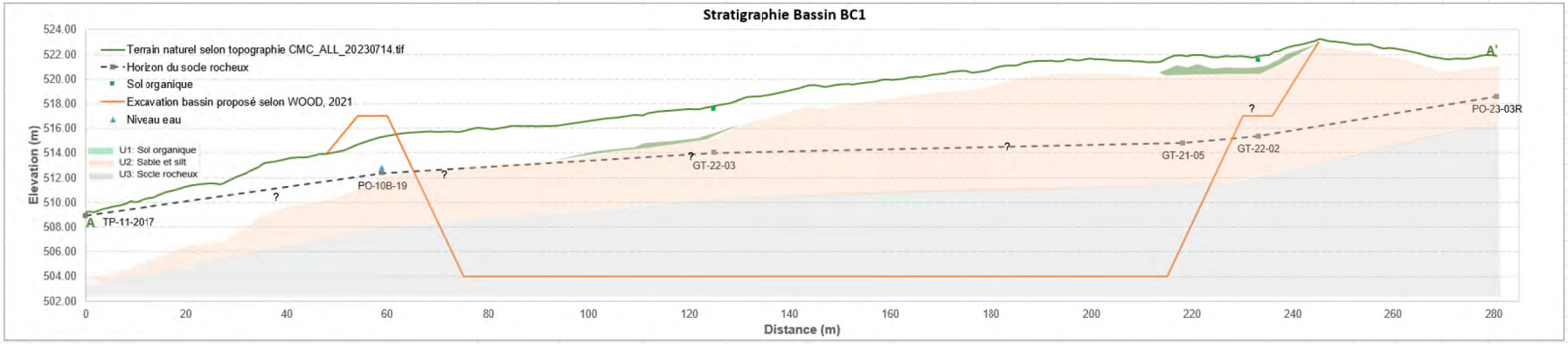

Figure 4-2 : Stratigraphie établie pour BC-1

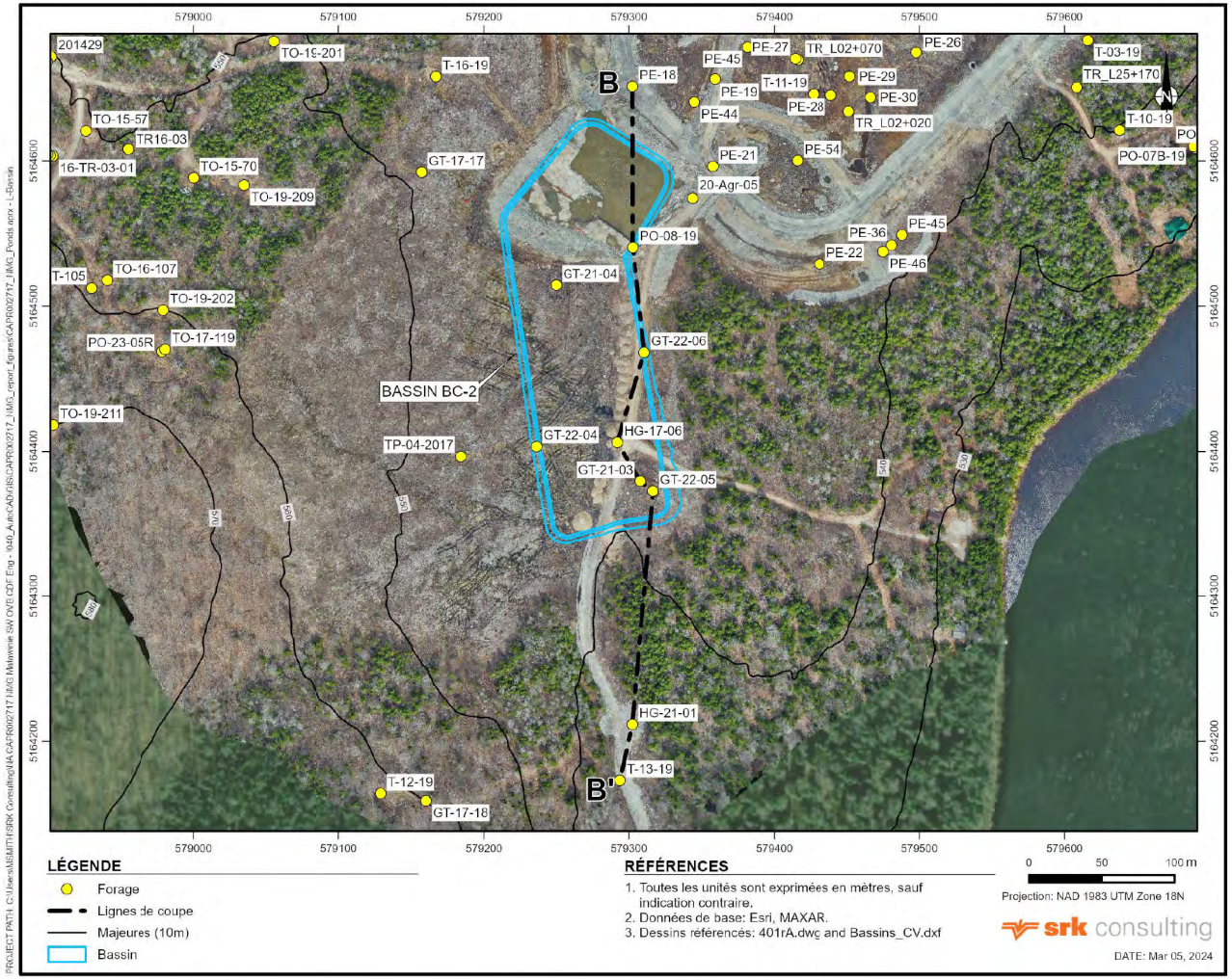

Figure 4-3 : Position des sondages géotechniques disponibles en date du 05 octobre 2023, Bassin BC-2

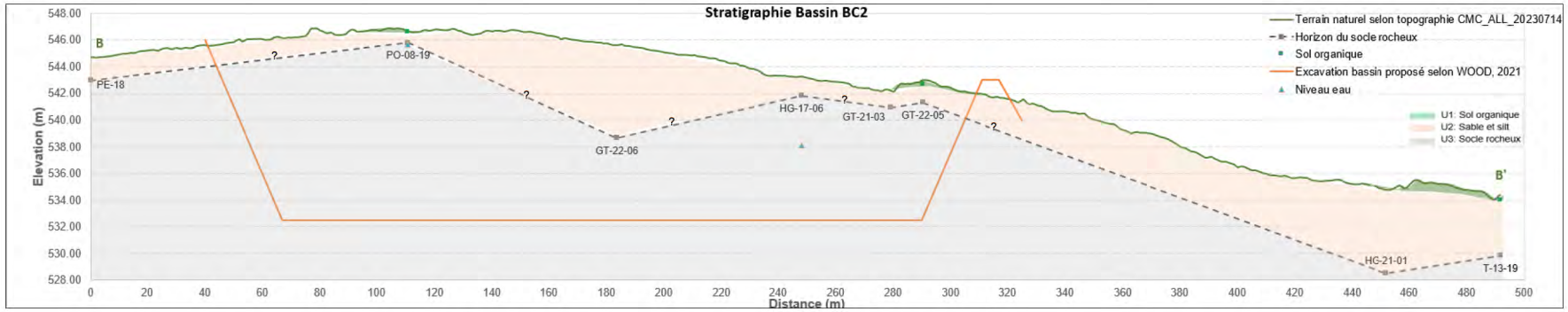

Figure 4-4 : Stratigraphie établie pour BC-2

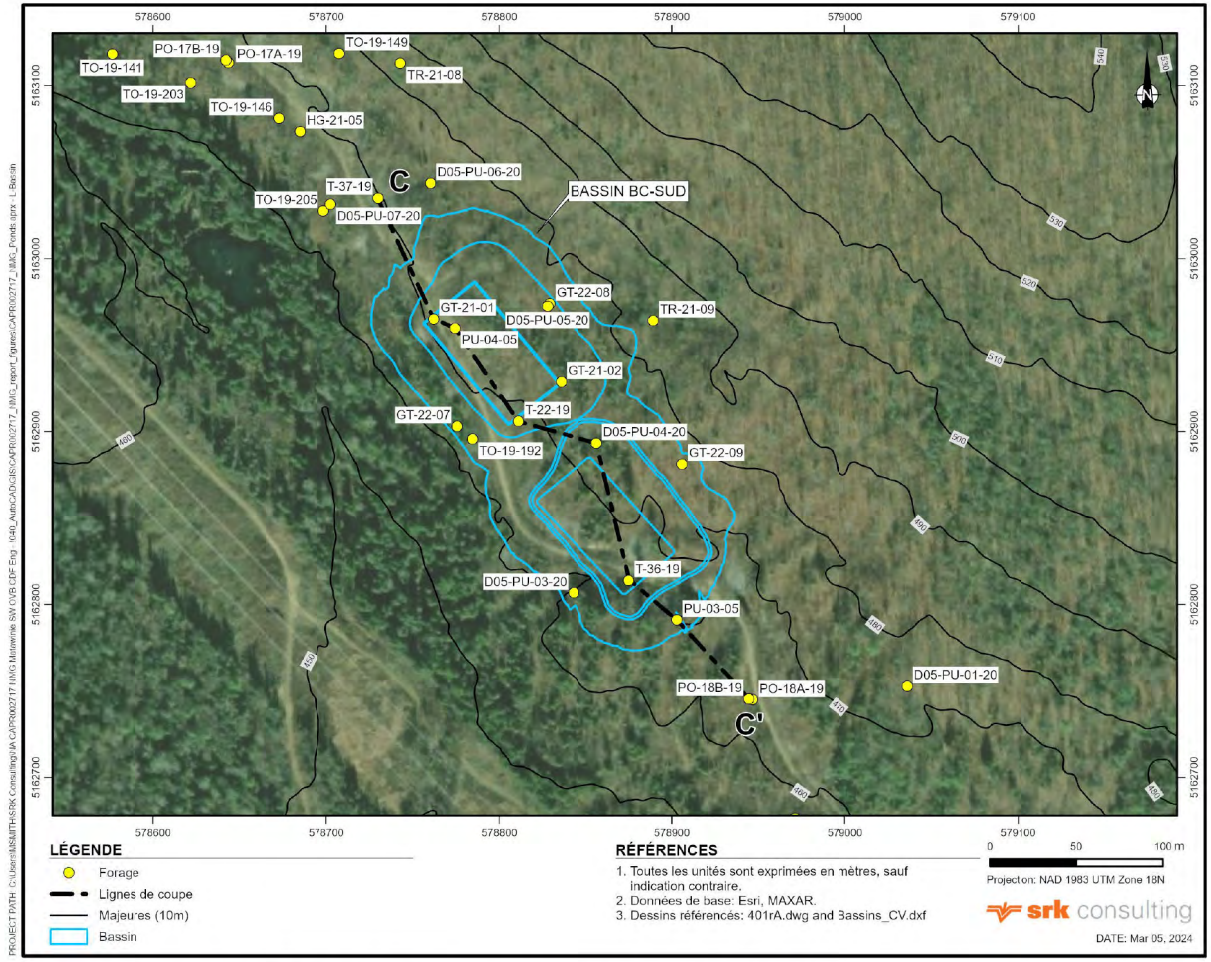

Figure 4-5 : Position des sondages géotechniques disponibles en date du 05 octobre 2023, Bassin BS

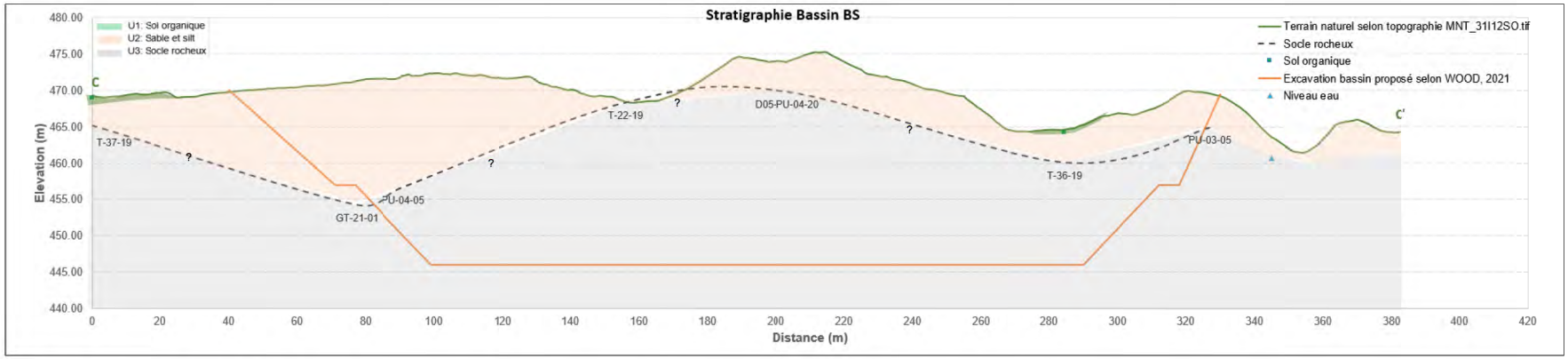

Figure 4-6 : Stratigraphie établie pour BS

4.3 Stratigraphie des FC

Les informations reliées à la stratigraphie des FC en périphérie de la HMT et de la HCD se retrouvent dans les rapports de conception propres à ces infrastructures (SRK, 2024b et 2024c). Plusieurs tranchées ont été réalisées et l'information recueillie a permis de déterminer une profondeur du socle rocheux en fonction des profils projetés.

Il est à noter que l'excavation du socle rocheux n'est pas anticipée pour la construction de tous les FC. Les FC ceinturant la HCD (voir **Tableau 2-1**) auront un profil surélevé par rapport au terrain naturel existant hormis pour un l'aval de FC-2 qui sera en excavation. Cet objectif de conception évitera de profondes excavations dans le mort-terrain ou le socle rocheux se situe généralement à environ un mètre de profondeur. Les possibles exfiltrations seront contenues par la barrière imperméable sous la plateforme de la HCD qui se prolongera au-delà du talus extérieur des FC.

Comme mentionné à la **section 3.4.3**, les FC projetés et existants au pourtour de la HMT (voir **Tableau 2-1**) ne sont pas imperméabilisés. Les informations géotechniques récoltées indiquent que le socle rocheux est généralement atteint à moins d'un mètre de la surface naturelle. Ainsi, le profil des FC sera peu profond et les bermes seront construites en remblai par rapport au terrain naturel, notamment pour éviter les activités de forage et de dynamitage. Advenant qu'en chantier l'atteinte de socle rocheux se produise à une élévation plus élevée que celle au plan, il sera alors envisagé d'élargir localement la section d'écoulement afin de laisser le socle rocheux intact tant que cela ne crée pas de point haut dans le profil qui nuirait au bon fonctionnement de l'ouvrage. Dans ce cas, des travaux au marteau-piqueur seront nécessaires.

4.4 Hydrologie

L'étude hydrologique du site a été réalisée par SNC-Lavalin (2020) et les résultats de cette étude ont été utilisés par Wood (2021) dans le cadre de l'étape d'ingénierie précédente. Une révision de l'étude hydrologique du site a été effectuée par SRK dans le cadre de ce mandat (**Annexe A**). Les conclusions de cette révision suggèrent qu'une majoration de 14 % doit être appliquée aux valeurs de précipitation établies en 2020 afin de tenir compte d'un effet d'altitude. Effectivement, le site est à une élévation supérieure (c.-à-d. : 170 mètres) à celles des stations météorologiques ayant servi comme points de référence. Cette différence d'élévation engendre une augmentation des précipitations.

De plus, afin de tenir compte de l'effet possible des changements climatiques, un facteur de majoration provisoire de 10 % sera utilisé sur la base des recommandations du projet Ouranos (Ouranos, 2015).

Par conséquent, les valeurs de précipitations majorées, qui ont été utilisées dans le cadre de ce mandat, pour le dimensionnement des fossés et ponceaux sont présentées au **Tableau 4-2** et le **Tableau 4-3** résume les précipitations moyennes mensuelles utilisées dans la conception.

Tableau 4-2 : Évènements de pluie considérés

Description	Équivalent en mm (Wood 2021)	Majoration de 14 % (SRK, 2023)	Incluant 10 % pour tenir compte des changements climatiques (Ouranos, 2015)
Averse de récurrence 1 : 100 ans sur une période de 24 h (mm)	89,2	101,7	110,6
Averse 1 : 2 000 ans sur une période de 24 h (mm)	133,7	152,4	165,8
Couvert de neige récurrence 1 : 100 ans (équivalent mm d'eau)	429	489,1	532,0
Couvert de neige récurrence 1 : 100 ans (équivalent mm d'eau) 24h	14,0	16,3	17,9
Averse 24 h de récurrence 1 : 2000 ans, combinée à la fonte moyenne du couvert de neige de récurrence 1 : 100 ans sur une période de 30 jours. (mm)	147,7	168,7	183,5
Pluie Maximale Probable (mm)	279	-	-

Le bilan des eaux utilisé pour le dimensionnement des BC considère l'impact possible des changements climatiques de façon évolutive en fonction de la durée de la vie de la mine dans l'optique d'optimiser les débits de pompages et traitement.

Tableau 4-3 : Précipitations moyennes mensuelles majorées, incluant changements climatiques

Mois	Précipitation moyenne		
	Neige[1] (mm)	Pluie (mm)	Précipitations totales (mm)
Jan	65,8	7,4	73,2
Feb	55,8	6,2	62
Mar	54,6	24,8	79,4
Avr	17,4	63,2	80,6
Mai	1,3	106,6	107,9
Jun	0	130,2	130,2
Jul	0	122,8	122,8
Aou	0	114,1	114,1
Sep	0	125,4	125,4
Oct	7,4	100,5	107,9
Nov	42,1	45,9	88
Dec	75,6	10,0	85,6
Total	**320,0**	**857,1**	**1177,1**

1 Équivalent eau du couvert de neige

Localisation des données:
https://srk.sharepoint.com/sites/NACAPR002717/Internal/!020_Project_Data/010_SRK/Water%20Balance/For%20Distribution/CAPR002717%20NMG-WaterBlanaceModel_DRAFT_2023-10-30_SRK_REV_A.xlsx?web=1

4.5 Hydrogéologie

Le relevé piézométrique réalisé par SNC-Lavalin en septembre et octobre 2019 (SNC, 2020), Hydrogéologie Richelieu (2024a), des puits existants du site ont été utilisés comme intrant afin d'établir les conditions hydrogéologiques des BC. Ces valeurs se retrouvent au **Tableau 4-4** ainsi que sur chacune des stratigraphies présentées à la **section 4.2**.

Tableau 4-4 : Niveau piézométrique par BC

Bassin	Élévation niveau nappe phréatique (m)	# sondage	Date	Élévation niveau nappe phréatique (m)	# sondage	Date
	512,89	PO-10B-19	2019-09-27	512,77	PO-10A-19	2019-09-27
	512,82	PO-10B-19	2023-05-31	513,41	PO-10A-19	2021-05-04
	517,52	P-GT-05	2023-05-31	513,44	PO-10A-19	2023-05-31
BC-2	545,50		PO-08-19	538,07	HG-17-06	
BS	460,61		PU-03-05			

Le niveau de la nappe phréatique a servi à concevoir les ancrages des géosynthétiques dans les BC. Ces ancrages sont requis pour éviter le soulèvement de la géomembrane par les poussées hydrostatiques. Le **Tableau 4-5** résume les niveaux piézométriques utilisés pour fin de conception.

Tableau 4-5 : Niveau piézométrique utilisé pour la conception par BC

Bassin	Hauteur des eaux souterraines mesurée au-dessus de la géomembrane (m)
BC-1	14
BC-2	13
BS	N/A

5 Conception des ouvrages de gestion de surface

5.1 Bassins versants

La **Figure 5-1** illustre les bassins versants utilisés dans le cadre du bilan des eaux (SRK, 2024a). Le **Tableau 5-1** présente quant à lui la superficie de chaque bassin versant. Le modèle PC SWMM a adapté ces superficies afin d'évaluer les débits de conception des divers ouvrages projetés.

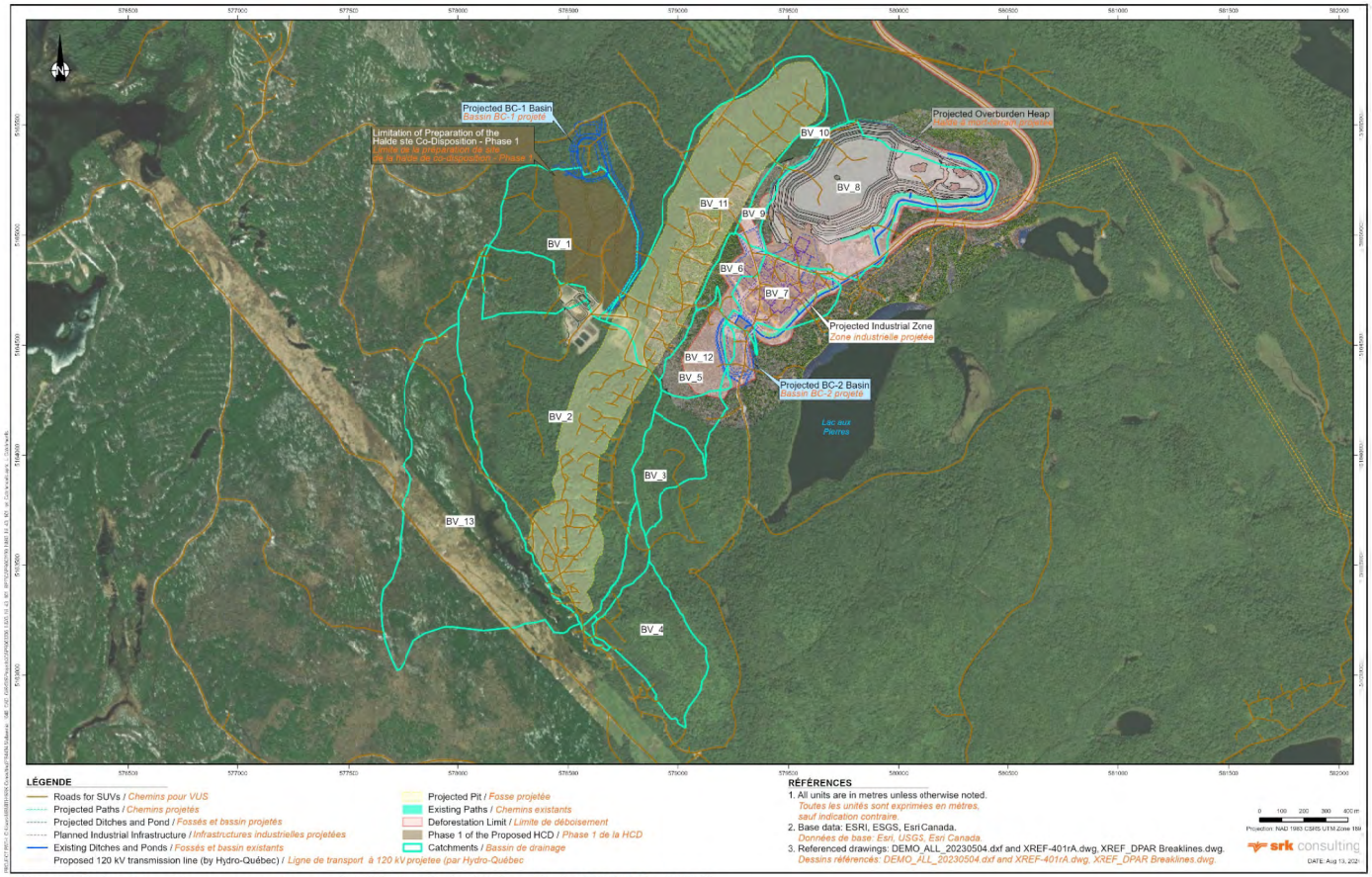

Figure 5-1 : Bassins versants projet Matawinie (Adapté de WOOD, 2021)

Tableau 5-1 : Superficie des bassins versants

Bassin versant ID	Superficie (m^2)
1	388 740
2	887 638
3	144 293
4	226 299
5	224 658
6	55 174
7	118 709
8	402 853
9	33 574
10	39 084
11	503 385
12	90 702
13	622 088

5.2 Coefficient de ruissellement

Un coefficient propre à chaque type d'utilisation des sols le plus critique en fonction de l'évolution du site minier a été assigné à chacun des bassins versants identifiés à la **section 5.1**. Ces valeurs ont servi dans la détermination des débits de pointes associés aux FC et sont résumées au **Tableau 5-2**.

Tableau 5-2 : Coefficient de ruissellement adopté en fonction des bassins versants

Emplacement	Coefficient de ruissellement
Halde à mort terrain (HMT)	0,7
Halde de co-disposition (HCD)	0,9
Zone industrielle (ZI)	0,85
Bassin d'accumulation des eaux (BC)	0,99

5.3 Débit de conception

Pour réaliser la conception des fossés collecteurs, le logiciel PC SWMM a été utilisé afin d'effectuer des modélisations hydrologique et hydraulique. Ce logiciel simule de façon dynamique les précipitations sur les bassins versants et l'évolution de la quantité d'eau dans les fossés collecteurs en fonction du temps. Cette façon de faire permet de générer un débit de pointe en tenant compte des caractéristiques physiques des bassins versants et des fossés collecteurs. En effet, plusieurs éléments sont pris en considération par PC SWMM, notamment : l'infiltration dans les sols, la pente et la longueur des bassins versants, ainsi que les coefficients de rugosité des fossés.

Les fossés ceinturant la HMT et la HCD ont été conçus avec la crue de projet incluant une majoration de 14 %. Une majoration de 10 % est également appliquée au volume total d'eau compris dans la crue de projet afin de tenir compte de l'effet des changements climatiques sachant que ces ouvrages seront requis pour la durée totale des opérations minières. Les valeurs des paramètres utilisés ainsi que les débits de pointe pour chaque ouvrage sont résumées au **Tableau 5-3**.

Tableau 5-3 : Paramètres et débit de conception des fossés de collecte

Éléments	Sous-secteur principal	Superficie drainée (m^2)	Coefficient de ruissellement	Temps de concentration (min)	Débit de pointe (m^3/s)
Fossés se rapportant au BC-1					
FC-1	HCD	150 730	0,9	30	8,2
FC-2*	HCD	260 800	0,9	30	12,1
FC-3	HCD	7 260	0,9	20	4,0
Fossés se rapportant au BC-2					
FC-4	HMT	153 700	0,7	30	4,2
FC-5A/B	HMT	175 700	0,7	40	4,5
FC-8	HCD	95 130	0,9	20	5,0
Fossé 3	HMT	102 780	0,85	20	3,3
Fossés se rapportant au BS					
FC-6	HCD	657 300	0,9	45	28,1
FC-7	HCD	177 950	0,9	25	9,8

* Inclut la contribution de FC-3

5.4 Fossés de collecte

La géométrie trapézoïdale a été sélectionnée pour la conception des fossés collecteurs. Ce type de fossé est couramment utilisé dans l'industrie puisque la méthode pour le calcul de l'écoulement est éprouvée et que la construction est relativement facile. Les dimensions minimales pour l'aire d'écoulement de l'eau des fossés collecteurs et l'enrochement proposé sont présentés dans le **Tableau 5-4**. Les dimensions exactes des fossés collecteurs ont été déterminées à la suite des résultats de la modélisation SWMM.

Tableau 5-4 : Dimensionnement des fossés de collecte

Éléments	Largeur au fond (m)	Profondeur de la section d'écoulement (m)	Pente des talus	Épaisseur de la lame d'eau (m)	Vitesse moyenne maximale (m/s)	D_{50} Enrochement (mm)	Épaisseur de l'enrochement (mm)
Fossés se rapportant au BC-1							
FC-1	1,5	1,5	2H : 1V	1,2	2,6	-	-
FC-2	1,5	2,0	2H : 1V	1,5	1,9	-	-
FC-3	1,5	1,0	2H : 1V	0,9	1,2	-	-
Fossés se rapportant au BC-2							
FC-4	2,0	1,2	2H : 1V	0,8	2,5	200	400
FC-5A/B	1,5	1,6	2H : 1V	1,3	3,4	200	400
FC-8	2,0	1,5	2H : 1V	0,5	5,0	-	-
Fossés se rapportant au BS							
FC-6	2,0	2,0	2H : 1V	1,8	2,9	-	-
FC-7	2	1,5	2H : 1V	1,2	4,6	-	-

5.5 Système de gestion des eaux pluviales périphérique

Le système de drainage périphérique est une mesure de gestion et de contrôle qui sera mise en place afin de réduire les impacts des eaux rejetées sur le potentiel d'érosion. Ce système comprend notamment les fossés en périphérie de la route d'accès au site qui sont existants ainsi que les fossés de déviation des eaux propres. Rappelons que toutes les eaux de contact seront collectées et gérées selon le mode décrit à la **section 2.1**.

5.5.1 Fossés de dérivation

Deux fossés de déviation, FD-1 et FD-2 seront construits de part et d'autre du BC-2. Ces fossés ont pour utilité de dévier l'eau propre à l'extérieur du réseau de collecte et de la diriger directement vers l'environnement. Il est à noter que le FD-2 sera démantelé lorsque le FC-8 sera construit. Les principaux paramètres des fossés de déviation se retrouvent au **Tableau 5-5**. Aucun empierrement n'est prévu pour ces fossés puisqu'il s'agit d'eau propre et que l'apport en matières en suspension est jugé faible. La

végétation dans ces fossés devra être entretenue afin de conserver la section d'écoulement libre d'obstacles pouvant nuire à son bon fonctionnement.

Tableau 5-5 : Paramètres des fossés de déviation

Éléments	Largeur au fond (m)	Profondeur de la section d'écoulement (m)	Pente des talus	Épaisseur de la lame d'eau (m)	Vitesse moyenne maximale (m/s)	D_{50} Enrochement (mm)	Épaisseur de l'enrochement (mm)
FD-1	1,5	1,0	2H : 1V	1,0	2,6	-	-
FD-2	1,5	1,0	2H : 1V	0,7	2,5	-	-

5.6 Chemins périphériques

Des chemins d'accès sont prévus en périphérie des FC et des BC afin d'effectuer la maintenance de ces ouvrages et d'y accueillir la clé d'ancrage de la géomembrane lorsque ces derniers seront imperméabilisés. D'une largeur de six mètres, ces chemins seront munis d'une surface de roulement de 300 mm d'épaisseur, composée de pierres concassées de type MG-56 (voir détail à la **Figure 3-2**).

5.7 Ponceaux

Le FC-4 devra accueillir deux ponceaux permanents pour permettre le passage des camions en direction du concasseur. Afin de se marier adéquatement aux dimensions du FC-4, il est prévu d'installer deux ponceaux côte à côte à l'endroit prévu de la traverse. La section d'écoulement du FC-4 devra toutefois être élargie localement, à proximité des ponceaux projetés. Les dimensions et caractéristiques des ponceaux sont identiques et résumées au **Tableau 5-6**.

Tableau 5-6 : Détails des ponceaux du fossé FC-4

Ponceau	Diamètre intérieur (mm)	Pente longitudinale (%)	Longueur (m)	Couvert minimum (m)
1	1 500	0,5	28	0.9

5.8 Bassins collecteurs

Le bilan des eaux (SRK, 2024a) a permis de déterminer les volumes utiles requis des BC afin de notamment contenir la crue de projet (pluie 1: 2000 ans sur 24 h combinée à la fonte du couvert de neige 1 : 100 ans répartie également sur 30 jours) et aussi de fournir les volumes d'eau requis à l'usine pour le traitement du minerai. Les bassins BC-1 et BC-2 sont requis dès le début de la phase de construction de la mine (Phase A) alors que le BS devra être opérationnel à l'année 8 (phase B2) selon le présent plan minier (SNC, 2022). Pour cette raison, les détails de conception de ce dernier ne font pas l'objet du présent rapport. Les bassins sont prévus d'être construits en une seule étape qui représente le volume final à contenir. Ces volumes se retrouvent au **Tableau 5-7**. Il est à noter que ces volumes ont été revus

à la hausse comparativement à ceux de WOOD (2021), notamment en raison de l'augmentation des précipitations décrite à la **section 4.3** et à l'application d'un facteur de majoration pour tenir compte de l'effet des changements climatiques.

Tableau 5-7 : Paramètres de conception des BC mis à jour

Description	Bassin BC-1	Bassin BC-2	BS
Élévation fond du bassin (masl)	504,0	532,5	446,0
Élévation maximale eau (masl)	517,0	541,5	456,0
Volume d'eau à élévation maximale (m^3)	172 500	170 000	256 000

Tel que présenté à la **section 4.2**, les BC seront excavés dans les dépôts meubles, mais aussi dans le roc. L'imperméabilisation des bassins sera assurée au moyen d'une géomembrane PeBD, 1,5 mm. Les plans détaillés des bassins se retrouvent à l'**Annexe B**. Un volume équivalent à 300mm de boues sur la superficie totale du fond des BC a été considéré dans le calcul.

5.8.1 Revanche

Une revanche d'un minimum de 1 mètre est prévue pour chacun des bassins, soit entre le radier du déversoir d'urgence et le dessus de la crête.

Une évaluation de la revanche a été réalisée pour chaque bassin selon la méthodologie de l'association canadienne des barrages (ACB, 2013). La configuration du vent et la montée des vagues ont été calculées en utilisant les méthodes suggérées par le *United States of America Bureau of Reclamation* (USBR, 2012) et ont permis de confirmer l'élévation minimale de la crête de chaque bassin. Pour fin de calcul l'élévation de l'eau a été fixée à celle du seuil du déversoir d'urgence des bassins d'accumulation.

L'ACB (2013) précise qu'une revanche adéquate doit être disponible pour chacun des scénarios suivants :

A. Pas de débordement par 95 % des vagues causées par des vents d'une fréquence de 1 : 1 000 ans lorsque le bassin est à l'élévation normale maximale.
B. Pas de débordement par 95 % des vagues causées par le vent critique Inflow Design Flood (IDF) plus l'événement de vent de 1 sur 100 ans.

À titre comparatif, *The British-Colombia Ministry of Environment* (MOE, 2016) recommande de maintenir une revanche d'un minimum de 500 mm lors d'une crue de récurrence d'au minimum 1: 200 ans.

La méthode de calcul USBR (2012) préconise l'utilisation de valeurs de vent horaire issues d'une analyse fréquentielle. La station météorologique installée au site près de l'usine de démonstration enregistre plutôt la vitesse des rafales à deux mètres du sol. De manière conservatrice l'analyse fréquentielle a été établie à partir de ces données dont les résultats sont résumés au **Tableau 5-8**.

Tableau 5-8 : Vitesse de pointe des vents

Période de retour (année)	Vitesse du vent (m/s)
10	20,3
50	22,9
100	24,1
1000	27,9

Sur la base de ces valeurs, les calculs de revanche minimale et normale sont résumés dans les **Tableau 5-9** et **Tableau 5-10** en utilisant les méthodes décrites dans USBR (2012). Pour BC-1, une revanche minimum de 0,41 m est requise pour le scénario A et de 0,73 m dans le cadre du scénario B. L'élévation minimale de la crête de BC à 518 m est jugée appropriée, considérant que le niveau d'eau maximum d'opération devrait être de 517,0 m. La même méthodologie a été appliquée pour BC-2. Ainsi des revanches minimales de 0,47 m et 0,85 m sont requises dans les conditions de vent de récurrence 1: 100 ans et 1: 1 000 ans respectivement. L'élévation de la crête du bassin à l'élévation 543,0 m est adéquate, considérant que le niveau d'eau maximum d'opération devrait être de 541,5 m. Rappelons que les rafales ne durent habituellement que quelques secondes alors que la méthode de calcul est basée sur une vitesse moyenne de vent soutenue qui s'échelonne sur plusieurs minutes.

Tableau 5-9 : Revanche minimale requise pour BC-1

Scénario	(A) Niveau d'opération maximal normal et vents de récurrence 1 : 1 000 ans	(B) Crue de projet combiné à des vents de récurrence 1 : 100 ans
Élévation de l'eau (m)	517,00	517,00
Longueur du fetch (m)	208	300
Profondeur d'eau (m)	11,0	11,0
Vitesse du vent (m/s)	24,1	27,9
Revanche requise (m)	0,41	0,73
Élévation minimale de la crête (m)	517,41	517,73
Condition acceptable?	Oui	Oui

Tableau 5-10 : Revanche minimale requise pour BC-2

Scénario	(A) Niveau d'opération maximal normal et vents de récurrence 1: 1 000 ans	(B) Crue de projet combiné à des vents de récurrence 1: 100 ans
Élévation de l'eau (m)	541,50	541,50
Longueur du fetch (m)	250	450
Profondeur d'eau (m)	9,0	9,0
Vitesse du vent (m/s)	24,1	27,9
Revanche requise (m)	0,47	0,85
Élévation minimale de la crête (m)	541,97	542,35
Condition acceptable?	Oui	Oui

5.9 Géomembrane

5.9.1 Paramètres de conception

La géomembrane installée dans les BC et les fossés de la HCD ainsi que ses ancrages seront exposés à diverses contraintes et déformations auxquelles ils doivent résister adéquatement. Les méthodes de calculs utilisées afin d'évaluer la résistance de la géomembrane et de ses ancrages sont détaillées dans les notes de calcul insérées à l'**Annexe D**. Les paramètres utilisés dans ces calculs sont présentés au **Tableau 5-11** et les justifications des valeurs utilisées sont les suivantes :

- La vitesse de vent de conception correspond à une période de retour de 100 ans, soit 87 km/h à 2 m du sol[9]. Elle a été sélectionnée puisque les BC seront en opération minimalement pour toute la durée de vie de la mine, que la membrane sera exposée et qu'un scénario ou un BC se retrouve vide est plausible. Les données utilisées pour estimer cette période de retour proviennent de la réanalyse des données horaires de rafales de vent enregistrées par la station météorologique de NMG installée près du site de démonstration. En effet, puisque des données n'étaient disponibles que pour la période du 19 octobre 2020 au 5 décembre 2022, la méthode de la réanalyse des données a été utilisée afin d'obtenir une série de données suffisamment longue pour estimer des périodes de retour. Cette réanalyse, présentée à l'**Annexe C**, utilise les données des stations météorologiques d'Environnement Canada situés près de St-Michel-des-Saints et de ERA5-Land.
- Un coefficient de succion (λ) est utilisé afin de refléter la variation de succion survenant le long d'une pente (voir calculs détaillés à l'**Annexe D**). Les valeurs utilisées pour des terrains plats ou légèrement pentus sont généralement de 0,40 et 0,55 alors qu'elles peuvent atteindre 0,80 dans le

[9] La mesure des vitesses de vent de la station météorologique de NMG se fait à 2 m du sol, tandis que les stations d'Environnement Canada prennent habituellement des mesurent à 10 m au-dessus du sol. La vitesse du vent à 10 m du sol est environ 1,5 fois plus élevée qu'à 2 m, pour des champs ou des terrains légèrement boisés (AMS, 2002; Manwell, 2009). Ainsi, à titre comparatif, une vitesse de 73 km/h à 2 m du sol serait de 109 km/h à 10 m du sol.

cas de pentes plus abruptes. Considérant le fond de BC plat, les calculs ont été effectués avec une valeur de 0,40 alors que les calculs d'ancrages des talus ont été effectués avec une valeur de 0,70 pour représenter la pente de 2H : 1V.

- L'angle de frottement entre une géomembrane texturée et un matériel adjacent dépend de plusieurs facteurs tels que la hauteur des aspérités de la géomembrane, la granulométrie et de la teneur en eau du matériau adjacent et la contrainte appliquée sur la géomembrane. Puisqu'un géotextile non-tissé sera déposé sous la géomembrane en tout temps, l'angle de frottement utilisé pour les calculs de 32° provient de Koerner 2012.

Les angles de frottement et poids volumiques typiques du mort-terrain ont été définis lors de l'ingénierie de la HMT (SRK, 2024b). Dans le cas de l'ingénierie des BC, une hypothèse conservatrice est faite selon laquelle le mort-terrain de type sable et silt humide et peu compacté (matériau et condition correspondant à un faible angle de frottement) pourrait être utilisé pour remblayer les tranchées d'ancrage des géomembranes.

Tableau 5-11 : Paramètres de conception

Paramètre	Symbole	Valeur	Unité	Références et commentaires
Élévation moyenne de BC-1		519	m	
Élévation moyenne de BC-2		538		
Pentes : - Talus - Fond bassin	 S_{moy} S_{moy}	 50 0.5	% (°)	Données de conception
Distance (fond de bassin) - Longitudinale maximale BC-1 - Transversale maximale BC-1 - Longitudinale maximale BC-2 - Transversale maximale BC-2		 135 65 225 60	m	
Vitesse du vent	V	87	km/h	Vitesse des rafales de vent à 2 m du sol, récurrence 1:100 ans
Coefficient de succion - Talus - Fond de bassin	λ	 0,70 0,40	----	Dedrick (1973) Giroud et al. (1995)
Composition de la géomembrane		PeBD		
Épaisseur nominale de la géomembrane		1,5	mm	
Finition de la géomembrane		Texturée 1 côté		Les angles de friction des géomembranes texturées sont supérieurs aux géomembranes lisses
Masse volumique de la géomembrane		0,94	g/cm³	Propriété d'une géomembrane Texel TM860-ST
Masse surfacique de la géomembrane		1,41	kg/m²	Propriété d'une géomembrane Texel TM860-ST
Résistance à rupture en tension de la géomembrane		44	kN/m	Propriété d'une géomembrane Texel TM860-ST
Élongation à la limite élastique de la géomembrane		800	%	Propriété d'une géomembrane Texel TM860-ST
Résistance au poinçonnement de la géomembrane		415	N	Propriété d'une géomembrane Texel TM860-ST
Angle de frottement géomembrane texturée sur - géotextile	d	32	°	Koerner (2012)
Angle de frottement interne du matériau utilisé pour remblayer les tranchées d'ancrage	f'	27	°	SRK (2024a)
Poids volumique du matériau utilisé pour remblayer les tranchées d'ancrage	g	17	kN/m³	SRK (2024a)

5.9.2 Choix de la géomembrane

Les conditions climatiques typiques de la région de Lanaudière caractérisées par des hivers plutôt long et froid ont influencé le choix final du type de géomembrane à préconiser dans les BC. Le type PeBD est donc retenu pour sa plus grande flexibilité lors de températures froides, facilitant son installation et procurant davantage de tolérance à l'élongation (800 % PeBD, vs 18 % pour le type Polyéthylène de haute densité (PEHD) en cas de poussée hydrostatique importante. La face placée directement sur le géotextile sera texturée afin d'assurer un angle de friction optimale entre la géomembrane et le géotextile. Quant à celle exposée, elle sera lisse dans le but de prévenir que des morceaux de glace s'accrochent aux aspérités comprises dans le type texturé et forcent l'élongation de la géomembrane advenant que le niveau d'eau dans le bassin diminue et que ces blocs demeurent en suspension. Finalement, l'épaisseur de la géomembrane est fixée à 1,5 mm, ce qui correspond à la norme de l'industrie pour ce type d'application considérant que la construction de l'assise sera contrôlée en chantier pour éviter.

5.9.3 Ancrages

Les ancrages de géomembrane utilisés pour l'imperméabilisation de la fondation de la Phase 1 peuvent être répartis en trois catégories :

- des ancrages en crête ;
- des ancrages en fond de bassin ;
- des ancrages intermédiaires.

Comme leur nom l'indique, les ancrages en crête et en fond de bassin se situent respectivement en crête de bassin au pourtour de ce dernier et en pied de talus à l'intérieur du bassin. Les ancrages intermédiaires sont pour leur part localisés sur le dessus des plateaux à l'interface entre les dépôts meubles et le socle rocheux, ainsi que dans les talus au besoin et servent à limiter la longueur de géomembrane non lestée, donc pouvant être soulevée par le vent. Les trois catégories d'ancrage et leur géométrie typique sont présentées à la **Figure 5-2**.

Il est à noter que pour les ancrages en L, puisque le fait de placer du sol au-dessus de la géomembrane (d_{cs}) apporte un gain de résistance à l'arrachement limité comparativement à celui généré par la tranchée d'ancrage (d_{at}), il a été décidé de concevoir les ancrages de la géomembrane à la base des BC sans cette couche de sol (d_{cs} = 0).

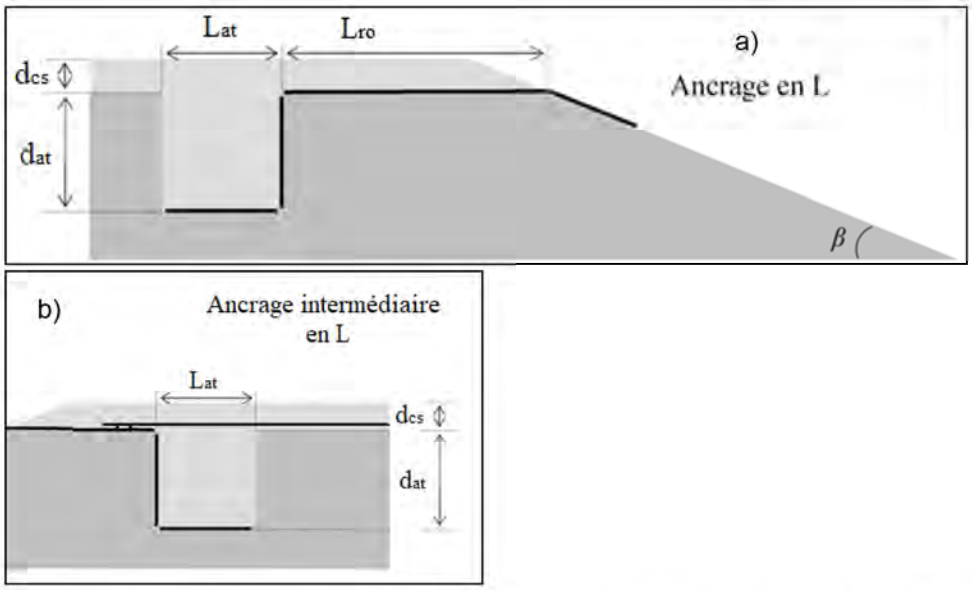

Figure 5-2 : Ancrages types : a) Ancrage en crête ; b) Ancrage intermédiaire

Source : Figure modifiée de Chareyre (2003)

5.9.4 Résultats

La hauteur des eaux souterraines mesurée à partir du dessus de la géomembrane dans chacun des BC présentée au **Tableau 4-5** a servi d'intrant selon le calcul du "*uplift*" tel que présenté dans (Giroud et Al., 2023). Ainsi, une poussée équivalente à 90 KN/m linéaire et 80 KN/m linéaire respectivement pour BC-1 et BC-2 sera transmise à la géomembrane en début de projet. Selon Hydrogéologie Richelieu (2024a), le cône de rabattement induit par la fosse lors de son développement soulagera la pression hydrostatique au droit des bassins. Puisque la géomembrane demeure exposée à l'intérieur des bassins donc non lestée par de l'enrochement par exemple, cette force est trop importante pour une clé d'ancrage conventionnel comme décrit à la **section 5.9.3**, et ce, même avec un espacement entre les ancrages de l'ordre de 40 mètres.

La **section 5.9.5** décrit la manière dont les poussées hydrostatiques seront contrôlées dans les BC minimalement pour la phase A, mais qui sera conservée au-delà de cette période pour fin de redondance. Ainsi les calculs suivants s'appliquent selon les conditions dans lesquelles les poussées hydrostatiques sont nulles et donc seulement le cas d'une géomembrane non lestée dans un bassin excavé est considéré.

Les déformations et résistances ont été calculées pour les conditions maximales possibles d'être observés dans chacun des BC. Le détail des calculs effectués se trouve à l'**Annexe C**. La position et géométrie des ancrages permet le respect des bonnes pratiques et des critères listés précédemment pour tous les cas d'analyse. Les résultats des calculs de résistance à la rupture en tension (générée par la succion due au vent et par les poussées hydrostatiques) sont résumés aux **Tableau 5-14** et **Tableau 5-15** et ceux pour la résistance à l'arrachement des ancrages sont au **Tableau 5-16**.

Les valeurs obtenues ont été comparées aux critères établis et les résultats sont présentés en utilisant le code de couleur décrit au **Tableau 5-12** pour le pourcentage d'élongation, et au **Tableau 5-13** pour les FS.

Il est à noter que pour le cas des ancrages périphériques avec fossés, l'analyse de la résistance à l'arrachement des ancrages a été effectuée en considérant que l'angle de frottement entre la géomembrane et le matériau de recouvrant est élevé (δ = 30°) puisqu'il s'agit du matériau granulaire utilisé pour la construction du chemin périphérique (voir **Annexe D**).

Tableau 5-12 : Codes de couleurs pour le pourcentage d'élongation

	Intervalle	Classification
	> 10,0 %	Inacceptable
	[6,0 % - 10,0 %]	Acceptable
	< 6.0 %	Excellent

Tableau 5-13 : Codes de couleurs pour les FS

	Intervalle	Description
	< 1,1	Inacceptable
	[1,1 – 1,3]	À risque
	[1,3 – 1,5]	Acceptable
	> 1,5	Excellent

Tableau 5-14 : Résultat des calculs d'élongation et de résistance à la rupture en tension à BC-1

Longueur de géomembrane non lestée (m)	Pourcentage d'élongation (%)	FS Résistance à la rupture en tension
5	0,5	20
10	0,7	13,5
50	2,2	4,5
100	3,5	2,8
250	6,7	1,5

Tableau 5-15 : Résultat des calculs d'élongation et de résistance à la rupture en tension à BC-2

Longueur de géomembrane non lestée (m)	Pourcentage d'élongation (%)	FS Résistance à la rupture en tension
5	0,5	20
10	0,7	13,5
50	2,2	4,5
100	3,5	2,8
250	6,7	1,5

Tableau 5-16 : Résultats des calculs de résistance à l'arrachement des ancrages

Type d'ancrage	Longueur de géomembrane non lestée (m)	Longueur de l'ancrage (L_{AT}, en m)	Profondeur de l'ancrage (d_{AT}, en m)	FS Résistance à l'arrachement de l'ancrage
Haut de talus	N/A	1,0	1,0	2,6
Intermédiaire	5	1,0	1,0	36,7
	10	1,0	1,0	18,3
Fond de bassin	50	1,0	1,0	3,7
	100	1,0	1,0	1,8

5.9.5 Puits de dénoyage

Des puits de dénoyage seront requis autour de BC-1 et BC-2 pour rabaisser le niveau d'eau souterraine et ainsi réduire les poussées hydrostatiques sur la géomembrane. Ces puits seront positionnés stratégiquement afin de maximiser l'effet du cône de rabattement.

Compte tenu de l'hétérogénéité du socle rocheux, il sera essentiel d'associer aux puits de dénoyage un programme de surveillance des pressions des eaux souterraines autour des bassins pour valider l'efficacité du dénoyage. Ce programme devra intégrer des puits d'observation afin de suivre l'efficacité du dénoyage et d'optimiser le nombre de puits de dénoyage nécessaires.

Pour évaluer le nombre de puits requis le socle rocheux a été représenté par une conductivité hydraulique uniforme estimées de 1 x 10^{-7} m/s (Hydrogéologie Richelieu (2024a) et pour tenir compte de l'hétérogénéité du socle rocheux, la conductivité du socle rocheux a été augmenter et diminuer par une demi-ordre de grandeur.

Pour maintenir le niveau d'eau souterraine en dessous du fond du bassin BC-1, il a été estimé que 8 puits d'une profondeur comprise entre 40 et 60 mètres seront nécessaires. Pour le bassin BC-2,

14 puits de même profondeur seront nécessaires. La figure x en annexe x présente la position préliminaire des puits et des puits d'observation autour du bassin BC-2.

Pour finaliser la conception des puits de dénoyage, les puits de dénoyage et d'observations devront être construits en phase et des essais de conductivité hydraulique devront être réalisés lors de la construction de ceux-ci pour mesurer le rayon d'influence du dénoyage et ajuster la location si nécessaire, car le socle rocheux est très hétérogène.

5.10 Déversoir d'urgence des bassins de collecte

Les détails des déversoirs d'urgence de BC-2 sont fournis sur les dessins GE-110 et GE-111. Le déversoir d'urgence possède une section trapézoïdale et est situé à l'extrémité sud du BC, à un endroit stratégique permettant à l'eau de s'évacuer adéquatement hors du périmètre du bassin, advenant son entrée en fonction. Le déversoir d'urgence est construit en remblai compacté et est imperméabilisé avec le prolongement de la géomembrane contenue dans le bassin.

Les déversoirs d'urgence ont été conçus pour évacuer une CMP issue de la Précipitation Maximal Probable (PMP) d'une durée de 24 heures (SRK, 2023). Le **Tableau 5-17** fournit un résumé de sa conception. Le débit de conception a été modélisé à l'aide du logiciel HEC-HMS alors que l'effet du laminage sur la longueur du bassin a été simulé avec le logiciel HEC-RAS. Ces deux logiciels sont développés par le centre HEC (Hydrologic Engineering Center) et sont constamment tenus à jour. Il est à noter que selon les règles de l'art, le niveau d'eau dans le BC a été fixé à l'élévation du radier du déversoir d'urgence au moment de l'occurrence du débit de pointe afin de simuler le pire cas probable.

Tableau 5-17 : Paramètres de conception des déversoirs d'urgence

Bassin	Débit de conception (m^3/s)	Largeur du seuil (m)	Profondeur de la section d'écoulement (m)	Pente des talus	Élévation du seuil du déversoir (m)	Épaisseur de la lame d'eau (m)
BC-1	14,4	20	1,0	10H : 1V	516,00	0,60
BC-2	28,9	27	1,0	10H : 1V	541,50	0,75
BS	À venir	À venir	À venir	À venir	À venir	À venir

5.11 Plateforme de l'usine de traitement des eaux

Comme décrit à la **section 3.5** et présenté au plan GE-110 (**Annexe A**), l'unité de traitement des eaux de contact sera localisée à proximité du BC-2. En plus d'accueillir les équipements proposés par Mabarex, la plateforme comprend des zones d'entreposages ainsi qu'une route permettant l'accès pour le ravitaillement, notamment des produits chimiques nécessaires. La plateforme sera profilée de sorte que l'eau de ruissellement en contact avec les opérations minières retournera vers le BC-2 et l'eau propre sera dirigée vers le canal d'évacuation du déversoir d'urgence.

Une excavation sur la pleine hauteur du bassin servira à l'installation de la conduite de succion (conçue par d'autres) qui alimentera les puits de pompage (usine de traitement des eaux et poste de suppression du réseau incendie). Le remblai de la conduite et du puits de pompage en béton préfabriqué sera fait en matériaux de type MG-56 et le talus sera profilé selon une pente de 2H : 1V pour se marier avec la pente prescrite du bassin. Un manchon d'étanchéité est prévu pour assurer le passage de la conduite au travers de la géomembrane.

5.12 Plateforme de la station de pompage de BC-1

Le plan GE-100 (**Annexe B**) présente l'emplacement et la configuration projetée pour la plateforme de la station de pompage prévue au BC-1. En plus de la station de pompage, un conteneur pour l'entreposage des matériaux et équipements ainsi qu'une roulotte de chantier y seront installés. Le remblai requis pour l'atteinte de la ligne d'infrastructure sera construit avec du mort-terrain compétent, et une couche de roulement fait en matériaux de type MG-56 sera appliquée au-dessus du mort-terrain.

Une excavation sur la pleine hauteur du bassin servira à l'installation de la conduite de succion (conçue par d'autres) qui alimentera le puits de pompage. Le remblai de la conduite et du puits de pompage en béton préfabriqué sera fait en matériaux de type MG-56 et le talus sera profilé selon une pente de 2H : 1V pour se marier avec la pente prescrite du bassin. Un manchon d'étanchéité est prévu pour assurer le passage de la conduite au travers de la géomembrane.

6 Phase de construction et d'opération

6.1 Séquences de construction

6.1.1 FC et BC

La méthode de construction des BC, FC et fossés temporaires à mettre en œuvre devra être établie conjointement avec l'entrepreneur et l'ingénieur concepteur et approuvée par NMG.

SRK considère que la construction des ouvrages de gestion des eaux de surface, pour chacun des secteurs (**Figure 2-1**), débutera par l'aménagement des BC. Ainsi, une gestion active des eaux de ruissellement proactive et efficace durant les travaux de terrassement pourra alors être réalisée.

Lors des travaux d'aménagement des BC et FC imperméabilisés, SRK considère que l'entrepreneur maintiendra les surfaces de travail sèches tel que recommandé dans les bonnes pratiques de l'industrie.

SRK considère que les FC et fossés temporaires seront construits de l'aval vers l'amont pour faciliter la gestion des eaux de surface durant les diverses étapes de construction.

Une attention particulière aux dévers de différents chemins d'accès sera de mise afin que le ruissellement des eaux de contact s'effectue adéquatement vers les fossés adjacents aux chemins.

Il est anticipé qu'il pourrait y avoir une différence d'élévation supérieure à trois mètres entre la surface de roulement des chemins d'accès et le terrain naturel ou le fond des fossés. Par conséquent, des bermes de sécurité servant à empêcher la chute d'un véhicule ou d'un équipement de chantier d'une telle hauteur seront requis. La hauteur de la berme, selon la loi sur la sécurité des mines (chapitre M-13.1), correspond à la mi-hauteur de la plus grande roue pouvant circuler sur ledit chemin. Ces bermes devront être érigées localement et des brèches devront être présentes afin de permettre l'écoulement libre du ruissellement.

Il est à noter qu'une portion de l'empreinte du futur BC-2 est excavée et que les entrées situées au nord-est (ponceau) et nord-ouest (fossé trapézoïdal) sont présentement aménagées. Ces travaux exécutés en 2022 furent nécessaires afin de contenir l'eau de ruissellement liée au développement de la HMT et de la ZI. Le bassin devra être agrandi en fonction du bassin versant à drainer et de son rôle de bassin tampon pour l'unité de traitement des eaux.

Afin d'améliorer la constructibilité des bassins et pour réduire les complexités potentielles futures, SRK est d'avis que les BC-1 et BC-2 doivent être construits dans leur intégralité en une seule étape, sans phasage tel qu'initialement proposé (WOOD, 2021). Effectivement, SRK est d'avis qu'une construction par phasage de ces deux BC représente un risque pour NMG :

- un dénoyage complet des BC serait requis, ce qui aurait un impact sur les opérations ;
- les activités de sautage - dynamitage pourraient avoir un impact négatif sur les sections des bassins déjà construits (c.-à-d. : perforation de géosynthétiques par blocs volants, vibration et fracturation du socle rocheux sous ou à proximité des géosynthétiques, rupture potentielle, socles rocheux sous ou à proximité des géosynthétiques, vibration qui pourraient affecter les stations de pompage à proximité, etc.) ; et

- la fusion de la nouvelle membrane avec celle en place nécessite un plus grand travail de préparation et présente un risque de fissures supplémentaires.

Puisque la construction du BC-2 a été entamée et mise sur pause présentement, le dénoyage sera requis lors de la reprise des travaux. Sachant qu'aucun géosynthétique n'a été installé, SRK n'entrevoit de problématique technique à poursuivre les travaux, le tout dans le respect des clauses techniques qui seront décrites dans le devis.

Le mort-terrain excavé lors des travaux de terrassement des BC sera mis en pile dans la HMT (SRK, 2024b). Le roc dynamité provenant de l'excavation des deux bassins collecteurs sera mis en pile temporairement dans un empilement qui sera construit au nord de BC-2. L'inclinaison du talus des paliers de l'empilement de roc sera de 26.6° (2H : 1V), la hauteur des paliers sera limitée à 3.0 m et un recul minimum de 10 m entre les paliers sera construit. L'espace disponible permet de construire un empilement d'une capacité de 1,47 Mm^3 à l'élévation de 570 m. La hauteur maximale de l'empilement temporaire est limitée à 20 m. La configuration de l'empilement temporaire est présentée sur les plans de l'**Annexe B**. L'utilisation de la roche dynamitée qui sera mise en pile dans cet empierrement sera dictée en fonction de ces caractéristiques et besoins en empierrement par les opérations de la mine.

Les fossés (FC-5A et FC-5B, Fossé 1 et Fossé 2) qui ont été conçus et construits en 2022 sur le site seront intégrés dans la prochaine phase de l'ingénierie afin de valider la gestion globale des eaux de surface et de confirmer que les engagements du décret seront respectés. Si requises, des recommandations seront émises afin d'assurer une intégration adéquate des ouvrages existants dans le plan de gestion des eaux proposé.

Le **Tableau 6-1** présente le séquençage du développement des ouvrages de gestion des eaux.

Tableau 6-1 : Séquençage des ouvrages de gestion des eaux

Infrastructure	Année de construction	Année de mise hors service
FC-1	0	Fermeture
FC-2	0	Fermeture
FC-3	2	Fermeture
FC-4	En fonction de l'évolution de la HMT	Fermeture
FC-5	Existant	Fermeture
FC-6A	5	Fermeture
FC-6B	5	Fermeture
FC-7	8	Fermeture
FC-8	8	Fermeture
FD-1	5	Fermeture
FD-2	0	Fermeture
BC1–172,000 m^3	0	Fermeture
BC2–170 000 m^3	0	Fermeture
BC–Sud 256 000 m^3	5	Fermeture

6.1.2 Installation des géosynthétiques

Les précautions suivantes devraient être prises lors des travaux d'installation des géosynthétiques.

- Installer la géomembrane sur une fondation et des talus exempte de racines, de pierres ou autres débris de 25 mm ou plus de diamètre qui risquent d'endommager la géomembrane lors de son installation.
- Idéalement, procéder aux travaux d'installation de la géomembrane à une période de l'année où les températures sont au-dessus du point de congélation tant de jour que de nuit. Ne pas permettre d'effectuer des opérations de soudure lorsqu'il pleut, neige ou grêle, ou sur une géomembrane mouillée ou avec des cristaux de glace.
- Installer la géomembrane sur une fondation ayant un niveau de compaction adéquat, afin de limiter les risques de tassements différentiels au sein de la fondation lors de l'opération des BC et FC associés et éviter par le fait même que la géomembrane ne soit trop fortement sollicitée en tension. Des recommandations sont formulées à cet effet à la **section 7**.

Lors des travaux de construction, un programme de contrôle de la qualité (CQ) et d'assurance de la qualité (AQ) devra être mis en œuvre pour la préparation de la fondation et l'installation de la géomembrane. Ce programme sera détaillé dans le devis technique qui accompagnera les plans émis en révision "Pour Construction" et devrait inclure au minimum un suivi de la nature et de la compacité

des matériaux situés sous la géomembrane ainsi qu'un suivi de la confection, expédition, manipulation et méthode d'installation de la géomembrane.

6.1.3 Gestion des eaux en phase de construction

Le mode de gestion des eaux en période de construction du bassin versant immédiat de BC-2, incluant le secteur de la HMT ainsi que de la zone industrielle a été décrit dans SNC (2021) et WSP (2023). Le mode de gestion des eaux de construction pour le secteur du BC-1 incluant la phase 1 de la construction de la plateforme de la HCD sera décrit ici-bas et utilise les mêmes critères que ceux utilisés par SNC-Lavalin et WSP précédemment mentionné.

Donnés d'entrées

Les données d'entrées tels que la topographie du site, les données climatiques, l'empreinte des infrastructures projetées, sont celles présentées dans le présent rapport. Les pluies de référence pour le calcul du ruissellement seront de type été/automne et sont résumés au **Tableau 6-2**.

Tableau 6-2 : Volume des pluies

Évènement	Pluie qualité	Pluie de récurrence 1: 5 ans	Pluie de récurrence 1: 25 ans	Pluie de récurrence 1: 100 ans
Volume (mm/24h)	25	68.2	98.8	124.1

Source : SRK, 2023

Le bassin versant considéré est représenté par la zone orangée à l'intérieur du BV_1 de la **Figure 6-1**, correspondant à une superficie de 19,4 ha, additionné de l'empreinte du BC-1 lui-même, évalué à 2,7 ha, totalisant 22,1 ha.

Figure 6-1 : Bassin versant pour le calcul du volume des eaux de construction de BC-1

Bassin d'accumulation temporaire et prélèvement

Un bassin d'accumulation temporaire sera aménagé à-même l'excavation du BC-1 afin d'accumuler les eaux de ruissellement avant qu'elles soient pompées sur une distance d'environ 850 mètres vers le BC-2, dont la construction sera terminée. C'est donc dire que la capacité totale de BC-2, moins les volumes correspondant à son propre bassin sera mise à contribution pour l'accumulation temporaire d'eau durant la totalité de la période de construction du BC-1 et de la phase 1 de la plateforme de la HCD. Le point de rejet près du PAR Démo comme décrit dans WSP (2023) demeurera inchangé. La majorité des installations et équipement en place pour la construction du BC-2 seront conservés. La capacité minimale d'emmagasinement du bassin d'accumulation temporaire dans BC-1, servant à déterminer le débit de pompage associé vers BC-2, a été étudiée selon les périodes de récurrence présentées au **Tableau 6-2**, conformément aux exigences reliées au règlement sur l'encadrement des activités en fonction de leur impact sur l'environnement (REAFIE). Un modèle hydrologique et hydraulique a été développé à l'aide du logiciel PCSWMM et le type SCS II a été employé pour simuler les pluies.

Les volumes présentés au **Tableau 6-3**, incluent également la contribution de l'eau souterraine, évaluée par Hydrogéologie Richelieu (2024b). Un débit de pompage pour une période de 24 et 48 heures est associé à chacune de ces périodes et est présenté au **Tableau 6-3**. Cette plage a pour but de donner davantage de flexibilité en chantier, en considérant que le volume d'emmagasinement dans l'excavation de BC-1 sera suffisant et qu'un effort aura été fait pour éloigner l'eau propre de la zone des travaux par la mise en place de bermes ou de fossés de déviation. La pompe de dénoyage du bassin d'accumulation temporaire proposée dans Hydrogéologie Richelieu (2024b) a la capacité requise pour gérer la gamme de débits proposés. Il est à noter que l'apport en eau sera tributaire des précipitations au site. Il se pourrait que le pompage soit arrêté pendant une période donnée si le temps s'avère sec.

Tableau 6-3 : Débit de rejet estimé en fonction des récurrences des pluies

	Pluie qualité	Pluie de récurrence 1: 5ans	Pluie de récurrence 1: 25 ans	Pluie de récurrence 1: 100 ans
Volume généré par l'évènement (m^3/24h)	1 260	9 815	16 500	22 040
Débit maximal généré par l'évènement (m^3/s)	0.3	2.1	4.8	6.6
Débit de pompage requis pour vider le bassin temporaire en 24h (m^3/h)	52	409	687[1]	918[1]
Débit de pompage requis pour vider le bassin temporaire en 48h (m^3/h)	26	205	344	459

Source : Calculs eau construction BC1.xlsx

1 Ces scénarios ne pourront être réalisés à moins d'augmenter la capacité de pompage projetée.

Le prélèvement des eaux de construction sera réalisé conformément aux exigences du REAFIE et à la méthode appliquée décrite dans Richelieu Hydrogéologie (2024b). Le lieu du prélèvement sera situé au fond de l'excavation de l'empreinte de BC-1, soit dans le bassin d'accumulation temporaire.

Traitement des eaux

Tel que décrit dans Richelieu Hydrogéologie (2024b), aucune eau ne sera relâchée vers l'environnement sans qu'elle n'ait subie un traitement et soit conforme aux exigences de rejet de la D019. La technologie proposée par Mabarex est la plus appropriée afin de couvrir la plage de débits présentés au **Tableau 6-4**. En effet, la solution proposée offre un traitement de type physico-chimique qui sera offert en deux trains de 225 m^3/h, totalisant 450 m^3/h. Ce débit est suffisant pour évacuer dans un délai de 24h le volume issu d'une pluie de qualité et de récurrence 1 : 5 ans, alors que les évènements de récurrence 1 : 25 ans et 1 : 100 ans le seront en environ 48h. Ce débit est également inférieur à l'augmentation de capacité de rejet demandé à l'effluent par WSP (WSP, 2023) près de l'usine de démonstration à 520 m^3/h. Le **Tableau 6-4** résume les débits attendus durant la construction de BC-1 et additionnant les quantités attendues à BC-2 en conditions de construction. Ceci, considère que les opérations de dépositions pourront débuter seulement une fois que le BC-1 et la HCD seront opérationnels. Ainsi, l'eau de construction sera pompée en provenance du BC-2 vers l'unité de traitement avant de rejoindre le point de décharge autorisée. Une partie de la décantation sera effectuée à-même le BC-2 et l'eau sera rendu conforme aux critères de rejets par le traitement en place. Pour les travaux de construction, c'est-à-dire lors des travaux de préparation de site (essouchage, décapage, remblai-déblai, etc.), le traitement requis est celui relié au MES. Puisque pour les travaux de préparation de site, il n'y a aucune activité qui touche les résidus miniers, le minerai ou le procédé, aucune charge en métaux n'est attendu au-delà des exigences de la D019. Des mesures compensatoires pourront être ajoutées dans les fossés en amont du bassin d'accumulation de manière à limiter l'apport en sédiment dans le bassin avant son pompage, si toutefois les eaux de rejets étaient chargées en MES.

Tableau 6-4 : Volumes combinés BC-1 et BC-2 en fonction du débit de traitement attendu

	Pluie qualité	Pluie de récurrence 1: 5ans	Pluie de récurrence 1: 25 ans	Pluie de récurrence 1: 100 ans
Volume d'eau à en provenance de BC-1 vers BC-2 en 24h (m^3)	1 256	9 816	16 496	22 036
Volume d'eau à en emmagasinner/traiter de BC-2 en 24h (m^3) (Scénario 2, WSP, 2023)	5 202[1]	10 002	18 502	26 302
Total d'eau à traiter en combinant l'apport des 2 bassins (m^3)	6 458	19 818	34 998	48 338
Capacité de traitement selon solution de Mabarex (m^3/24h)	10 800	10 800	10 800	10 800
Jours requis pour traiter et évacuer l'évènement	0.6	1.8	3.2	4.5

Source : Calculs eau construction BC1.xlsx

1 Volume équivalent à une récurrence 1 : 2 ans et non une pluie qualité

6.2 Bilan des matériaux

Un bilan de production des matériaux d'excavation est actuellement en processus de validation par NMG. Selon leur nature, leur quantité, et leur qualité, les différents types de matériaux rencontrés seront stockés directement à la HMT ou réutilisés comme matériaux de construction à même le site.

6.3 Estimation des quantités

Le **Tableau 6-5** présente une estimation des quantités des divers matériaux nécessaires pour mener à terme la construction des ouvrages de gestion des eaux de surface. Ces quantités incluent une contingence de 20 % qui pourra être revue à la baisse lorsque les méthodes de construction seront confirmées avec l'Entrepreneur.

Tableau 6-5 : Estimation des quantités

Description détaillée	Remblais total (m^3)	Déblais sol total (m^3)	Excavation roc (m^3)	Volume empierrement (m^3)	Volume de la berme de sécurité le long du fossé (m)	Superficie de la geomembrane (m^2)	Superficie géocomposite (m^2)	Superficie géotextile protection (m^2)
BC1	-	105,810	179,410	-	-	23,670	23,670	23,670
BC2	-	99,680	182,370	-	-	39,918	39,918	39,918
Chemin le long du fossé FC-4 PH C	23,868	82	-	4,286	2,820	-	-	-
Chemin le long du fossé FC-1 de la HCD	13,789	4,339	-	2,321	1,872	-	-	-
Chemin le long du fossé FC-2 de la HCD	5,406	8	-	534	430	-	-	-
Chemin le long du fossé FC-2 de la PHASE B de la HCD	24,352	26	-	1,761	1,420	-	-	-
Chemin le long du fossé FC-4 PH A au nord de la HMT	10,839	3	-	1,257	827	-	-	-
Chemin le long du fossé FC-4 PH B	23,920	26	-	432	284	-	-	-
Chemin le long du fossé FC-4 TEMP	5,698	18	-	672	420	-	-	-
Chemin au pourtour de BC-1	18,418	4	-	3,216	2,898	-	-	-
Chemin au pourtour de BC-2	5,108	1,044	-	3,550	2,154	-	-	-
Fossé 3 au sud de la HMT	112	4,339	-	1,211	-	360	-	-
Fossé 3 Extension du sud de la HMT	78	8	-	417	-	360	-	-
Fossé FC-1 à l'est de la HCD PH1	4,207	4,311	-	-	-	10,185	-	-
Fossé FC-2 PHASE A	961	469	-	-	-	2,343	-	-
Fossé FC-2 PHASE B	572	2,156	-	-	-	7,727	-	-
Fossé FC-4 PH A au nord de la HMT	4,215	26	-	1,151	-	343	-	-
Fossé FC-4 PH B sous rampe du concasseur	66	1,044	-	341	-	125	-	-
Fossé FC-4 PH C au nord-ouest de la HMT	9,177	9,849	-	3,384	-	1,139	-	-
Fossé FC-4 TEMP	3,354	4	-	504	-	179	-	-
Fossé FD-2 à l'est de BC2	54	6,096	-	1,012	-	3,192	-	-
Fossé FD-2 à l'ouest de BC2	346	3,771	-	1,432	-	4,516	-	-

7 Halde d'entreposage temporaire des déblais de roc

Les déblais de roc issus de l'excavation du BC-2 seront réutilisés comme matériaux de construction pour certains ouvrages au site notamment dans l'aménagement des routes d'accès et de production. Avant d'être concassé, l'empierrement issus de l'excavation de BC-2 sera entreposé temporairement dans une halde située à proximité de la zone des travaux d'excavation, à l'ouest du BC-2.

L'étendue, la configuration et la hauteur de cette halde d'empierrement variera dynamiquement en fonction des besoins. Les matériaux qui y seront entreposés seront éventuellement complétement excavé afin de faire place au fossé FC-8 (voir **section 6.1.1**).

Une configuration d'une halde d'empierrement, respectant les critères de stabilité géotechnique applicables de la D019 a été développée et présentée l'**Annexe E**. La configuration proposée permet d'accumuler un total 189 365 m^3 ce qui pourrait permettre d'accumuler la totalité de l'empierrement qui sera généré lors de l'excavation de BC-2 (situation qui ne devrait pas survenir). Les résultats des analyses de stabilité de la halde temporaire de BC-2 sont disponibles à l'**Annexe E**.

8 Recommandations et opportunités

Les ouvrages de gestion des eaux (fossés et bassins de collectes) requis dans le cadre du projet requièrent de l'excavation de mort-terrain et du socle rocheux. En parallèle, l'atteinte des élévations finales pour la construction de ces mêmes ouvrages nécessitera par endroit du remblai. Ainsi, la valorisation de l'empierrement qui aura été excavé des BC sera à prioriser vs l'ouverture et l'opération de banc d'emprunt.

9 Clôture

Ce document, Rapport d'ingénierie des ouvrages de gestion des eaux de surface du projet minier Matawinie, a été préparé par :

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10 Approbation

Ce document est approuvé et endossé par :

Entreprise	Nom imprimé	Titre	Date (aaaa-mm-jj)	Signature
Nouveau Monde Graphite (NMG)– Site Matawinie	Martine Paradising, MSc, PMP	VP Environnement & Infrastructures durables		
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11 Contrôle des versions

Version	Auteur(s)	Date d'émission	Objectif/modification
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Les opinions exprimées dans ce document ont été basées sur les informations dont disposait SRK au moment de sa préparation. SRK a fait preuve de tout le soin nécessaire dans l'examen des informations fournies par d'autres pour une utilisation sur ce projet. Bien que SRK ait comparé les données clés fournies avec les valeurs attendues, l'exactitude des résultats et des conclusions de l'examen dépend entièrement de l'exactitude et de l'exhaustivité des données fournies. SRK n'accepte aucune responsabilité pour toute erreur ou omission dans les informations fournies, sauf dans la mesure où SRK a été engagé pour vérifier les données.

Références

Association canadienne des barrages (ACB, 2013). Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams. 2013.

BBA (2022). NI 43-101 Technical Feasibility Study Report for The Matawinie Mine and the Bécancour Battery Material Plant Integrated Graphite Projects. Bécancour, Québec, Canada. Prépared for : Nouveau Monde Graphite. July 6, 2022. 548 pages.

Budhu, M. (2011) Soil Mechanics and Foundations. 3rd edn, John Wiley and sons, Inc. 3rd edn. Edited by D. Fowley and J. Welter.

Giroud & Al., (2023). Design of canals lined with geomembranes, GeoAfrica 2023, E3S Web of Conferences. 368. 10.1051/e3sconf/202336801001.

MDDEP, 2012 MINISTÈRE DU DÉVELOPPEMENT DURABLE, DE L'ENVIRONNEMENT ET DES PARCS (MDDEP). Directive 019 sur l'industrie minière. 66 p. et annexes.

Koerner, R. M. (2012). *Designing with geosynthetics-Vol. 2* (Vol. 2). Xlibris Corporation.

NMG, 2022 (a). Appel d'offres ingénierie de la halde de co-disposition et la gestion des eaux – Plans et devis. 11 avril 2023.

Ouranos, 2015 Vers l'adaptation. Synthèse des connaissances sur les changements climatiques au Québec. Édition 2015. Montréal, Québec : Ouranos. 415 p.

Phoon, K. K., & Kulhawy, F. H. (1999). Characterization of geotechnical variability. Canadian geotechnical journal, 36(4), 612-624.

Richelieu Hydrogéologie, 2022, Projet de graphite Matawinie, Modélisation hydrogéologique des phases de développement.

Richelieu Hydrogéologie, 2024a, Nouveau Monde Graphite – Projet Matawinie, Modélisation hydrogéologique des bassins BC1, BC2 et BS. Note technique. Janvier 2024. 52 pages.

Richelieu Hydrogéologie, 2024b. Nouveau Monde Graphite Note Technique prélèvement d'eau global du site.

SNC Lavalin (2019a), Investigation géotechnique et hydrogéologique - Campagne 2019 N/Dossier n° : 666896.

SNC-Lavalin (2019b). Plan de réaménagement et de restauration pour le site du projet minier Matawinie. Projet 654068-6200-4EER-0001Octobre 2019.

SNC-Lavalin (2019c), Projet Matawinie- Étude d'impact environnemental et social – Nouveau Monde Graphite. Projet No 653897. Mars 2019.

SNC Lavalin, 2020, Rapport de faisabilité sur la gestion de l'eau, des résidus et stériles miniers, 654068-4000-40 ER-0001.

SNC Lavalin. 2020a. Project Matawinie – Rapport d'investigation géotechnique et hydrogéologique. 23 Jan. 2020. 319 pages.

SNC-Lavalin, 2021. Retour à l'environnement des eaux au complexe humide CP3 lors des travaux de construction et d'aménagement de la plateforme industrielle du site minier Matawinie – Volet bassin de sédimentation temporaire. Projet : 669469. Juillet 2021.

SNC Lavalin, 2022 (a). Plan de déposition de la halde à mort-terrain et de la halde à terre végétale. Projet : 669469-1015-41ER-0001_02. Émis le 12 décembre 2022.

SRK Consulting (Canada) Inc. 2022. Matawinie Project – Open Pit Slope Stability Assessment and Design. FINAL. Prepared for Nouveau Monde Graphite: Saint-Michel-des-Saints, QC. Project number: 2CN044.001. Issued August. 2022.

SRK Consulting (Canada) Inc. 2023. Precipitation parameters correction due to orographic effect. Draft. Project : CAPR0002717. Issued: Oct. 04, 2023. 10 pages.

SRK Consulting (Canada) Inc. 2024a. Site overall Water Balance for BC1 and BC2 sizing Project number. CAPR002717. Issued July 19, 2024. 43 pages.

SRK Consulting (Canada) Inc. 2024b. Conception de la halde à mort-terrain de la mine de graphite Matawinie. Final. Préparé pour Nouveau Monde Graphite: Saint-Michel-des-Saints, Québec. Numéro de projet : CAPR002717. Émis le 12 janvier 2024.

SRK Consulting (Canada) Inc. 2024c. Préparation de site de la première phase de la halde de co-disposition du projet minier Matawinie. Final. Préparé pour Nouveau Monde Graphite: Saint-Michel-des-Saints, Québec. Numéro de projet : CAPR002717. Émis le 28 juin 2024.

Texel Matériaux Techniques inc. (2017), Fiche technique Série TM860-ST. Révision 2021-05-25.

[USBR] United States Bureau of Reclamation, 2012. Design Standards No. 13 – Embankment Dams. Chapter 2: Embankment Design, Phase 4 (Final). December.

WOOD, 2021, Rapport de conception – Gestion des eaux et des rejets, TX20035103-02800-RGE-0001-B. Émis le 14 mai 2021.

WSP, 2022. Étude géotechnique 2022 – bassins, halde à mort terrain et site démonstrateur projet matawinie réf. Wsp : tx20035103-21000-rge-0001. 28 février 2023.

WSP,2023. Gestion des eaux de construction du projet Matawinie dans les bassins du site démonstrateur. Ref : TX20035103-16000-NGE-002-0. Septembre 2023.

Annexe A Precipitation parameters correction due to orographic effect

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Final

Memo

To	Tony Fedec, Charles Veilleux	**Client**	Nouveau Monde Graphite Inc.
From	Camilo Gallard	**Project**	CAPR002717
Cc	Victor Munoz	**Date**	18 juillet 2024
Subject	Precipitation parameters correction due to orographic effect		

File name: CAPR002717_NMG_Matawinie_Orografic_Effect_Final_Memo_20240718.docx

1 Introduction

Nouveau Monde Graphite Inc. (NMG) (the Client) asked SRK Consulting (Canada) Inc. (SRK) to support their water management strategy and water balance for the Matawinie Mine (the Site) as a part of the Surface Water Management, Overburden Stockpile and Co-disposal Facility Engineering project initiated in 2023. As a part of its preliminary works, SRK performed a review of the existing hydrology analysis for the Site.

The Site is located at an elevation of around 550 meters above mean sea level (m amsl). Previous water balance (Wood, 2020) includes precipitation inputs developed for the site from the Environment and Climate Change Canada (ECCC) Saint Michel des Saints station as an analogous station (SNC-Lavalin, 2020). However, this station is located at an elevation of 370 m amsl. In meteorology, the orographic effect occurs when air masses are forced to flow over high topography resulting in rainfall increasing with elevation.

Due to the elevation difference (170 m) between the Site and the location of the analogous station at Saint Michel des Saints, SRK considered the orographic effect to be potentially significant. SRK completed a high-level regional precipitation analysis to assess the magnitude of the orographic effect around the site, and the results are presented in this memorandum.

2 Regional Orographic Effects Analysis for Precipitation

2.1 Available Information

The following meteorological datasets were consulted to perform the orographic effect analysis in the region around the Site for precipitation and snow cover:

- Site data: NMG operates a meteorological station at the Matawinie site. The records available for this analysis cover the June 2021 to November 2022 period.
- Environment and Climate Change Canada (ECCC) historical weather records: meteorological records from stations within 150 kilometers from Site.
- Daymet: reanalysis tool developed by the Oak Ridge National Laboratory and supported by NASA, Daymet provides long-term, continuous, gridded estimates of daily weather and climatology in North America (Daymet, 2023).
- Merra2: long-term global reanalysis tool developed by NASA (GMAO, 2015). Used to validate Daymet results.
- CanSWE5: Canadian historical water equivalent of snow cover (SWE) dataset version 5 (Vionnet, 2023)

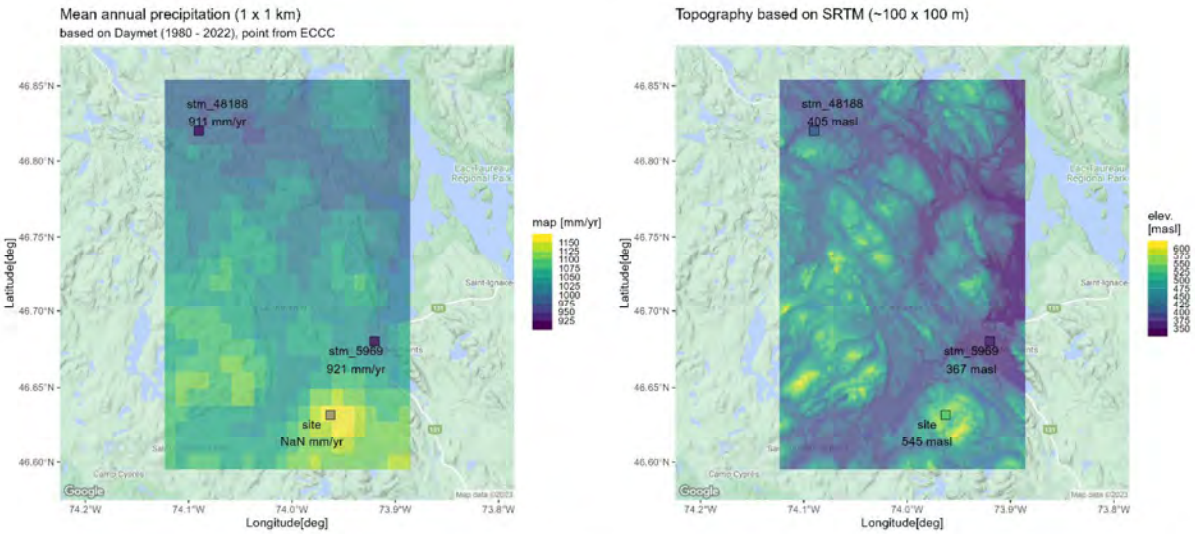
2.2 Maximum Annual Precipitation Regional Analysis

ECCC maintains records for two stations labeled as Saint Michel des Saints (id 5969 and id 48188). The previous hydrology analysis (SNC-Lavalin, 2020) results match the data from station 48188.

Site data was compared to Saint-Michel-des-Saints ECCC station 48188 data as a preliminary check for elevation influence in precipitation. During the June 2021 to November 2022 period, Site data recorded an additional 6% cumulative precipitation compared to Saint Michel des Saints ECCC station. Due to the short length of records of the site station, further analysis on a broader spatial and temporal scale was deemed necessary to validate this observation.

Figure 1 is a spatial representation of Daymet mean annual precipitation (MAP) between 1980 and 2022 compared to digital elevation model STRM (NASA, 2013) near Site. The Site, and the Saint Michel des Saints ECCC stations locations are also represented. In this figure, areas with higher MAP match higher elevation areas, like the site location.

Figure 1: Mean Annual Precipitation (Daymet, and ECCC) comparison to Topography (STRM) in the Project region



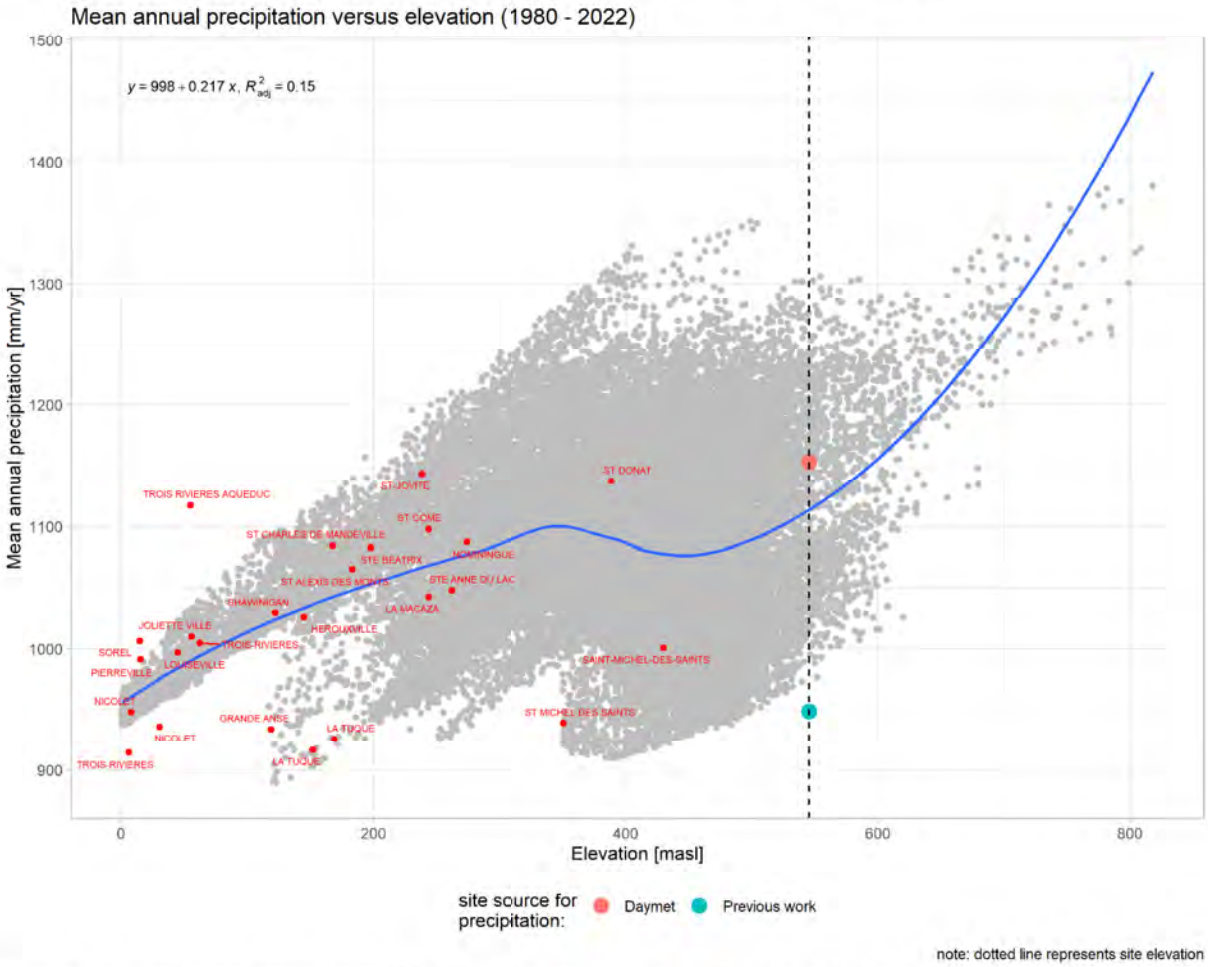
Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR002717/Internal/!020_Project_Data/010_SRK/Hydrologie/reports/meteo_review_rev3.Rmd

To confirm this on a broader regional scale, MAP from ECCC stations with records after 1980 and Daymet within 150 km from site were plotted against their corresponding elevations, and the results are presented in Figure 2.

In Figure 2, ECCC stations are represented as red dots, Daymet pixels are represented as grey dots. Site elevation is signaled by the dotted vertical line, with the corresponding MAP results from the previous analysis (teal) and Daymet (pink) as large points. An overall trendline is also presented in blue (locally estimated scatterplot smoothing method).

Based on this analysis, MAP tends to increase with elevation on a regional scale. Although there are no ECCC stations at a similar elevation to site, MAP estimated through previous is below the expected result range for site elevation.

Figure 2: Regional Mean Annual Precipitation versus Elevation Analysis



Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR002717/Internal/!020_Project_Data/010_SRK/Hydrologie/reports/meteo_review_rev3.Rmd

2.3 Seasonal Precipitation Analysis

To assess the relevance of seasonal variations in rainfall and snowfall between the Site location and previous analysis based on Saint-Michel-des-Saints data, the monthly distribution between rain and snow was developed for the Daymet dataset at the Site location. These values were normalized to their corresponding yearly totals and compared to the values presented in the previous analysis (SNC-Lavalin, 2020). The values are presented in Table 1.

The normalized difference columns show the change between precipitation, rainfall and, snowfall distributions between both analyses, relative to their corresponding yearly totals. All these values are below 1.4% showcasing little variation between the relative monthly distribution of precipitation, rainfall and snowfall between both analyses. This suggests that there are no major changes in seasonality between the previous analysis and Daymet for Site.

Table 1: Rainfall, Snowfall, and Precipitation distribution difference between the previous analysis and Daymet for Site

Month	Previous Analysis[1]			Daymet at Site[2]			Normalized Difference[3]		
	Total PP (mm)	Rain (mm)	Snow (mm)	Total PP (mm)	Rain (mm)	Snow (mm)			
Jan	59	6	53	78	8	70	-0.5%	-0.1%	0.3%
Feb	50	5	45	65	5	60	-0.3%	0.1%	0.2%
Mar	64	20	43	76	21	55	0.2%	0.3%	0.7%
Apr	65	51	14	86	63	24	-0.5%	-0.2%	-1.4%
May	87	86	1	101	99	2	0.6%	0.5%	-0.1%
Jun	105	105	0	123	123	0	0.5%	0.3%	0.0%
Jul	99	99	0	119	119	0	0.2%	-0.1%	0.0%
Aug	92	92	0	115	115	0	-0.1%	-0.6%	0.0%
Sep	101	101	0	117	117	0	0.6%	0.5%	-0.1%
Oct	87	81	6	106	98	9	0.1%	-0.1%	-0.1%
Nov	71	37	34	91	44	47	-0.3%	0.0%	-0.5%
Dec	69	8	61	92	13	78	-0.5%	-0.5%	1.0%

Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR002717/Internal/!020_Project_Data/010_SRK/Hydrologie/reports/meteo_review_rev3.Rmd

Notes:

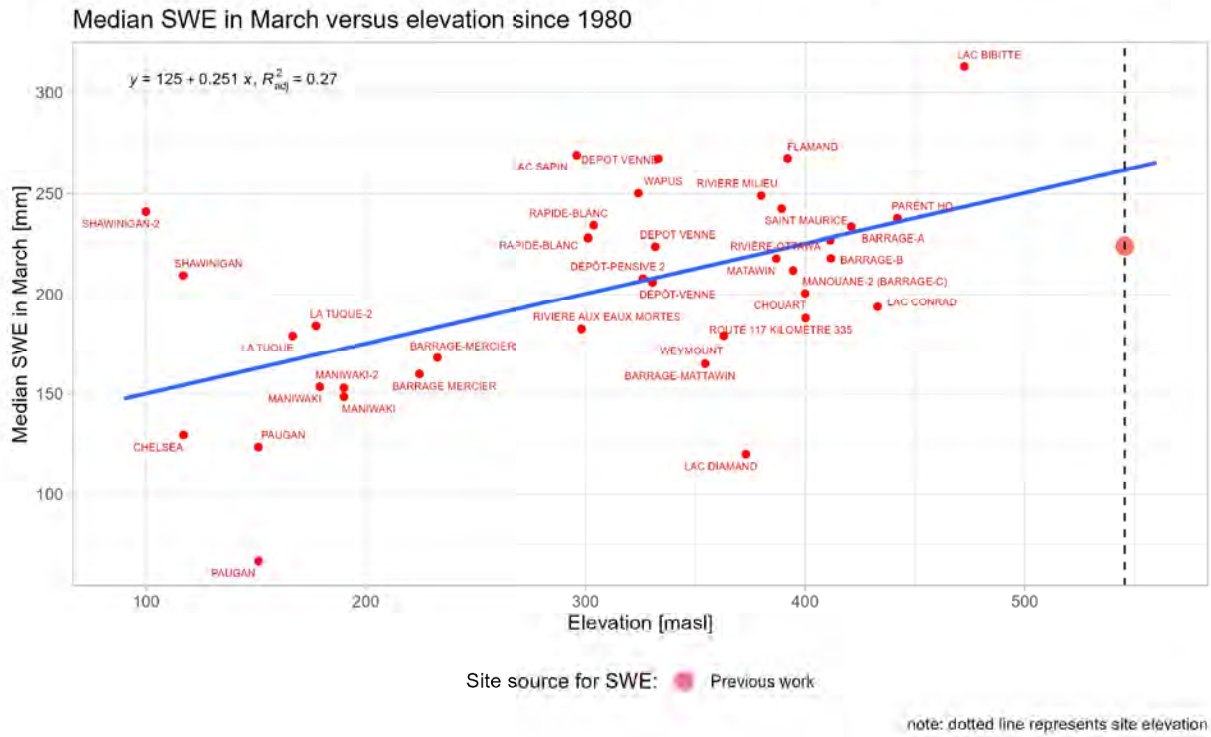
1. SNC-Lavalin, 2020
2. For reference only
3. Difference in percentage of the corresponding yearly total between the Previous Analysis and Daymet values.

2.4 Regional Snowpack Verification

In addition, a regional verification was performed on snowpack records using the Canadian historical water equivalent of snow cover dataset version 5 (CanSWE5) (Vionnet, 2023). For each station within 200 km of Site, median SWE surveyed during the month of March was plotted against elevation obtaining Figure 3. Median SWE for Site based on the previous analysis is also represented by a pink dot, and a linear approximation of the median SWE/elevation relationship is shown by the blue line.

The month of March was picked for consistency of measurements. The selected CanSWE5 results might be an underestimation of the SWE observed due to further accumulation during the spring. Despite this, the previous analysis median SWE of 224 mm (SNC-Lavalin, 2020) is under the corresponding linear regression for Site based on CanSWE median March SWE data by a about 16% of its value. This seems consistent with the regional precipitation and seasonality analysis findings.

Figure 3: Median equivalent of snow cover (SWE) in March since 1980 versus Elevation



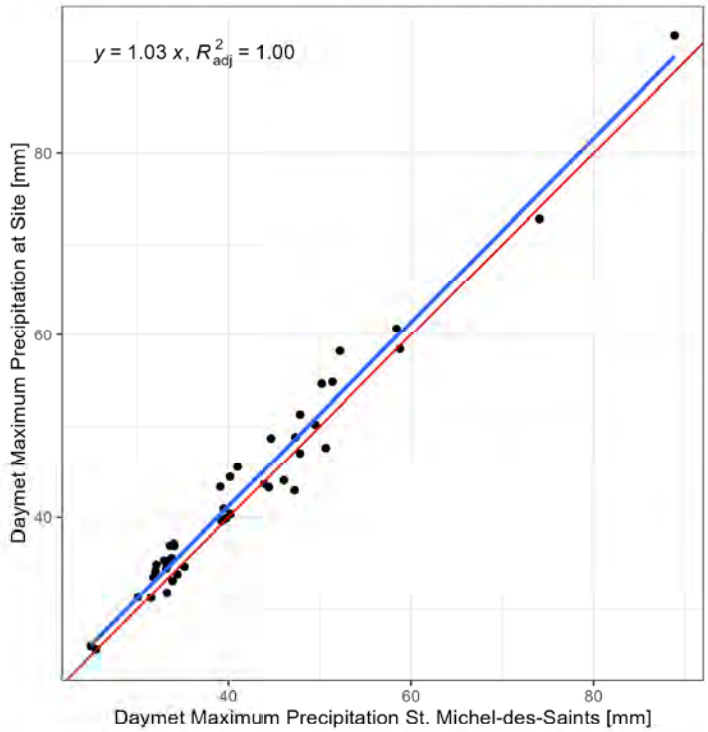
Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR002717/Internal/!020_Project_Data/010_SRK/Hydrologie/reports/meteo_review_rev3.Rmd

2.5 Extreme Precipitation Events Verification

Extreme events increase in intensity could also be expected due to orographic effects. The daily maximum precipitation every year between 1980 and 2022 from the Daymet dataset at the Site location was compared to the corresponding values at the Saint-Michel-des-Saints station location. The results are presented in Figure 4.

An average 3% increase in this parameter is also observed within the Daymet dataset with the change in elevation between both locations. Frequency analyses were not included as a part of this scope, however an increase in extreme events resulting from these values could also be inferred.

Figure 4: Daymet Maximum Daily Precipitation every year between 1980 and 2022 comparison between Site and Saint-Michel-des-Saints



Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR002717/Internal/!020_Project_Data/010_SRK/Hydrologie/reports/meteo_review_rev3.Rmd

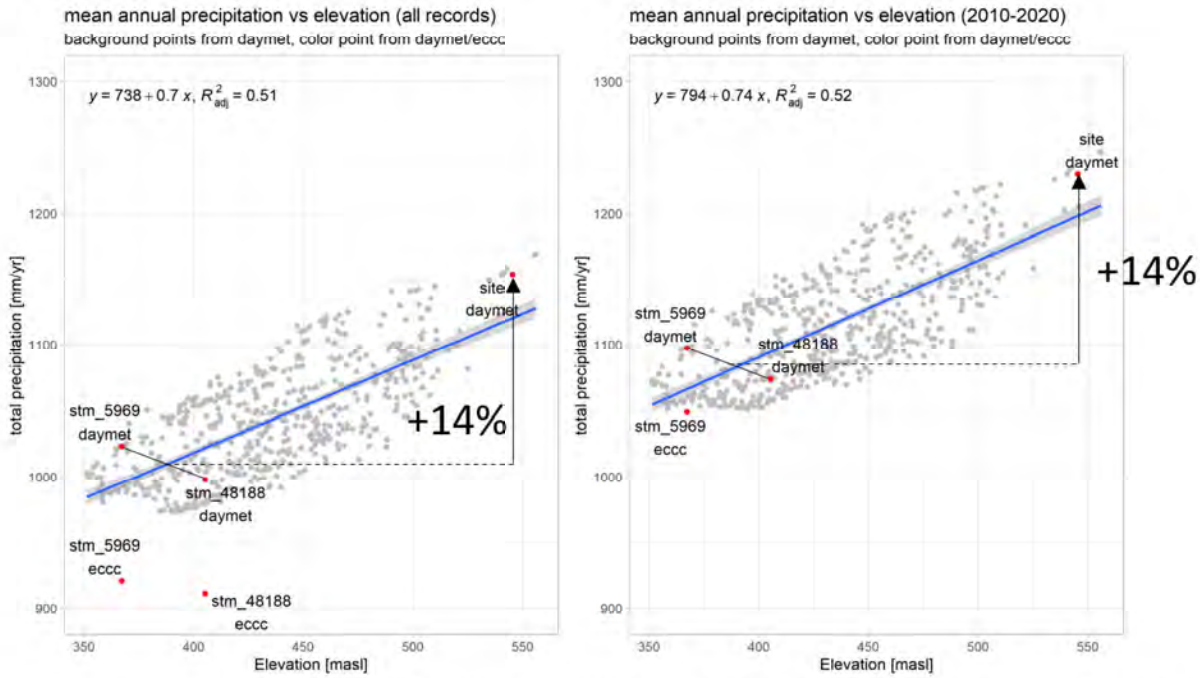
2.6 Conclusion

The prevalence of an orographic effect for all precipitation parameters in the Site region can be inferred from the previous analysis, however no major seasonal distribution of rain and snow changes are expected between site location and the previous analysis analogous station.

Based on the Daymet dataset, mean annual precipitation is expected to be 14% higher at the Site location compared to the Saint-Michel-des-Saints stations as shown in Figure 5. A similar magnitude increase is expected when comparing regional SWE between the elevations of these two locations. An increase in the intensity of extreme precipitation events can also be inferred due to orographic effects but remains uncertain.

Therefore, a single correction factor of 14% is proposed as an interim measure to be applied to all precipitation related design criteria to advance design and water management planning for Site. It is important to note that Daymet values were compared against each other to obtain this correction factor to try to reduce the effects of any dataset bias that might be intrinsically present within the Daymet reanalysis tool or within these specific Saint-Michel-des-Saints ECCC data processing methods, like undercatch consideration. The average Daymet MAP of both Saint-Michel-des-Saints stations locations was used to calculate the correction factor.

Figure 5: Precipitation Increase Estimation for Site due to Orographic Effect



Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR002717/Internal/I020_Project_Data/010_SRK/Hydrologie/reports/meteo_review_rev3.Rmd

3 Recommendations

SRK recommends developing a site-specific hydrology study for the Matawinie Site, accounting for the orographic effect as well as including climate change considerations.

Based on the previous orographic effects analysis, a safety increase of 14% magnitude is proposed for all previously developed precipitation parameters, including:

- Extreme events (IDF),
- Daily, Monthly and Annual Precipitation values.

Note that SRK considers the application of this factor is an interim measure. All designs and models having used this factor must be verified when the next hydrology analysis is completed.

This factor doesn't account for climate change effects that might alter weather patterns at the site location.

Regards,

SRK Consulting (Canada) Inc.

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Camilo Gallard, ing, MSc, Eng
Senior Consultant

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Victor Munoz Saavedra, PEng, Meng
Principal Consultant

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The opinions expressed in this document have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. While SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

References

Daymet: Daily Surface Weather Data on a 1-km Grid for North America, Version 4 R1 https://doi.org/10.3334/ORNLDAAC/2129

Global Modeling and Assimilation Office (GMAO) (2015), inst3_3d_asm_Cp: MERRA-2 3D IAU State, Meteorology Instantaneous 3-hourly (p-coord, 0.625x0.5L42), version 5.12.4, Greenbelt, MD, USA: Goddard Space Flight Center Distributed Active Archive Center (GSFC DAAC), Accessed Enter User Data Access Date at doi: 10.5067/VJAFPLI1CSIV.

NASA Shuttle Radar Topography Mission (SRTM)(2013). Shuttle Radar Topography Mission (SRTM) Global. Distributed by OpenTopography. https://doi.org/10.5069/G9445JDF. Accessed: 2023-10-04

SNC-Lavalin, 2020 Rapport 654068-4000-40 ER-0001 (SNC-Lavalin, 2020), Rapport de faisabilité sur la gestion de l'eau, des résidus et stériles miniers.

Vionnet, Vincent, Mortimer, Colleen, Brady, Mike, Arnal, Louise, & Brown, Ross. (2023). Canadian historical Snow Water Equivalent dataset (CanSWE, 1928-2022) (Version v5) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.7734616

Wood, 2020. Nouveau Monde Graphite – Projet Matawinie. Ingénierie détaillée - Données de base et critères de conception. TX20035103-02000-NGE-0001-B. 2020-11-25. Wood – Solutions en environnement & infrastructure, une division de Wood Canada limitée.

Annexe B Plans de la gestion des eaux – pour demande de permis

MINE DE GRAPHITE MATAWINIE

SAINT-MICHEL-DES-SAINTS, QUÉBEC, CANADA

NUMÉRO DU DESSIN	NUMÉRO PRÉCÉDENT DU DESSIN	TITRE DU DESSIN	DESCRIPTION	DATE	RÉVISION
GE-100	--	BASSIN BC-1 VUE EN PLAN ET SECTION	ÉMIS POUR DEMANDE DE PERMIS	2024-12-13	0
GE-101	--	BASSIN BC-1 SECTIONS	ÉMIS POUR DEMANDE DE PERMIS	2024-12-13	0
GE-110	GE-100	BASSIN BC-2 VUE EN PLAN ET SECTIONS	ÉMIS POUR DEMANDE DE PERMIS	2024-12-13	0
GE-111	--	BASSIN BC-2 SECTION ET DÉTAILS	ÉMIS POUR DEMANDE DE PERMIS	2024-12-13	0
GE-300	--	DÉTAILS DES BASSINS	ÉMIS POUR DEMANDE DE PERMIS	2024-12-13	0
GE-301	--	DÉTAILS DES POMPAGE FOSSE	ÉMIS POUR DEMANDE DE PERMIS	2024-12-13	0
GE-400	--	CHEMIN D'ACCÈS AU BASSIN BC-1 PLAN ET PROFIL ET COUPE TYPE	ÉMIS POUR DEMANDE DE PERMIS	2024-12-13	0
GE-401	--	CHEMIN D'ACCÈS AU BASSIN BC-2 0+000 À 0+375 PLAN ET PROFIL	ÉMIS POUR DEMANDE DE PERMIS	2024-12-13	0
GE-402	--	CHEMIN D'ACCÈS AU BASSIN BC-2 0+375 À 0+589 PLAN ET PROFIL ET COUPE TYPE	ÉMIS POUR DEMANDE DE PERMIS	2024-12-13	0
GE-450	--	FOSSÉ FD-2 SECTION OUEST PLAN ET PROFIL	ÉMIS POUR DEMANDE DE PERMIS	2024-12-13	0
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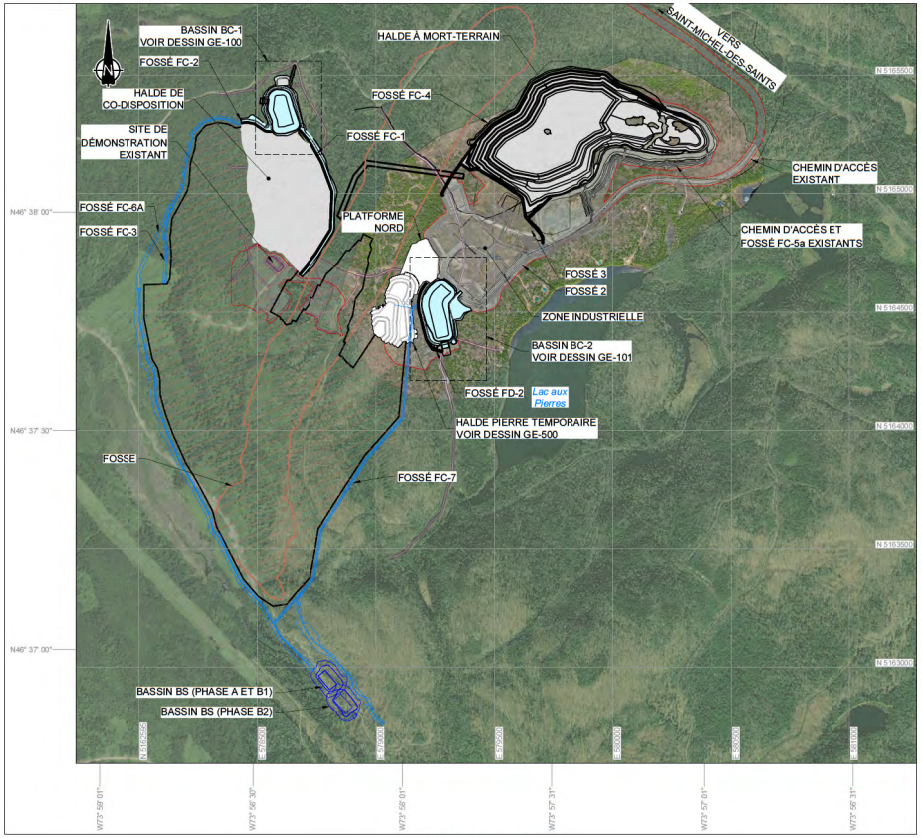
PLAN CLÉ
SANS ÉCHELLE



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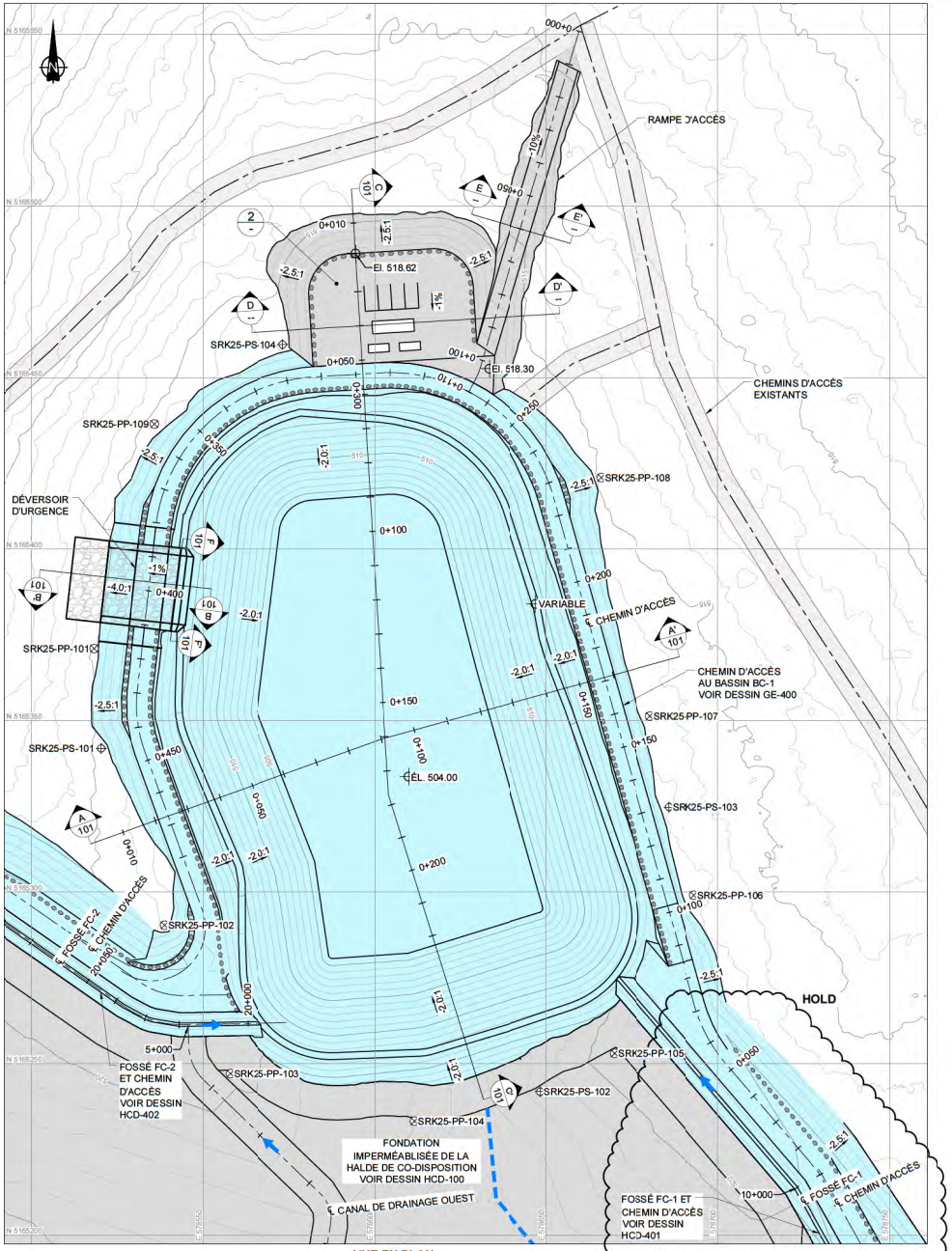
NOUVEAU MONDE GRAPHITE

srk consulting

NUMÉRO DU PROJECT DE SRK: CAPR002717

PAS POUR CONSTRUCTION



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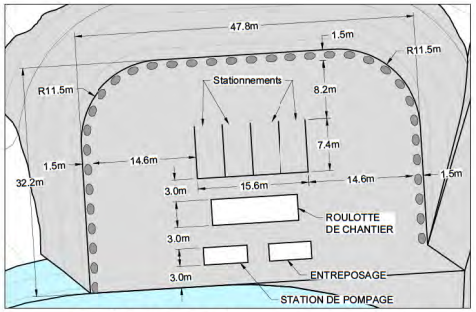

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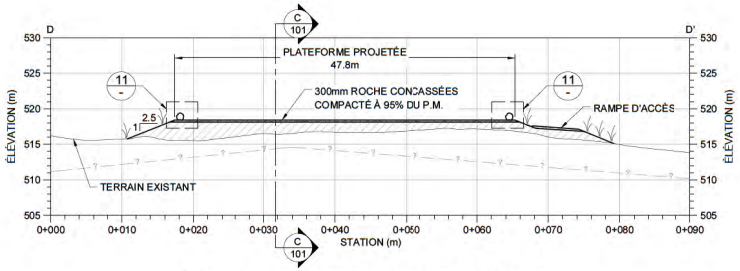

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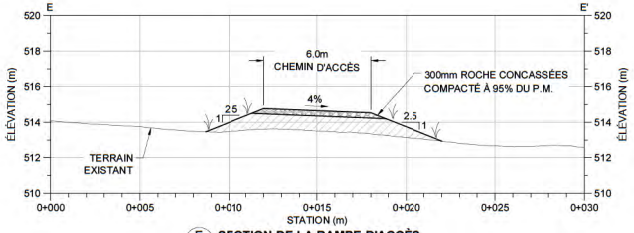

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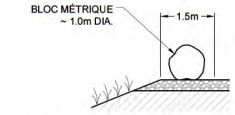

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LÉGENDE

- PUITS DE POMPAGE
- PIÉZOMÈTRE
- SENS DE L'ÉCOULEMENT
- VÉGÉTATION
- GÉOSYNTHÉTIQUES
- BARRIÈRE DE SÉCURITÉ
- LIGNE DE PARTAGE DES EAUX DE RUISELLEMENT
- NIVEAU D'EAU MAXIMUM
- ROC PRÉSUMÉ
- CHEMIN D'ACCÈS EXISTANT
- TERRAIN EXISTANT
- DÉBLAIS
- FOSSÉS, BASSIN COLLECTEUR ET CHEMIN D'ACCÈS
- LIMITE DE LA FRÉPARATION DE SITE DE LA HA..DE DE CO-DISPOSITION - PHASE 1
- REMBLAIS COMPACTÉ À 95% DU M.P.

NOTES

1. TOUTES LES MESURES SONT EN MÈTRES, À MOINS D'INDICATION CONTRAIRE.
2. LES COURBES DE NIVEAU SONT À 1 MÈTRE D'INTERVALLE.

RÉFÉRENCES

UTM ZONE 18 NAD 83 CSRS
LA TOPOGRAPHIE PROVIENT D'UN RELEVÉ LIDAR DE SEPTEMBRE 2023 FOURNI PAR NMG (DEMO_PAR_20230921_dsm.tif) ET D'UN MODÈLE NUMÉRIQUE DE TERRAIN DU GOUVERNEMENT DU QUÉBEC (MNT_3112NO.tif).

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NO.	DESCRIPTION	VÉRIF.	APPR.	DATE
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D	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/11/25
C	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/08/28
B	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/07/26
A	ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/03

RÉVISIONS

2024-12-13
SCEAUX PROFESSIONNELS

srk consulting

CONÇU: CV	DESSINÉ: JAB	VÉRIFIÉ: JFSTL
RÉVISÉ: JFSTL	APPROUVÉ: CV	DATE: 2024/12/13

NOM DU FICHIER: CAPR0027 17-BASSIN BC-1 SP and X.S.dwg
SRK JOB NO.: CAPR0027 17 FEUILLE: A0 REG. NO.:

NOUVEAU MONDE GRAPHITE

MINE DE GRAPHITE MATAWINIE

GESTION DES EAUX

TITRE DU DESSIN: BASSIN BC-1 VUE EN PLAN ET SECTION

NO. DU DESSIN: GE-100 RÉVISION NO.: 0

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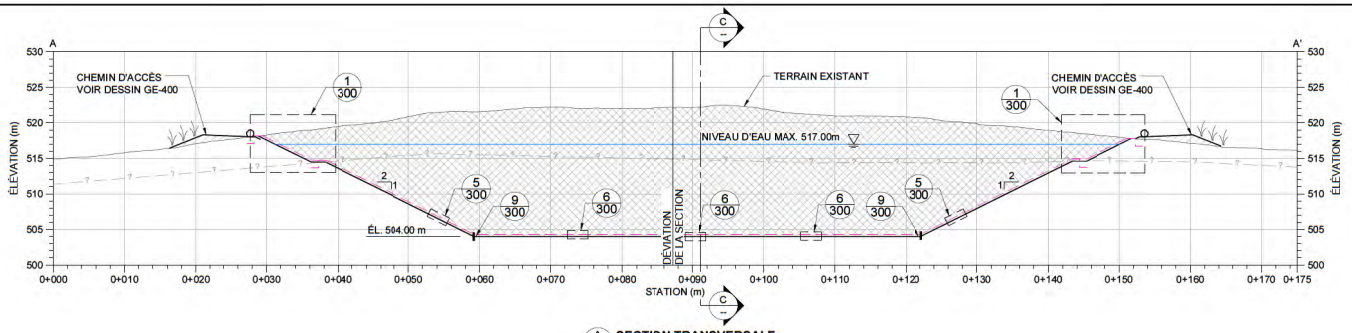

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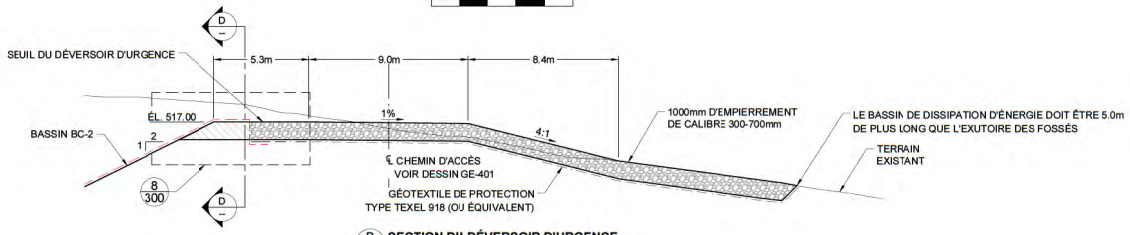

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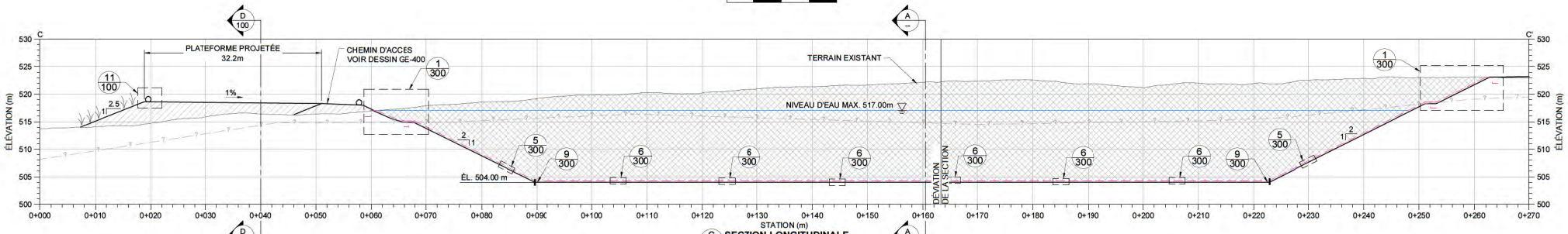

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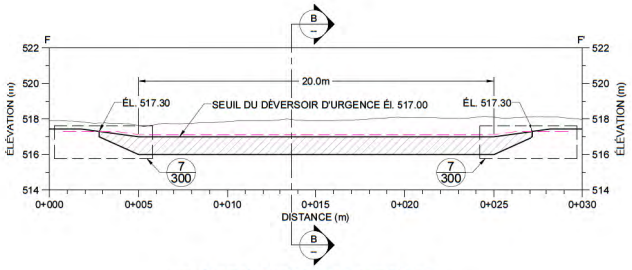

F 100 **SECTION DU DÉVERSOIR D'URGENCE**

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LÉGENDE

- VÉGÉTATION
- GÉOSYNTHETIQUE
- NIVEAU D'EAU MAXIMUM
- ROC PRÉSUMÉ
- TERRAIN EXISTANT
- DÉBLAIS
- REMBLAIS COMPACTÉ À 95% DU M.P.

NOTES

1. TOUTES LES MESURES SONT EN MÈTRES, À MOINS D'INDICATION CONTRAIRE.
2. LES COURBES DE NIVEAU SONT À 1 MÈTRE D'INTERVALLE.

RÉFÉRENCES

UTM ZONE 18 NAD 83 CSRS
LA TOPOGRAPHIE PROVIENT D'UN RELEVÉ LIDAR DE SEPTEMBRE 2023 FOURNI PAR NMG (DEMO_PAR_20230921_dsm.tif) ET D'UN MODÈLE NUMÉRIQUE DE TERRAIN DU GOUVERNEMENT DU QUÉBEC (MNT_3112NO.tif).

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B	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/07/26
A	ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/03

RÉVISIONS

2024-12-13
SCEAUX PROFESSIONNELS

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CONÇU: CV	DESSINÉ: JAB	VÉRIFIÉ: JFSTL
RÉVISÉ: JFSTL	APPROUVÉ: CV	DATE: 2024/12/13

NOM DU FICHIER: CAPR02717-BASSIN BC-1 SP and XS.dwg
SRK JOB NO.: CAPR02717 FEUILLE: A0 REG. NO.:

NOUVEAU MONDE GRAPHITE

MINE DE GRAPHITE MATAWINIE

GESTION DES EAUX

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NO. DU DESSIN: GE-101

RÉVISION NO.: 0

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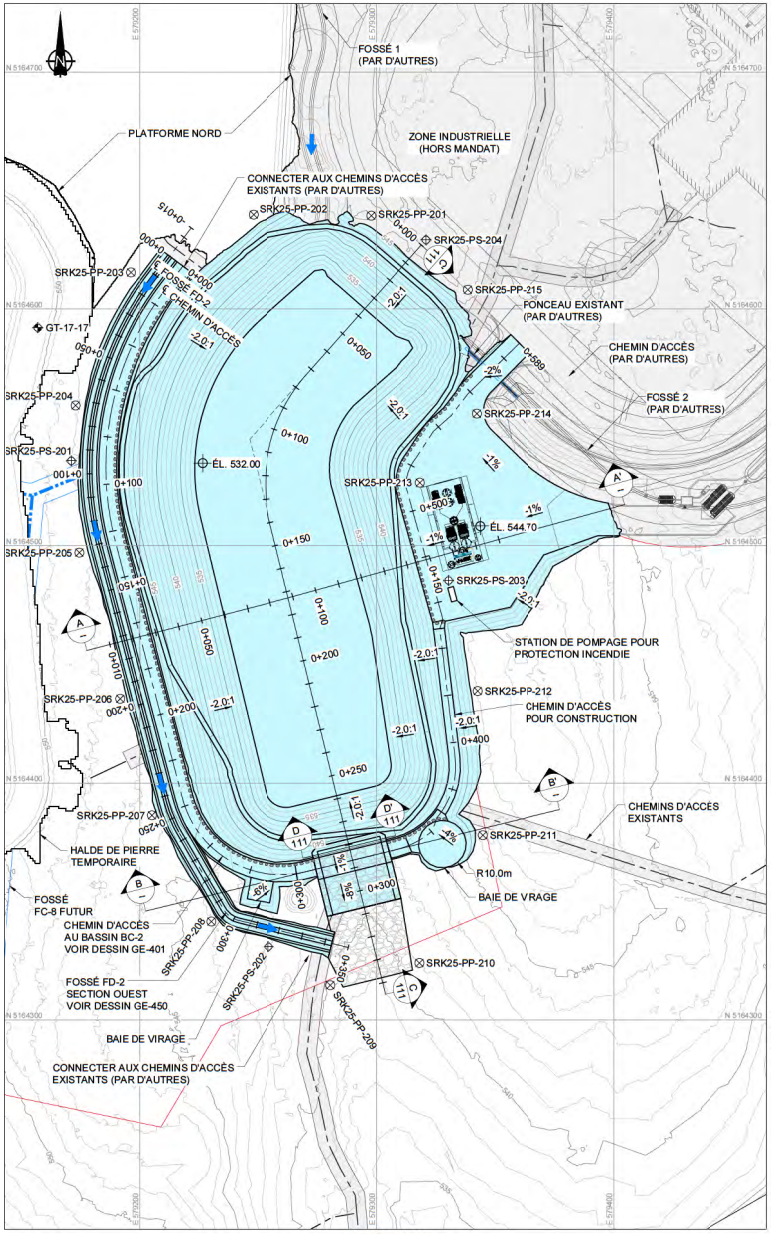

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LÉGENDE

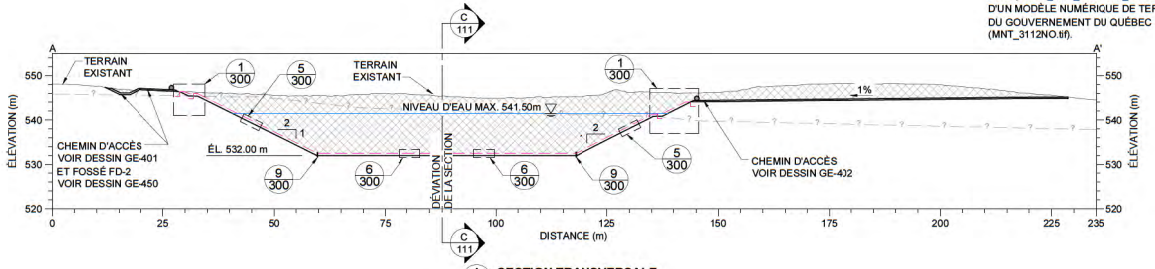
- PUITS DE POMPAGE
- PIÉZOMÈTRE
- PIÉZOMÈTRE EXISTANTS
- SENS DE L'ÉCOULEMENT
- VÉGÉTATION
- GÉOSYNTHÉTIQUES
- BARRIÈRE DE SÉCURITÉ
- NIVEAU D'EAU MAXIMUM
- PONCEAU
- ROC PRÉSUMÉ
- CHEMIN D'ACCÈS EXISTANT
- TERRAIN EXISTANT
- DÉBLAIS
- FOSSÉS, BASSIN COLLECTEUR ET CHEMIN D'ACCÈS
- REMBLAIS COMPACTÉ À 95% DU M.P.
- ZONE DÉBOISEE

NOTES

1. TOUTES LES MESURES SONT EN MÈTRES, À MOINS D'INDICATION CONTRAIRE.
2. LES COURBES DE NIVEAU SONT À 1 MÈTRE D'INTERVALLE.

RÉFÉRENCES

UTM ZONE 18 NAD 83 CSRS
LA TOPOGRAPHIE PROVIENT D'UN RELEVÉ LIDAR DE SEPTEMBRE 2023 FOURNI PAR NMG (DEMO_PAR_20230921_dsm.tif) ET D'UN MODÈLE NUMÉRIQUE DE TERRAIN DU GOUVERNEMENT DU QUÉBEC (MNT_3112NO.tif).



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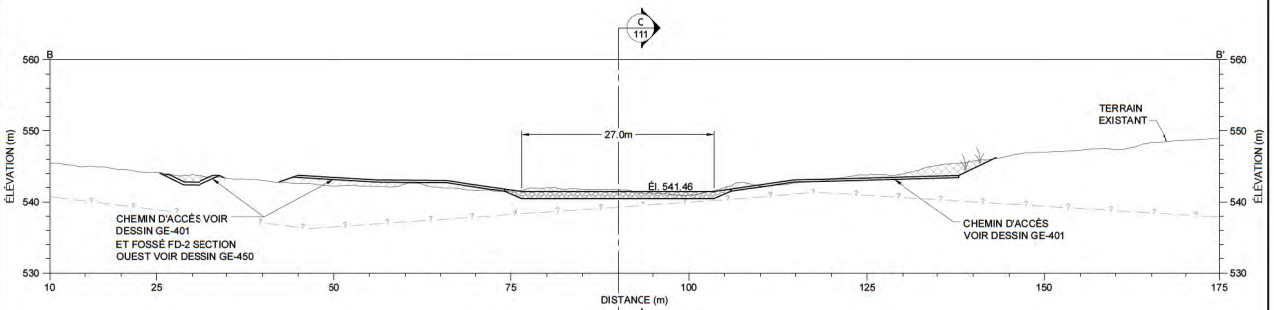

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PAS POUR CONSTRUCTION

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RÉVISIONS				

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A	ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/03

2024-12-13
SCEAU PROFESSIONNEL

srk consulting

CONÇU: CV	DESSINÉ: JAB	VÉRIFIÉ: JFSTL
VÉRIFIÉ: JFSTL	APPROUVÉ: CV	DATE: 2024/12/13

NOM DU FICHIER: CAPR002717-Basin BC-2 SP and XS and DET.dwg
SRK JOB NO.: CAPR002717 FEUILLE: A0 REG. NO.:

NMG NOUVEAU MONDE GRAPHITE

MINE DE GRAPHITE MATAWINIE

GESTION DES EAUX

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BASSIN BC-2
VUE EN PLAN ET SECTIONS

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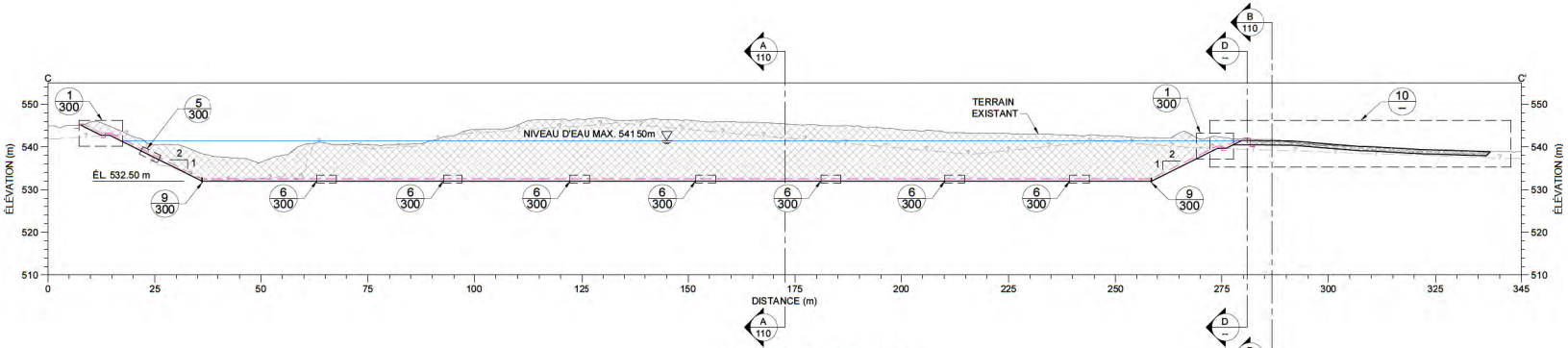

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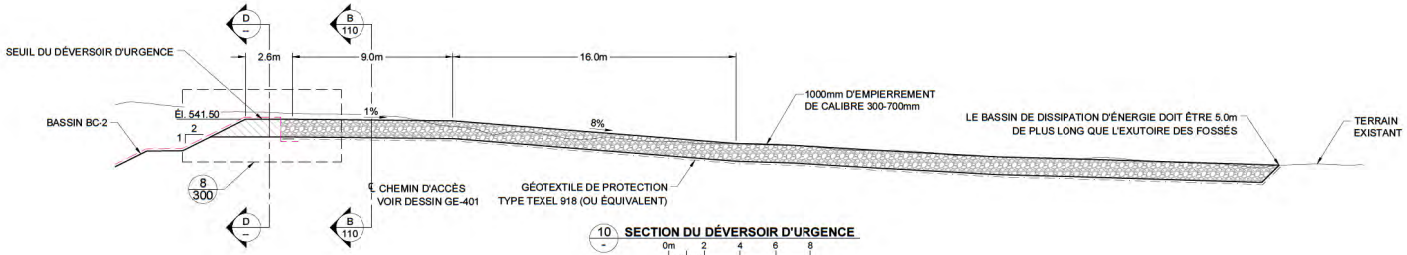

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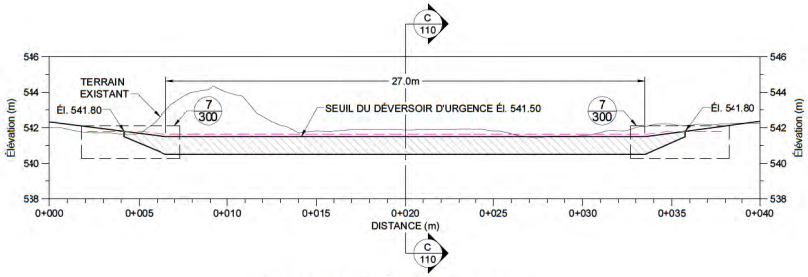

D 110 **SECTION DU DÉVERSOIR D'URGENCE**

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LÉGENDE

- GÉOSYNTHÉTIQUES
- GÉOTEXTILE
- NIVEAU D'EAU MAXIMUM
- ROC PRÉSUMÉ
- TERRAIN EXISTANT
- DÉBLAIS
- MATÉRIAUX GRANULAIRE 25mm OU MOINS COMPACTÉ À 90% DU P.M.
- ROCHE CONCASSÉES TYPE MG-56 COMPACTÉ À 95% DU M.P.

NOTES

1. TOUTES LES MESURES SONT EN MÈTRES, À MOINS D'INDICATION CONTRAIRE.

RÉFÉRENCES

UTM ZONE 18 NAD 83 CSRS
LA TOPOGRAPHIE PROVIENT D'UN RELEVÉ LIDAR DE SEPTEMBRE 2023 FOURNI PAR NMG (DEMO_PAR_20230921_dsm.tif) ET D'UN MODÈLE NUMÉRIQUE DE TERRAIN DU GOUVERNEMENT DU QUÉBEC (MNT_3112NO.tif).

PAS POUR CONSTRUCTION

NO. DESSIN	TITRE DU DESSIN
DESSINS DE RÉFÉRENCES	

NO.	DESCRIPTION	VÉRIF.	APPR.	DATE

NO.	DESCRIPTION	VÉRIF.	APPR.	DATE
0	ÉMIS POUR DEMANDE DE PERMIS	CV	JFSTL	2024/12/13
D	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/11/05
C	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/08/05
B	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/07/26
A	ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/03

RÉVISIONS

2024-12-13
SCEAU PROFESSIONNEL

srk consulting

CONÇU: CV	DESSINÉ: JAB	VÉRIFIÉ: JFSTL
VÉRIFIÉ: JFSTL	APPROUVÉ: CV	DATE: 2024/12/13

NOM DU FICHIER: CAPR002717-Bassin BC-2 SP and XS and DET.dwg

NMG NOUVEAU MONDE GRAPHITE

MINE DE GRAPHITE MATAWINIE

SRK JOB NO.: CAPR002717 FEUILLE: A0 REG. NO.:

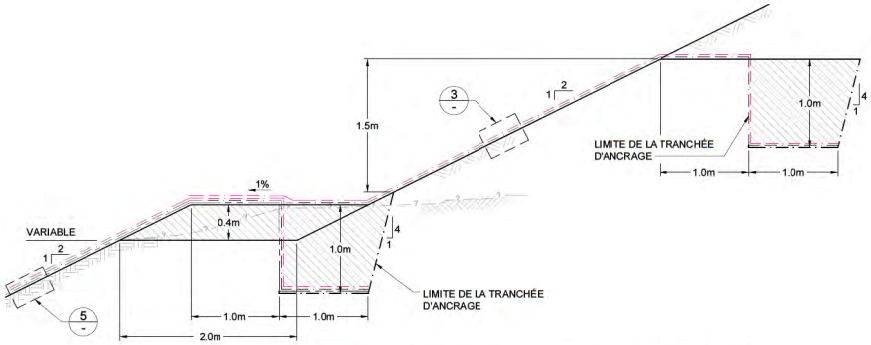
GESTION DES EAUX

TITRE DU DESSIN: BASSIN BC-2 SECTION ET DÉTAILS

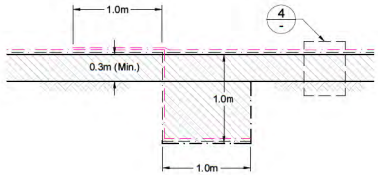
NO. DU DESSIN: GE-111

RÉVISION NO.: 0

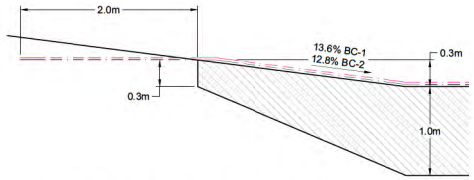
C:\Users\jeanbaptiste.consulting\Public\Matawinie - NMG CAD_SDA\CAD_CONCEPTS\CAPR002717_BM CNB CDP\drawings - Essais\CAPR002717-Bassin BC-2 SP and XS and DET.dwg



1 DÉTAIL TRANCHÉE D'ANCRAGE DES GEOSYNTHETIQUES AU POURTOUR DE BC-1 ET DE BC-2
101, 110, 111
0m 0.4 0.8 1.2 1.6

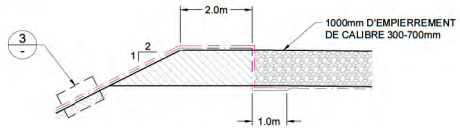


6 DÉTAIL ANCRAGE INTERMÉDIAIRE DANS LE FOND DU BASSIN
101, 110, 111
0m 0.4 0.8 1.2 1.6



7 DÉTAIL D'ANCRAGE DES GEOSYNTHETIQUES AU DÉVERSOIR
110
0m 0.4 0.8 1.2 1.6

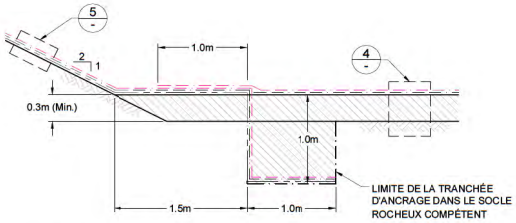
DÉTAIL ÉTANCHÉITÉ - TALUS DU BASSIN SUR SOL FIN OU EN REMBLAIS
3
101, 300
ÉCHELLE: AUCUNE



8 DÉTAIL D'ANCRAGE AU DÉVERSOIR
101, 111
0m 1.0 2.0 3.0 4.0

DÉTAIL ÉTANCHÉITÉ - FOND DU BASSIN SUR SOL FIN OU EN REMBLAIS
4
101, 300
ÉCHELLE: AUCUNE

5 DÉTAIL ÉTANCHÉITÉ - SUR SOCLE ROCHEUX
101, 110, 111, 300
ÉCHELLE: AUCUNE



9 DÉTAIL ANCRAGE EN BAS DE TALUS AU FOND DU BASSIN
101, 110, 111
0m 0.4 0.8 1.2 1.6

LÉGENDE

- GÉOMEMBRANE PEHD 2 mm TEXTURÉ UNE FACE
- GÉOTEXTILE DE PROTECTION TYPE TEXEL 918 (OU ÉQUIVALENT)
- GÉOGRILLE TYPE 1400 (OU ÉQUIVALENT)
- ROC PRÉSUMÉ
- MATÉRIAUX GRANULAIRE 25mm OU MOINS COMPACTÉ À 90% DU P.M.
- SOCLE ROCHEUX
- ROCHES CONCASSÉES TYPE MG-56 COMPACTÉ À 95% DU M.P.
- SOL FIN (SABLE SILLEUX OU SILT SABLEUX) COMPACTÉ À 95% M.P.

NOTES

1. TOUTES LES MESURES SONT EN MÈTRES, À MOINS D'INDICATION CONTRAIRE.

RÉFÉRENCES

UTM ZONE 18 NAD 83 CSRS
LA TOPOGRAPHIE PROVENT D'UN RELEVÉ LiDAR DE SEPTEMBRE 2023 FOURNI PAR NMG (DEMO_PAR_20230921_dsm.tif) ET D'UN MODÈLE NUMÉRIQUE DE TERRAIN DU GOUVERNEMENT DU QUÉBEC (MNT_3112NO.tif).

PAS POUR CONSTRUCTION

NO. DESSIN	TITRE DU DESSIN
DESSINS DE RÉFÉRENCES	

NO.	DESCRIPTION	VÉRIF.	APPR.	DATE

NO.	DESCRIPTION	VÉRIF.	APPR.	DATE
0	ÉMIS POUR DEMANDE DE PERMIS	CV	JFSTL	2024/12/13
D	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/11/05
C	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/08/28
B	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/07/26
A	ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/03

RÉVISIONS

2024-12-13
SCEAU PROFESSIONNEL

srk consulting

CONÇU: CV	DESSINÉ: JAB	VÉRIFIÉ: JFSTL	
VÉRIFIÉ: JFSTL	APPROUVÉ: CV	DATE: 2024/12/13	
NOM DU FICHIER: CAPR002717-Bassins DET.dwg			

NMG NOUVEAU MONDE GRAPHITE

MINE DE GRAPHITE MATAWINIE

SRK JOB NO.: CAPR002717 FEUILLE: A0 REG. NO.:

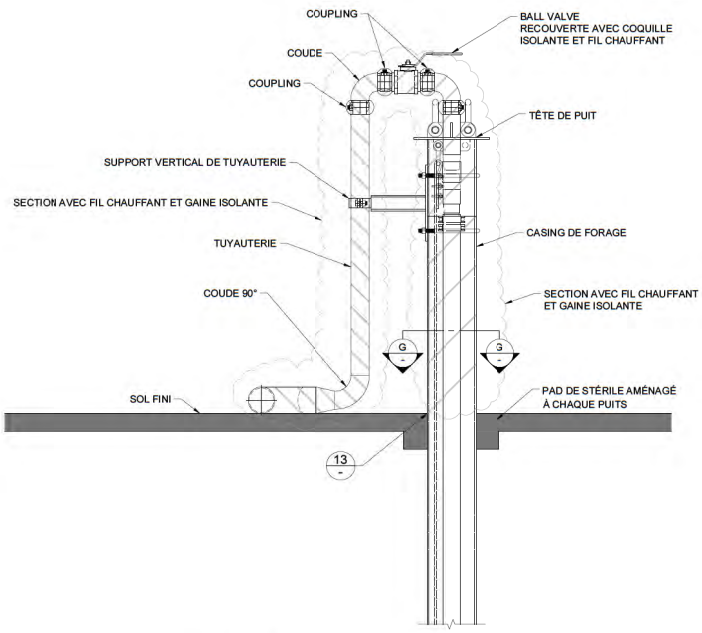
GESTION DES EAUX

TITRE DU DESSIN: DÉTAILS DES BASSINS

NO. DU DESSIN: GE-300

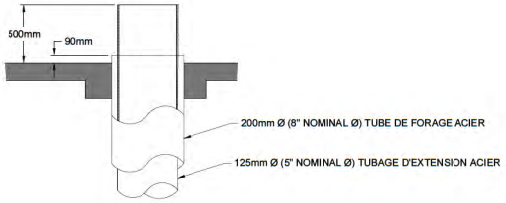
RÉVISION NO.: 0

C:\Users\jfstoicho\OneDrive\Desktop\Data Matawinie - NMG\CAD_DONNÉES\CAPR002717_SM_DWG CDP\Hydrologie - Bassins\CAPR002717-Bassins DET.dwg

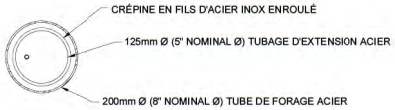


12 - **DÉTAIL TÊTE DE PUITS STANDARD D'INSTALLATION**

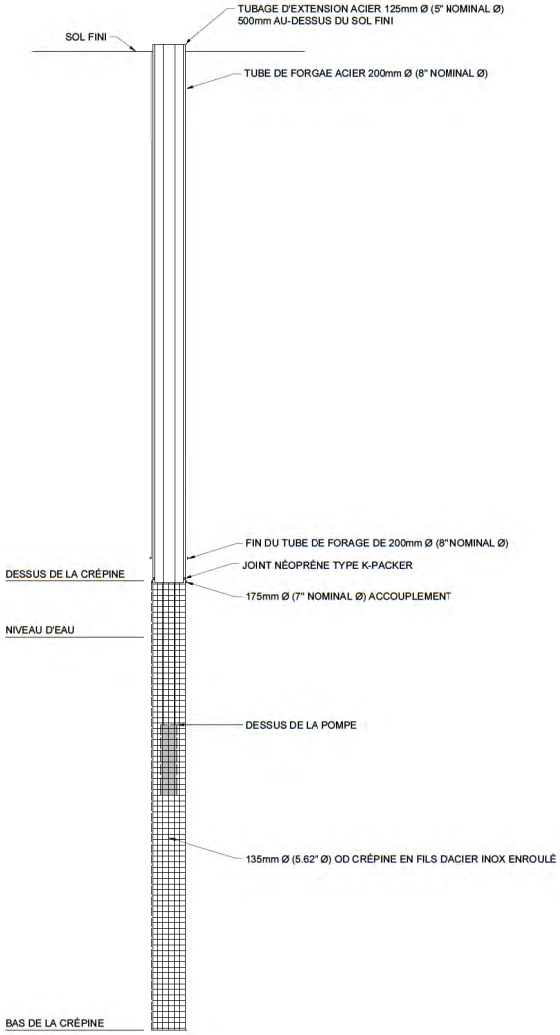
0mm 100 200 300 400



13 - **DÉTAIL BOÎTIER DE FORAGE**
ÉCHELLE: AUCUNE



G - **SECTION DU BOÎTIER DE FORAGE**
ÉCHELLE: AUCUNE



DÉTAIL SOUTERRAIN DU PUITS DE POMPAGE
ÉCHELLE: AUCUNE

LÉGENDE

CIMENT BENTONITE

NOTES

1. TOUTES LES MESURES SONT EN MÈTRES, À MOINS D'INDICATION CONTRAIRE.

RÉFÉRENCES

UTM ZONE 18 NAD 83 CSRS
LA TOPOGRAPHIE PROVENT D'UN RELEVÉ LIDAR DE SEPTEMBRE 2023 FOURNI PAR NMG (DEMO_PAR_20230921_dsm.tif) ET D'UN MODÈLE NUMÉRIQUE DE TERRAIN DU GOUVERNEMENT DU QUÉBEC (MNT_3112NO.tif).

PAS POUR CONSTRUCTION

NO. DESSIN	TITRE DU DESSIN
DESSINS DE RÉFÉRENCES	

NO.	DESCRIPTION	VÉRIF.	APPR.	DATE
0	ÉMIS POUR DEMANDE DE PERMIS	CV	JFSTL	2024/12/13
NO.	DESCRIPTION	VÉRIF.	APPR.	DATE
RÉVISIONS				

2024-12-13
SCEAU PROFESSIONNEL

srk consulting

CONÇU: CV	DESSINÉ: JAB	VÉRIFIÉ: JFSTL	
VÉRIFIÉ: JFSTL	APPROUVÉ: CV	DATE: 2024/12/13	
NOM DU FICHIER: CAPR002717-Bassins DET.dwg		SRK JOB NO.: CAPR002717	FEUILLE: A0 REG. NO.:

NMG NOUVEAU MONDE GRAPHITE

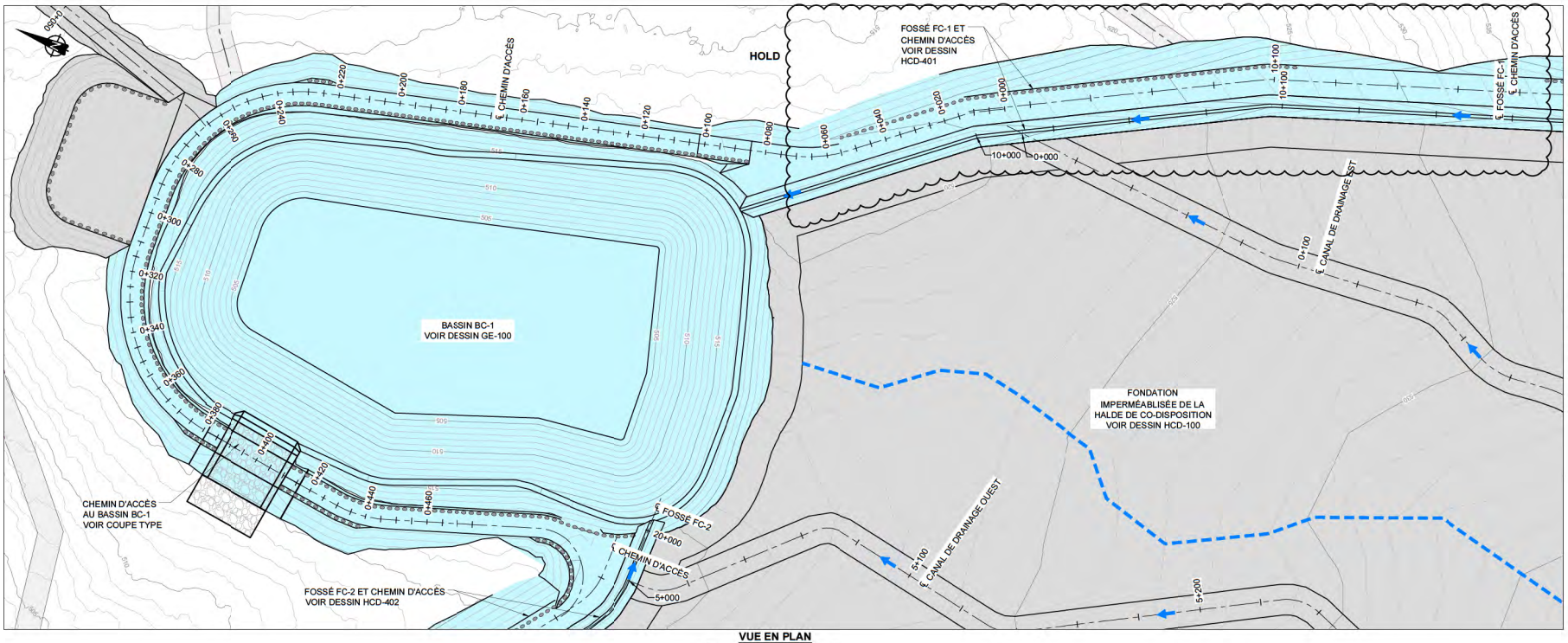
MINE DE GRAPHITE MATAWINIE

GESTION DES EAUX

TITRE DU DESSIN: DÉTAILS DES POMPAGE FOSSE

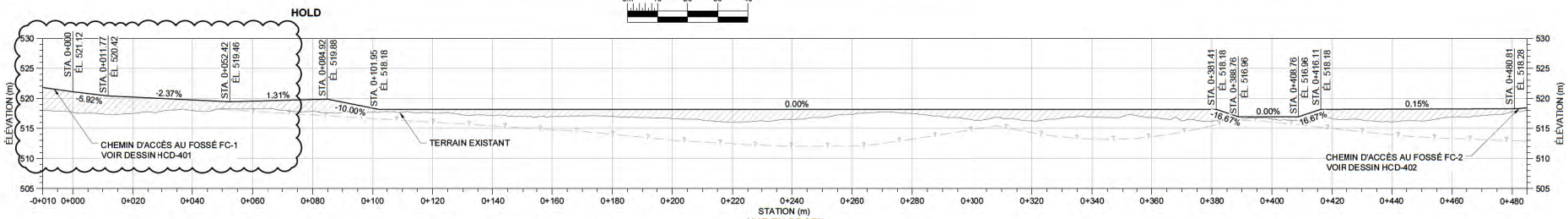
NO. DU DESSIN: GE-301

RÉVISION NO.: 0



VUE EN PLAN

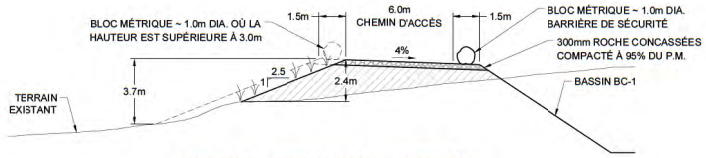
0m 10 20 30 40



VUE EN PROFIL

HORIZONTALE 0m 10 20 30 40

VERTICALE 0m 4 8 12 16 20



COUPE TYPE CHEMIN D'ACCÈS AU BASSIN BC-1

0m 2 4 6 8

LÉGENDE

- SENS DE L'ÉCOULEMENT
- VÉGÉTATION
- BARRIÈRE DE SÉCURITÉ
- LIGNE DE PARTAGE DES EAUX DE RUISELLEMENT
- ROC PRÉSUMÉ
- CHEMIN D'ACCÈS EXISTANT
- TERRAIN EXISTANT
- FOSSÉS, BASSIN COLLECTEUR ET CHEMIN D'ACCÈS
- LIMITE DE LA FRÉPARATION DE SITE DE LA HA..DE DE CO-DISPOSITION - PHASE 1
- ROCHE CONCASSÉES TYPE MG-56 COMPACTÉ À 95% DU M.P.
- REMBLAIS COMPACTÉ À 95% DU M.P.

NOTES

1. TOUTES LES MESURES SONT EN MÈTRES, À MOINS D'INDICATION CONTRAIRE.
2. LES COURBES DE NIVEAU SONT À 1 MÈTRE D'INTERVALLE.

RÉFÉRENCES

UTM ZONE 18 NAD 83 CSRS

LA TOPOGRAPHIE PROVIENT D'UN RELEVÉ LIDAR DE SEPTEMBRE 2023 FOURNI PAR NMG (DEMO_PAR_20230921_dsm.tif) ET D'UN MODÈLE NUMÉRIQUE DE TERRAIN DU GOUVERNEMENT DU QUÉBEC (MNT_3112NO.tif).

PAS POUR CONSTRUCTION

NO. DESSIN	TITRE DU DESSIN
DESSINS DE RÉFÉRENCES	

NO.	DESCRIPTION	VÉRIF.	APPR.	DATE

NO.	DESCRIPTION	VÉRIF.	APPR.	DATE
0	ÉMIS POUR DEMANDE DE PERMIS	CV	JFSTL	2024/12/13
D	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/11/05
C	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/08/08
B	RÉ-ÉMIS POUR RÉVISION DU CLIENT	DV	JFSTL	2024/07/26
A	ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/03

RÉVISIONS

2024-12-13

SCEAUX PROFESSIONNELS

srk consulting

CONÇU: CV	DESSINÉ: JAB	VÉRIFIÉ: JFSTL
RÉVISÉ: JFSTL	APPROUVÉ: CV	DATE: 2024/12/13

NOM DU FICHIER: CAPR0027 17-CHEMIN ACCES BASSIN BC-1 PP.dwg

SRK JOB NO.: CAPR0027 17 FEUILLE: A0 REG. NO.:

NOUVEAU MONDE GRAPHITE

MINE DE GRAPHITE MATAWINIE

GESTION DES EAUX

TITRE DU DESSIN: CHEMIN D'ACCÈS AU BASSIN BC-1 PLAN ET PROFILE ET COUPE TYPE

NO. DU DESSIN: GE-400

RÉVISION NO.: 0

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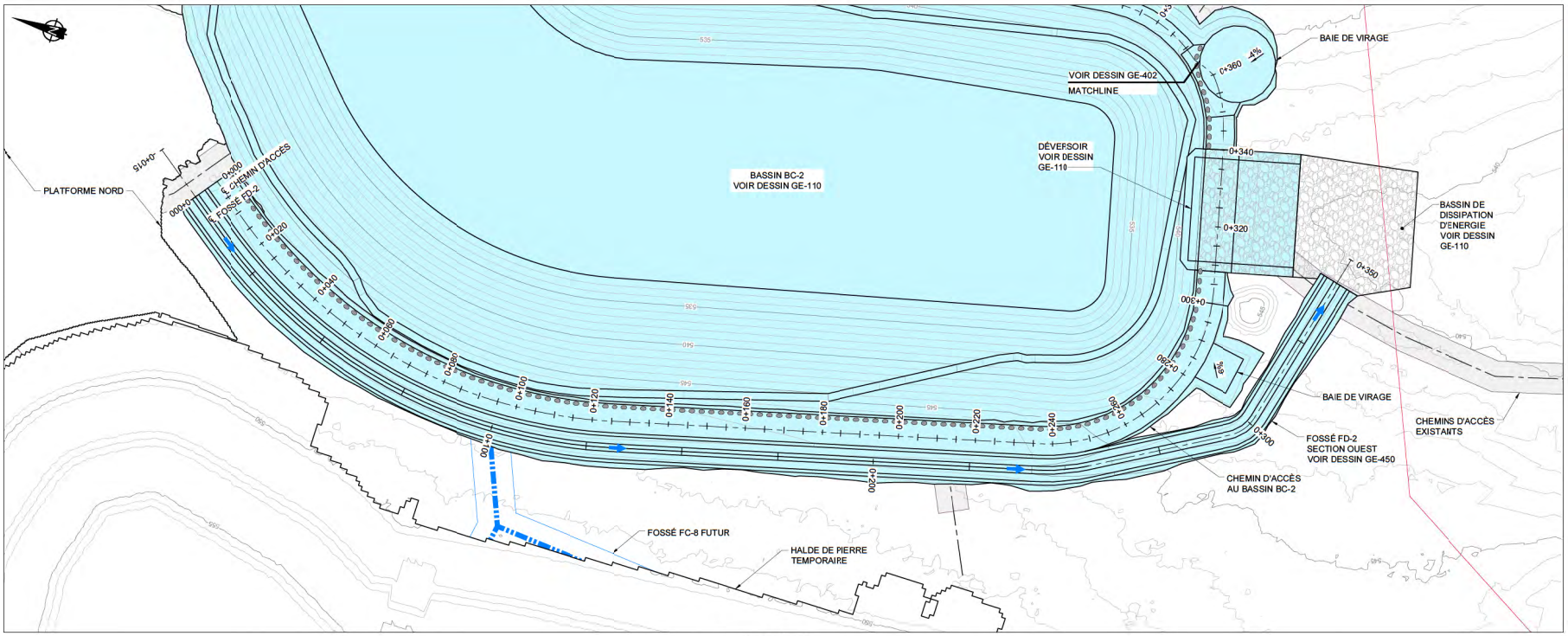
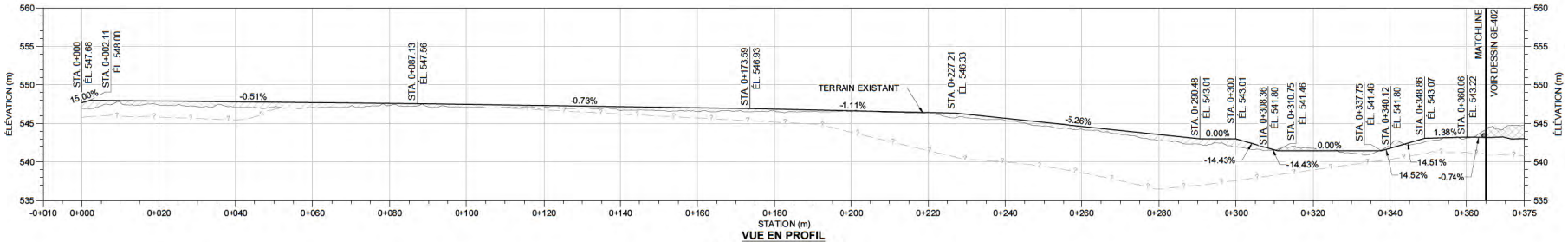


VUE EN PLAN

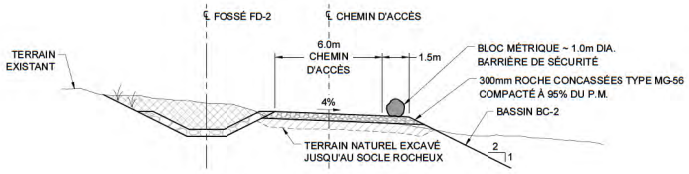
0m 8 16 24 32



VUE EN PROFIL

HORIZONTALE 0m 8 16 24 32

VERTICALE 0m 4 8 12 16



COUPE TYPE CHEMIN D'ACCÈS AU BASSIN BC-2

0m 2 4 6 8

LÉGENDE

- SENS DE L'ÉCOULEMENT
- VÉGÉTATION
- BARRIÈRE DE SÉCURITÉ
- ROC PRÉSUMÉ
- CHEMIN D'ACCÈS EXISTANT
- TERRAIN EXISTANT
- DÉBLAIS
- FOSSÉS, BASSIN COLLECTEUR ET CHEMIN D'ACCÈS
- REMBLAIS COMPACTÉ À 95% DU M.P.
- ZONE DÉBOISEE

NOTES

1. TOUTES LES MESURES SONT EN MÈTRES, À MOINS D'INDICATION CONTRAIRE.
2. LES COURBES DE NIVEAU SONT À 1 MÈTRE D'INTERVALLE.

RÉFÉRENCES

UTM ZONE 18 NAD 83 CSRS
LA TOPOGRAPHIE PROVIENT D'UN RELEVÉ LIDAR DE SEPTEMBRE 2023 FOURNI PAR NMG (DEMO_PAR_20230921_dsm.tif) ET D'UN MODÈLE NUMÉRIQUE DE TERRAIN DU GOUVERNEMENT DU QUÉBEC (MNT_3112NO.tif).

PAS POUR CONSTRUCTION

NO. DESSIN	TITRE DU DESSIN
DESSINS DE RÉFÉRENCES	

NO.	DESCRIPTION	VÉRIF.	APPR.	DATE
REVISIONS				

NO.	DESCRIPTION	VÉRIF.	APPR.	DATE
0	ÉMIS POUR DEMANDE DE PERMIS	CV	JFSTL	2024/12/13
D	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/11/25
C	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/08/28
B	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFCTL	2024/07/26
A	ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/03

2024-12-13
SCEAU PROFESSIONNEL

srk consulting

CONÇU: CV	DESSINÉ: JAB	VÉRIFIÉ: JFSTL
VÉRIFIÉ: JFSTL	APPROUVÉ: CV	DATE: 2024/12/13

NOM DU FICHIER: CAPR002717-CHEMIN ACCES BASSIN BC-2 PP.dwg
SRK JOB NO.: CAPR002717 FEUILLE: A0 REG. NO.:

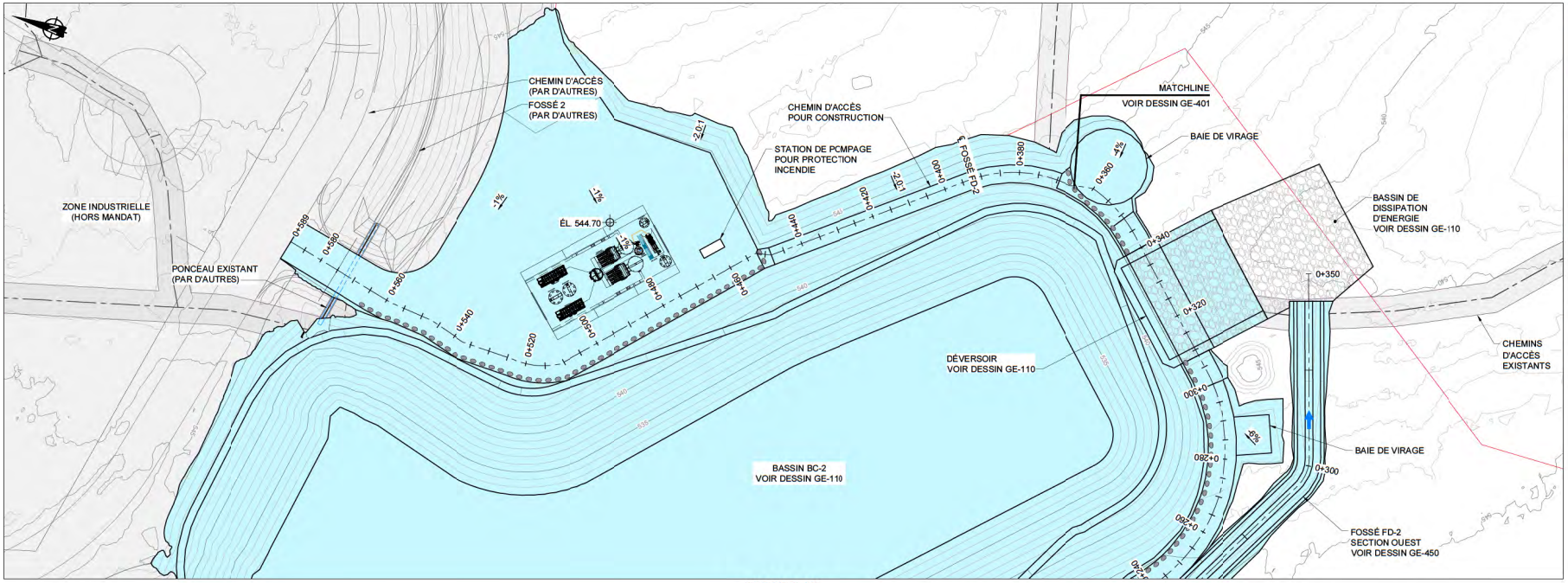
NMG NOUVEAU MONDE GRAPHITE

MINE DE GRAPHITE MATAWINIE

GESTION DES EAUX

TITRE DU DESSIN: CHEMIN D'ACCÈS AU BASSIN BC-2 STA 0+000 À 0+375 PLAN ET PROFIL

NO. DU DESSIN: GE-401 RÉVISION NO.: 0



LÉGENDE

- SENS DE L'ÉCOULEMENT
- VÉGÉTATION
- BARRIÈRE DE SÉCURITÉ
- PONCEAU
- ROC PRÉSUMÉ
- CHEMIN D'ACCÈS EXISTANT
- TERRAIN EXISTANT
- DÉBLAIS
- FOSSÉS, BASSIN COLLECTEUR ET CHEMIN D'ACCÈS
- REMBLAIS COMPACTÉ À 95% DU M.P.
- ROCHES CONCASSÉES TYPE MG-56 COMPACTÉ À 95% DU M.P.
- ZONE DÉBOISEE

NOTES

1. TOUTES LES MESURES SONT EN MÈTRES, À MOINS D'INDICATION CONTRAIRE.
2. LES COURBES DE NIVEAU SONT À 1 MÈTRE D'INTERVALLE.

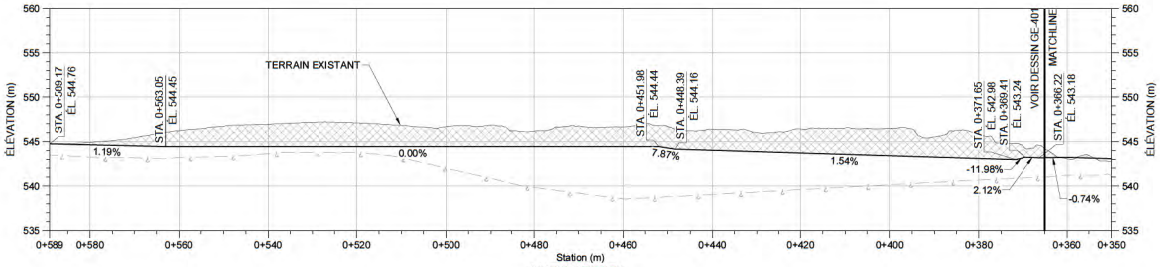
RÉFÉRENCES

UTM ZONE 18 NAD 83 CSRS

LA TOPOGRAPHIE PROVIENT D'UN RELEVÉ LIDAR DE SEPTEMBRE 2023 FOURNI PAR NMG (DEMO_PAR_20230921_dsm.tif) ET D'UN MODÈLE NUMÉRIQUE DE TERRAIN DU GOUVERNEMENT DU QUÉBEC (MNT_3112NO.tif).

VUE EN PLAN

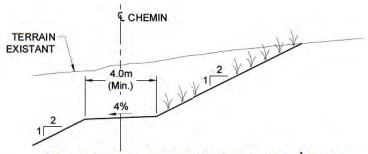
0m 10 20 30 40 50 60



VUE EN PROFIL

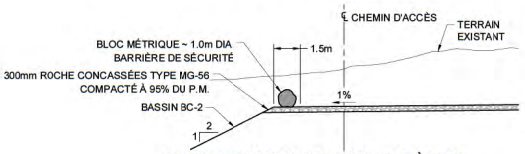
HORIZONTALE 0m 8 16 24 32

VERTICALE 0m 4 8 12 16



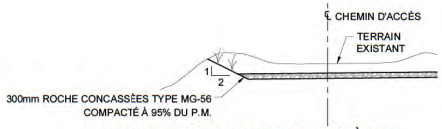
COUPE TYPE AU BASSIN BC-2 STA 0+365 À 0+452

0m 2 4 6 8



COUPE TYPE AU BASSIN BC-2 STA 0+452 À 0+565

0m 2 4 6 8



COUPE TYPE AU BASSIN BC-2 STA 0+565 À 0+589

0m 2 4 6 8

PAS POUR CONSTRUCTION

NO. DESSIN	TITRE DU DESSIN

DESSINS DE RÉFÉRENCES

NO.	DESCRIPTION	VÉRIF.	APPR.	DATE

RÉVISIONS

NO.	DESCRIPTION	VÉRIF.	APPR.	DATE
0	ÉMIS POUR DEMANDE DE PERMIS	CV	JFSTL	2024/12/13
D	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/11/05
C	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/08/28
B	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/07/26
A	ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/03

2024-12-13

SCEAU PROFESSIONNEL

srk consulting

CONÇU: CV	DESSINÉ: JAB	VÉRIFIÉ: JFSTL
VÉRIFIÉ: JFSTL	APPROUVÉ: CV	DATE: 2024/12/13

NOM DU FICHIER: CAPR0027 17-CHEMIN ACCES BASSIN BC-2 PP.dwg

SRK JOB NO.: , FEUILLE: A0 REG. NO.:

NMG NOUVEAU MONDE GRAPHITE

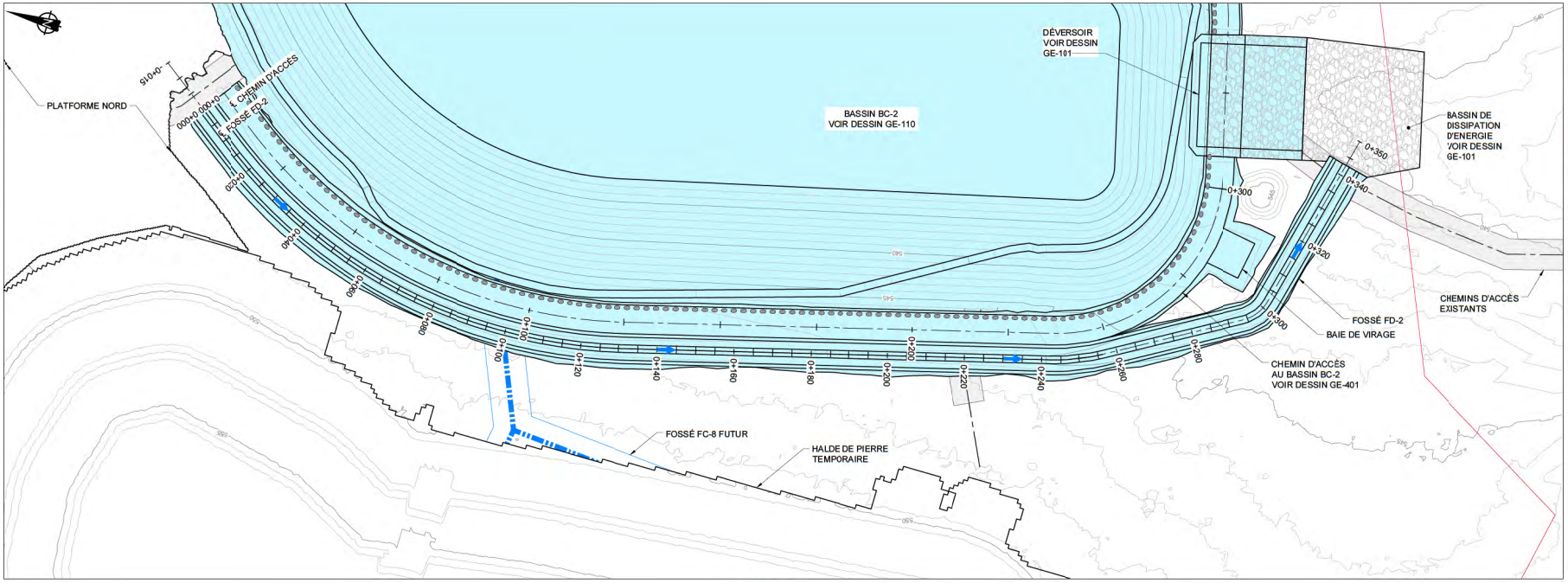
MINE DE GRAPHITE MATAWINIE

GESTION DES EAUX

TITRE DU DESSIN: CHEMIN D'ACCÈS AU BASSIN BC-2 STA 0+375 À 0+589 PLAN ET PROFIL ET COUPE TYPE

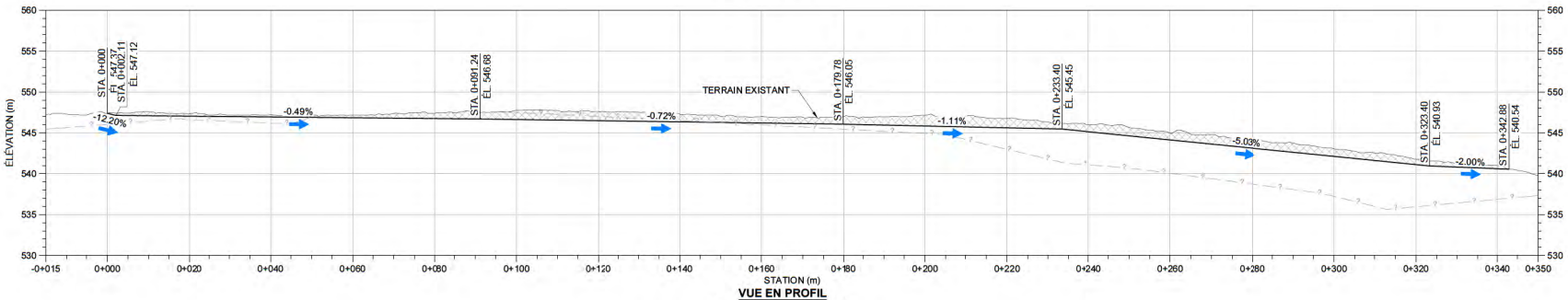
NO. DU DESSIN: GE-402

RÉVISION NO.: 0



VUE EN PLAN

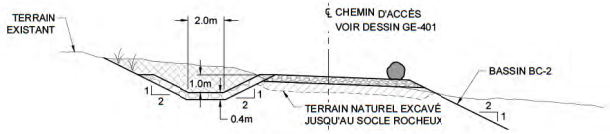
0m 8 16 24 32



VUE EN PROFIL

HORIZONTALE 0m 8 16 24 32

VERTICALE 0m 4 8 12 16



COUPE TYPE FOSSÉ FD-2

0m 2 4 6 8

LÉGENDE

- SENS DE L'ÉCOULEMENT
- VÉGÉTATION
- BARRIÈRE DE SÉCURITÉ
- ROC PRÉSUMÉ
- CHEMIN D'ACCÈS EXISTANT
- TERRAIN EXISTANT
- DÉBLAIS
- FOSSÉS, BASSIN COLLECTEUR ET CHEMIN D'ACCÈS
- REMBLAIS COMPACTÉ À 95% DU M.P.
- ZONE DÉBOISEE

NOTES

1. TOUTES LES MESURES SONT EN MÈTRES, À MOINS D'INDICATION CONTRAIRE.
2. LES COURBES DE NIVEAU SONT À 1 MÈTRE D'INTERVALLE.

RÉFÉRENCES

UTM ZONE 18 NAD 83 CSRS

LA TOPOGRAPHIE PROVIENT D'UN RELEVÉ LiDAR DE SEPTEMBRE 2023 FOURNI PAR NMG (DEMO_PAR_20230921_dsm.tif) ET D'UN MODÈLE NUMÉRIQUE DE TERRAIN DU GOUVERNEMENT DU QUÉBEC (MNT_3112NO.tif).

PAS POUR CONSTRUCTION

NO. DESSIN	TITRE DU DESSIN
DESSINS DE RÉFÉRENCES	

NO.	DESCRIPTION	VÉRIF.	APPR.	DATE
RÉVISIONS				

NO.	DESCRIPTION	VÉRIF.	APPR.	DATE
0	ÉMIS POUR DEMANDE DE PERMIS	CV	JFSTL	2024/12/13
D	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/11/29
C	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/08/29
B	RÉ-ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/07/26
A	ÉMIS POUR RÉVISION DU CLIENT	CV	JFSTL	2024/03

2024-12-13

SCEAU PROFESSIONNEL

srk consulting

CONÇU: CV	DESSINÉ: JAB	VÉRIFIÉ: JFSTL
VÉRIFIÉ: JFSTL	APPROUVÉ: CV	DATE: 2024/12/13

NOM DU FICHIER: CAPR002717-FOSSE FD-2 PP.dwg

SRK JOB NO.: CAPR002717 FEUILLE: A0 REG. NO.:

NMG NOUVEAU MONDE GRAPHITE

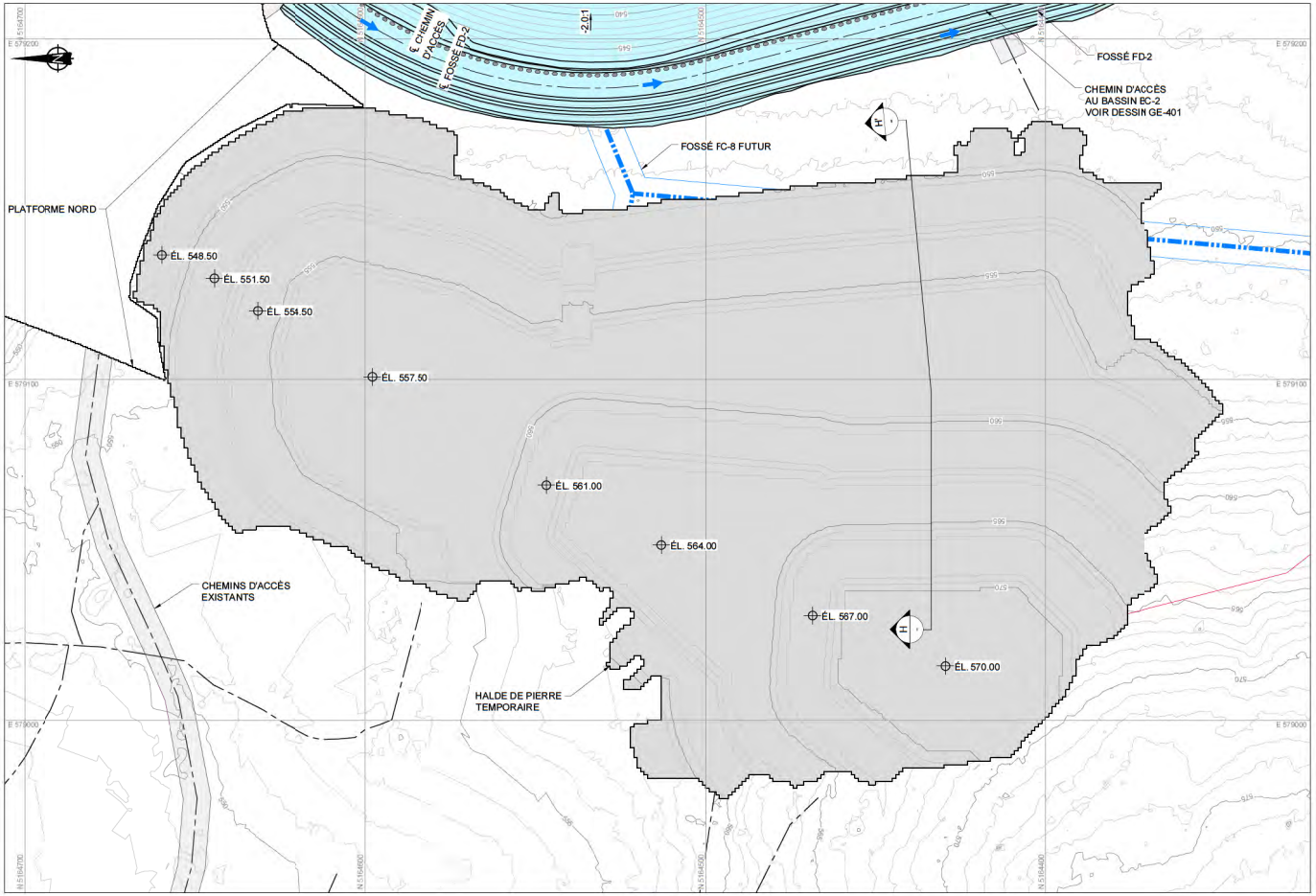
MINE DE GRAPHITE MATAWINIE

GESTION DES EAUX

TITRE DU DESSIN: FOSSÉ FD-2 SECTION OUEST PLAN ET PROFIL

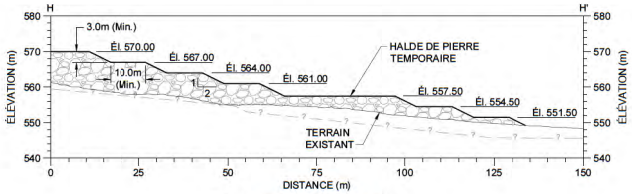
NO. DU DESSIN: GE-450

RÉVISION NO.: 0



VUE EN PLAN

0m 10 20 30 40



SECTION TRANSVERSALE

0m 10 20 30 40

LÉGENDE

- SENS DE L'ÉCOULEMENT
- BARRIÈRE DE SÉCURITÉ
- ROC PRÉSUMÉ
- CHEMIN D'ACCÈS EXISTANT
- TERRAIN EXISTANT
- FOSSÉS, BASSIN COLLECTEUR ET CHEMIN D'ACCÈS
- ZONE DÉBOISEE

NOTES

1. TOUTES LES MESURES SONT EN MÈTRES, À MOINS D'INDICATION CONTRAIRE.
2. LES COURBES DE NIVEAU SONT À 1 MÈTRE D'INTERVALLE.

RÉFÉRENCES

UTM ZONE 18 NAD 83 CSRS

LA TOPOGRAPHIE PROVIENT D'UN RELEVÉ LIDAR DE SEPTEMBRE 2023 FOURNI PAR NMG (DEMO_PAR_20230921_dsm.tif) ET D'UN MODÈLE NUMÉRICUE DE TERRAIN DU GOUVERNEMENT DU QUÉBEC (MNT_3112NO.tif).

PAS POUR CONSTRUCTION

NO. DESSIN	TITRE DU DESSIN
DESSINS DE RÉFÉRENCES	

NO.	DESCRIPTION	VÉRIF.	APPR.	DATE
0	ÉMIS POUR DEMANDE DE PERMIS	CV	JFSTL	2024/12/13

RÉVISIONS

2024-12-13

SCEAU PROFESSIONNEL

srk consulting

CONÇU: CV	DESSINÉ: JAB	VÉRIFIÉ: JFSTL
VÉRIFIÉ: JFSTL	APPROUVÉ: CV	DATE: 2024/12/13

NOM DU FICHIER: CAPR002717-HALDE DE PIERRE TEMPORAIRE.dwg

SRK JOB NO.: CAPR002717 FEUILLE: A0 REG. NO.:

NMG NOUVEAU MONDE GRAPHITE

MINE DE GRAPHITE MATAWINIE

GESTION DES EAUX

TITRE DU DESSIN: HALDE D'ENTREPOSAGE TEMPORAIRE DE ROC

NO. DU DESSIN: GE-500

RÉVISION NO.: 0

Annexe C Analyse de vent

Wind Speed Review

AUTHOR
Victor Munoz

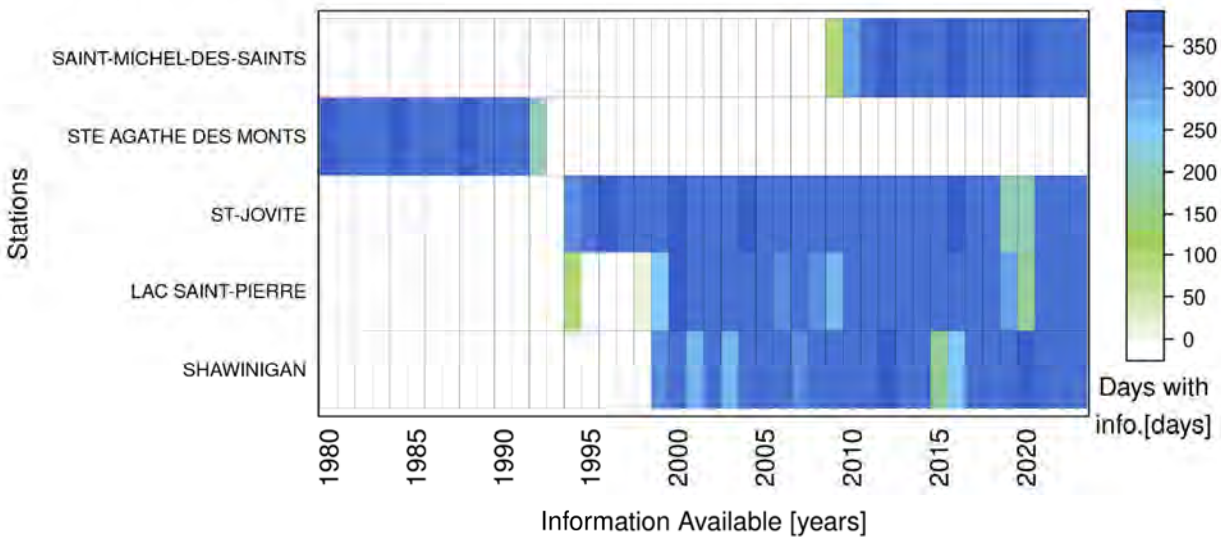
1 Sources

1.1 ERA5-Land Records

Capture ERA5-Land at the site. <Code>

1.2 ECCC Records

Information available for comparison ERA5-Land vs regional observations. <Code>



Comparison ERA5-Land with ECCC records

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1.2.1 SAINT-MICHEL-DES-SAINTS

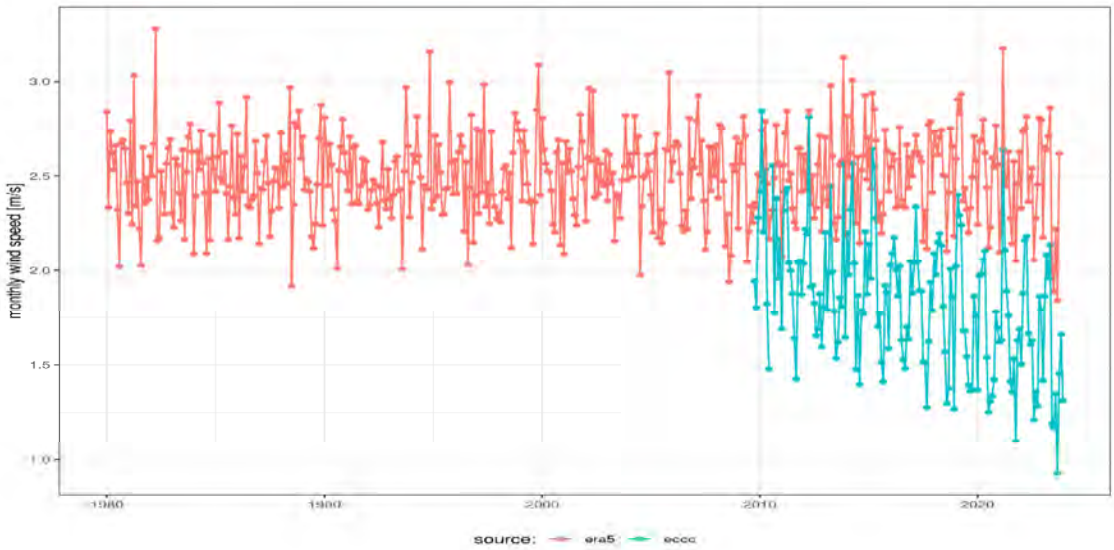


Tableau 1-1 : Comparison of monthly wind speed [m/s]

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5	2.5	2.5	2.6	2.7	2.5	2.4	2.3	2.2	2.5	2.6	2.6	2.5	2.5
eccc	1.9	2.1	2.3	2.3	2	1.7	1.6	1.4	1.5	1.7	1.9	1.8	1.8

1.2.2 STE AGATHE DES MONTS

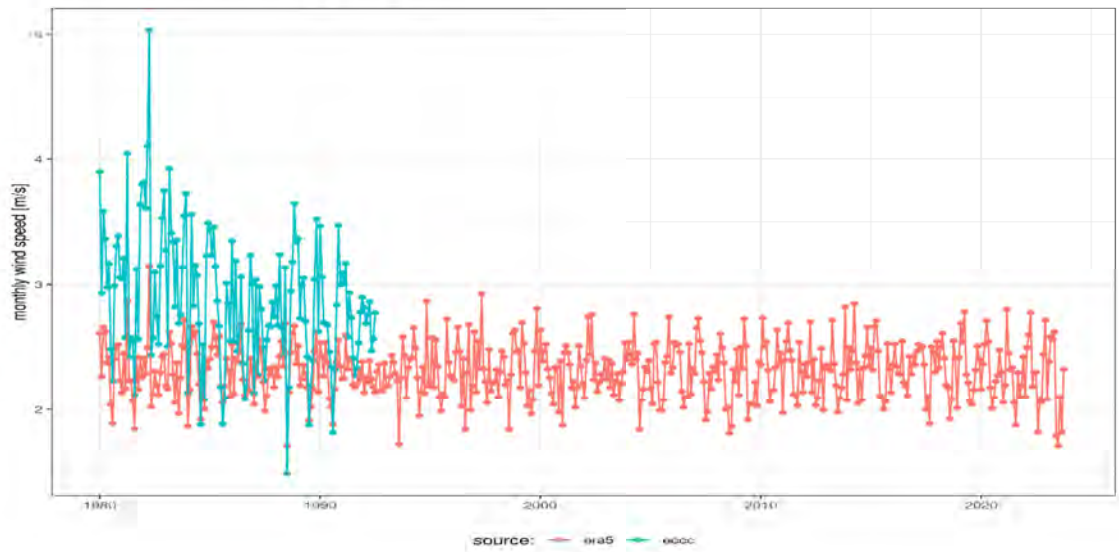


Tableau 1-2 : Comparison of monthly wind speed [m/s]

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5	2.3	2.4	2.5	2.6	2.4	2.2	2.1	2	2.2	2.4	2.4	2.3	2.3
eccc	3.1	2.9	3.2	3.2	2.8	2.7	2.4	2.2	2.6	2.8	3.3	3.2	2.9

1.2.3 ST-JOVITE

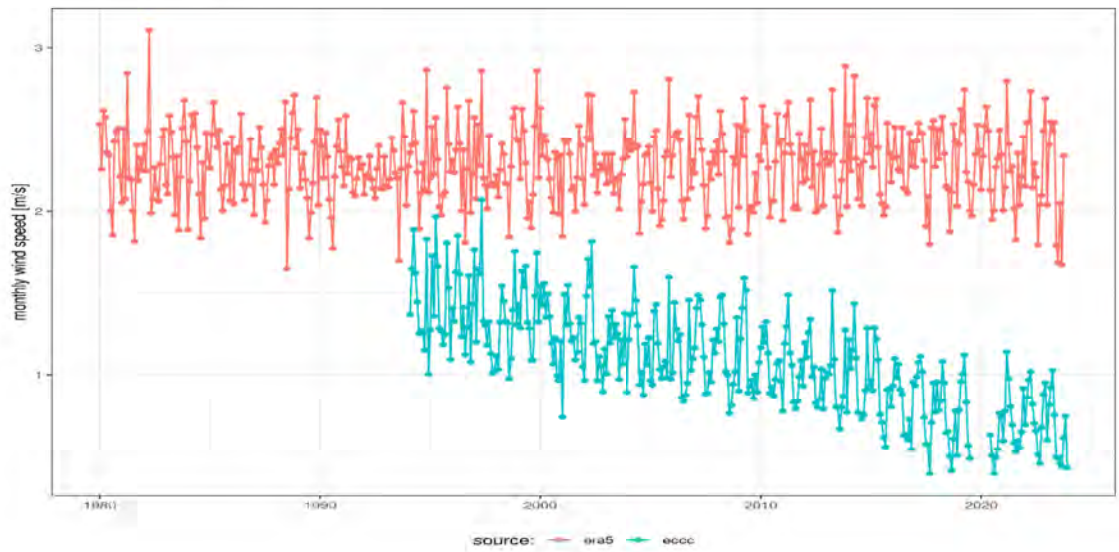
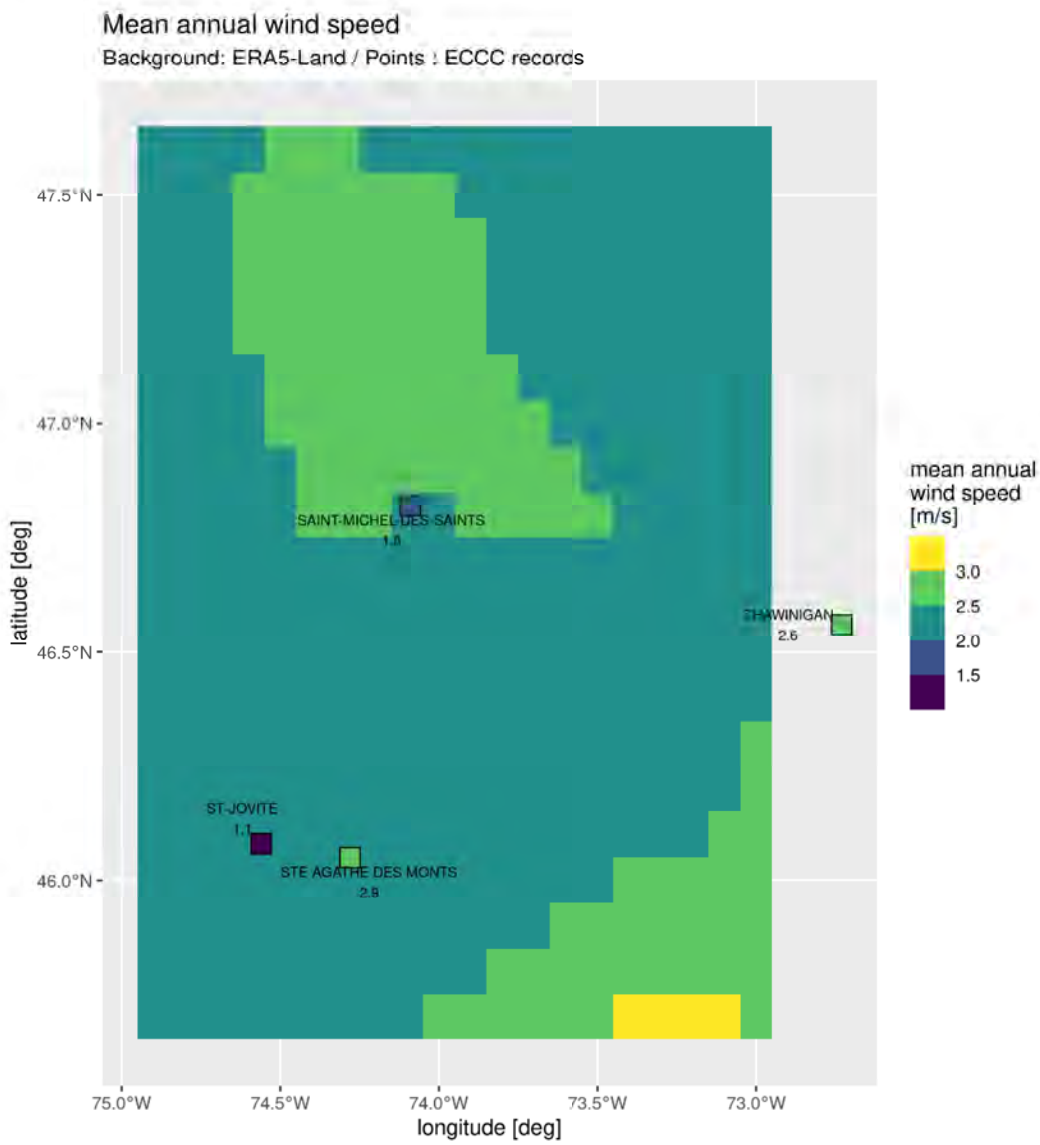


Tableau 1-3 : Comparison of monthly wind speed [m/s]

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5	2.3	2.3	2.4	2.5	2.3	2.2	2	2	2.2	2.4	2.4	2.3	2.3
eccc	1.1	1.2	1.3	1.4	1.3	1	1	0.8	0.9	1	1.1	1	1.1

1.3 Mean Annual Wind Speed

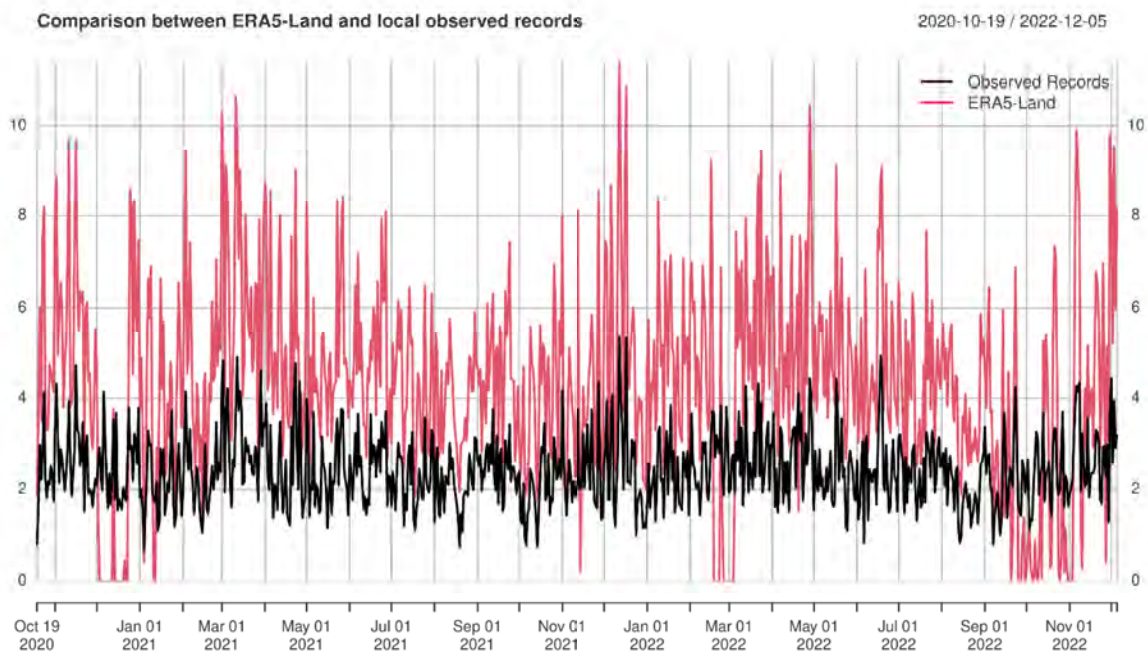
Code

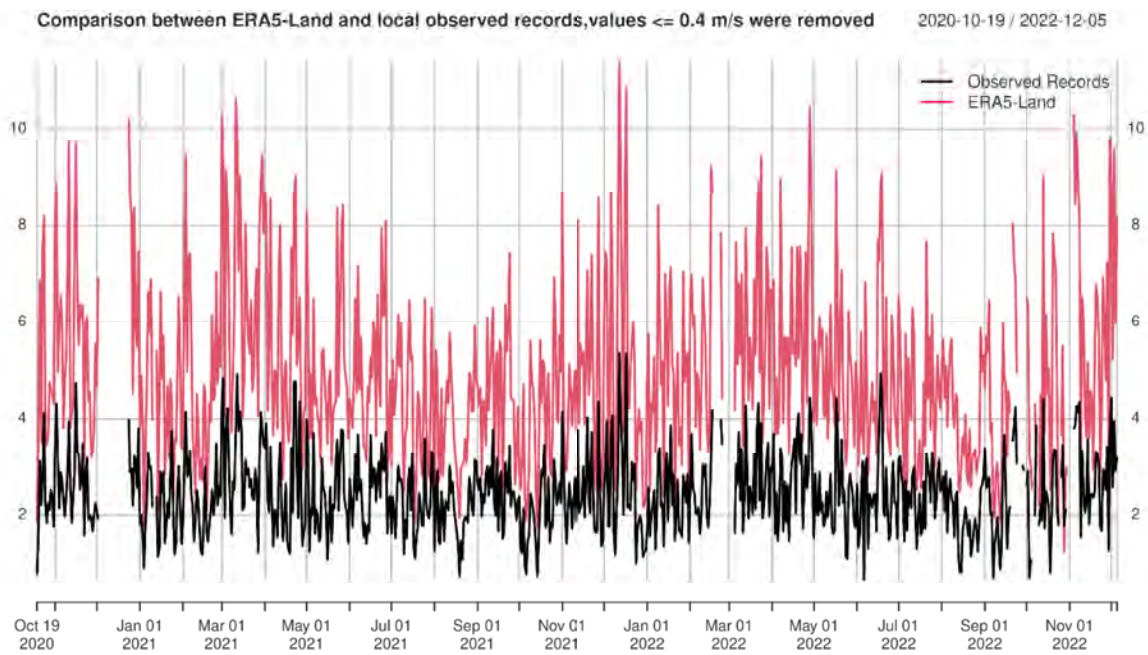


2 Local Records

It is noted zero values may affect the bias correction process, then the values less than 0.4 m/s were removed. <Code>

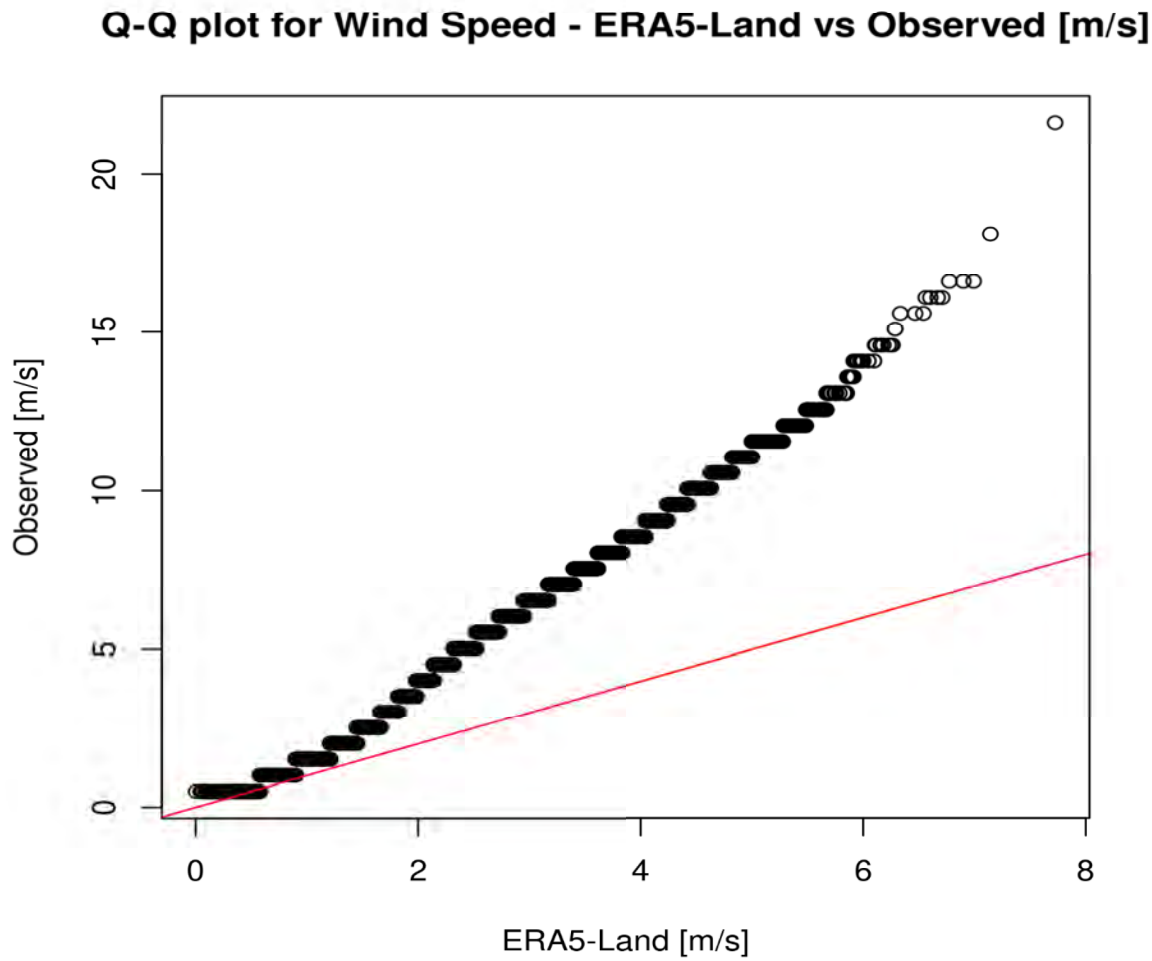
Note: Observed records = Hourly wind gust recorded at NMG Weather Station, from Oct. 19, 2020 to Dec. 5, 2022.



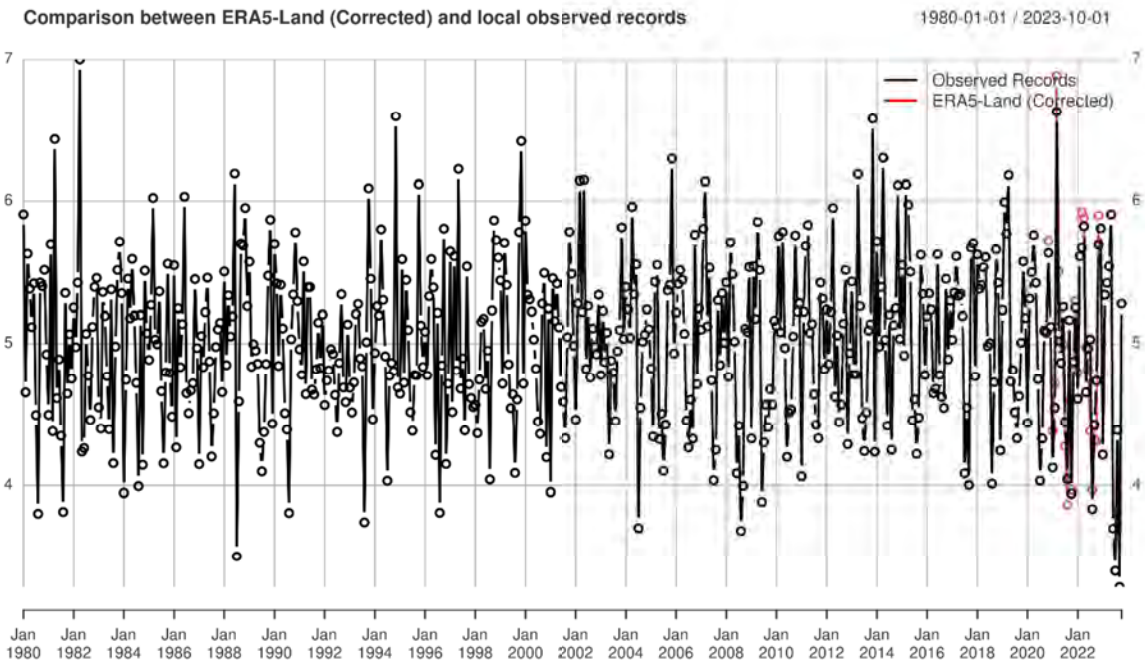


2.1 Bias Correction

<Code>



Comparison of the results after quantile delta mapping matching (bias correction). <Code>



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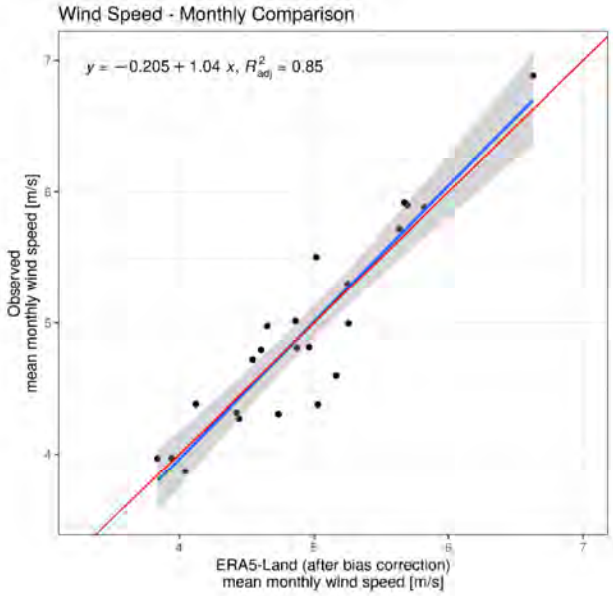
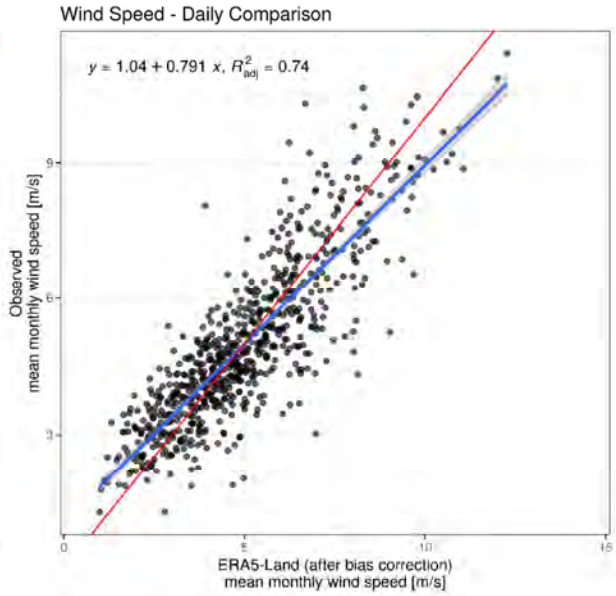




3 Frequency Analysis

Frequency analysis is a process used to estimate the frequency of occurrence of a value based on a long-term time series. The desired frequency is typically in months or years and the periods are called return periods. The historical information is adjusted into a probabilistic distribution, and the most suitable distribution is selected.

In this case, the frequency analysis was prepared considering the following probabilistic distributions: Normal, Log-Normal, Generalized Extreme Value (GEV), Gumbel, Pearson III, and Log-Pearson III. The selection of the distribution parameters was prepared with the L-moments methodology.

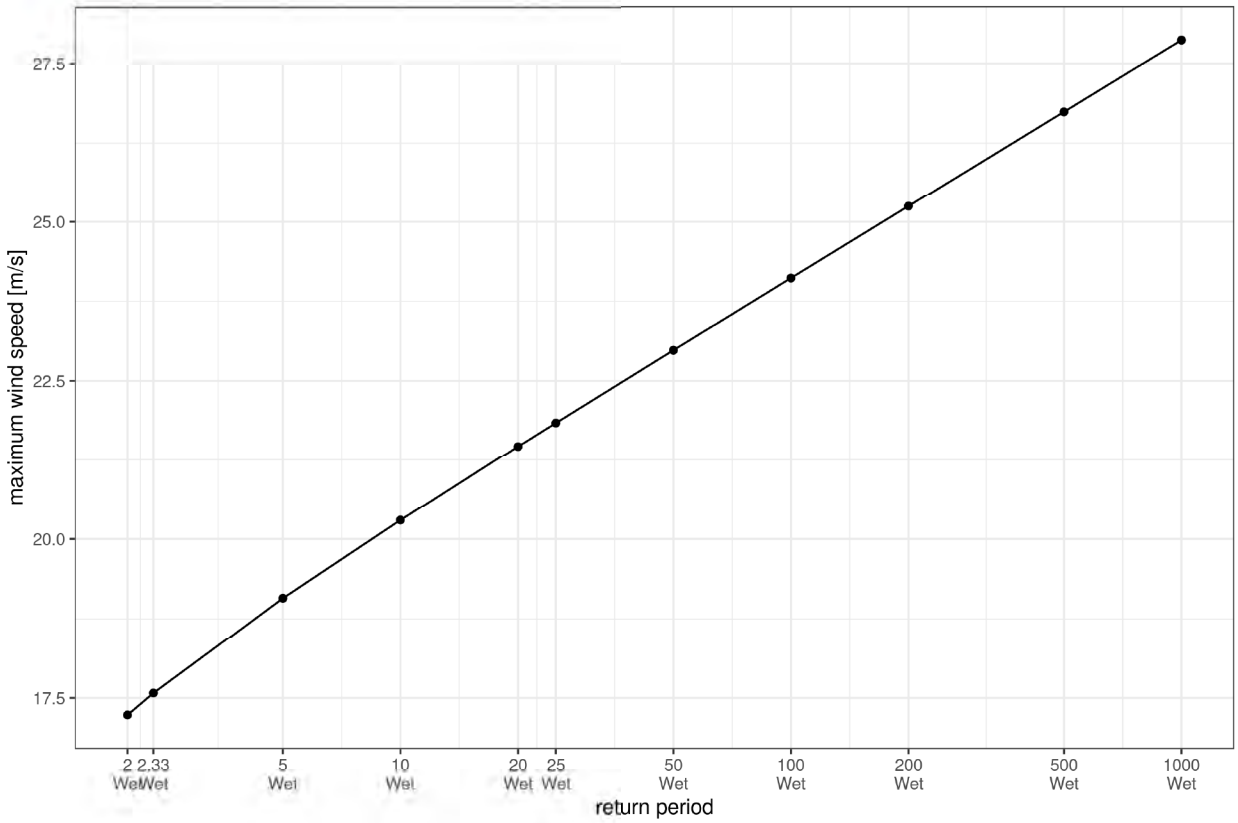
The L-moments approach provides a more resistant estimation to outliers when compared with typical moment estimations. The selection of the best-fit distribution was prepared based on three criteria: Akaike Information Criterion, Anderson-Darling Criterion, and Bayesian Information Criterion, as described by Laio et al. (2009) and implemented in the statistical software, R.

With this information it was selected a Gumbel distribution.

<Code>

Tested distributions: NORM LN GEV GUMBEL P3 LP3
Chosen distributions: AIC AICc BIC ADC GUMBEL GUMBEL GUMBEL GUMBEL
whose Maximum-Likelihood parameters are: GUMBEL parameters of x: 16.65707 1.520097

<Code>



<Code>

Tableau 3-1 : Frequency analysis of site records extended with ERA5-Land at hourly scale in m/s

Prob	Wind_speed	Return Period
0.5	17.23	2
0.5708	17.58	2.33
0.8	19.08	5
0.9	20.3	10
0.95	21.47	20
0.96	21.84	25
0.98	22.98	50
0.99	24.12	100

Annexe D Note de calculs ancrages

Nouveau Monde Graphique
Projet Matawinie
CAPR002717
Objet : Ancrage BC-1 talus 5m
Résumé - Calclus de la succion due aux vents et ancrages requis

srk consulting 55

Par :	Charles veilleux	OIQ 5038360
Rev. Par :	Tarik Hadj-Hamou	
# Rev	**A**	14-Nov-24

	Symboles	Valeurs	Unités
Propriétés géomembranes			
Type de GM		PEBD Texturée 1 côté	texturée
Épaisseur		1.5	mm
Ultimate strength in the cross machine direction at 13% strain		44	kN/m
Seam strength (approximately 90% of the geomembrane tensile strength) at 60% strai		39.6	kN/m
Puncture resistance per ASTM D 4833		415	N
Propriétés du site			
Slope	s	2	to 1
sideslope angle, measured from horizontal	b	26.6	°
Wind	V	87	km/hr
Effets de la succion due aux vents			
Facteur de géométrie de pente	Lambda (l)	0.70	
Succion effective	SE (Pa)	235.4	Pa
Longueur de GM non ancrée	L	5	m
Tension induite par le vent dans la GM	**T wind (N)**	**1.1**	**kN**
Déformation de la GM due à la tension	Eps wind	5.90%	
Facteur de sécurité Résistance GM vs Tension vent	FS wind	41.13	
Angle entre la pente du sol et la GM soulevée par le vent	Theta (°)	33.4	°
Propriétés des matériaux de l'ancrage			
unit weight of cover soil	g c	17	kN/m³
unit weight of backfill soil	g s	17	kN/m³ (sable sil
friction angle of backfill soil in anchor trench	f b	28	°
friction angle between the GM and the underlying soil	d c	32	°
friction angle between the GM and the backfill soil (in trench)	d F	25	°
Force de l'ancrage			
Si ancrage en L (extérieur)			
Runout length	L RO	0.00	m
Anchor length	L AT	1.30	m
Depth of cover soil	d CS	0.00	m
Anchor trench depth	d AT	1.00	m
Force de l'ancrage	**T**	**29.0**	kN/m
Facteur de sécurité ancrage vs tension vent	FS ancrage	27.14	
Si ancrage Intermédiaire			
Force verticale due à la succion du vent	**R**	**1.3**	**kN/m.lin**
En "L"			
Anchor length	L AT	1.20	m
Anchor trench depth	d AT	1.00	m
Force de l'ancrage	**T**	**27.2**	kN/m
Facteur de sécurité ancrage vs tension vent	FS v	20.66	

Nouveau Monde Graphique
Projet Matawinie
CAPR002717
Objet : Ancrage BC-1 talus 6m
Résumé - Calclus de la succion due aux vents et ancrages requis

srk consulting 55

Par :	Charles veilleux	OIQ 5038360
Rev. Par :	Tarik Hadj-Hamou	
# Rev	**A**	14-Nov-24

	Symboles	Valeurs	Unités
Propriétés géomembranes			
Type de GM		PEBD Texturée 1 côté	texturée
Épaisseur		1.5	mm
Ultimate strength in the cross machine direction at 13% strain		44	kN/m
Seam strength (approximately 90% of the geomembrane tensile strength) at 60% strai		39.6	kN/m
Puncture resistance per ASTM D 4833		415	N
Propriétés du site			
Slope	s	2	to 1
sideslope angle, measured from horizontal	b	26.6	°
Wind	V	87	km/hr
Effets de la succion due aux vents			
Facteur de géométrie de pente	Lambda (l)	0.70	
Succion effective	SE (Pa)	235.4	Pa
Longueur de GM non ancrée	L	6	m
Tension induite par le vent dans la GM	**T wind (N)**	**1.2**	**kN**
Déformation de la GM due à la tension	Eps wind	6.70%	
Facteur de sécurité Résistance GM vs Tension vent	FS wind	36.22	
Angle entre la pente du sol et la GM soulevée par le vent	Theta (°)	35.5	°
Propriétés des matériaux de l'ancrage			
unit weight of cover soil	g c	17	kN/m³
unit weight of backfill soil	g s	17	kN/m³ (sable sil
friction angle of backfill soil in anchor trench	f b	28	°
friction angle between the GM and the underlying soil	d c	32	°
friction angle between the GM and the backfill soil (in trench)	d F	25	°
Force de l'ancrage			
Si ancrage en L (extérieur)			
Runout length	L RO	0.00	m
Anchor length	L AT	1.30	m
Depth of cover soil	d CS	0.00	m
Anchor trench depth	d AT	1.00	m
Force de l'ancrage	**T**	**29.0**	kN/m
Facteur de sécurité ancrage vs tension vent	FS ancrage	23.90	
Si ancrage Intermédiaire			
Force verticale due à la succion du vent	**R**	**1.6**	**kN/m.lin**
En "L"			
Anchor length	L AT	1.20	m
Anchor trench depth	d AT	1.00	m
Force de l'ancrage	**T**	**27.2**	kN/m
Facteur de sécurité ancrage vs tension vent	FS v	17.21	

Nouveau Monde Graphique
Projet Matawinie
CAPR002717
Objet : Ancrage BC-1 talus 10m
Résumé - Calclus de la succion due aux vents et ancrages requis

srk consulting 55

Par :	Charles veilleux	OIQ 5038360
Rev. Par :	Tarik Hadj-Hamou	
# Rev	**A**	14-Nov-24

	Symboles	Valeurs	Unités
Propriétés géomembranes			
Type de GM		PEBD Texturée 1 côté	texturée
Épaisseur		1.5	mm
Ultimate strength in the cross machine direction at 13% strain		44	kN/m
Seam strength (approximately 90% of the geomembrane tensile strength) at 60% strai		39.6	kN/m
Puncture resistance per ASTM D 4833		415	N
Propriétés du site			
Slope	s	2	to 1
sideslope angle, measured from horizontal	b	26.6	°
Wind	V	87	km/hr
Effets de la succion due aux vents			
Facteur de géométrie de pente	Lambda (l)	0.70	
Succion effective	SE (Pa)	235.4	Pa
Longueur de GM non ancrée	L	10	m
Tension induite par le vent dans la GM	**T wind (N)**	**1.8**	**kN**
Déformation de la GM due à la tension	Eps wind	9.66%	
Facteur de sécurité Résistance GM vs Tension vent	FS wind	25.12	
Angle entre la pente du sol et la GM soulevée par le vent	Theta (°)	42.2	°
Propriétés des matériaux de l'ancrage			
unit weight of cover soil	g c	17	kN/m³
unit weight of backfill soil	g s	17	kN/m³ (sable sil
friction angle of backfill soil in anchor trench	f b	28	°
friction angle between the GM and the underlying soil	d c	32	°
friction angle between the GM and the backfill soil (in trench)	d F	25	°
Force de l'ancrage			
Si ancrage en L (extérieur)			
Runout length	L RO	0.00	m
Anchor length	L AT	1.30	m
Depth of cover soil	d CS	0.00	m
Anchor trench depth	d AT	1.00	m
Force de l'ancrage	**T**	**29.0**	kN/m
Facteur de sécurité ancrage vs tension vent	FS ancrage	16.58	
Si ancrage Intermédiaire			
Force verticale due à la succion du vent	**R**	**2.6**	**kN/m.lin**
En "L"			
Anchor length	L AT	1.20	m
Anchor trench depth	d AT	1.00	m
Force de l'ancrage	**T**	**27.2**	kN/m
Facteur de sécurité ancrage vs tension vent	FS v	10.33	

Nouveau Monde Graphique
Projet Matawinie
CAPR002717
Objet : BC-2 ancrage talus 5m
Résumé - Calclus de la succion due aux vents et ancrages requis

srk consulting 55

Par :	Charles Veilleux	OIQ 5038360
Rev. Par :	Tarik Hadj-Hamou	
# Rev	**A**	14-Nov-24

	Symboles	Valeurs	Unités
Propriétés géomembranes			
Type de GM		PEBD Texturée 1 côté	texturée
Épaisseur		1.5	mm
Ultimate strength in the cross machine direction at 13% strain		44	kN/m
Seam strength (approximately 90% of the geomembrane tensile strength) at 60% strai		39.6	kN/m
Puncture resistance per ASTM D 4833		415	N
Propriétés du site			
Slope	s	2	to 1
sideslope angle, measured from horizontal	b	26.6	°
Wind	V	87	km/hr
Effets de la succion due aux vents			
Facteur de géométrie de pente	Lambda (l)	0.70	
Succion effective	SE (Pa)	235.4	Pa
Longueur de GM non ancrée	L	5	m
Tension induite par le vent dans la GM	**T wind (N)**	**1.1**	**kN**
Déformation de la GM due à la tension	Eps wind	5.26%	
Facteur de sécurité Résistance GM vs Tension vent	FS wind	39.18	
Angle entre la pente du sol et la GM soulevée par le vent	Theta (°)	31.6	°
Propriétés des matériaux de l'ancrage			
unit weight of cover soil	g c	17	kN/m³
unit weight of backfill soil	g s	17	kN/m³ (sable sil
friction angle of backfill soil in anchor trench	f b	28	°
friction angle between the GM and the underlying soil	d c	32	°
friction angle between the GM and the backfill soil (in trench)	d F	25	°
Force de l'ancrage			
Si ancrage en L (extérieur)			
Runout length	L RO	0.00	m
Anchor length	L AT	1.00	m
Depth of cover soil	d CS	0.00	m
Anchor trench depth	d AT	1.00	m
Force de l'ancrage	**T**	**23.5**	kN/m
Facteur de sécurité ancrage vs tension vent	FS ancrage	20.90	
Si ancrage Intermédiaire			
Force verticale due à la succion du vent	**R**	**1.3**	**kN/m.lin**
En "L"			
Anchor length	L AT	1.00	m
Anchor trench depth	d AT	1.00	m
Force de l'ancrage	**T**	**23.5**	kN/m
Facteur de sécurité ancrage vs tension vent	FS v	17.84	

Nouveau Monde Graphique
Projet Matawinie
CAPR002717
Objet : BC-2 ancrage talus 6m
Résumé - Calclus de la succion due aux vents et ancrages requis

srk consulting 55

Par :	Charles Veilleux	OIQ 5038360
Rev. Par :	Tarik Hadj-Hamou	
# Rev	**A**	14-Nov-24

	Symboles	Valeurs	Unités
Propriétés géomembranes			
Type de GM		PEBD Texturée 1 côté	texturée
Épaisseur		1.5	mm
Ultimate strength in the cross machine direction at 13% strain		44	kN/m
Seam strength (approximately 90% of the geomembrane tensile strength) at 60% strai		39.6	kN/m
Puncture resistance per ASTM D 4833		415	N
Propriétés du site			
Slope	s	2	to 1
sideslope angle, measured from horizontal	b	26.6	°
Wind	V	87	km/hr
Effets de la succion due aux vents			
Facteur de géométrie de pente	Lambda (l)	0.70	
Succion effective	SE (Pa)	235.4	Pa
Longueur de GM non ancrée	L	6	m
Tension induite par le vent dans la GM	**T wind (N)**	**1.3**	**kN**
Déformation de la GM due à la tension	Eps wind	5.98%	
Facteur de sécurité Résistance GM vs Tension vent	FS wind	34.46	
Angle entre la pente du sol et la GM soulevée par le vent	Theta (°)	33.6	°
Propriétés des matériaux de l'ancrage			
unit weight of cover soil	g c	17	kN/m³
unit weight of backfill soil	g s	17	kN/m³ (sable sil
friction angle of backfill soil in anchor trench	f b	28	°
friction angle between the GM and the underlying soil	d c	32	°
friction angle between the GM and the backfill soil (in trench)	d F	25	°
Force de l'ancrage			
Si ancrage en L (extérieur)			
Runout length	L RO	0.00	m
Anchor length	L AT	1.00	m
Depth of cover soil	d CS	0.00	m
Anchor trench depth	d AT	1.00	m
Force de l'ancrage	**T**	**23.5**	kN/m
Facteur de sécurité ancrage vs tension vent	FS ancrage	18.38	
Si ancrage Intermédiaire			
Force verticale due à la succion du vent	**R**	**1.6**	**kN/m.lin**
En "L"			
Anchor length	L AT	1.00	m
Anchor trench depth	d AT	1.00	m
Force de l'ancrage	**T**	**23.5**	kN/m
Facteur de sécurité ancrage vs tension vent	FS v	14.86	

Nouveau Monde Graphique
Projet Matawinie
CAPR002717
Objet : BC-2 ancrage talus 10m
Résumé - Calclus de la succion due aux vents et ancrages requis

srk consulting 55

Par :	Charles Veilleux	OIQ 5038360
Rev. Par :	Tarik Hadj-Hamou	
# Rev	**A**	14-Nov-24

	Symboles	Valeurs	Unités
Propriétés géomembranes			
Type de GM		PEBD Texturée 1 côté	texturée
Épaisseur		1.5	mm
Ultimate strength in the cross machine direction at 13% strain		44	kN/m
Seam strength (approximately 90% of the geomembrane tensile strength) at 60% strai		39.6	kN/m
Puncture resistance per ASTM D 4833		415	N
Propriétés du site			
Slope	s	2	to 1
sideslope angle, measured from horizontal	b	26.6	°
Wind	V	87	km/hr
Effets de la succion due aux vents			
Facteur de géométrie de pente	Lambda (l)	0.70	
Succion effective	SE (Pa)	235.4	Pa
Longueur de GM non ancrée	L	10	m
Tension induite par le vent dans la GM	**T wind (N)**	**1.8**	**kN**
Déformation de la GM due à la tension	Eps wind	8.59%	
Facteur de sécurité Résistance GM vs Tension vent	FS wind	23.99	
Angle entre la pente du sol et la GM soulevée par le vent	Theta (°)	39.9	°
Propriétés des matériaux de l'ancrage			
unit weight of cover soil	g c	17	kN/m³
unit weight of backfill soil	g s	17	kN/m³ (sable sil
friction angle of backfill soil in anchor trench	f b	28	°
friction angle between the GM and the underlying soil	d c	32	°
friction angle between the GM and the backfill soil (in trench)	d F	25	°
Force de l'ancrage			
Si ancrage en L (extérieur)			
Runout length	L RO	0.00	m
Anchor length	L AT	1.00	m
Depth of cover soil	d CS	0.00	m
Anchor trench depth	d AT	1.00	m
Force de l'ancrage	**T**	**23.5**	kN/m
Facteur de sécurité ancrage vs tension vent	FS ancrage	12.80	
Si ancrage Intermédiaire			
Force verticale due à la succion du vent	**R**	**2.6**	**kN/m.lin**
En "L"			
Anchor length	L AT	1.00	m
Anchor trench depth	d AT	1.00	m
Force de l'ancrage	**T**	**23.5**	kN/m
Facteur de sécurité ancrage vs tension vent	FS v	8.92	

Nouveau Monde Graphique
Projet Matawinie
CAPR002717
Objet : Ancrage BC-2 fond 100m
Résumé - Calclus de la succion due aux vents et ancrages requis

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Par :	Charles Veilleux	OIQ 5038360
Rev. Par :	Tarik Hadj-Hamou	
# Rev	**A**	14-Nov-24

	Symboles	Valeurs	Unités
Propriétés géomembranes			
Type de GM		PEBD Texturée 1 côté	texturée
Épaisseur		1.5	mm
Ultimate strength in the cross machine direction at 13% strain		44	kN/m
Seam strength (approximately 90% of the geomembrane tensile strength) at 60% strai		39.6	kN/m
Puncture resistance per ASTM D 4833		415	N
Propriétés du site			
Slope	s	100	to 1
sideslope angle, measured from horizontal	b	0.6	°
Wind	V	87	km/hr
Effets de la succion due aux vents			
Facteur de géométrie de pente	Lambda (l)	0.40	
Succion effective	SE (Pa)	127.8	Pa
Longueur de GM non ancrée	L	100	m
Tension induite par le vent dans la GM	**T wind (N)**	**14.6**	**kN**
Déformation de la GM due à la tension	Eps wind	3.51%	
Facteur de sécurité Résistance GM vs Tension vent	FS wind	3.02	
Angle entre la pente du sol et la GM soulevée par le vent	Theta (°)	26.0	°
Propriétés des matériaux de l'ancrage			
unit weight of cover soil	g c	17	kN/m³
unit weight of backfill soil	g s	17	kN/m³ (sable sil
friction angle of backfill soil in anchor trench	f b	28	°
friction angle between the GM and the underlying soil	d c	32	°
friction angle between the GM and the backfill soil (in trench)	d F	25	°
Force de l'ancrage			
Si ancrage en L (extérieur)			
Runout length	L RO	0.00	m
Anchor length	L AT	1.00	m
Depth of cover soil	d CS	0.00	m
Anchor trench depth	d AT	1.00	m
Force de l'ancrage	**T**	**23.5**	kN/m
Facteur de sécurité ancrage vs tension vent	FS ancrage	1.61	
Si ancrage Intermédiaire			
Force verticale due à la succion du vent	**R**	**12.8**	**kN/m.lin**
En "L"			
Anchor length	L AT	1.00	m
Anchor trench depth	d AT	1.00	m
Force de l'ancrage	**T**	**23.5**	kN/m
Facteur de sécurité ancrage vs tension vent	FS v	1.84	

Nouveau Monde Graphique
Projet Matawinie
CAPR002717
Objet : Ancrage BC-2 fond 100m
Résumé - Calclus de la succion due aux vents et ancrages requis

srk consulting 55

Par :	Charles Veilleux	OIQ 5038360
Rev. Par :	Tarik Hadj-Hamou	
# Rev	**A**	14-Nov-24

	Symboles	Valeurs	Unités
Propriétés géomembranes			
Type de GM		PEBD Texturée 1 côté	texturée
Épaisseur		1.5	mm
Ultimate strength in the cross machine direction at 13% strain		44	kN/m
Seam strength (approximately 90% of the geomembrane tensile strength) at 60% strai		39.6	kN/m
Puncture resistance per ASTM D 4833		415	N
Propriétés du site			
Slope	s	100	to 1
sideslope angle, measured from horizontal	b	0.6	°
Wind	V	87	km/hr
Effets de la succion due aux vents			
Facteur de géométrie de pente	Lambda (l)	0.40	
Succion effective	SE (Pa)	127.8	Pa
Longueur de GM non ancrée	L	150	m
Tension induite par le vent dans la GM	**T wind (N)**	**19.3**	**kN**
Déformation de la GM due à la tension	Eps wind	4.65%	
Facteur de sécurité Résistance GM vs Tension vent	FS wind	2.28	
Angle entre la pente du sol et la GM soulevée par le vent	Theta (°)	29.8	°
Propriétés des matériaux de l'ancrage			
unit weight of cover soil	g c	17	kN/m³
unit weight of backfill soil	g s	17	kN/m³ (sable sil
friction angle of backfill soil in anchor trench	f b	28	°
friction angle between the GM and the underlying soil	d c	32	°
friction angle between the GM and the backfill soil (in trench)	d F	25	°
Force de l'ancrage			
Si ancrage en L (extérieur)			
Runout length	L RO	0.00	m
Anchor length	L AT	1.00	m
Depth of cover soil	d CS	0.00	m
Anchor trench depth	d AT	1.00	m
Force de l'ancrage	**T**	**23.5**	kN/m
Facteur de sécurité ancrage vs tension vent	FS ancrage	1.22	
Si ancrage Intermédiaire			
Force verticale due à la succion du vent	**R**	**19.2**	**kN/m.lin**
En "L"			
Anchor length	L AT	1.00	m
Anchor trench depth	d AT	1.00	m
Force de l'ancrage	**T**	**23.5**	kN/m
Facteur de sécurité ancrage vs tension vent	FS v	1.22	

Annexe E Halde à entreposage temporaire des stériles issus de la construction de BC-2

Stability Analysis results
BC-2 Stockpile Design

Mine Matawinie Graphite, Saint-Michel-des-Saints, Québec, Canada

Notes:	srk consulting	NOUVEAU MONDE GRAPHITE MINE DE GRAPHITE MATAWINIE	Stability Analysis Results No. de project : CAPR003306 Matawinie Graphite Mine	Title: Stability analysis – Conceptual stockpile design – NMG Date : December 2024 Approved : JFSTL Figure: 1

Context

Rockfill from the BC-2 excavation should be stockpiled nearby the working area. The size, height, and configuration of the stockpile will vary over time. At this stage, it is not possible to determine how large the stockpile will become or how long it will be needed.

A conceptual design that complies with applicable regulations should be developed. The storage capacity of the stockpile should be sufficient to accommodate 100% of the rockfill from BC-2 (182,370 m^3), even though this scenario is unlikely to occur. Material from BC-2 will be used as construction material.

The stability assessment should identify the appropriate bench height, inter-bench slope, and bench setbacks. These directives should guide the construction of the stockpile.

Stability Analysis assumptions

Assessed Scenarios:

- Short-term: Stockpile conditions before open pit's activities and groundwater drawdown.

Loading Conditions considered:

- Drained (no fine material showing undrained behavior)

Limit Equilibrium Methods implemented:

- Morgenstern-Price

Slip surface search method applied:

- Cuckoo – search
- Entry and Exit method
- Block specified

Slip surface characteristics selected :

- Non-circular
- Non-circular optimized

Phreatic surface defined:

- User-defined (at the base of the stockpile)

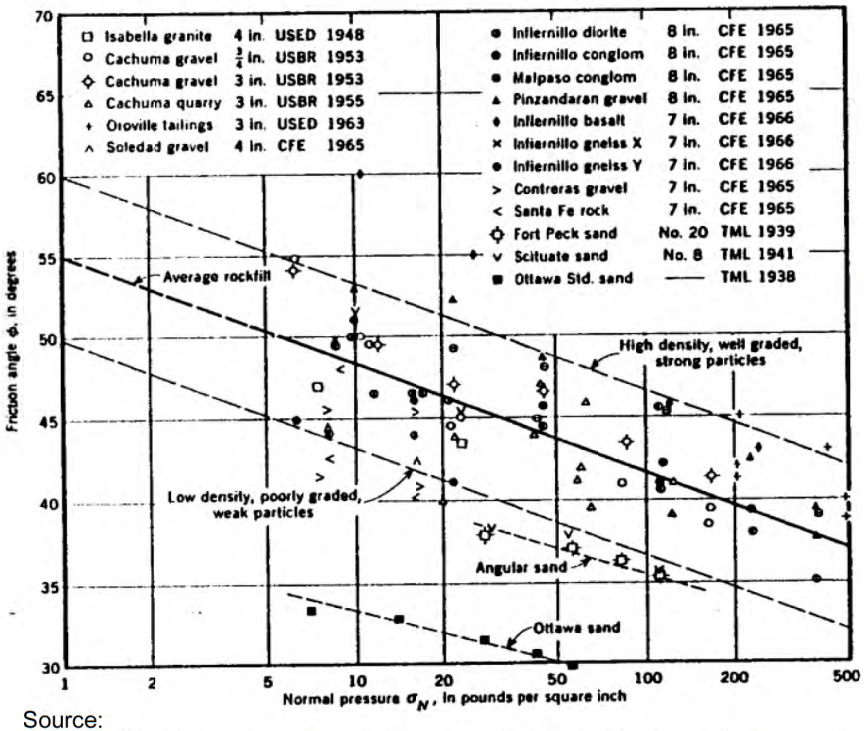
Materials defined into the ground-models:

- Mohr – Coulomb Materials:
  - Till
  - Topsoil
  - Mg-56
  - Bedrock
- Shear/Normal strength function*:
  - Stockpile material

Notes:

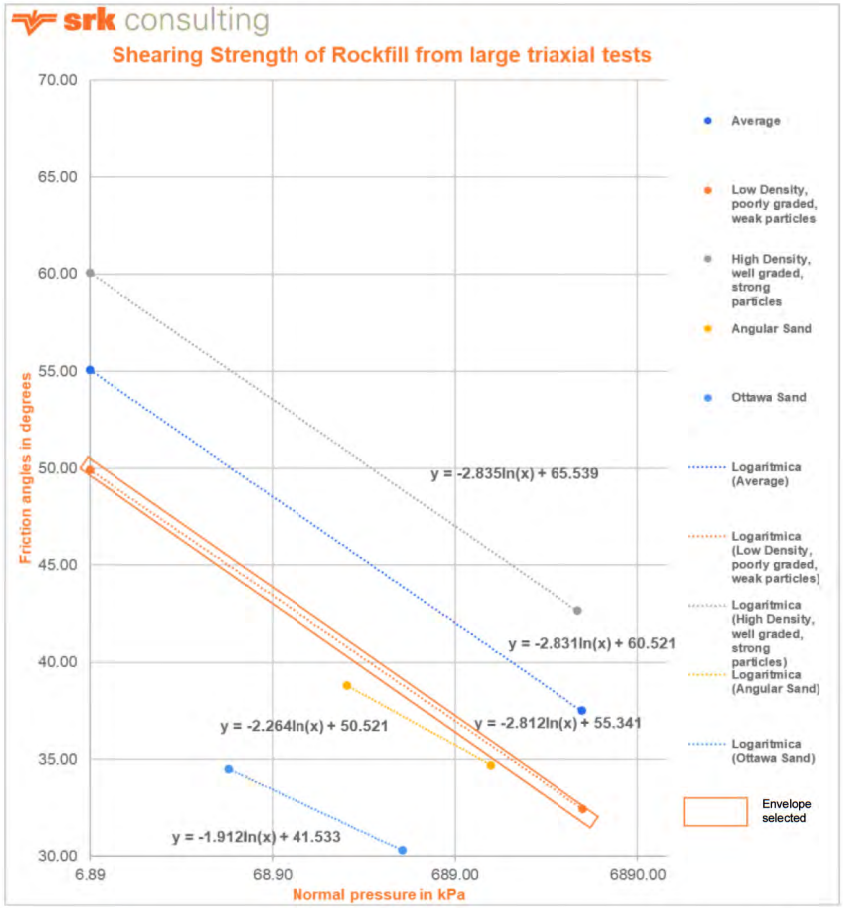
* The Shear/Normal strength function is based on lower bound envelope from Leps's publication (Leps, 1970).

Leps Approach – Assumed Strength envelope Selected for the rockfill



Source:

Leps, T. (1970). Review of shearing strength of rockfill. Journal of the soil Mechanics and foundations Division. Proceedings of the American Society of Civil Engineers



Notes:

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NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
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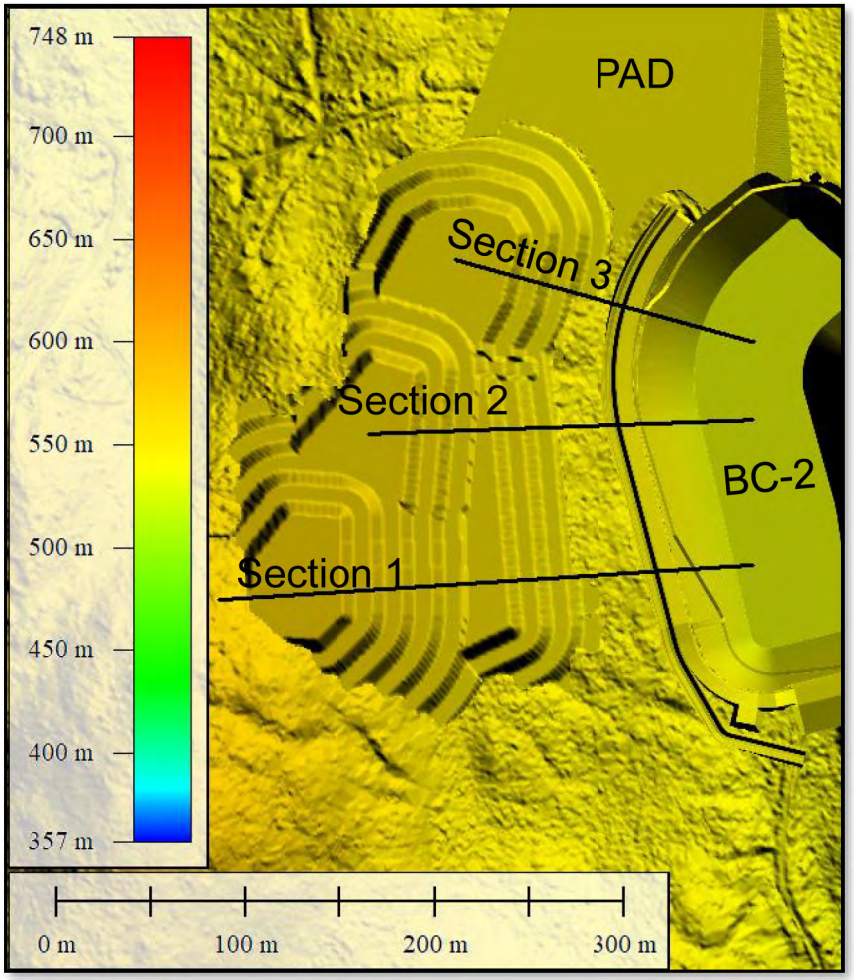
Figure: 4

Cross-sections selected

Conceptual rockfill and associate pad next to BC-2 with a storage capacity of 189 365 m^3

3 sections used to assess the stability of the stockpile

The stockpile will be temporary



Notes:

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NOUVEAU MONDE GRAPHITE
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Stability Analysis Results

No. de project : CAPR003306
Matawinie Graphite Mine

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Date : December 2024
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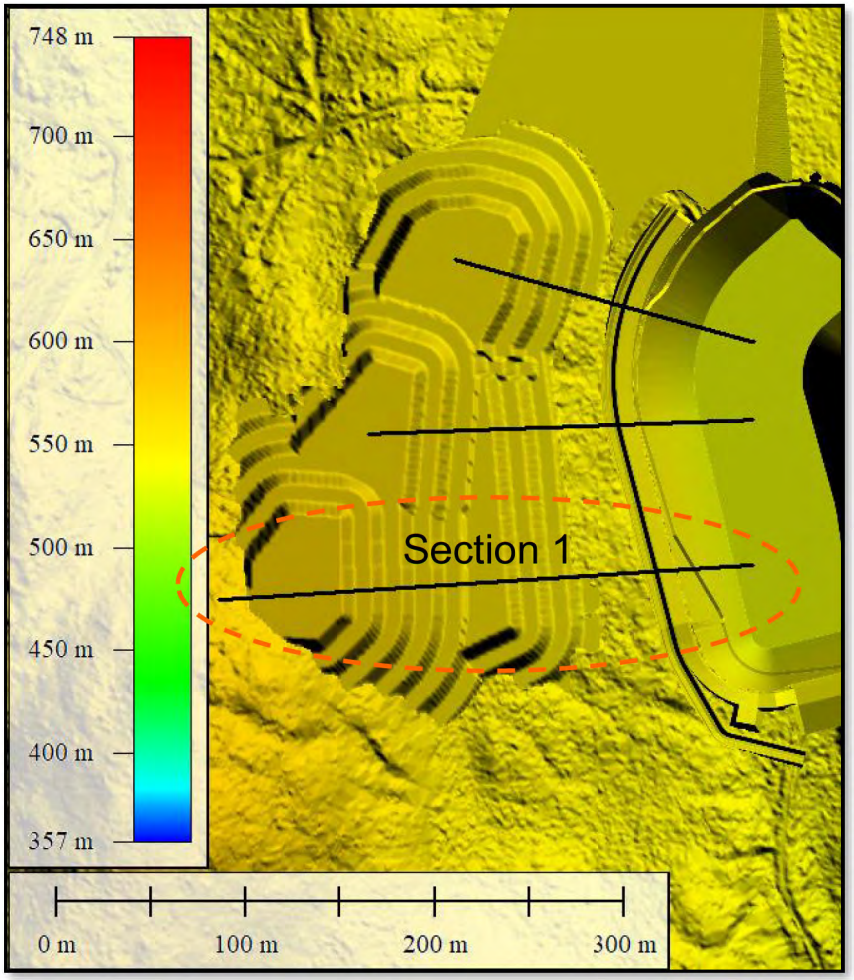
Location Section 1



Notes:

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NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

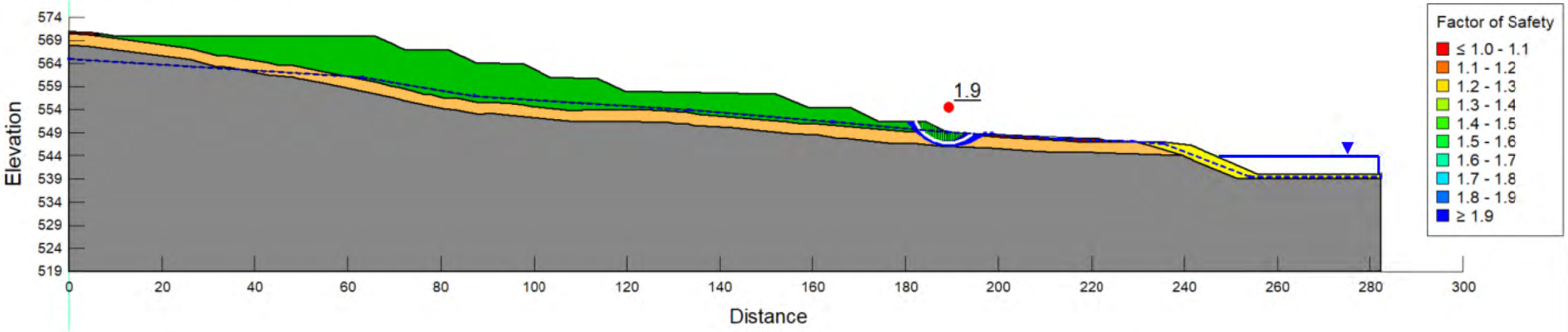
Stability Analysis Results

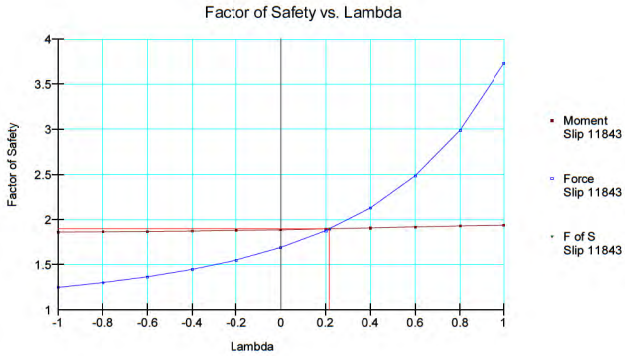
No. de project : CAPR003306
Matawinie Graphite Mine

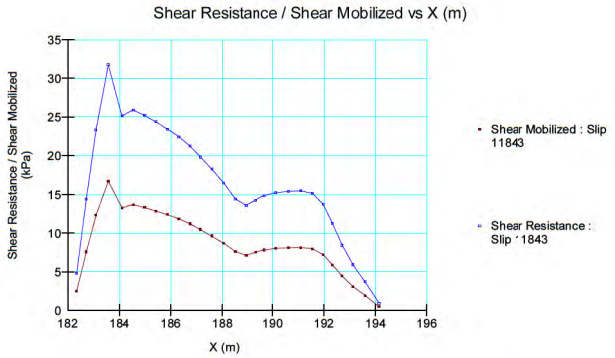
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 6

Section 1 – Stability Analysis (Short-term)

Loading conditions : Drained
Search method : Cuckoo search
Failure Slip Surface: Circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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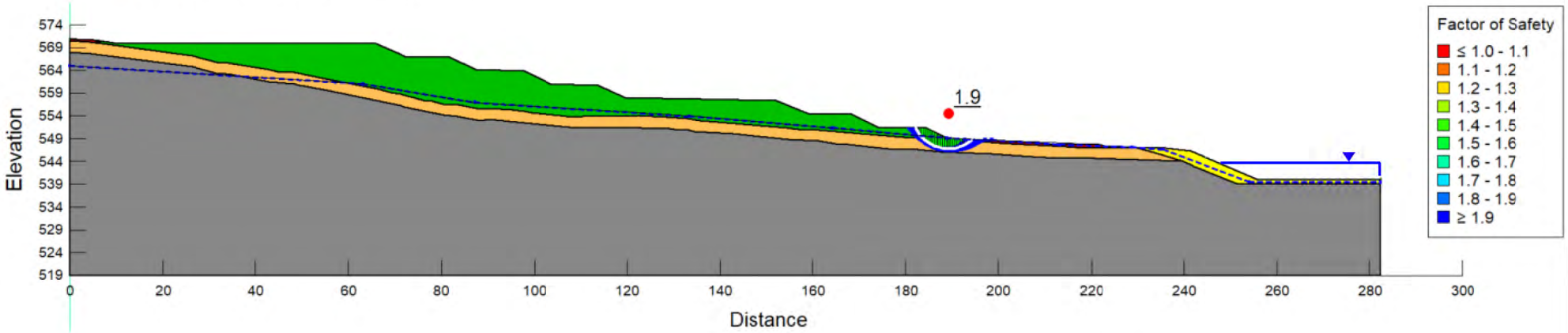
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

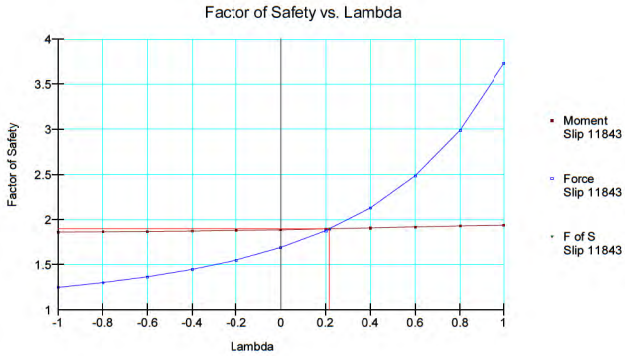
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

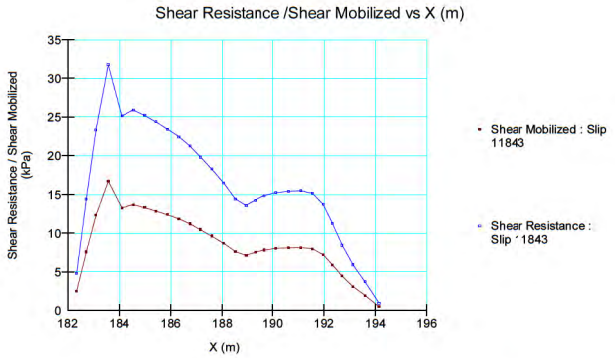
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 7

Section 1 – Stability Analysis (Short-term)

Loading conditions : Drained
Search method : Cuckoo search
Failure Slip Surface: Non-circular - optimized







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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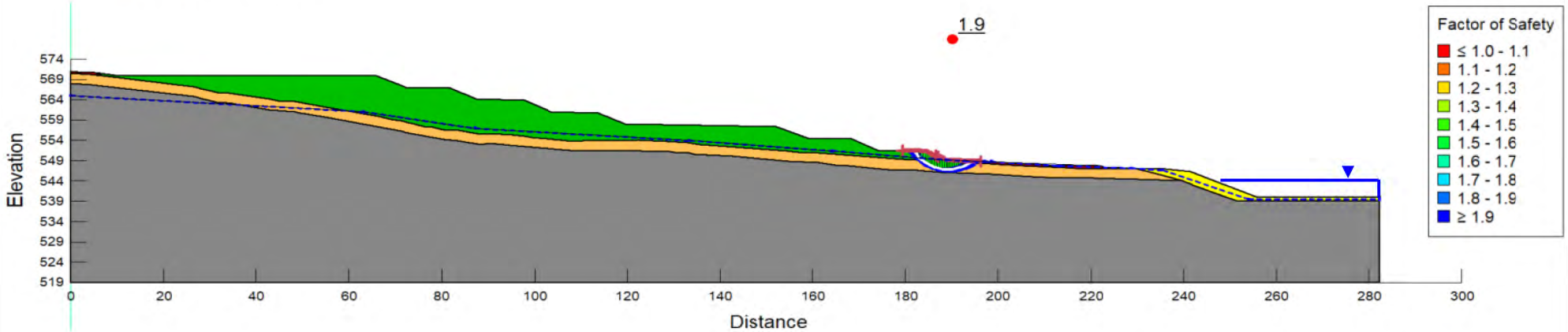
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

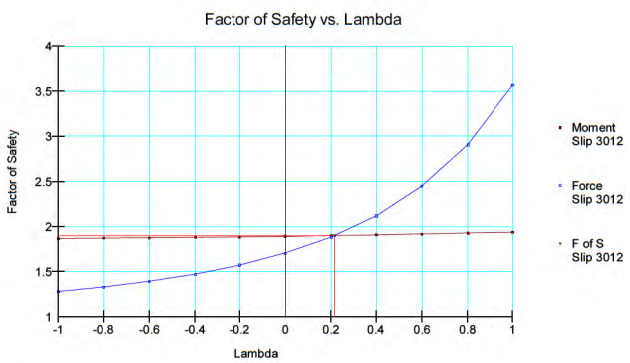
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

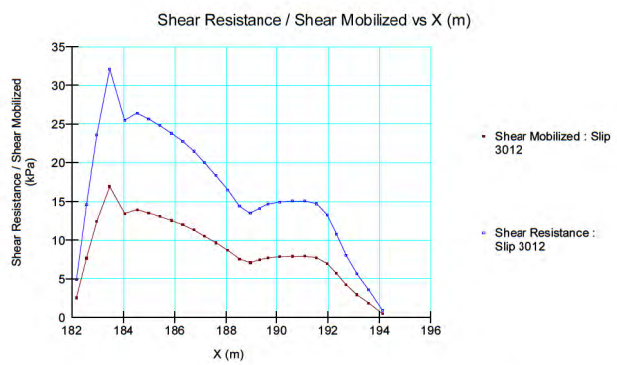
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 8

Section 1 – Stability Analysis (Short-term)

Loading conditions : Drained
Search method : Entry and Exit
Failure Slip Surface: Circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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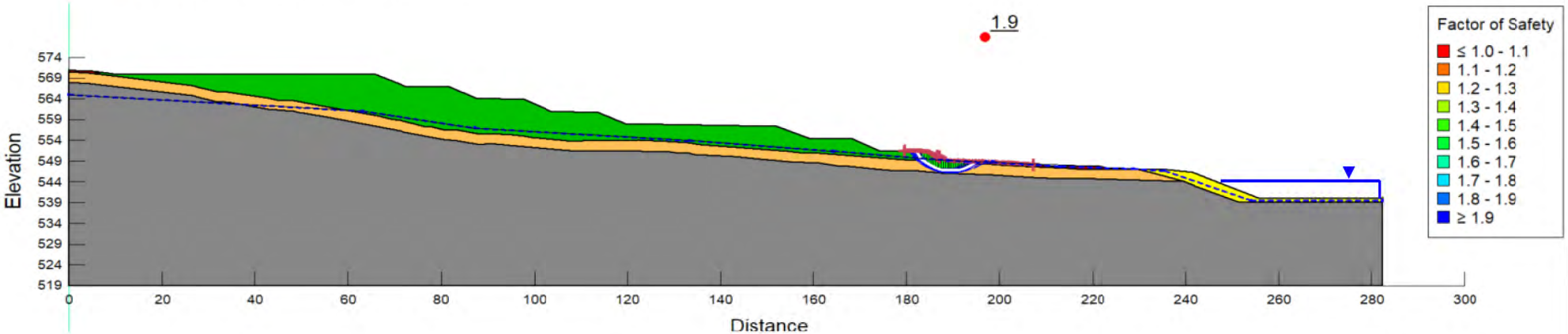
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

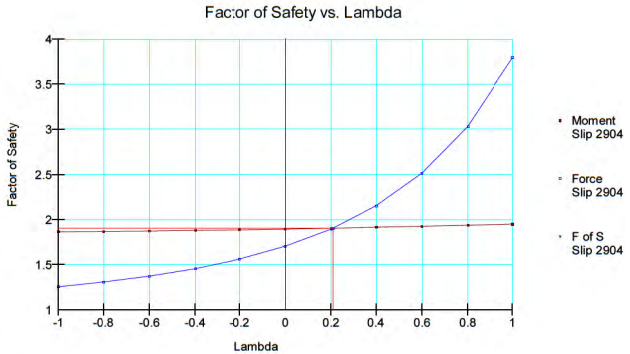
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

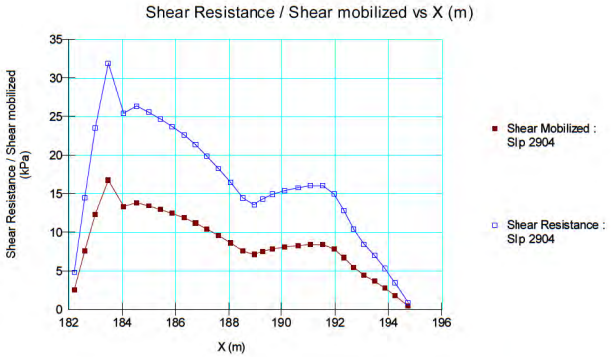
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 9

Section 1 – Stability Analysis (Short-term)

Loading conditions : Drained
Search method : Entry and Exit
Failure Slip Surface: Non-circular optimized







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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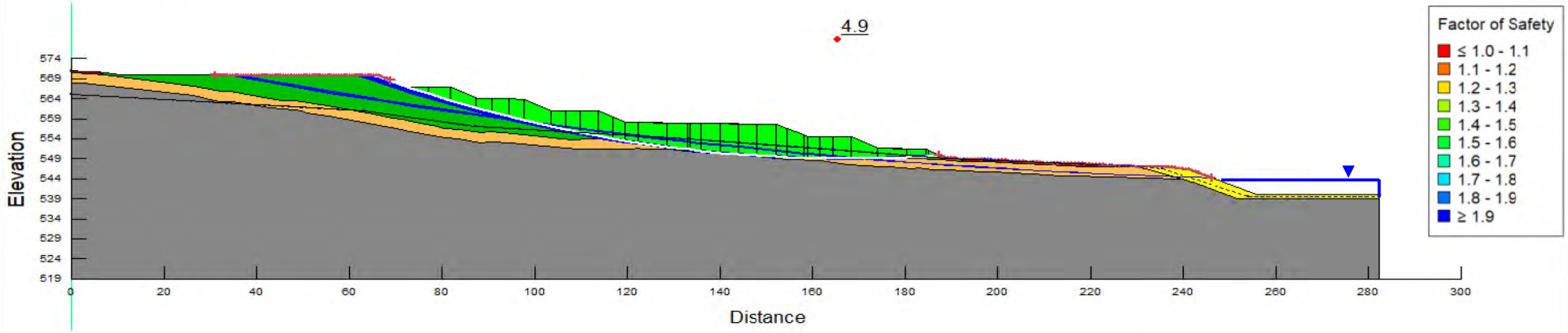
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

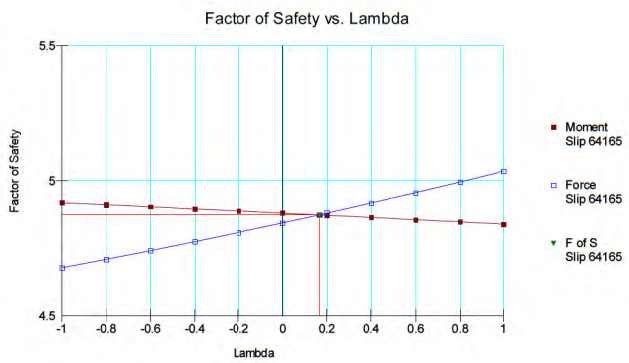
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

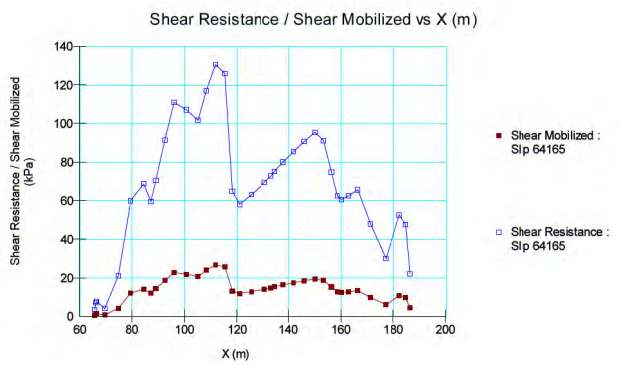
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 10

Section 1 – Stability Analysis - Global (Short-term)

Loading conditions : Drained
Search method : Entry and Exit
Failure Slip Surface: Circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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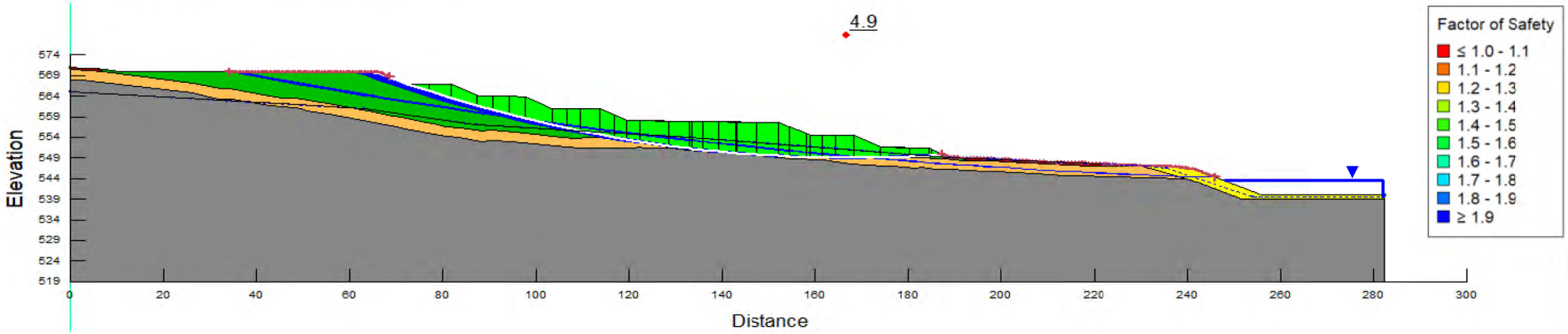
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

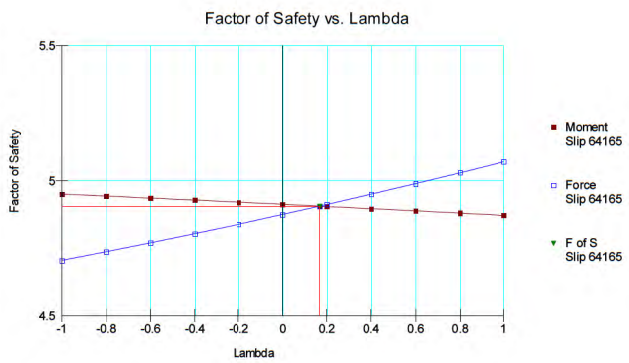
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

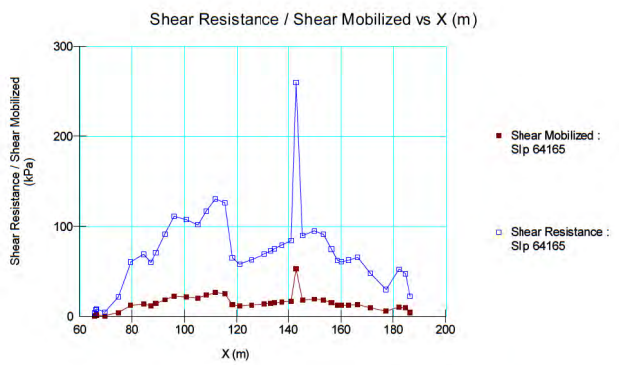
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 11

Section 1 – Stability Analysis - Global (Short-term)

Loading conditions : Drained
Search method : Entry and Exit
Failure Slip Surface: Non-circular optimized







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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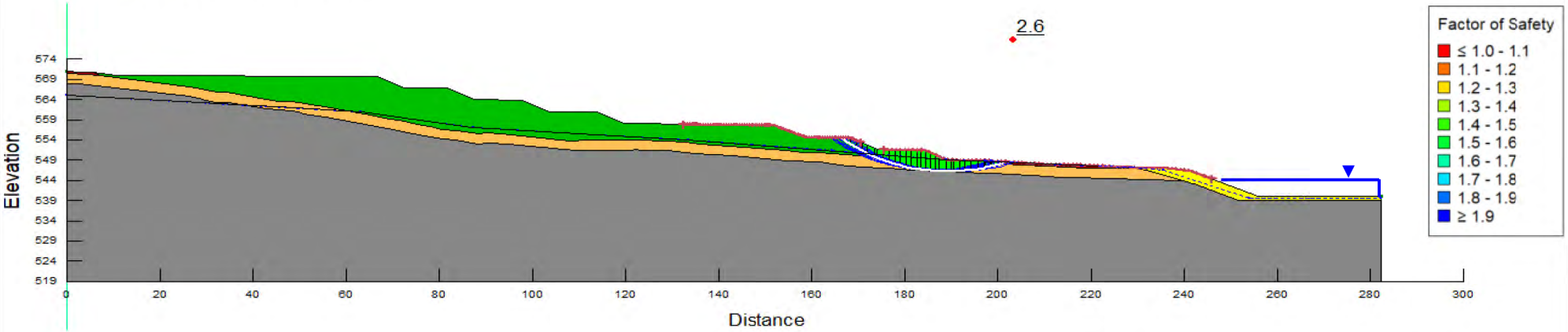
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

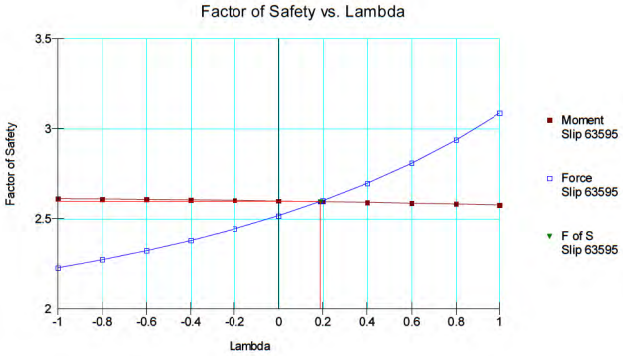
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

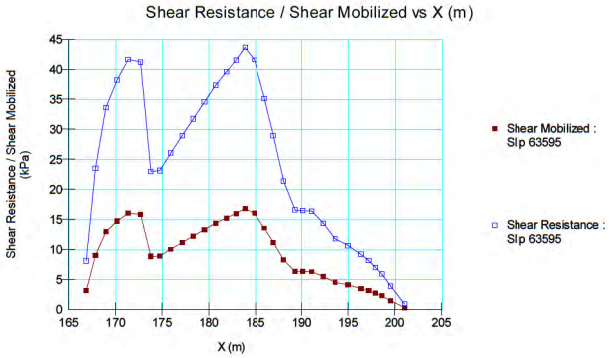
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 12

Section 1 – Stability Analysis - Intermediate (Short-term)

Loading conditions : Drained
Search method : Entry and Exit
Failure Slip Surface: Circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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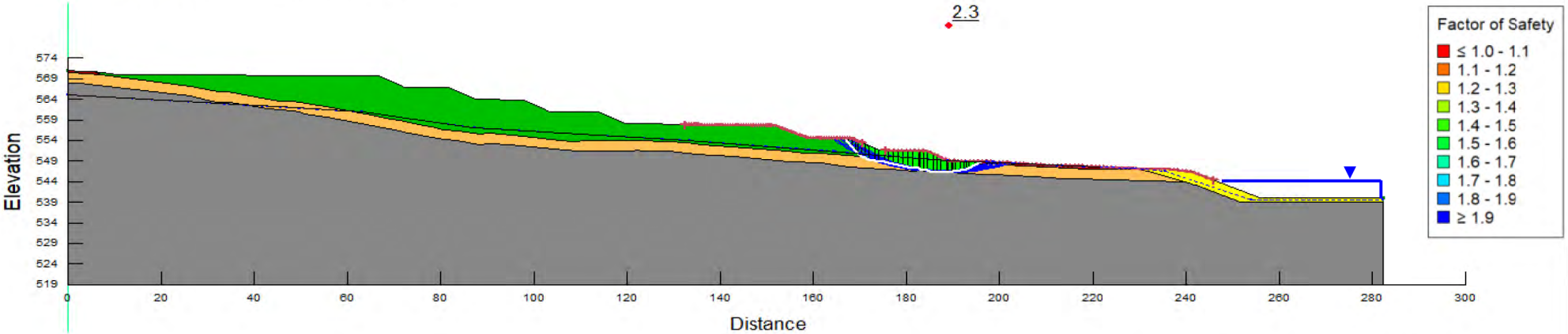
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

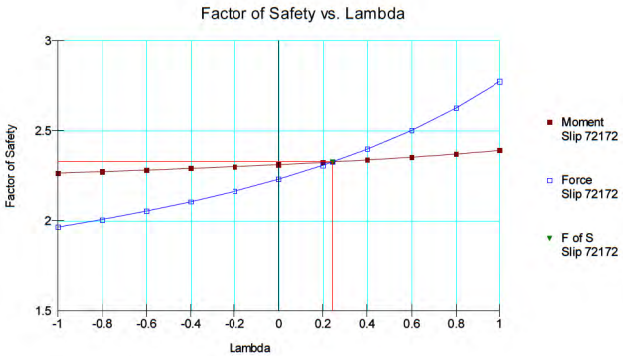
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

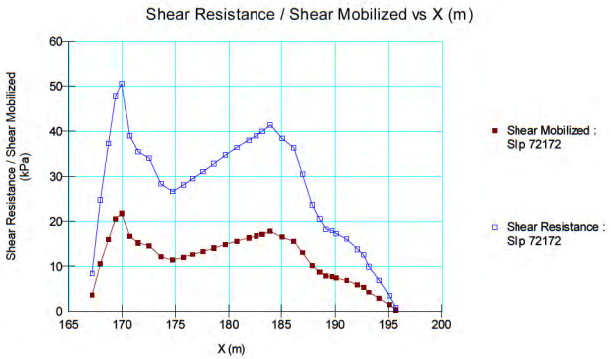
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 13

Section 1 – Stability Analysis - Intermediate (Short-term)

Loading conditions : Drained
Search method : Entry and Exit
Failure Slip Surface: Non-circular optimized







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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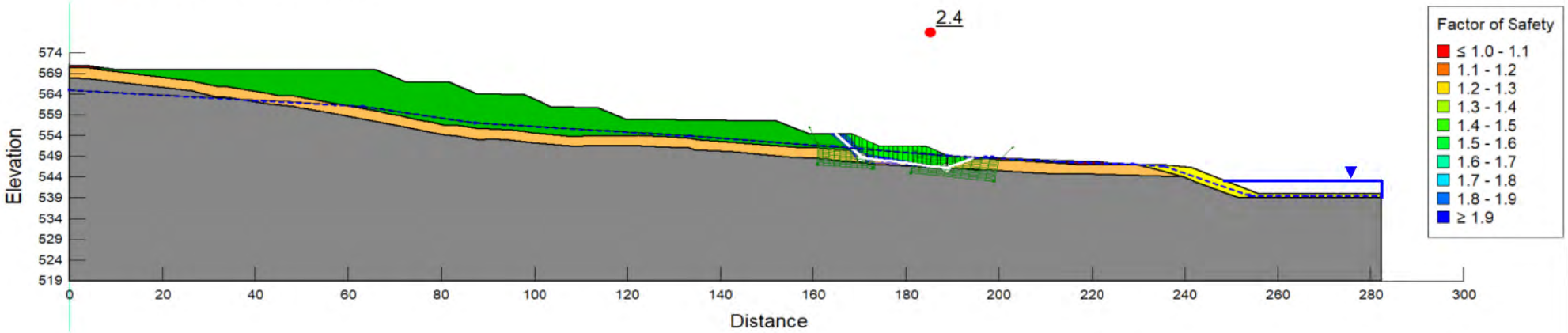
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

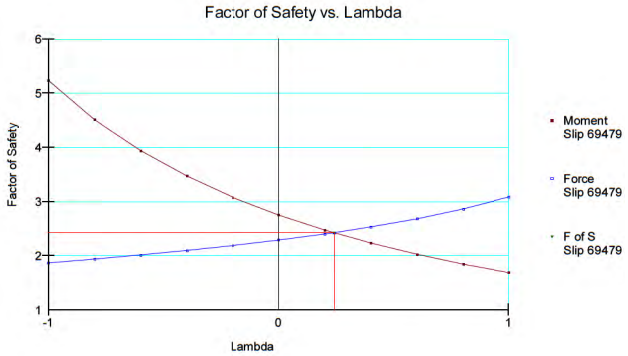
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

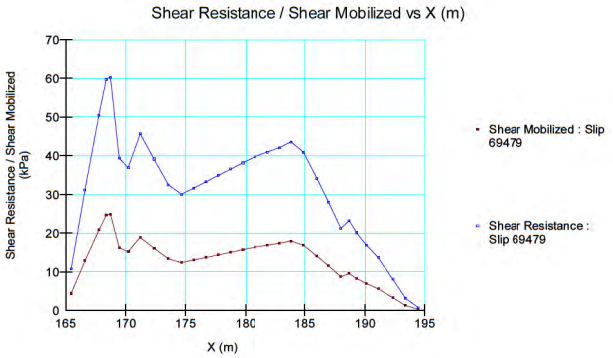
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 14

Section 1 – Stability Analysis (Short-term)

Loading conditions : Drained
Search method : Block Search
Failure Slip Surface: Non-circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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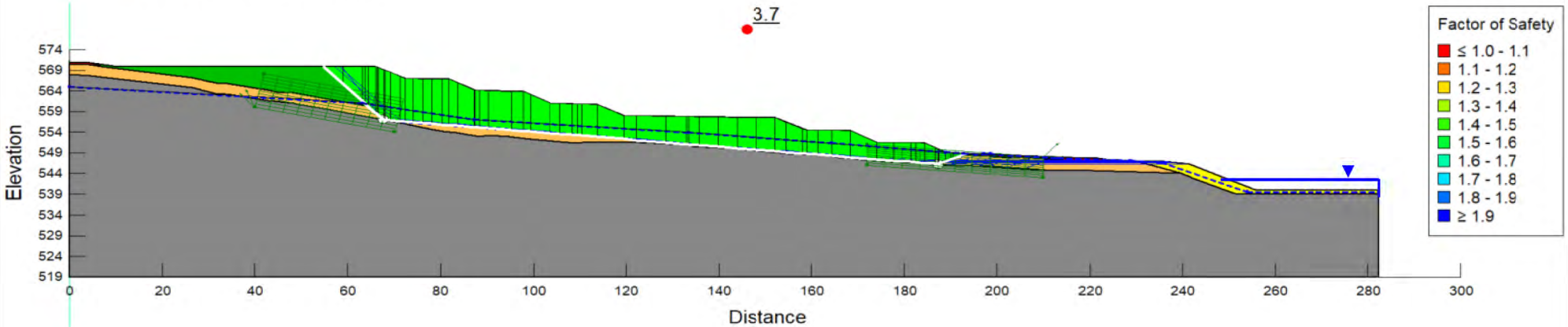
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

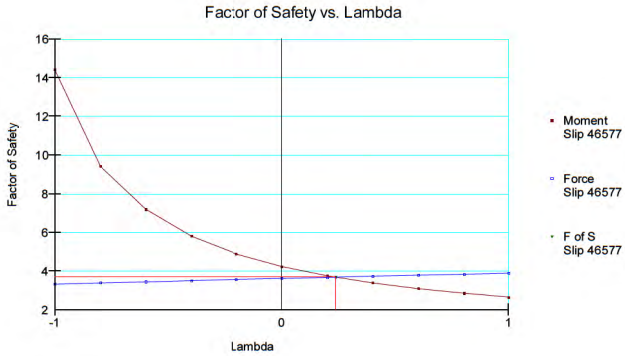
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

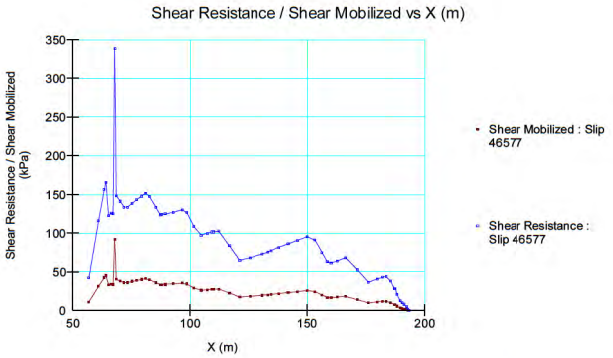
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 15

Section 1 – Stability Global (Short-term)

Loading conditions : Drained
Search method : Block Search
Failure Slip Surface: Non-circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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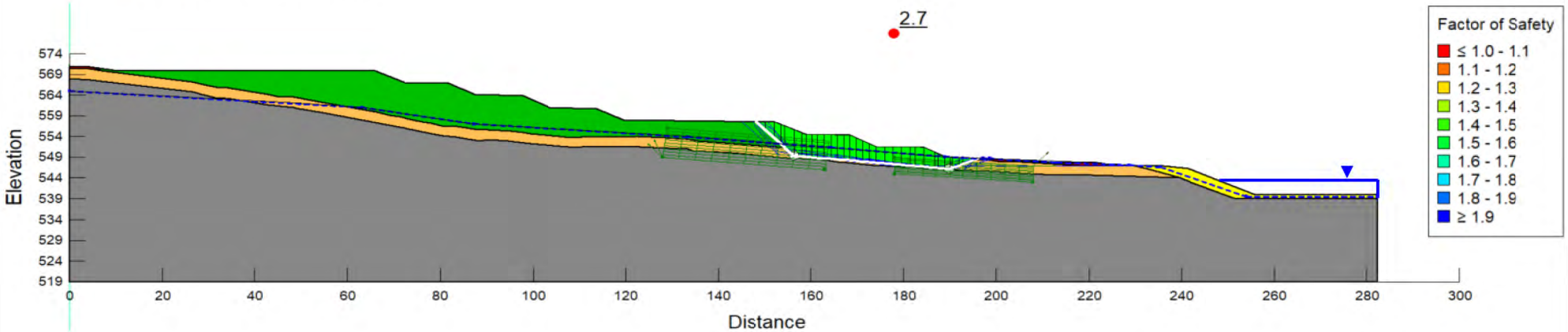
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

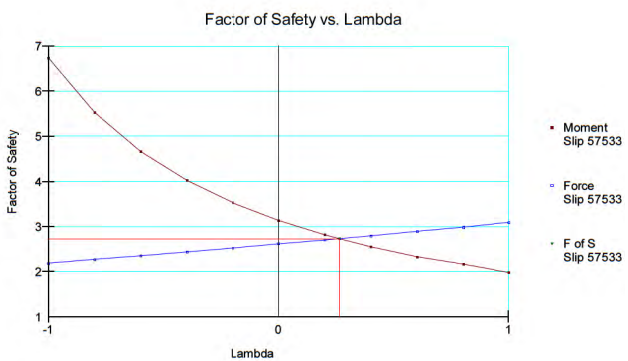
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

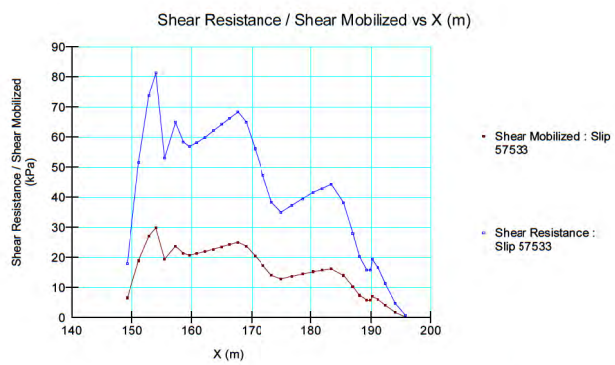
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 16

Section 1 – Stability Intermediate (Short-term)

Loading conditions : Drained
Search method : Block Search
Failure Slip Surface: Non-circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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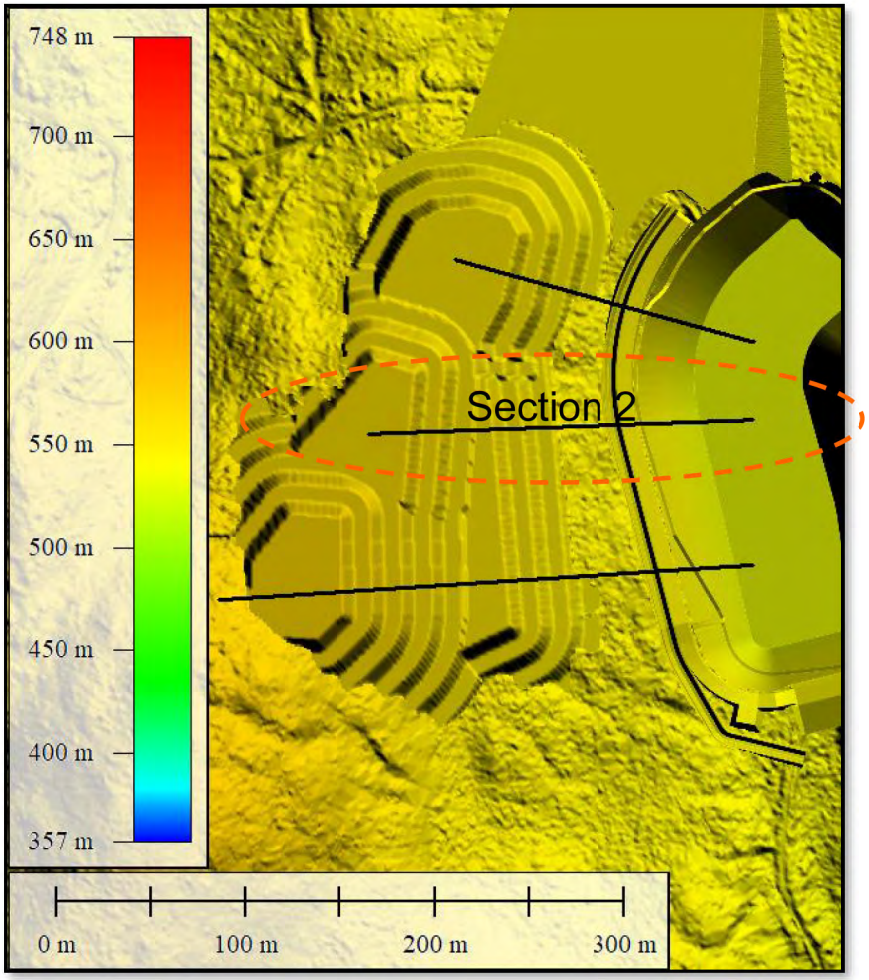
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 17

Location Section 2



Notes:

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NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

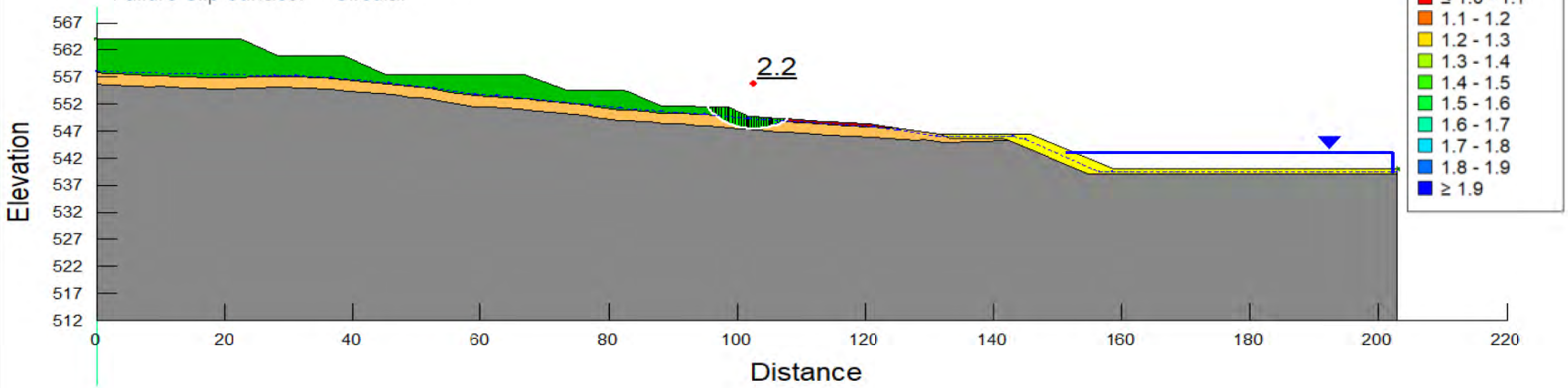
Stability Analysis Results

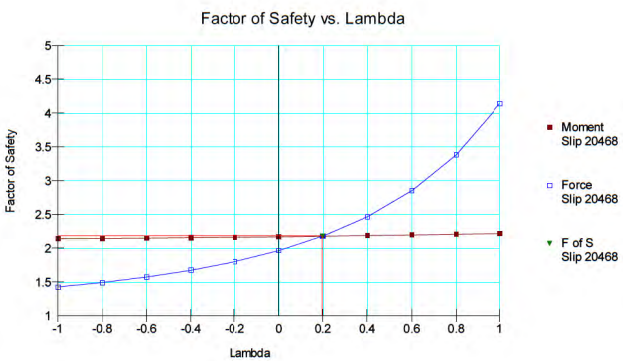
No. de project : CAPR003306
Matawinie Graphite Mine

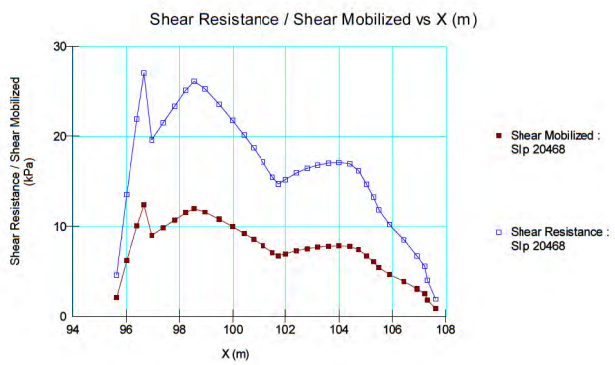
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 18

Section 2 – Stability Analysis (Short-term)

Loading conditions : Drained
Search method : Cuckoo search
Failure Slip Surface: Circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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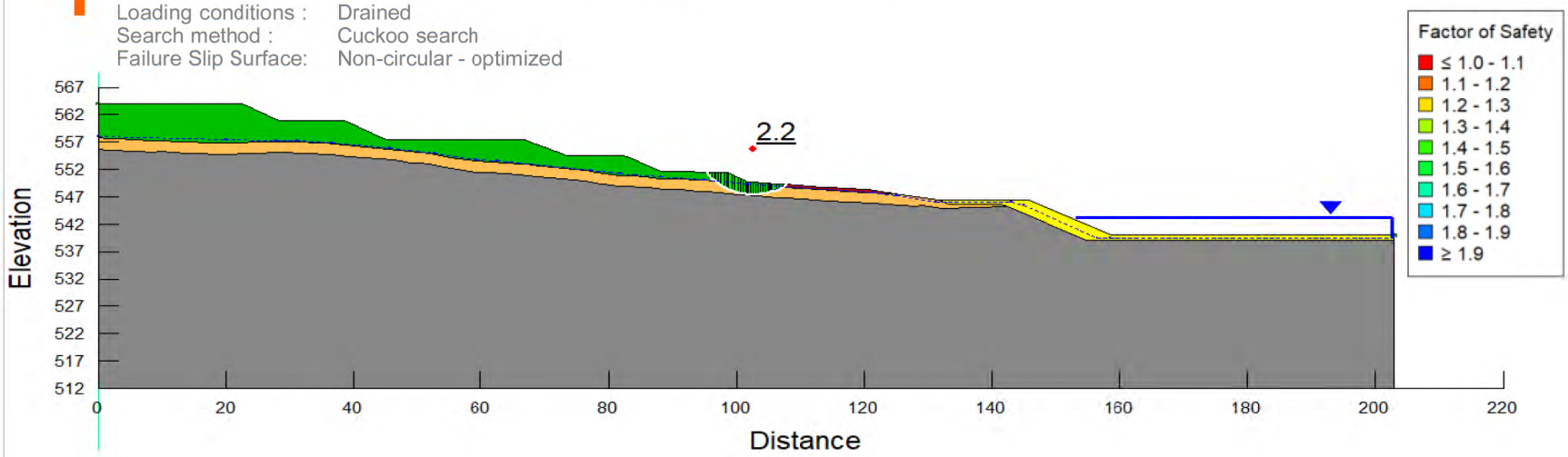
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

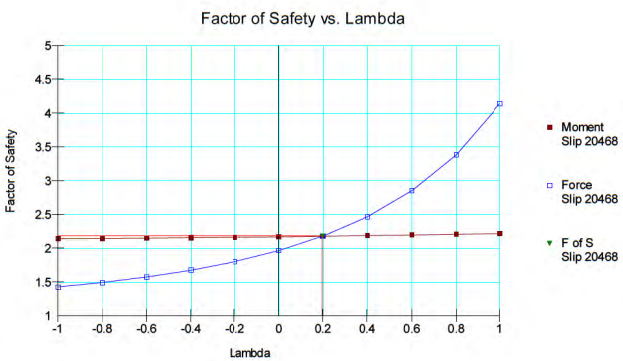
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

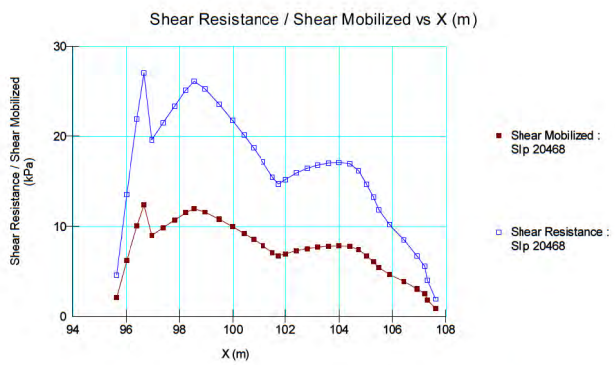
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 19

Section 2 – Stability Analysis (Short-term)

Loading conditions : Drained
Search method : Cuckoo search
Failure Slip Surface: Non-circular - optimized







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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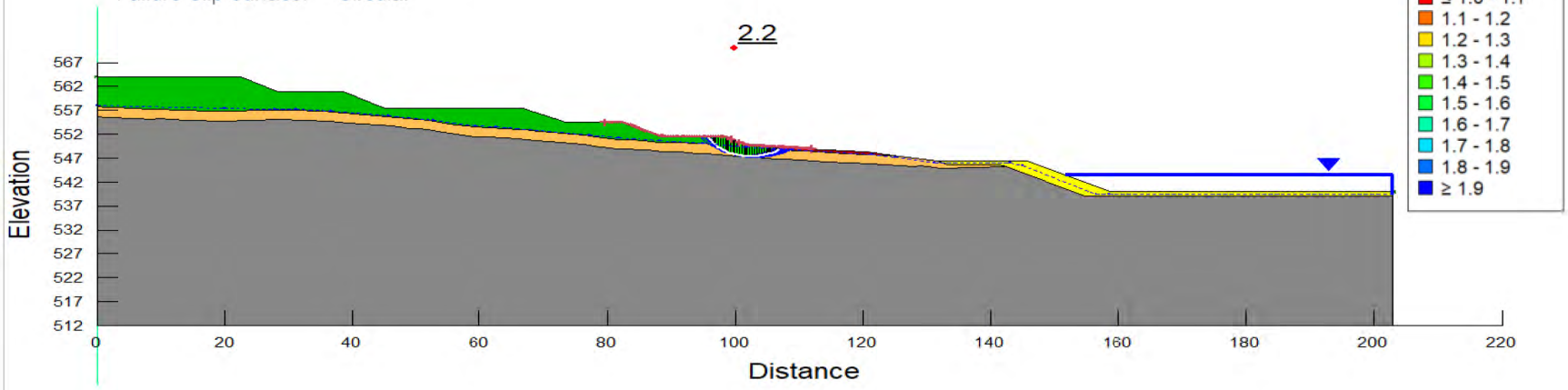
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

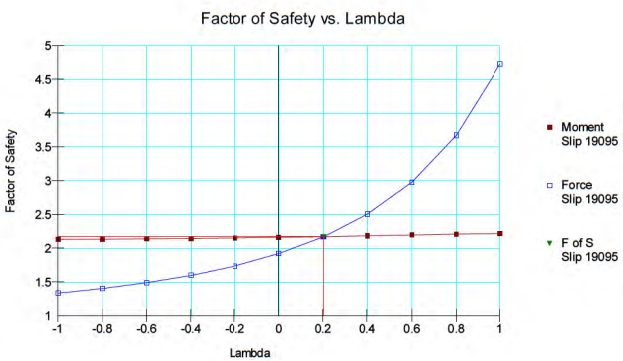
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

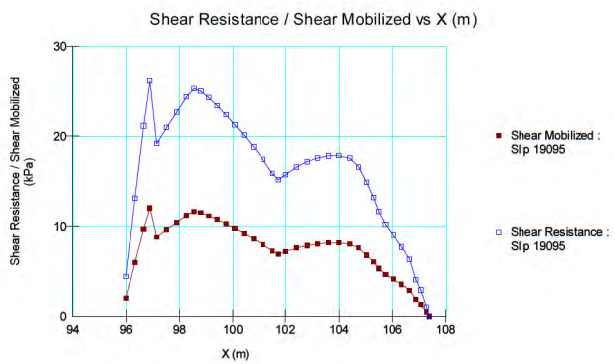
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 20

Section 2 – Stability Analysis (Short-term)

Loading conditions : Drained
Search method : Entry and Exit
Failure Slip Surface: Circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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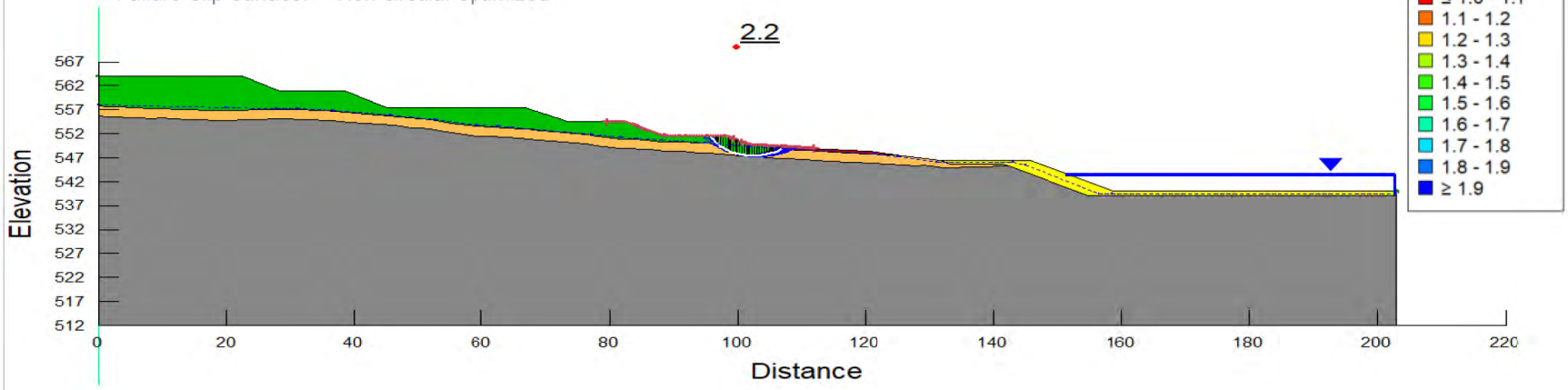
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

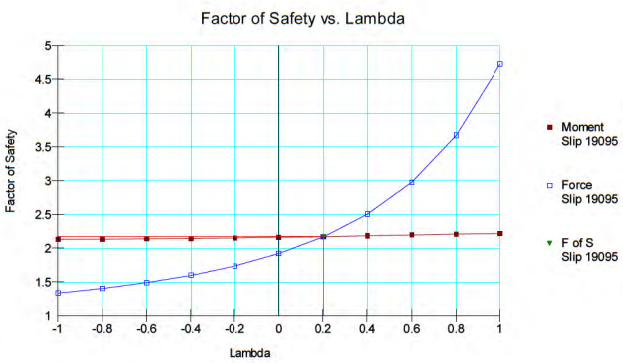
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

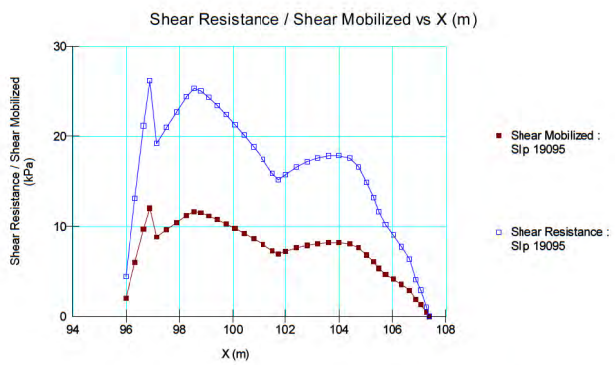
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 21

Section 2 – Stability Analysis (Short-term)

Loading conditions : Drained
Search method : Entry and Exit
Failure Slip Surface: Non-circular optimized







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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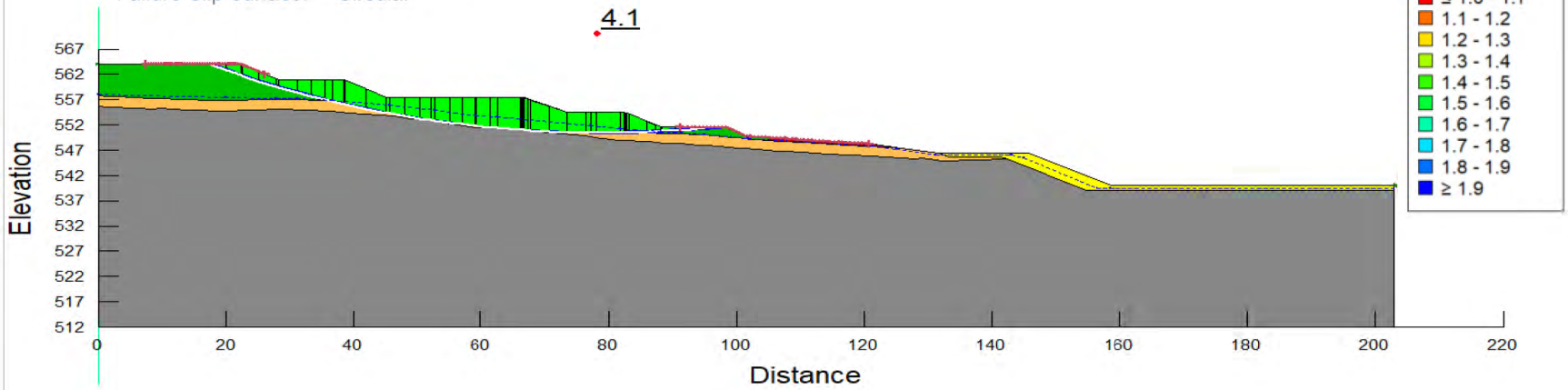
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

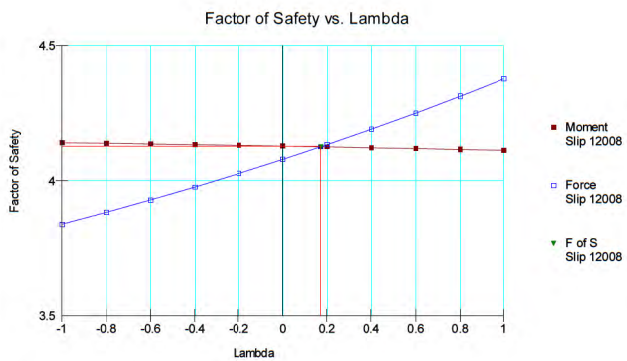
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

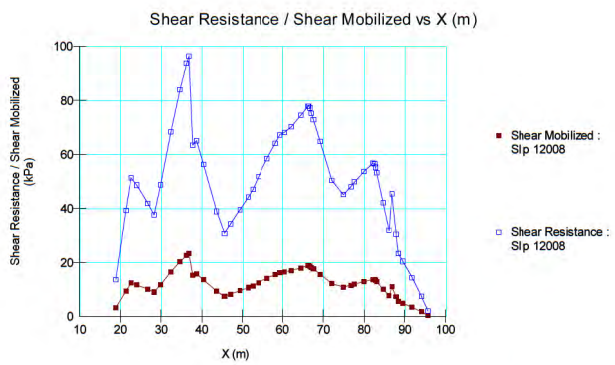
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 22

Section 2 – Stability Analysis - Global (Short-term)

Loading conditions : Drained
Search method : Entry and Exit
Failure Slip Surface: Circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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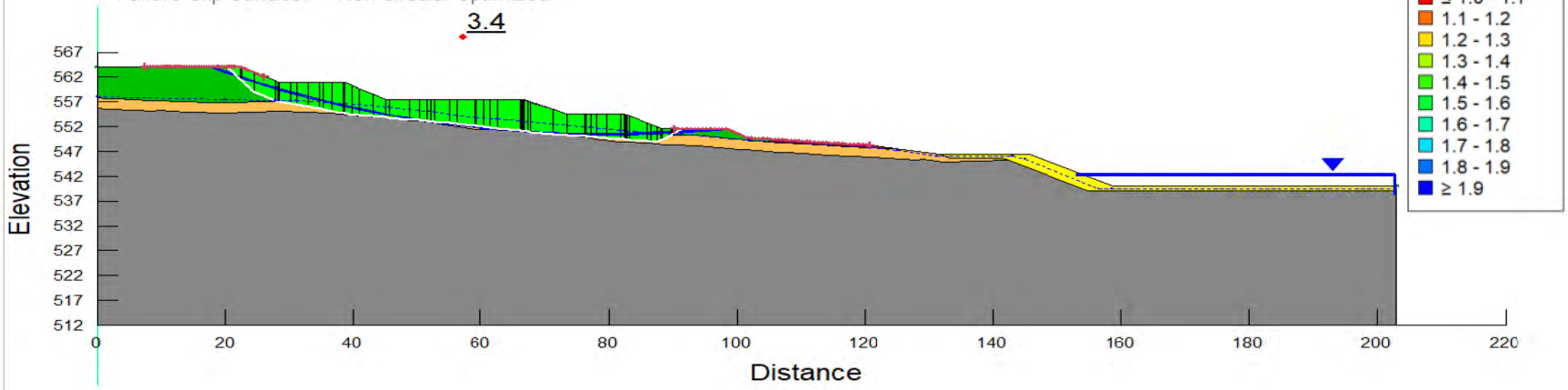
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

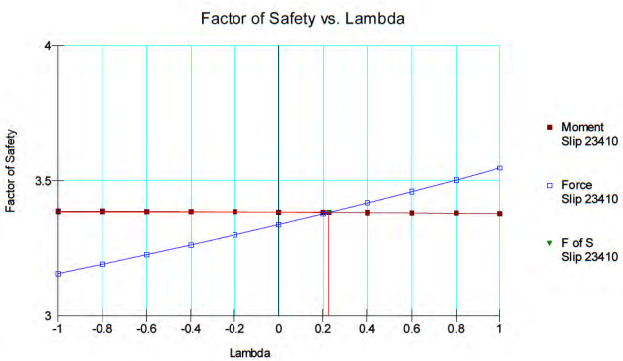
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

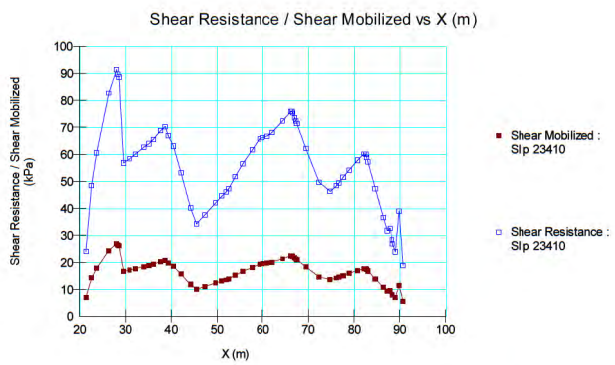
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 23

Section 2 – Stability Analysis - Global (Short-term)

Loading conditions : Drained
Search method : Entry and Exit
Failure Slip Surface: Non-circular optimized







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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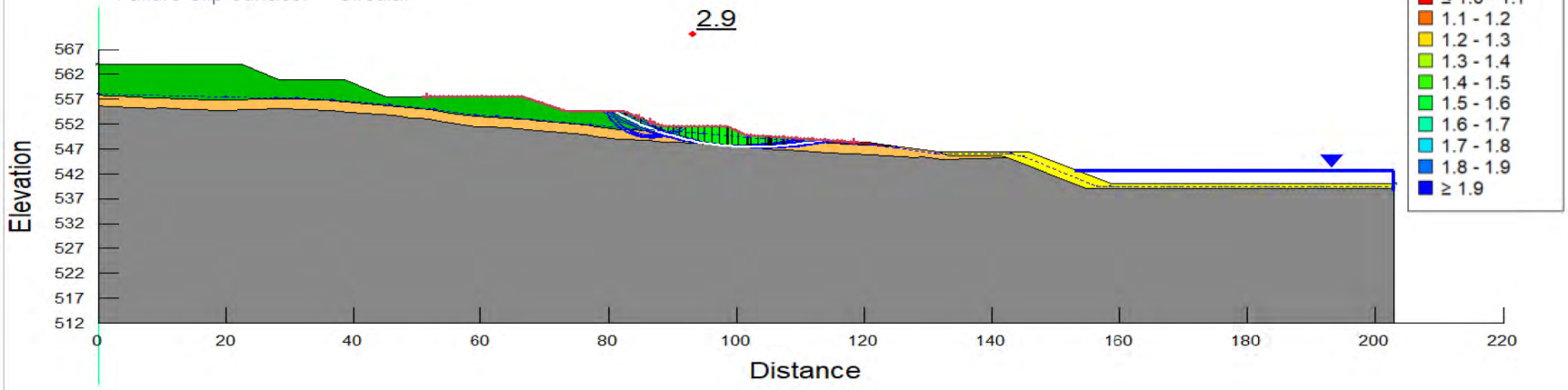
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

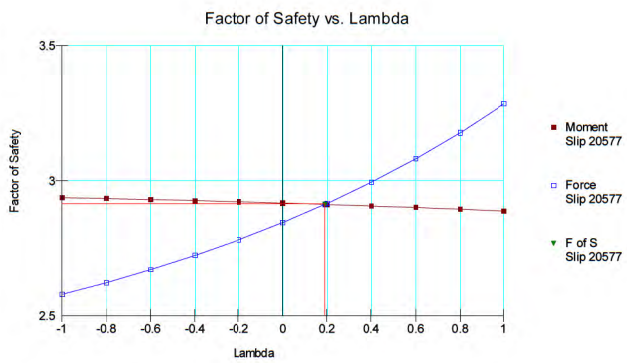
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

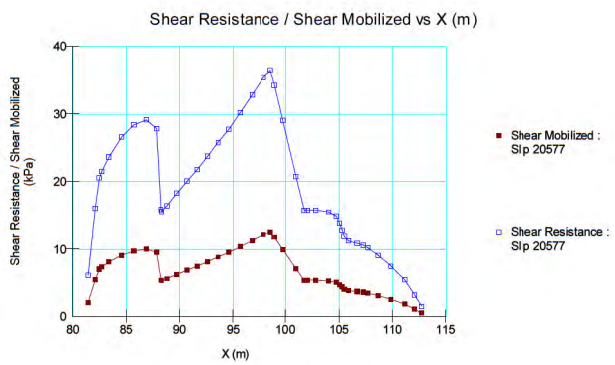
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 24

Section 2 – Stability Analysis - Intermediate (Short-term)

Loading conditions : Drained
Search method : Entry and Exit
Failure Slip Surface: Circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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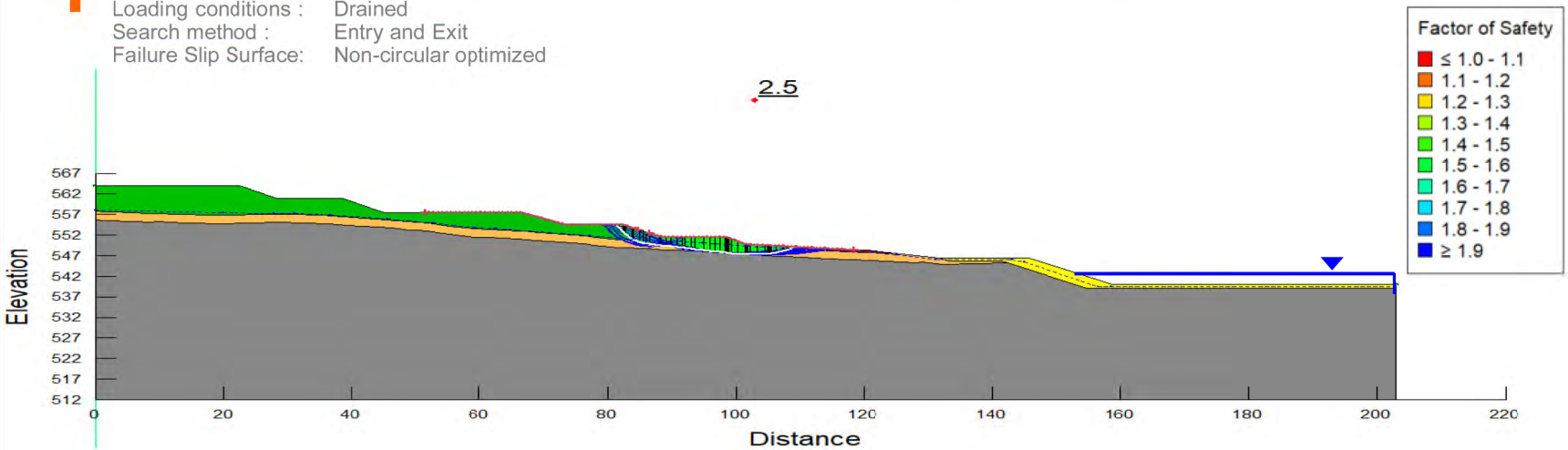
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

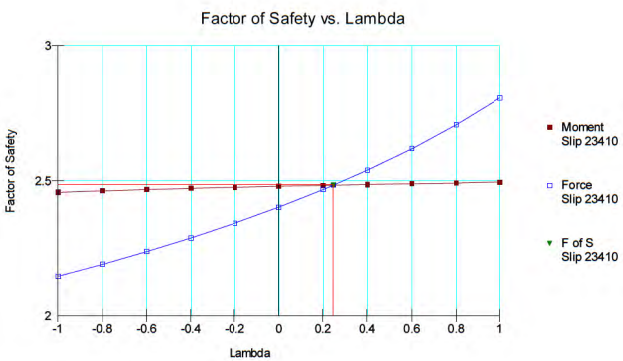
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

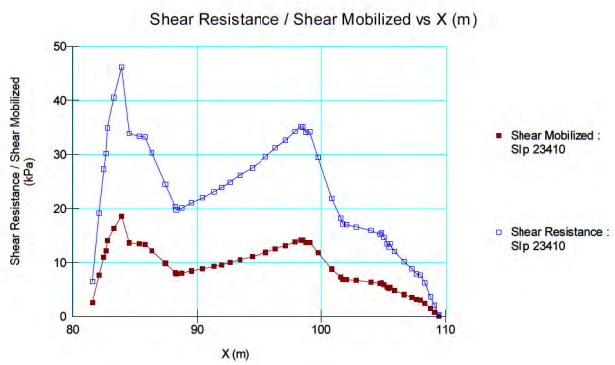
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 25

Section 2 – Stability Analysis - Intermediate (Short-term)

Loading conditions : Drained
Search method : Entry and Exit
Failure Slip Surface: Non-circular optimized







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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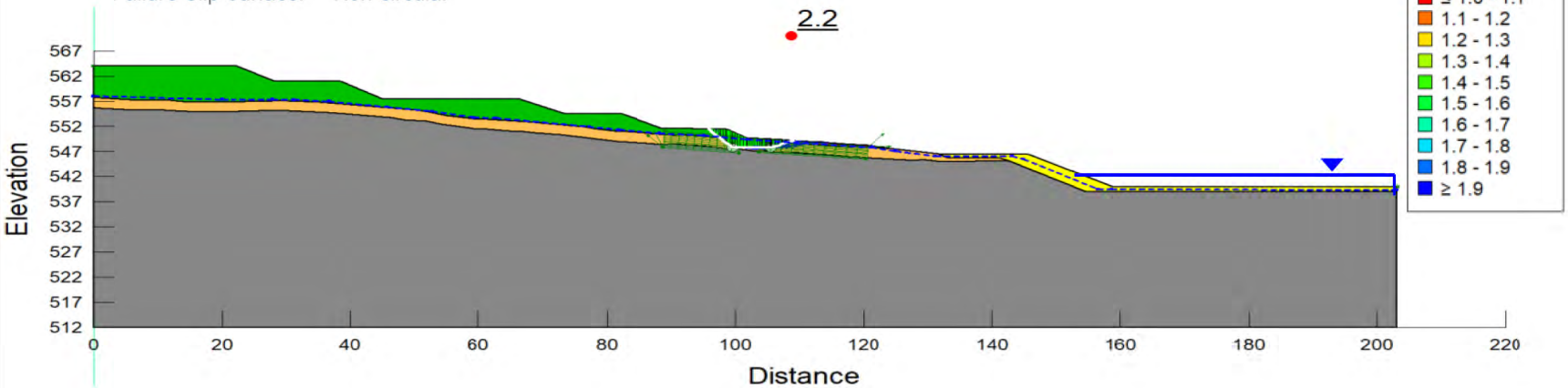
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

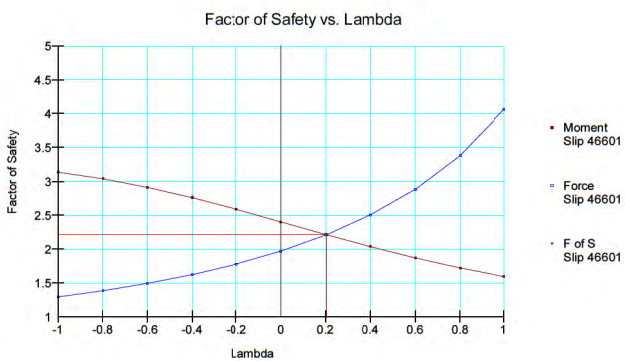
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

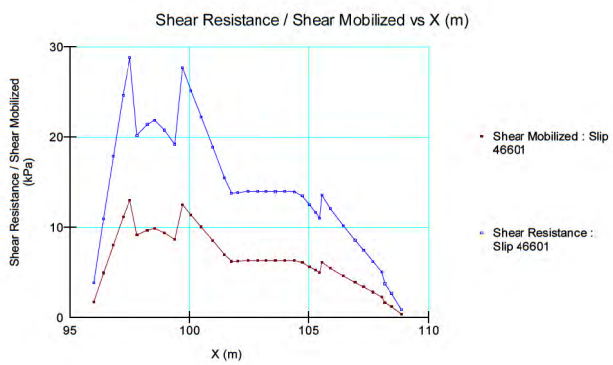
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 26

Section 2 – Stability Analysis (Short-term)

Loading conditions : Drained
Search method : Block Search
Failure Slip Surface: Non-circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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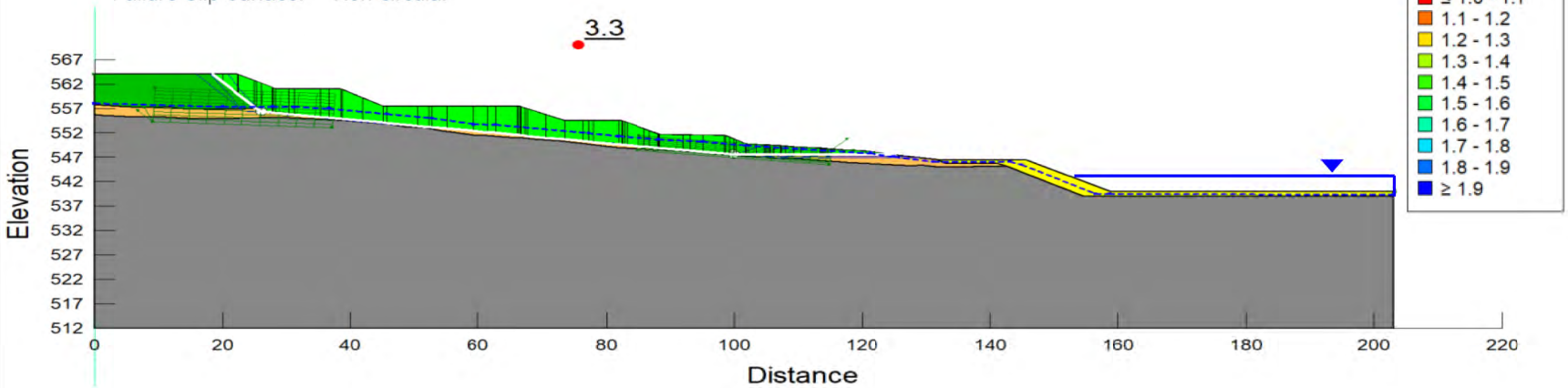
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

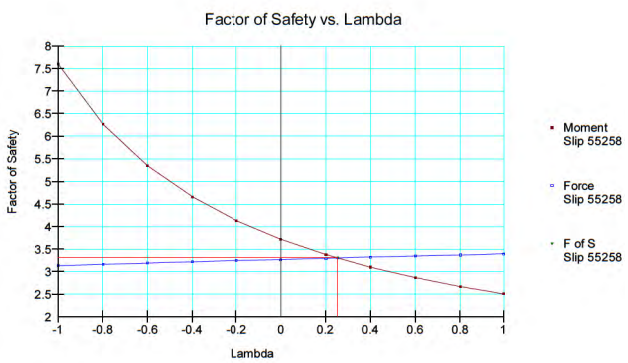
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

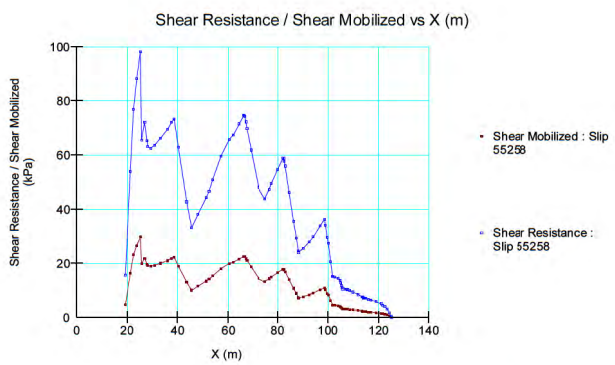
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 27

Section 2 – Stability Global (Short-term)

Loading conditions : Drained
Search method : Block Search
Failure Slip Surface: Non-circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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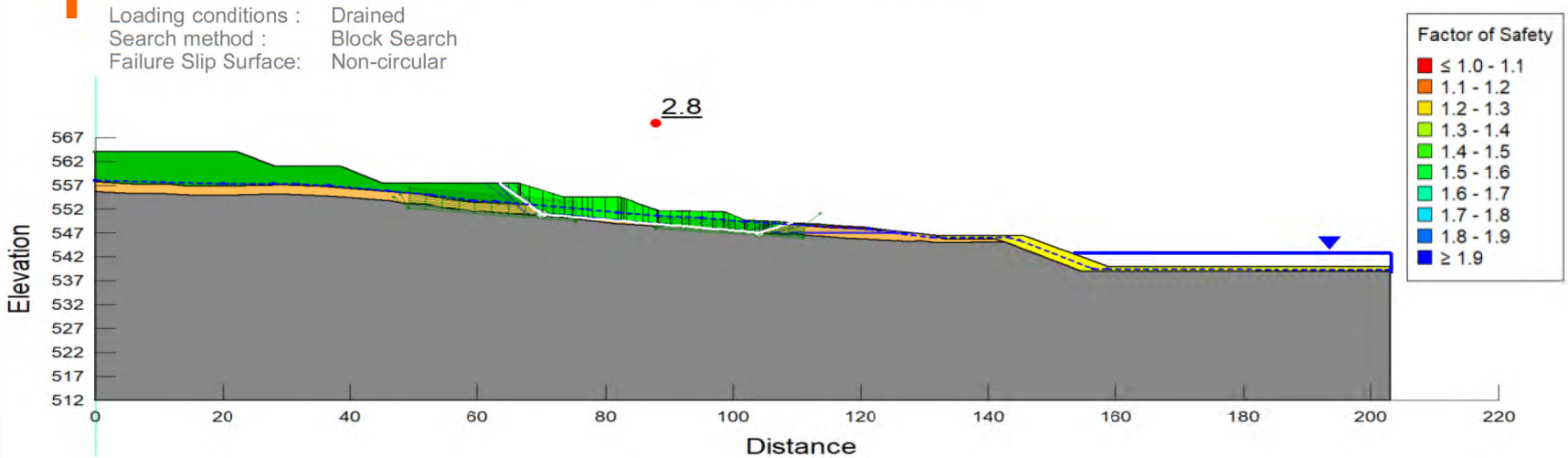
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

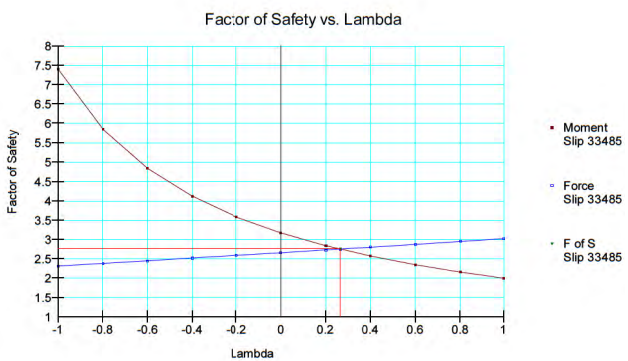
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

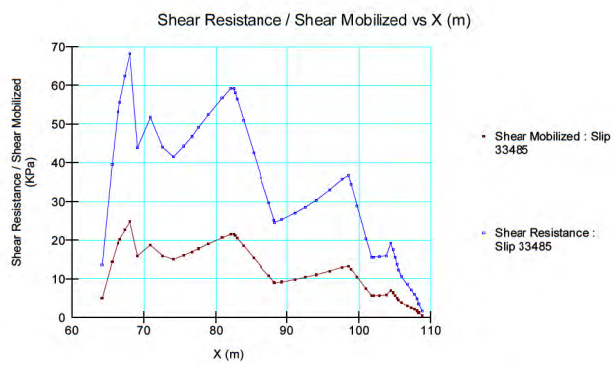
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 28

Section 2 – Stability Intermediate (Short-term)

Loading conditions : Drained
Search method : Block Search
Failure Slip Surface: Non-circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

Title: Stability analysis – Conceptual stockpile design – NMG
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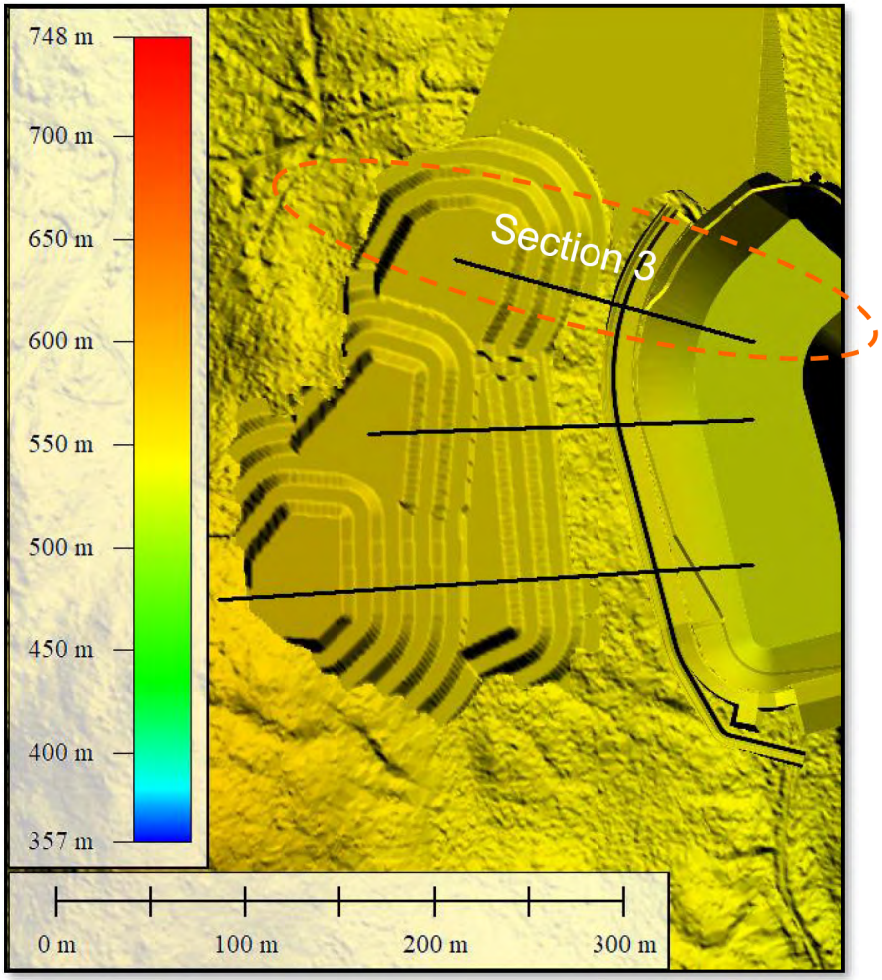
Figure: 29

Location Section 3



Notes:

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NMG NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

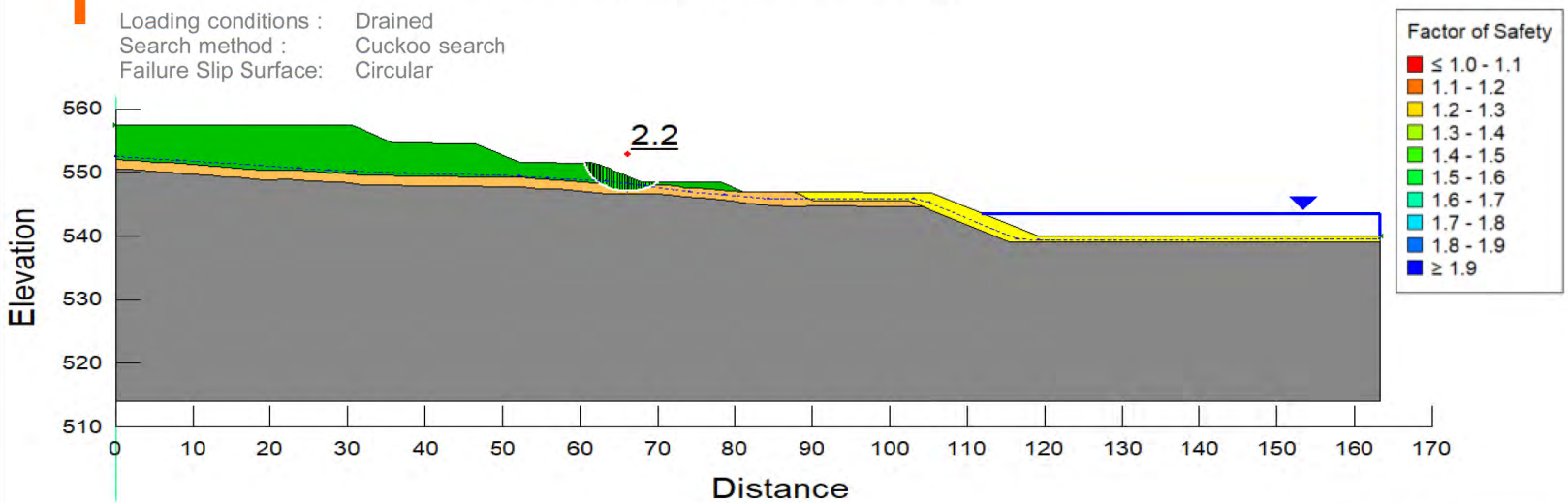
Stability Analysis Results

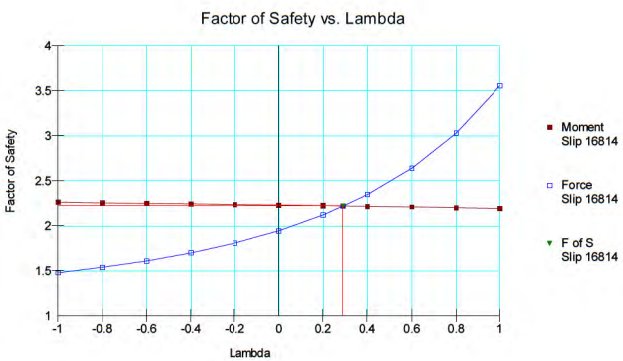
No. de project : CAPR003306
Matawinie Graphite Mine

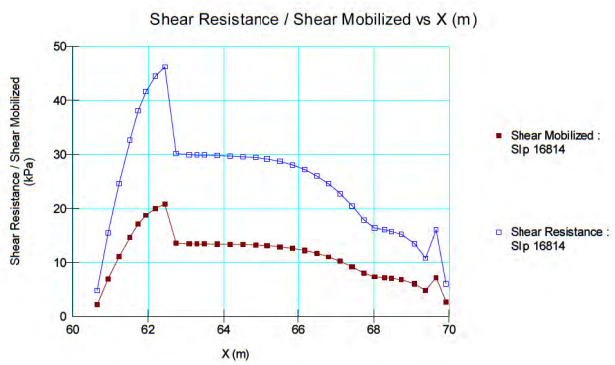
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 30

Section 3 – Stability Analysis (Short-term)

Loading conditions : Drained
Search method : Cuckoo search
Failure Slip Surface: Circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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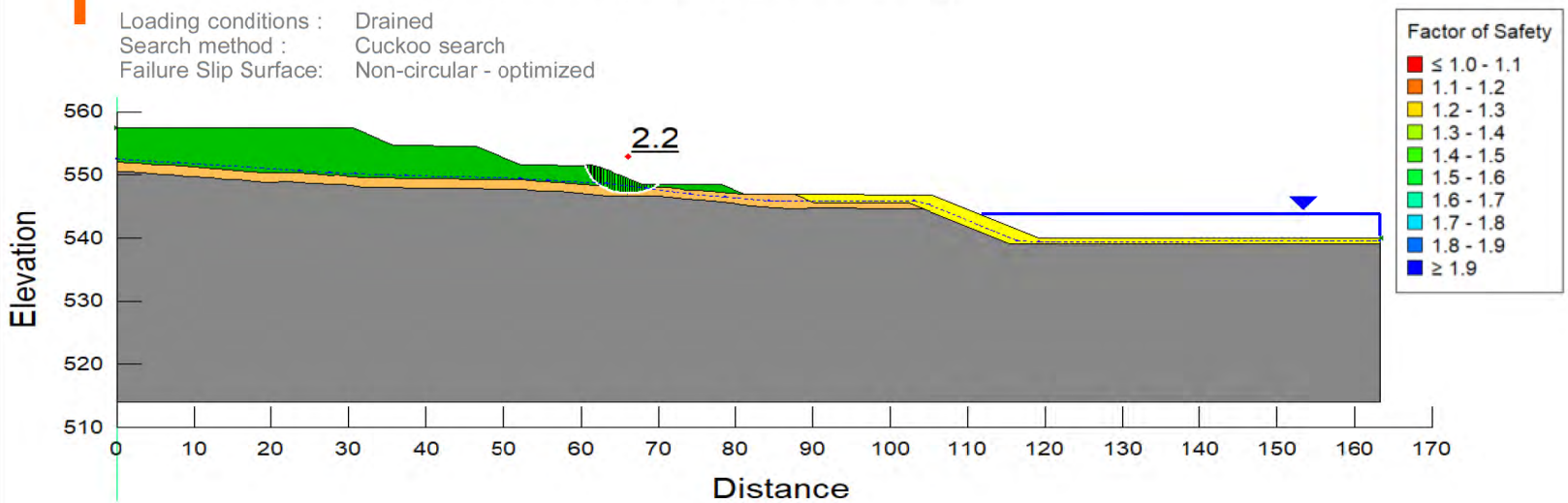
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

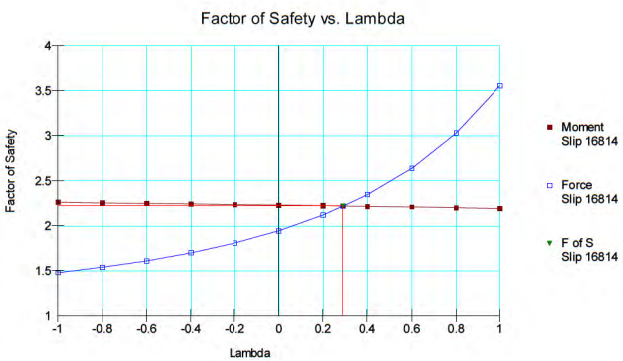
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

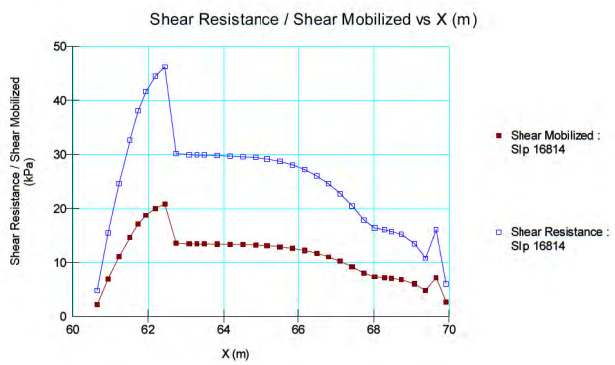
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 31

Section 3 – Stability Analysis (Short-term)

Loading conditions : Drained
Search method : Cuckoo search
Failure Slip Surface: Non-circular - optimized







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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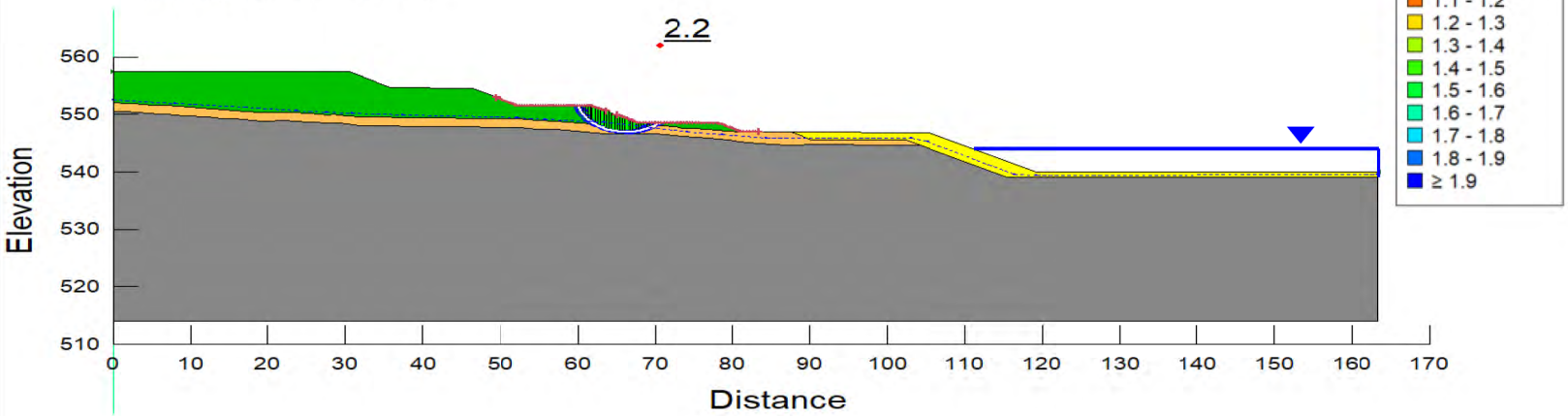
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

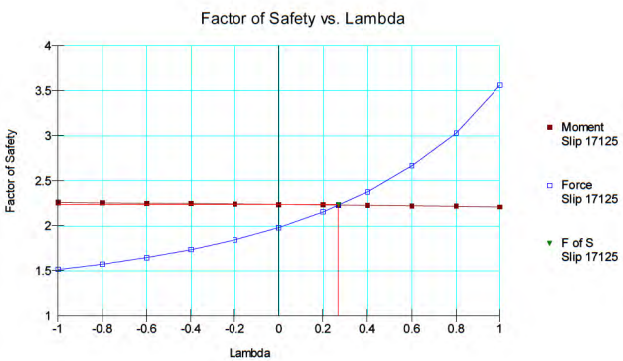
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

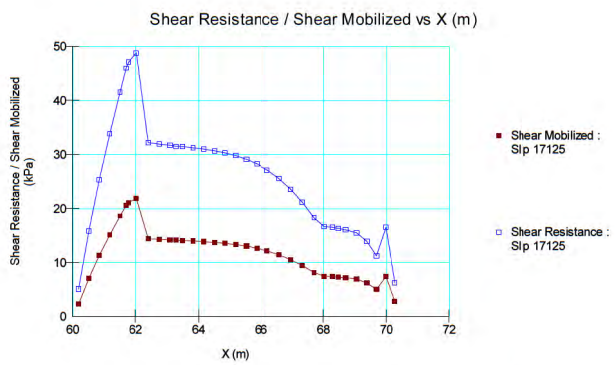
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 32

Section 3 – Stability Analysis (Short-term)

Loading conditions : Drained
Search method : Entry and Exit
Failure Slip Surface: Circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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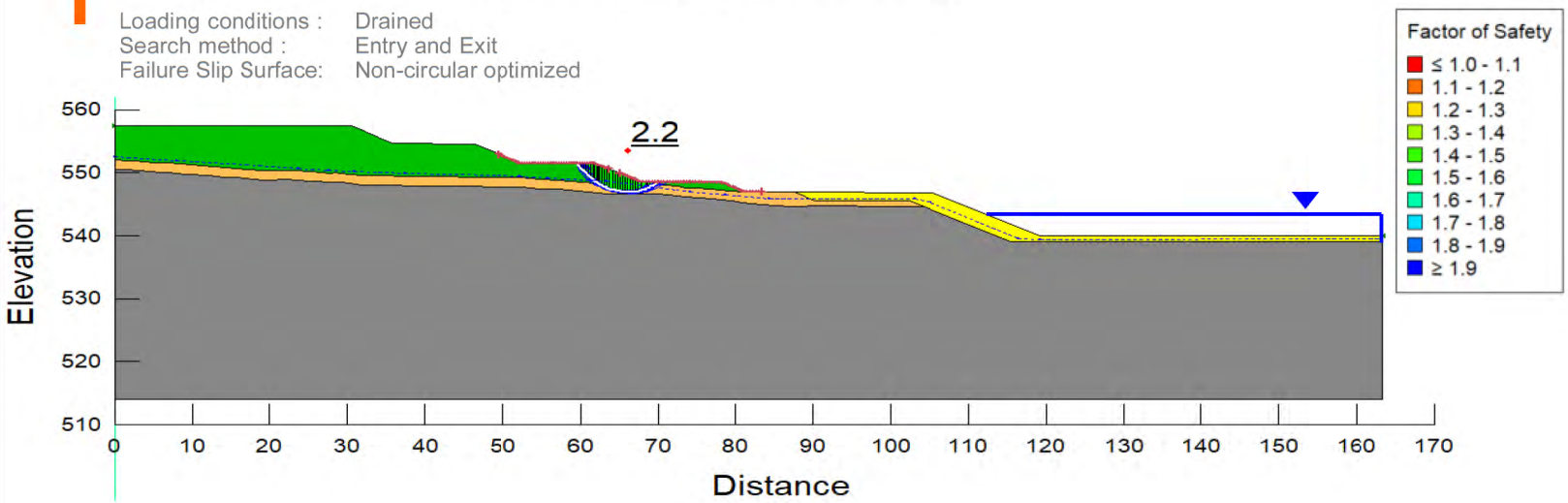
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

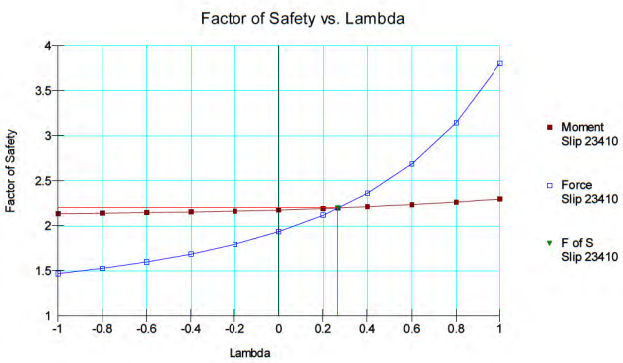
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

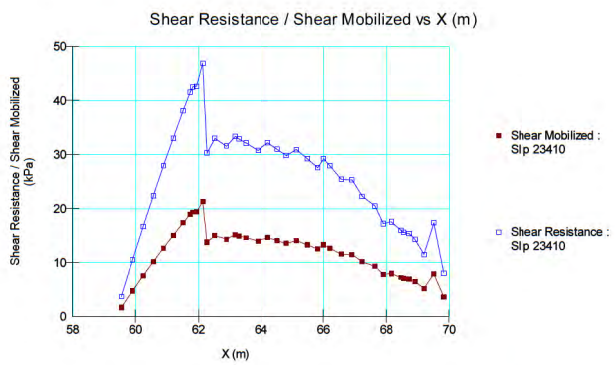
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 33

Section 3 – Stability Analysis (Short-term)

Loading conditions : Drained
Search method : Entry and Exit
Failure Slip Surface: Non-circular optimized







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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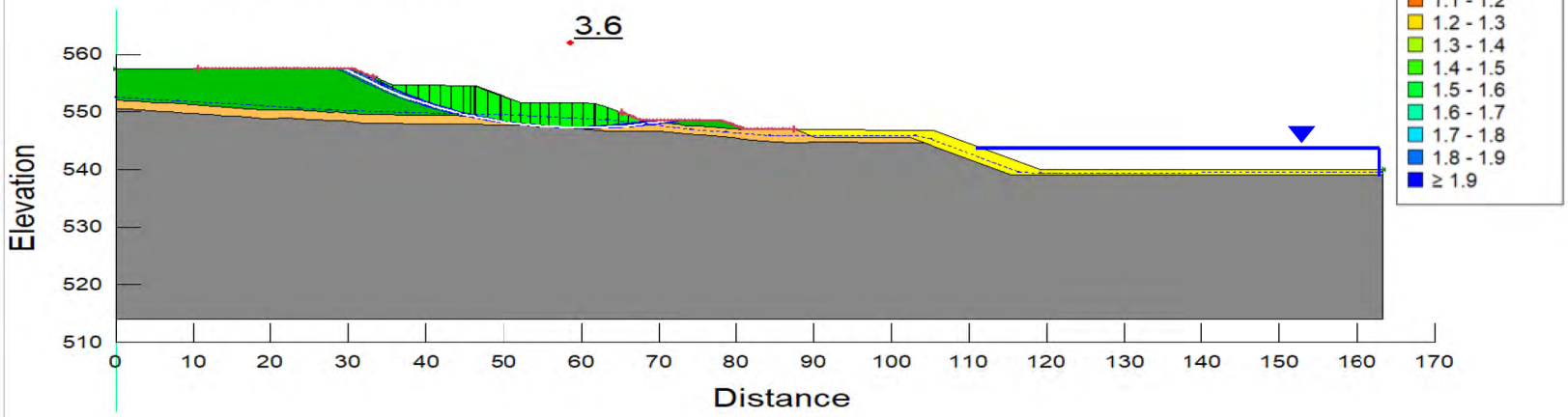
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

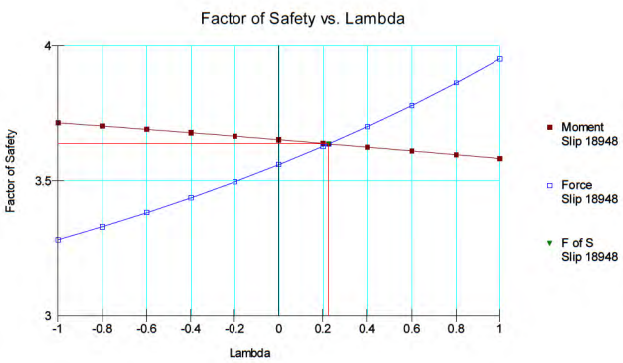
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

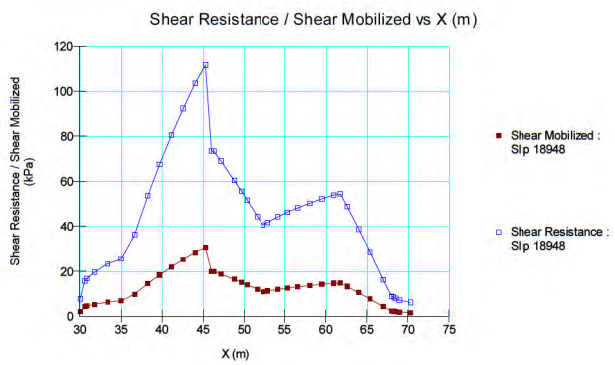
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 34

Section 3 – Stability Analysis - Global (Short-term)

Loading conditions : Drained
Search method : Entry and Exit
Failure Slip Surface: Circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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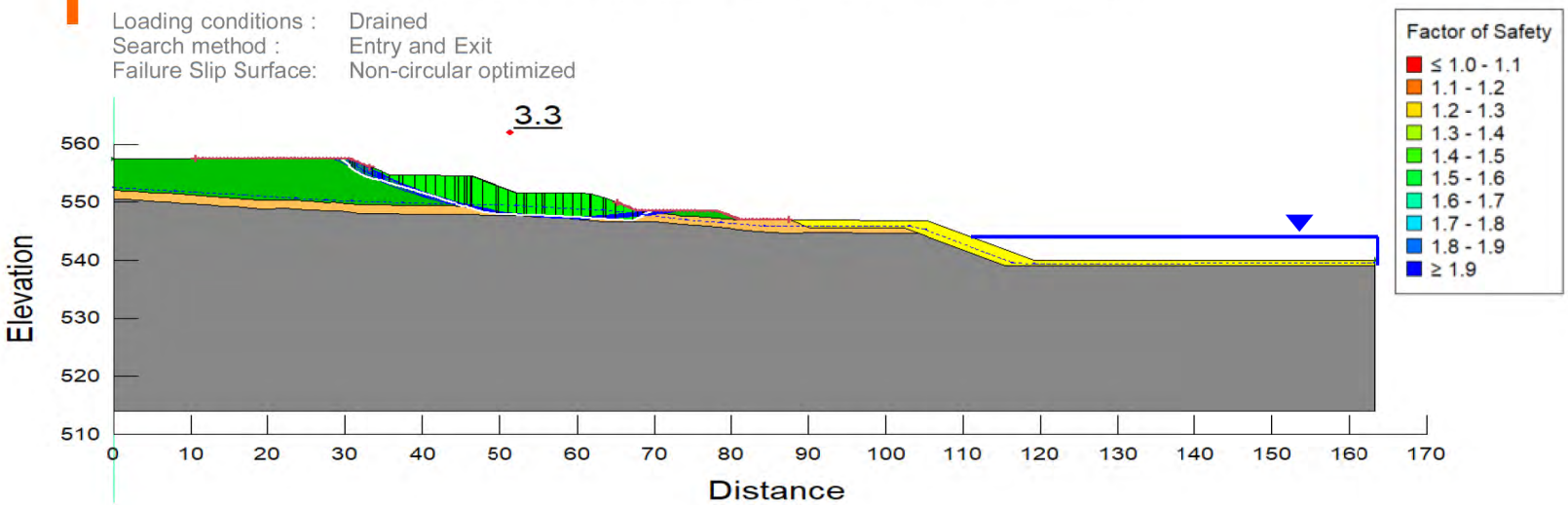
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

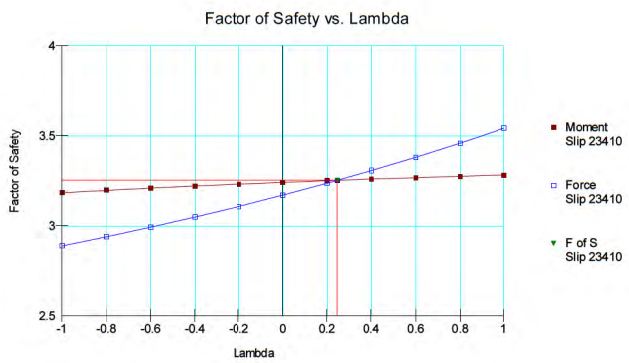
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

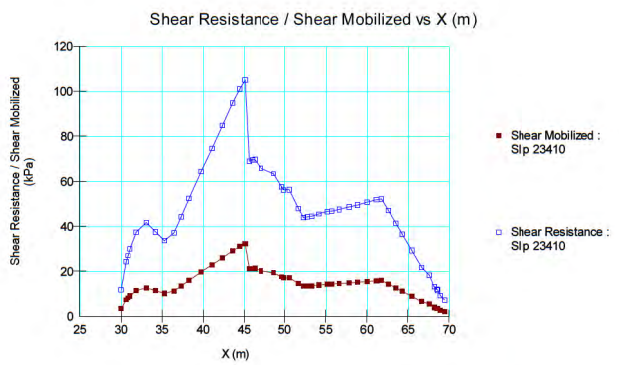
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 35

Section 3 – Stability Analysis - Global (Short-term)

Loading conditions : Drained
Search method : Entry and Exit
Failure Slip Surface: Non-circular optimized







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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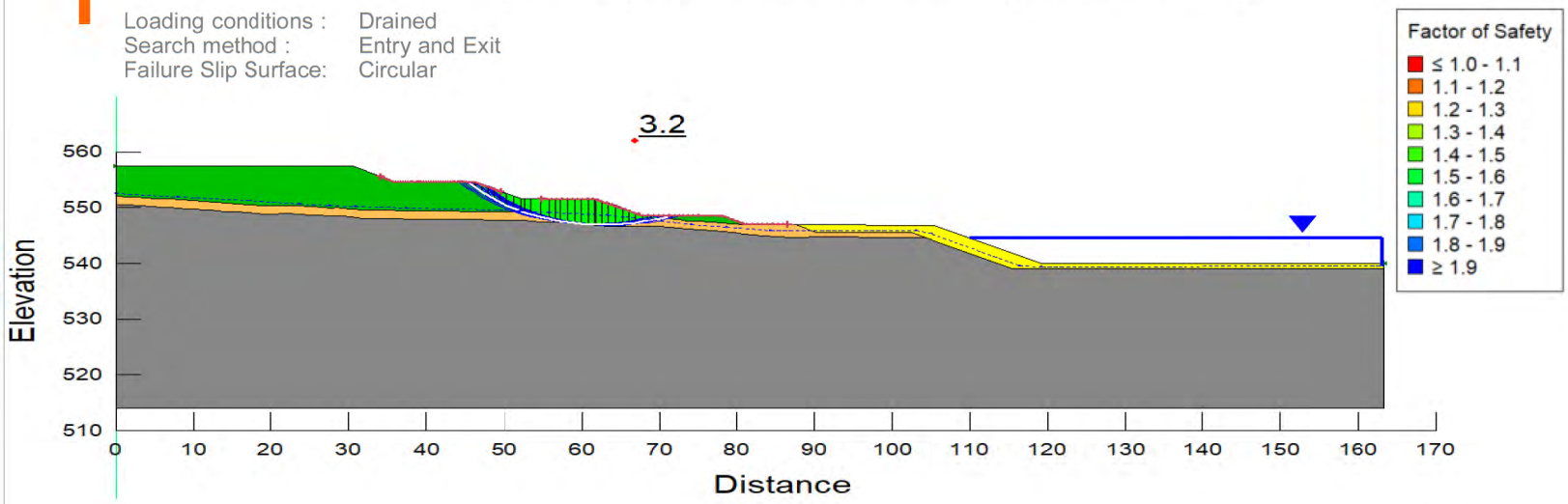
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

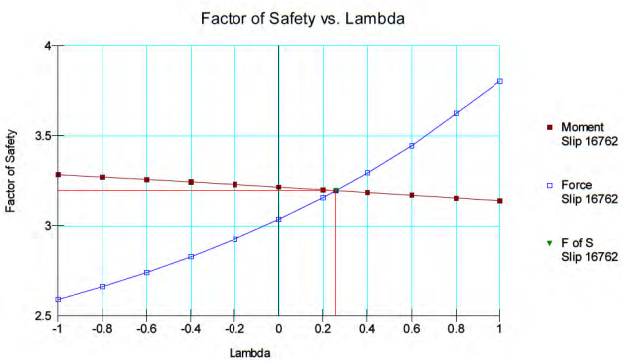
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

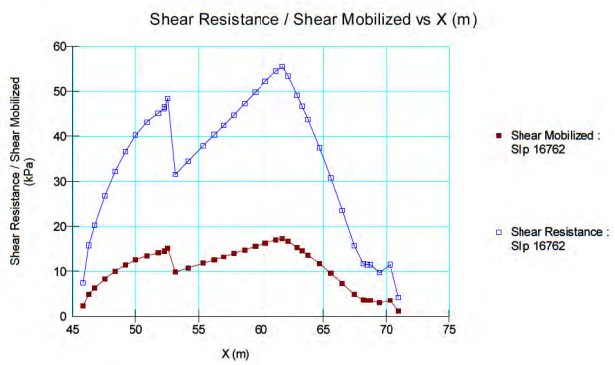
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 36

Section 3 – Stability Analysis - Intermediate (Short-term)

Loading conditions : Drained
Search method : Entry and Exit
Failure Slip Surface: Circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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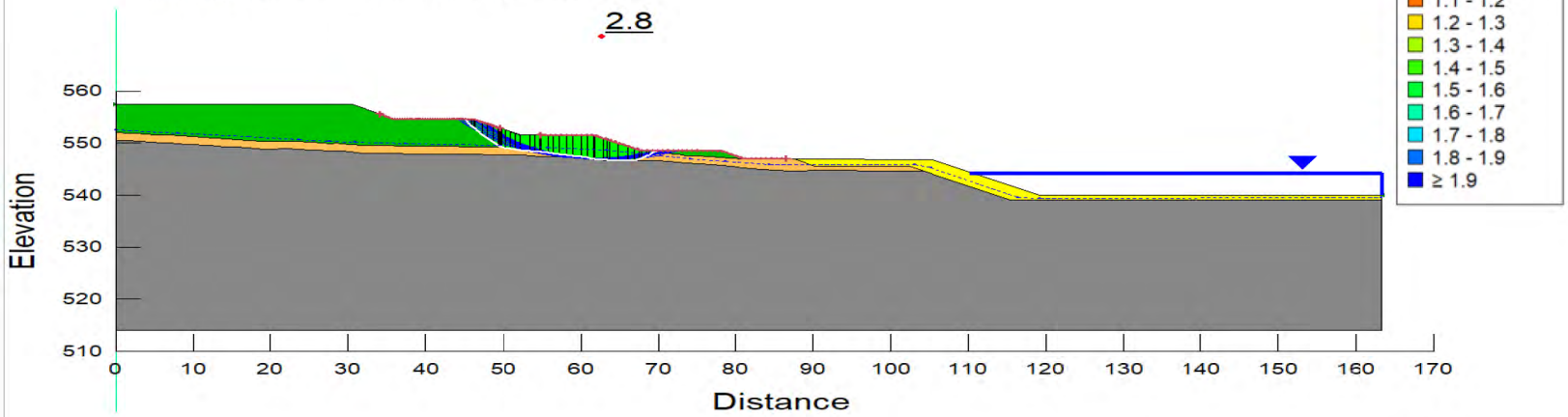
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

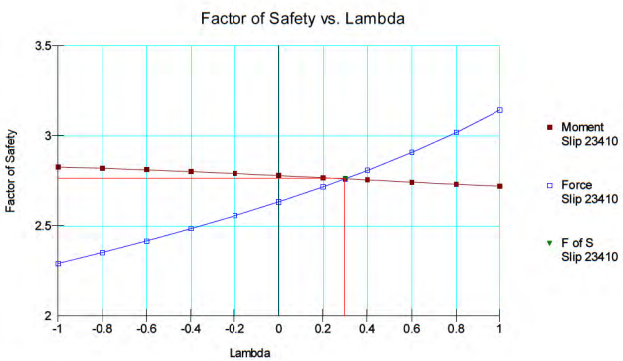
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

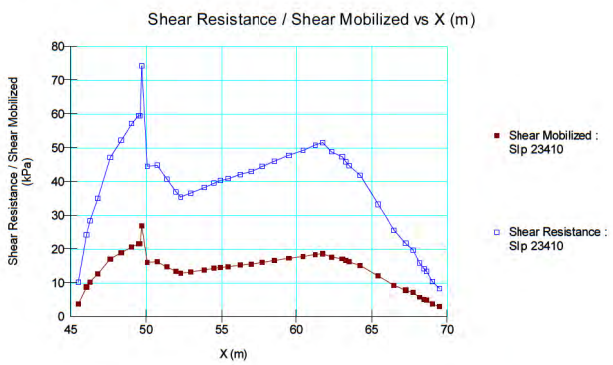
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 37

Section 3 – Stability Analysis - Intermediate (Short-term)

Loading conditions : Drained
Search method : Entry and Exit
Failure Slip Surface: Non-circular optimized







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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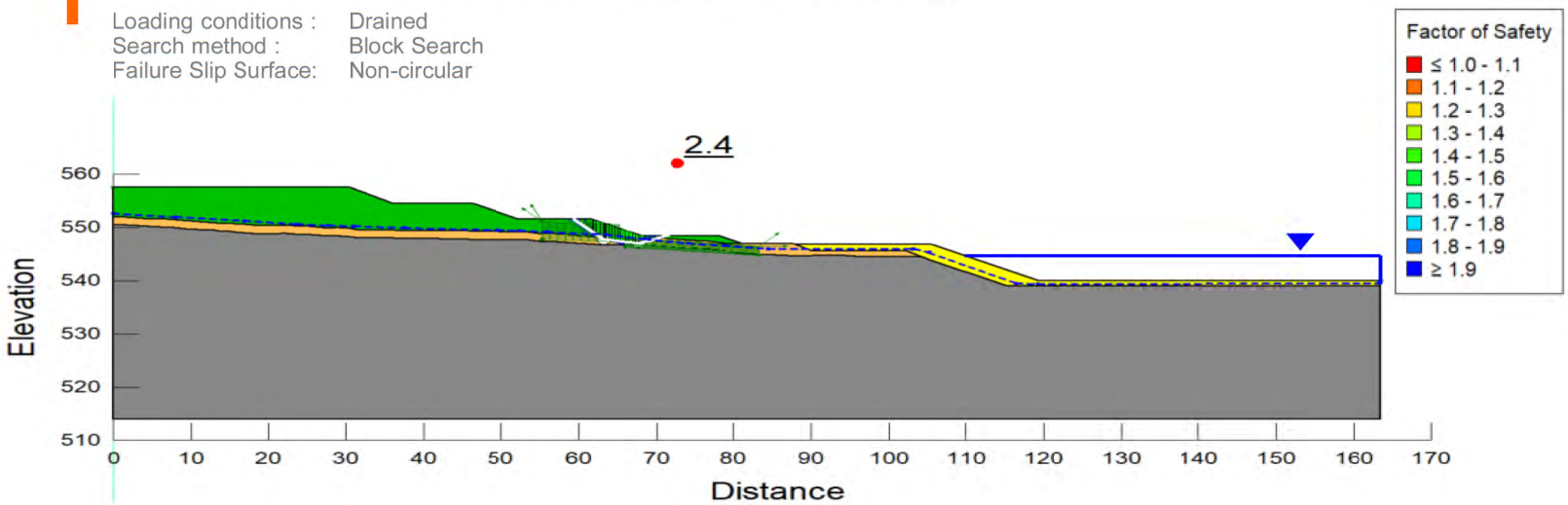
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

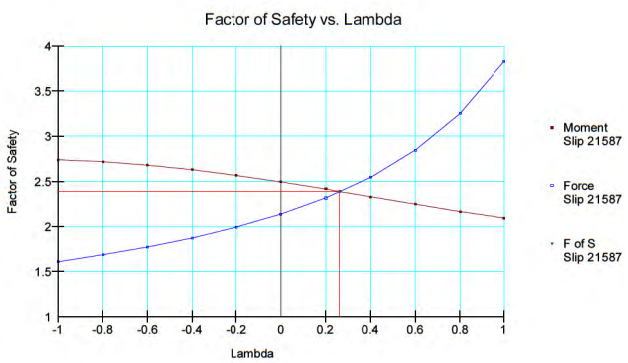
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

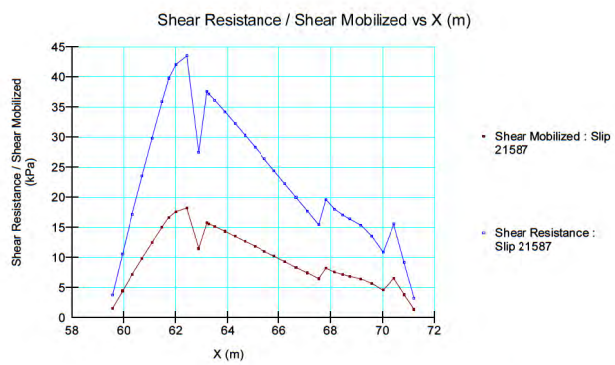
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 38

Section 3 – Stability Analysis (Short-term)

Loading conditions : Drained
Search method : Block Search
Failure Slip Surface: Non-circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-56	Mohr-Coulomb	18	0	33
	Stockpile_lb_leps	Shear/Normal Fn.	25		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left-hand) – Shear strength mobilized (figure at right-hand)
- Momentum Equilibrium (figure at left-hand) – Shear strength (figure at right-hand)

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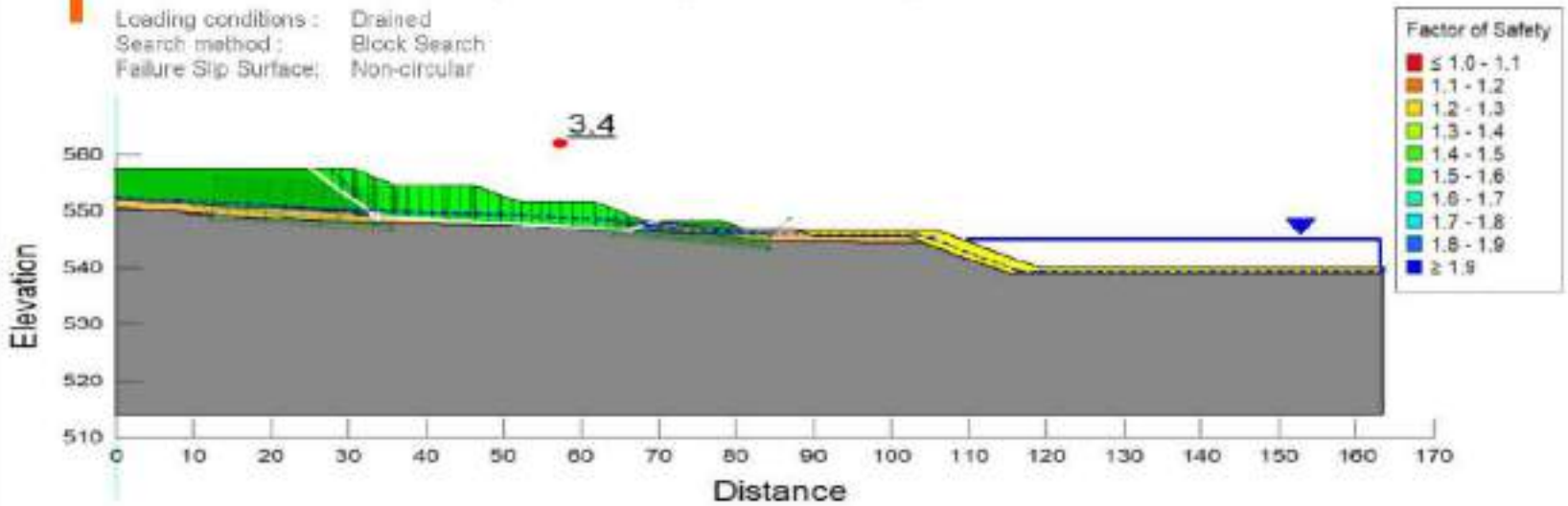
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

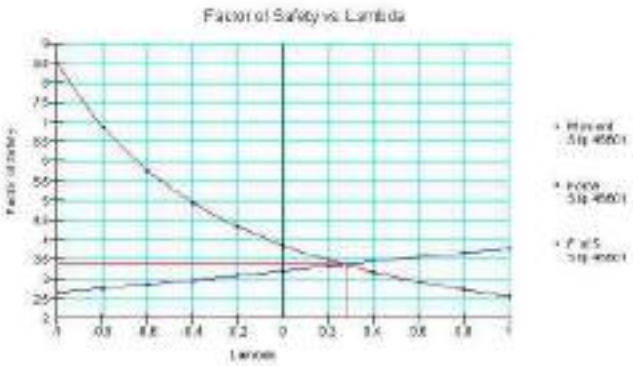
Stability Analysis Results
No. de project : CAPR003306
Matawinie Graphite Mine

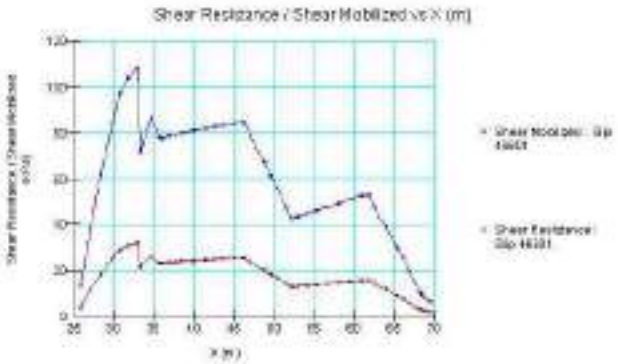
Title: Stability analysis – Conceptual stockpile design – NMG
Date : December 2024
Approved : JFSTL
Figure: 39

Section 3 – Stability Global (Short-term)

Loading conditions : Drained
Search method : Block Search
Failure Slip Surface: Non-circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-66	Mohr-Coulomb	18	0	33
	Stockpile_to_eps	Shear Normal Fn	25		
	Till	Mohr-Coulomb	17	0	32
	Topsoil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left/bottom) – Shear strength mobilized (figure at right/top)
- Momentum Equilibrium (figure at left/bottom) – Shear strength (figure at right/top)

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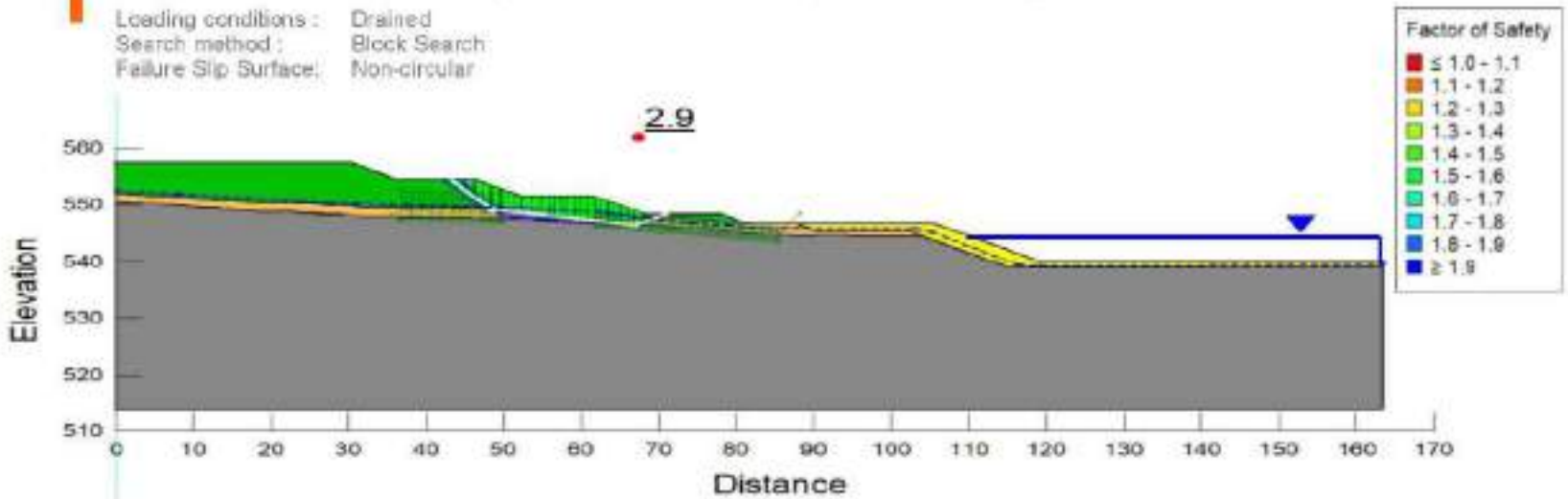
NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

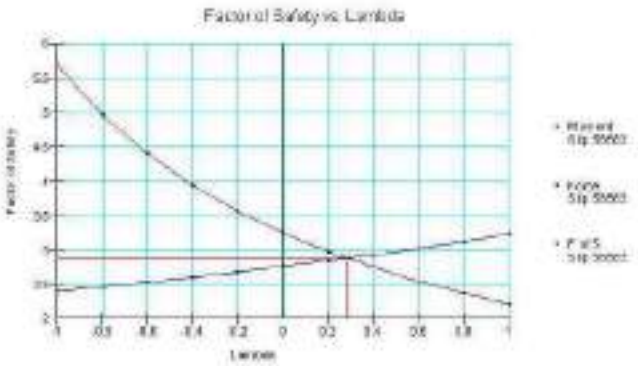
Stability Analysis Results
File name/path: CAPR002006
Matawinie Graphite Mine

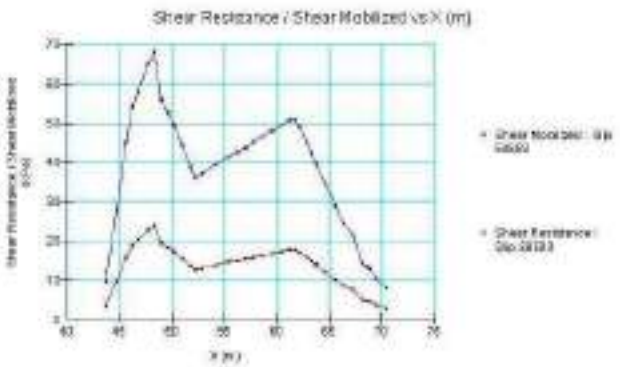
Title: Stability analysis – Conceptual stockpile design – NMG
Date: December 2020
Approved:
Figure: 40

Section 3 – Stability Intermediate (Short-term)

Loading conditions : Drained
Search method : Block Search
Failure Slip Surface: Non-circular







Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Mohr-Coulomb	20	150	38
	Mg-66	Mohr-Coulomb	18	0	33
	Stockpile_to_eps	Shear/Normal Fn	26		
	Till	Mohr-Coulomb	17	0	32
	Top-soil	Mohr-Coulomb	15	0	27

Notes:
- Forces Equilibrium (figure at left hand) – Shear strength mobilized (figure at right hand)
- Momentum Equilibrium (figure at left hand) - Shear strength (figure at right hand)

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NOUVEAU MONDE GRAPHITE
MINE DE GRAPHITE MATAWINIE

Stability Analysis Results
File name project : CAPR02006
Matawinie Graphite Mine

Title: Stability analysis – Conceptual stockpile design – NMG
Date: December 2024
Approved:
Figure: 41

Appendix G Solar Radiation Analysis

NMG - Matawinie Solar Radiation Analysis

CAPR003306

Camilo Gallard

February 14, 2025

Abstract

This report compiles the solar radiation anlaysis that was carried out by SRK Consulting (Canada) Inc. for the Nouveau Monde Graphite Matawinie Site in 2024 to support Engineering Design. The data compilation and subsequent analysis was conducted in the R Software environment.

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List of Tables

Chapter 1

Glossary

- **AMS**: Annual Maximum Series.
- **Daymet**: Reanalysis tool developed by the Oak Ridge National Laboratory and supported by NASA (Thornton et al. 2022).
- **ECCC**: Environment and Climate Change Canada.
- **ERA5**: Reanalysis tool developed by the European Centre for Medium-Range Weather Forecasts (Hersbach et al. 2020).
- **ERA5-Land**: Reanalysis tool based on ERA5 but for Land surfaces and a smaller grid, and developed by the European Centre for Medium-Range Weather Forecasts (Muñoz-Sabater et al. 2021).
- **ET**: Evapotranspiration
- **ET0**: Reference Evapotranspiration
- **IDF**: Intensity-Duration-Frequency (IDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
- **KST**: Kolmogorov–Smirnov Test.
- **MAAT**: Mean Annual Air Temperature.
- **MAP**: Mean Annual Precipitation.
- **MERRA2**: Modern-Era Retrospective analysis from Research and Applications, Version 2, is a global climate reanalysis model from the U.S. National Aeronautics and Space Administration (Gelaro et al. 2017).
- **NMG**: Nouveau Monde Graphite.
- **PCC**: Pearson Correlation Coefficient.
- **PDF**: Precipitation-Duration-Frequency (PDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
- **PMP**: Probable Maximum Precipitation.
- **RH**: Relative Humidity.

- **SRAD**: Shortwave (solar) radiation. Incident shortwave radiation flux density in watts per square meter.
- **SRK**: SRK Consulting (Canada) Inc.
- **SSR**: Surface net shortwave (solar) radiation. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth (both direct and diffuse) minus the amount reflected by the Earth's surface (which is governed by the albedo).
- **SSRD**: Surface short-wave (solar) radiation downwards. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth. This parameter comprises both direct and diffuse solar radiation.
- **Tavg**: Mean or Average Air Temperature over a given temporal unit (day, month, year…).
- **Tdew**: Mean or Average Dew Point Temperature over a given temporal unit (day, month, year…).
- **Tmax**: Maximum Air Temperature over a given temporal unit (day, month, year…).
- **Tmin**: Minimum Air Temperature over a given temporal unit (day, month, year…).

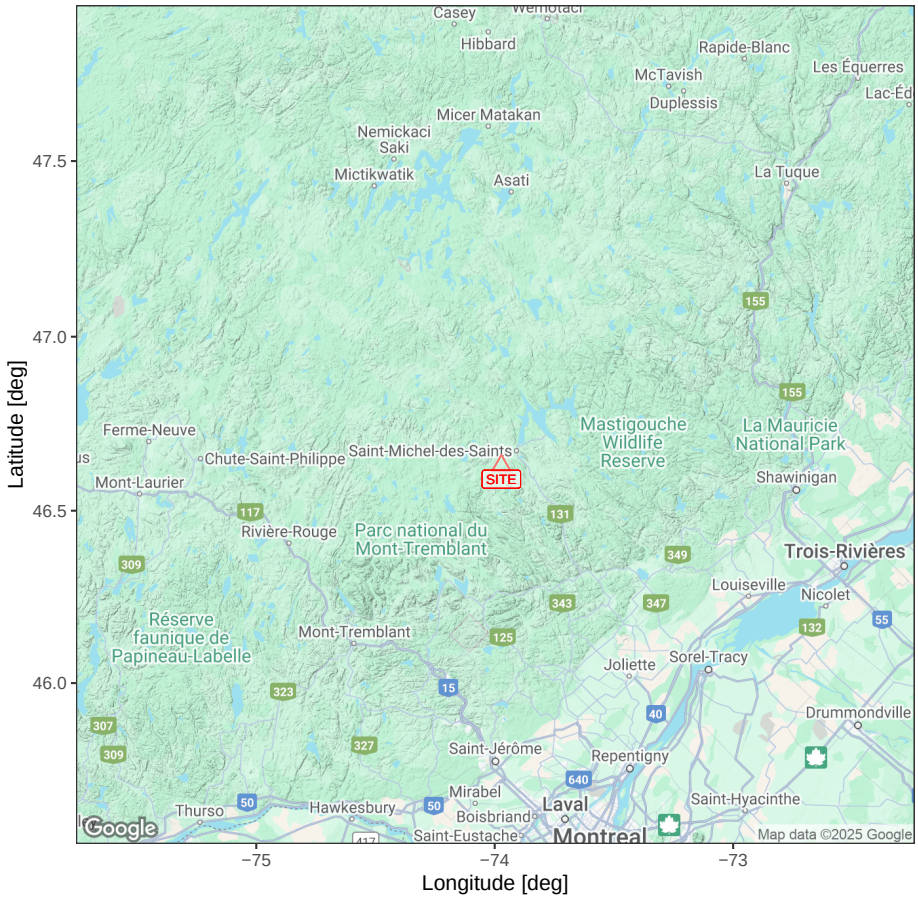
Chapter 2

General Parameters

The NMG Matawinie site is located in southern Quebec, 125 km north of Montreal. Site latitude is 46.63 degrees, and longitude is -73.97 degrees, at an elevation of 562 masl. These coordinates were selected to match the location of the meteorological station on site.

Site Location and Area of Interest for this Study

Area of interest covers a distance of up to 125km from Site



Chapter 3

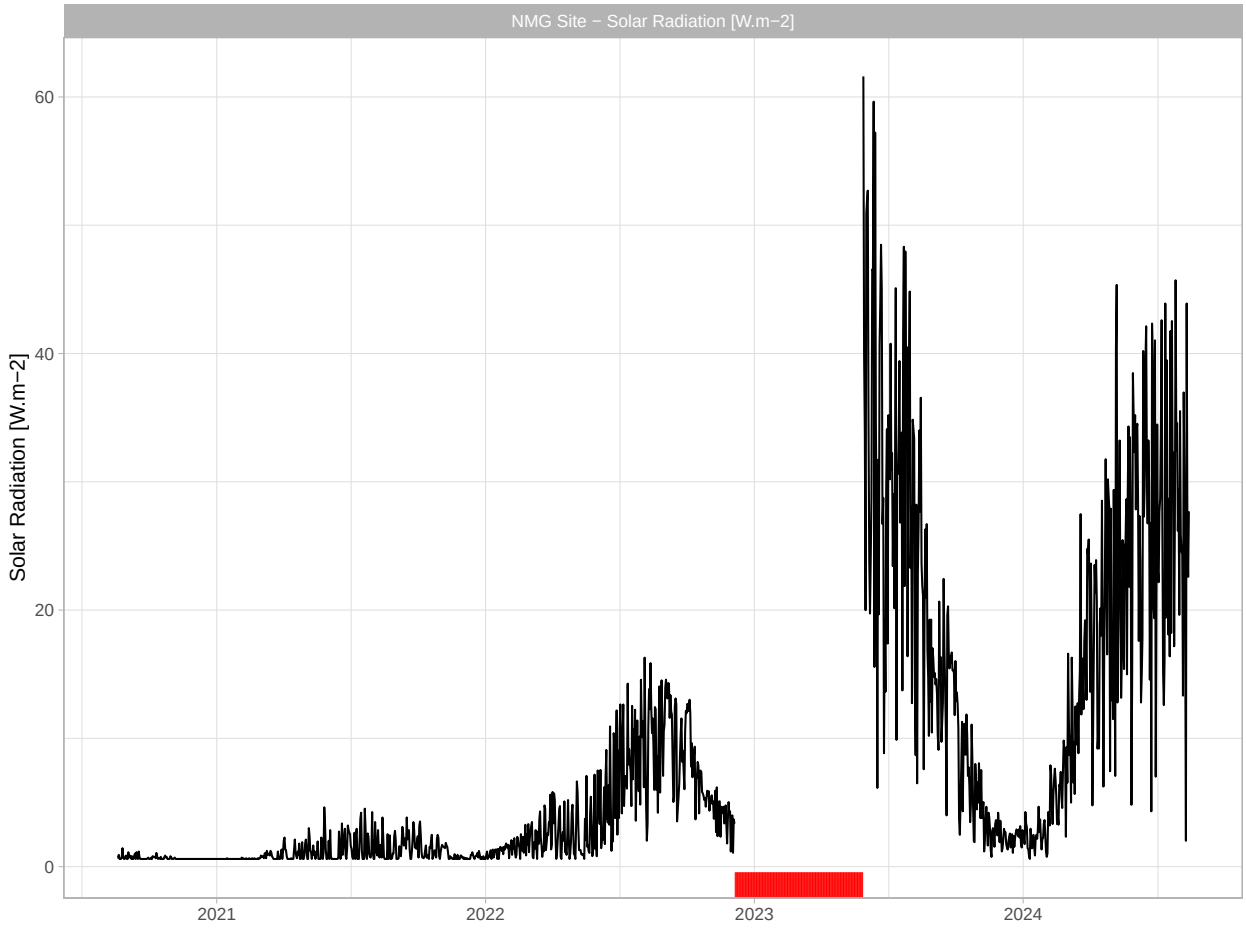
NMG Data

Site data is collected by NMG from two meteorological stations. The first station is located on Site, and the second station, called SoftdB, is located 1.5 km north at the following address: 200 Chemin des Hauteurs, Saint-Michel-des-Saints. SoftdB station does not measure solar radiation and was left out of this analysis.

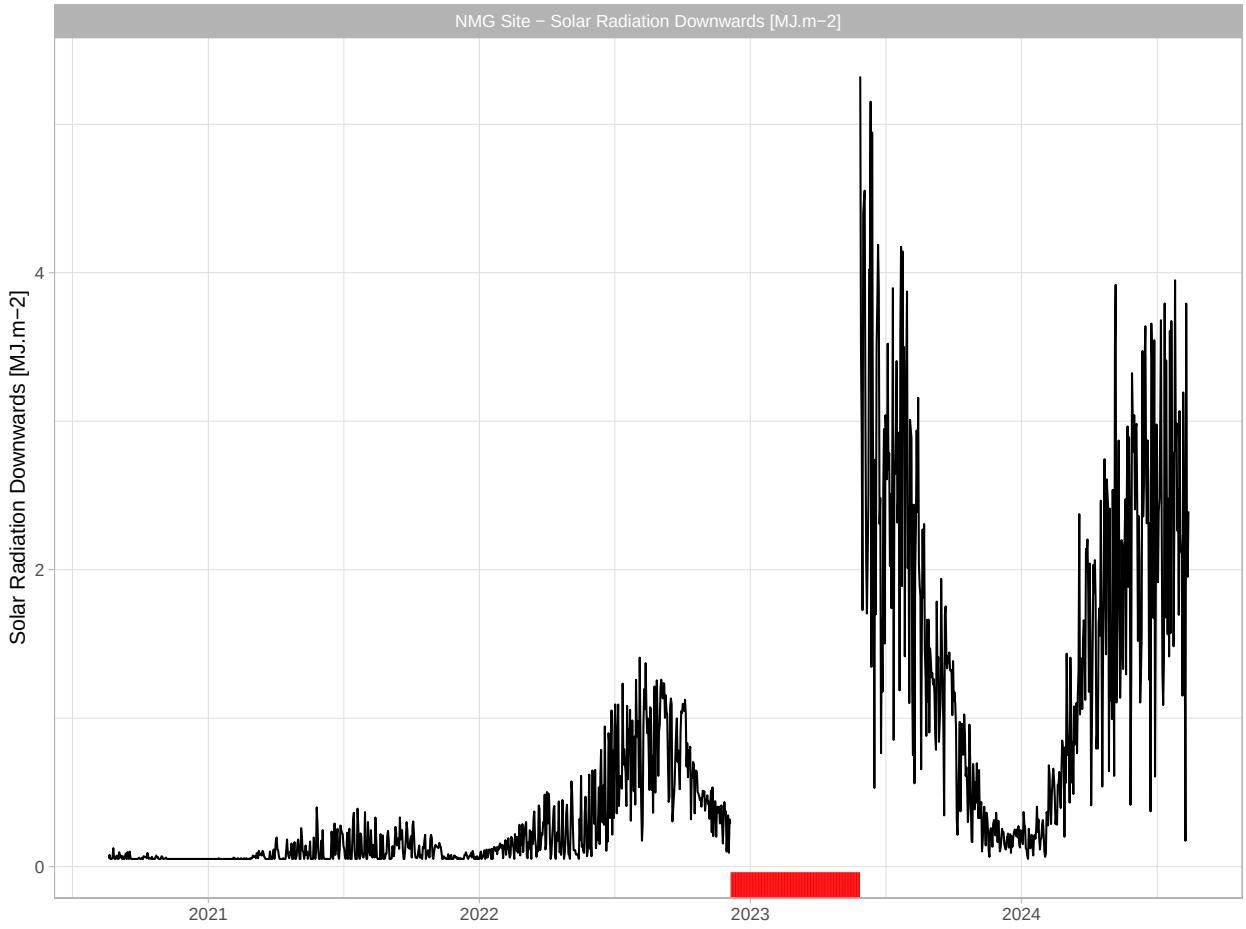
The following graph summarizes average daily NMG solar radiation measurements on site. Solar radiation downwards was calculatred by multiplying daily average SRAD by day lenght in seconds.

Records prior to station reconnection in the summer of 2023 are considered unreliable due to low values compared to usual solar radiation ranges. In 2023 the recorded values are within an order of magnitude of usual observations in the region.

NMG Stations Average Daily Solar Radiation Records and Missing Data



NMG Stations Daily Solar Radiation Downwards Records and Missing Data



Chapter 4

Reanalysis Data

Similarly to wind data, solar radiation can be variable over short distance in mountain regions due to vegetation cover, and slope orientation relative to the sun. MERRA2 and ERA5 grid sizes (>30km) are too large to be realistically representative of site. Daymet and ERA5-Land are the reanalysis tools selected for solar radiation analysis.

Typically solar radiation is evaluated in terms of surface solar radiation downwards (SSRD). This parameter is the amount of solar radiation that reaches a horizontal plane at the surface of the Earth. This parameter comprises both direct and diffuse solar radiation. Radiation from the Sun is partly reflected back to space by clouds and particles in the atmosphere (aerosols) and some of it is absorbed. The rest is incident on the Earth's surface (represented by this parameter).

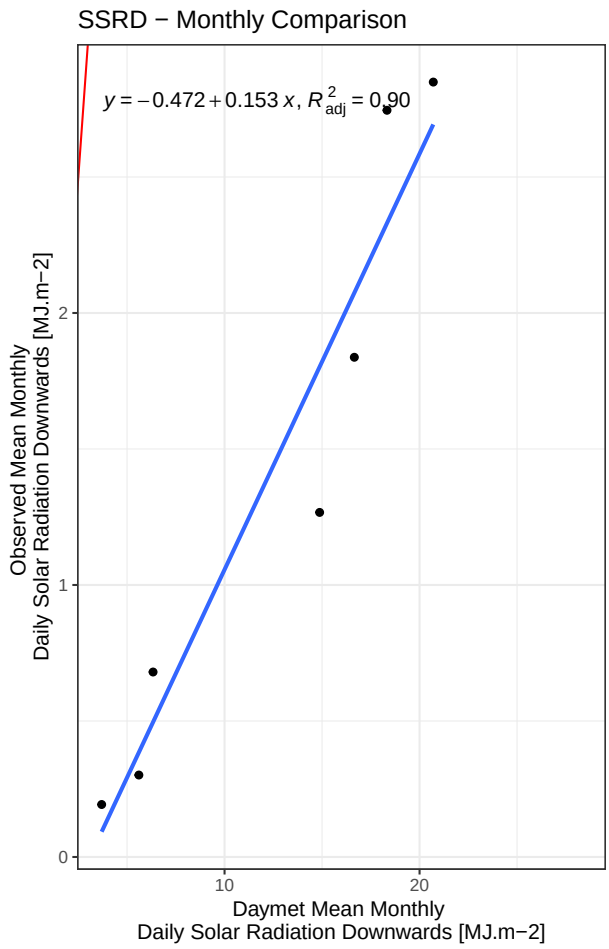
4.1 Daymet

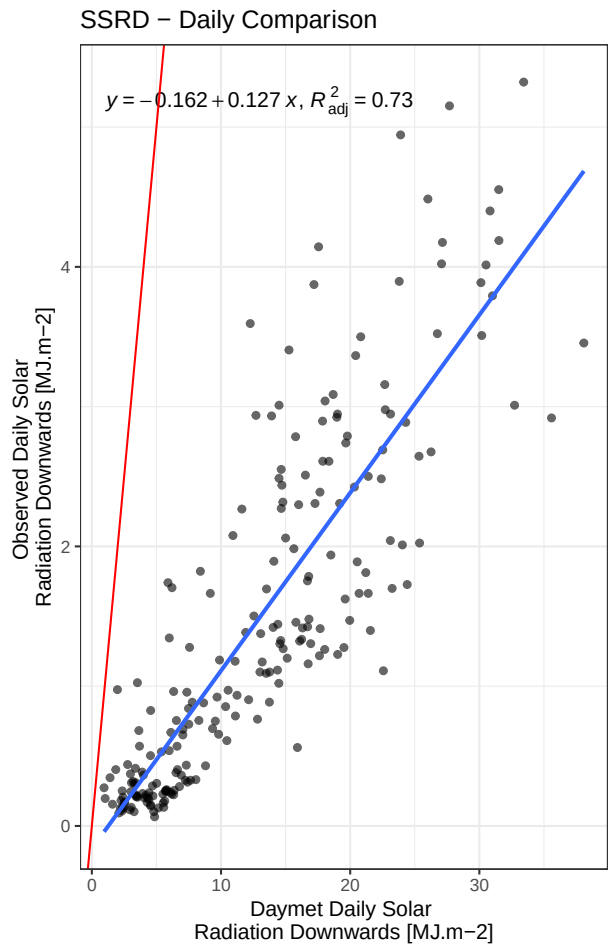
Daymet solar radiation is available as incident shortwave radiation flux density in watts per square meter (SRAD), taken as an average over the daylight period of the day. Daily total radiation (SSRD) (in MJ/m2) can be calculated as follows (Thornton et al. 2022):

$$SSRD = SRAD * DayLength/1000000$$

Day length is also available within the Daymet dataset.

The following graphs present a comparison of site data with Daymet data for overlapping periods of record.

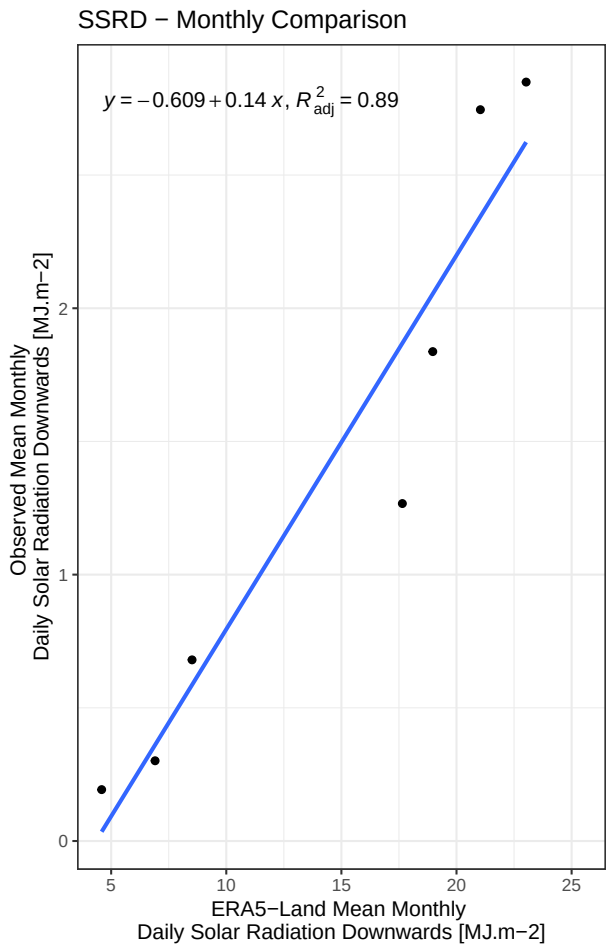


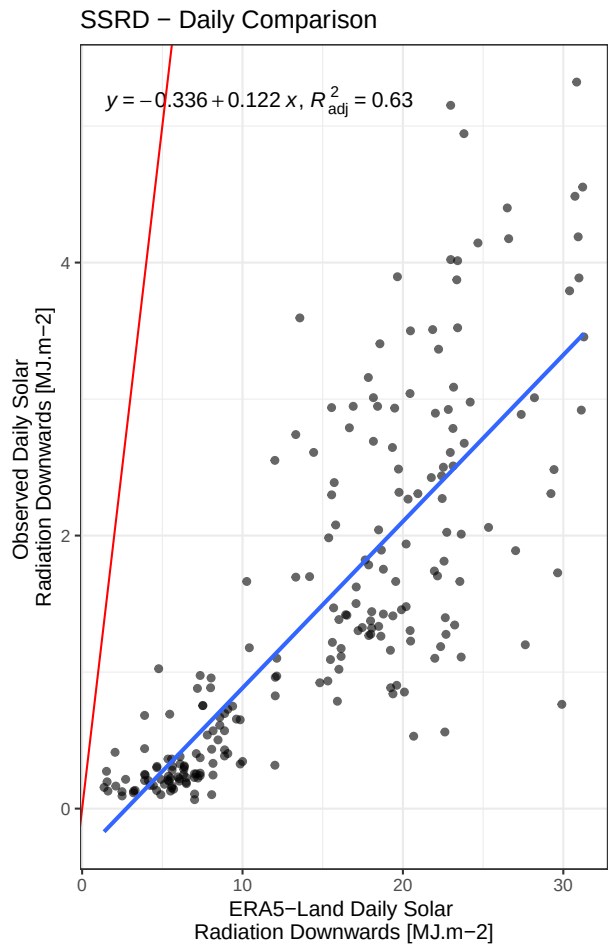


4.2 ERA5-Land

Daymet solar radiation is available as Surface short-wave (solar) radiation downwards (SSRD), and was extracted directly.

The following graphs present a comparison of site data with ERA5-Land data for overlapping periods of record.

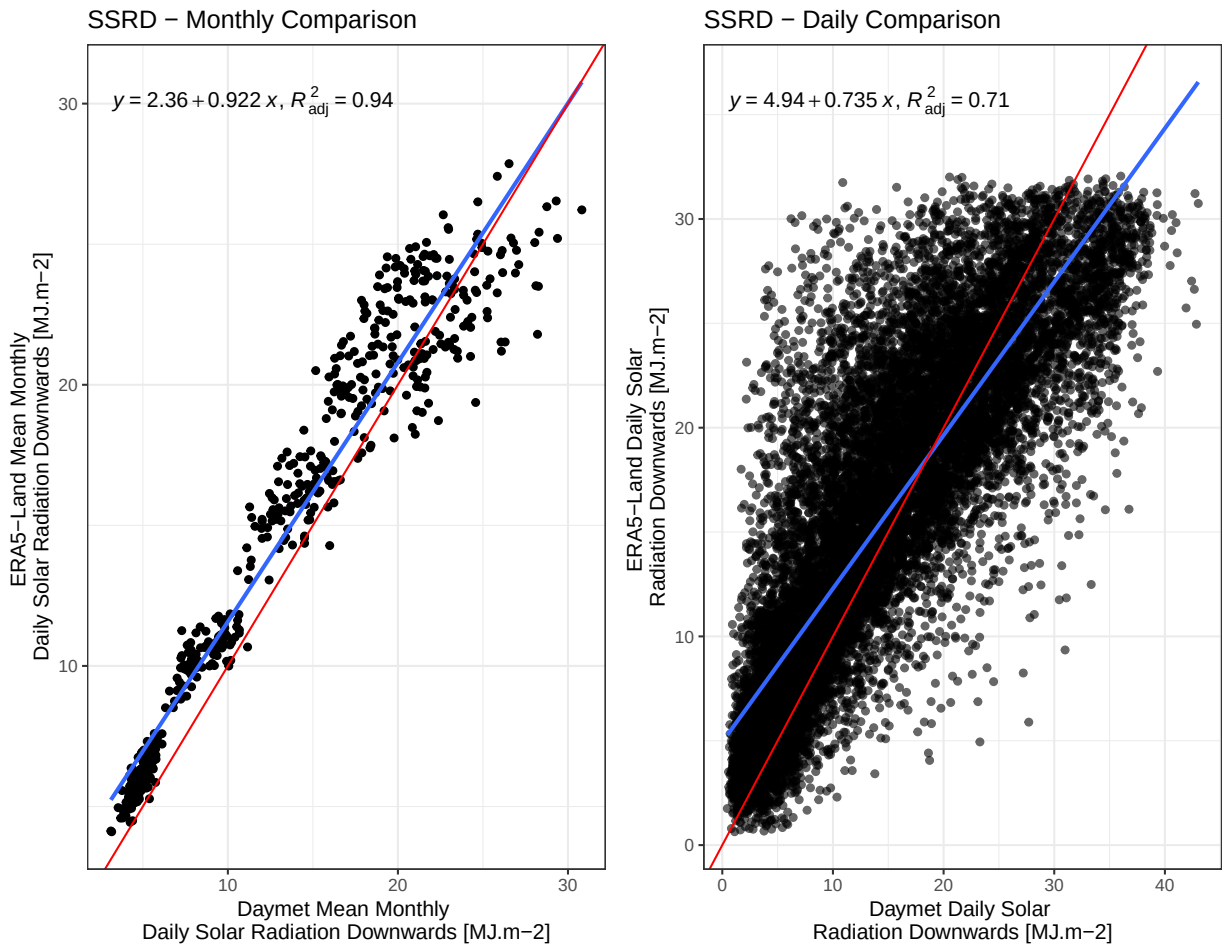




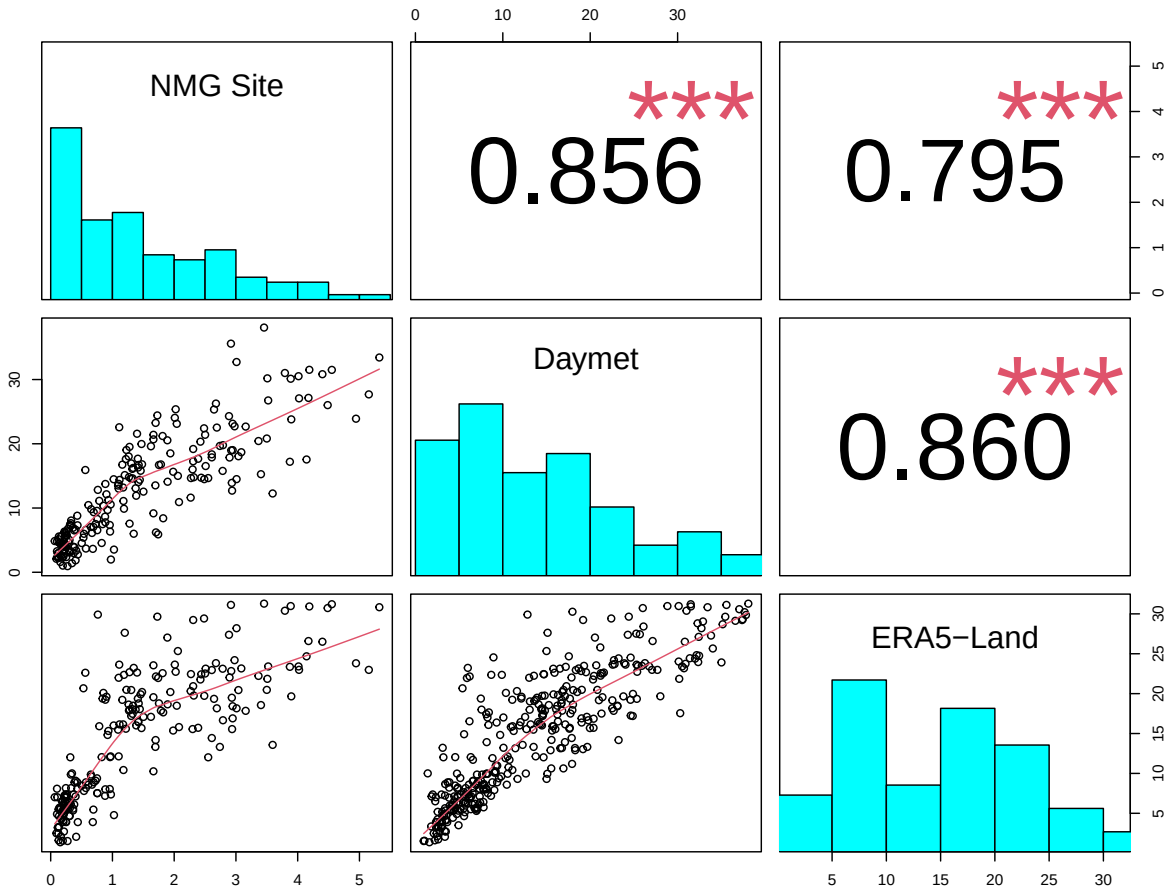
4.3 ERA5-Land and Daymet Comparison

Reanalysis sources have consistent data for SSRD at the site location. The Site station pyranometer might be partially obstructed, or the reporting units might be inaccurate, causing the discrepancy between reanalysis data and measured data on site. Regardless of this, both reanalysis sources present good correlations with site data.

The following graphs present a comparison of Daymet with ERA5-Land data for overlapping periods of record.



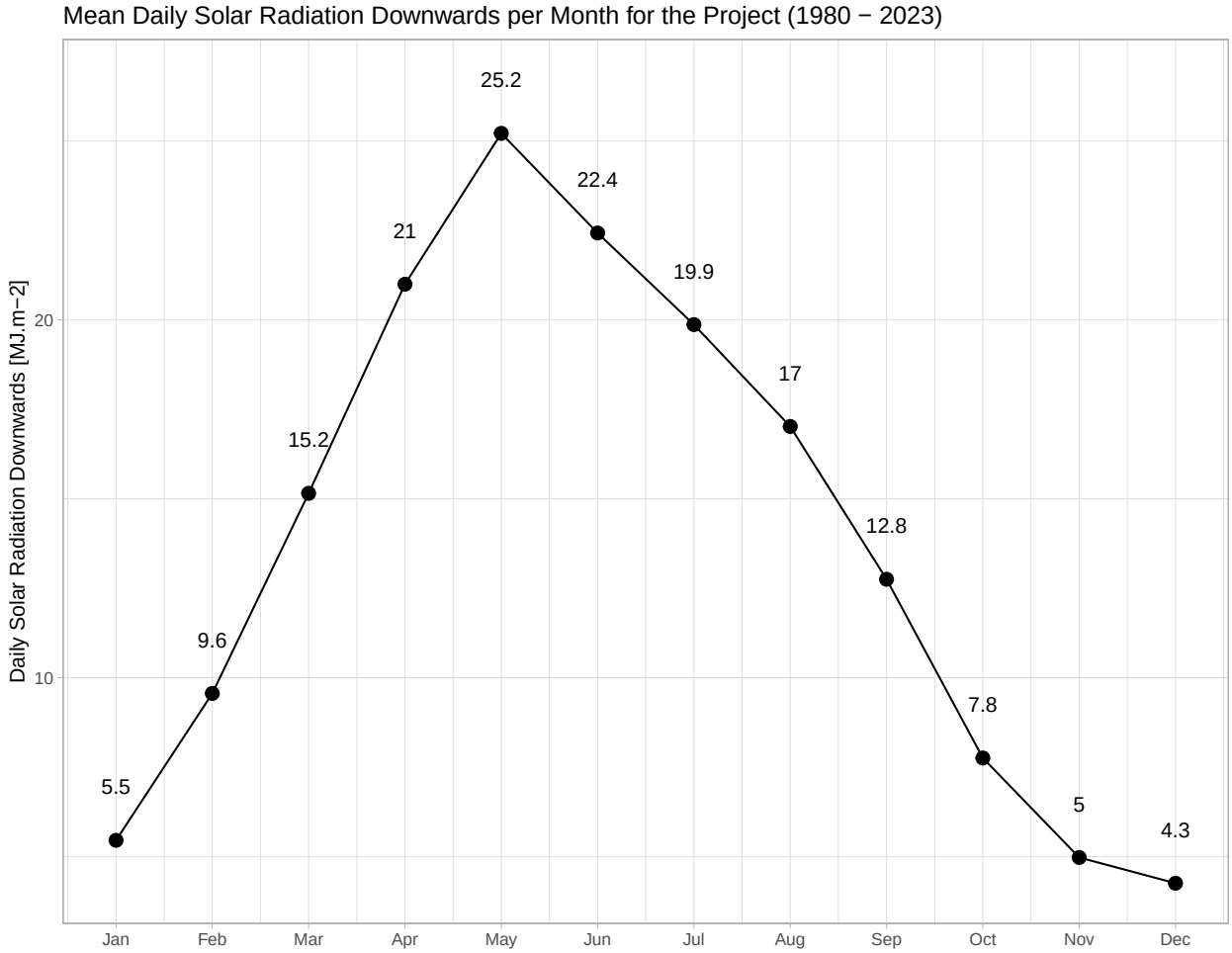
The following visualization is a correlation matrix between daily SSRD records from site data and reanalysis products. On the top right quadrant, the (absolute) value of the correlation is presented together with the result of the Pearson's product moment correlation coefficient as stars. On bottom-left quadrant the bivariate scatterplots, with a fitted line are presented. On the diagonal there is an histogram of each variable.


NMG Site
0.856
***
0.795
***
Daymet
0.860
***
ERA5−Land

Chapter 5

Site Timeseries Selection and Results

Based on the previous analysis, Daymet is the dataset most likely to be the most representative of solar radiation on site for the analysis period. Due to probable issues with the solar radiation measurements on site, this dataset cannot be bias-corrected to site data, and is taken 'as is' for the project.



Chapter 6

Outputs

Output of this code has been backed up and saved as an rds file in the **/01_Data/rds** project folder.

References

Gelaro, Ronald, Will McCarty, Max J. Suárez, Ricardo Todling, Andrea Molod, Lawrence Takacs, Cynthia A. Randles, et al. 2017. "The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2)." *Journal of Climate* 30 (14): 5419–54. https://doi.org/10.1175/jcli-d-16-0758.1.

Hersbach, Hans, Bill Bell, Paul Berrisford, Shoji Hirahara, András Horányi, Joaquín Muñoz-Sabater, Julien Nicolas, et al. 2020. "The ERA5 Global Reanalysis." *Quarterly Journal of the Royal Meteorological Society* 146 (730): 1999–2049. https://doi.org/10.1002/qj.3803.

Muñoz-Sabater, Joaquín, Emanuel Dutra, Anna Agustí-Panareda, Clément Albergel, Gabriele Arduini, Gianpaolo Balsamo, Souhail Boussetta, et al. 2021. "ERA5-Land: A State-of-the-Art Global Reanalysis Dataset for Land Applications." *Earth System Science Data* 13 (9): 4349–83. https://doi.org/10.5194/essd-13-4349-2021.

Thornton, M. M., R. Shrestha, Y. Wei, P. E. Thornton, and S-C. Kao. 2022. "Daymet: Daily Surface Weather Data on a 1-Km Grid for North America, Version 4 R1," November. https://doi.org/10.3334/ORNLDAAC/2129.

Appendix H Evaporation Calculations

NMG - Matawinie Evaporation Analysis

CAPR003306

Camilo Gallard

February 14, 2025

Abstract

This report compiles the evaporation anlaysis that was carried out by SRK Consulting (Canada) Inc. for the Nouveau Monde Graphite Matawinie Site in 2024 to support Engineering Design. The data compilation and subsequent analysis was conducted in the R Software environment.

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Chapter 1

Glossary

- **AMS**: Annual Maximum Series.
- **Daymet**: Reanalysis tool developed by the Oak Ridge National Laboratory and supported by NASA (Thornton et al. 2022).
- **ECCC**: Environment and Climate Change Canada.
- **ERA5**: Reanalysis tool developed by the European Centre for Medium-Range Weather Forecasts (Hersbach et al. 2020).
- **ERA5-Land**: Reanalysis tool based on ERA5 but for Land surfaces and a smaller grid, and developed by the European Centre for Medium-Range Weather Forecasts (Muñoz-Sabater et al. 2021).
- **ET**: Evapotranspiration
- **ET0**: Reference Evapotranspiration
- **IDF**: Intensity-Duration-Frequency (IDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
- **KST**: Kolmogorov–Smirnov Test.
- **MAAT**: Mean Annual Air Temperature.
- **MAP**: Mean Annual Precipitation.
- **MERRA2**: Modern-Era Retrospective analysis from Research and Applications, Version 2, is a global climate reanalysis model from the U.S. National Aeronautics and Space Administration (Gelaro et al. 2017).
- **NMG**: Nouveau Monde Graphite.
- **PCC**: Pearson Correlation Coefficient.
- **PDF**: Precipitation-Duration-Frequency (PDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
- **PMP**: Probable Maximum Precipitation.
- **RH**: Relative Humidity.

- **SRAD**: Shortwave (solar) radiation. Incident shortwave radiation flux density in watts per square meter.
- **SRK**: SRK Consulting (Canada) Inc.
- **SSR**: Surface net shortwave (solar) radiation. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth (both direct and diffuse) minus the amount reflected by the Earth's surface (which is governed by the albedo).
- **SSRD**: Surface short-wave (solar) radiation downwards. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth. This parameter comprises both direct and diffuse solar radiation.
- **Tavg**: Mean or Average Air Temperature over a given temporal unit (day, month, year…).
- **Tdew**: Mean or Average Dew Point Temperature over a given temporal unit (day, month, year…).
- **Tmax**: Maximum Air Temperature over a given temporal unit (day, month, year…).
- **Tmin**: Minimum Air Temperature over a given temporal unit (day, month, year…).

Chapter 2

General Parameters

The NMG Matawinie site is located in southern Quebec, 125 km north of Montreal. Site latitude is 46.63 degrees, and longitude is -73.97 degrees, at an elevation of 562 masl. These coordinates were selected to match the location of the meteorological station on site.

Chapter 3

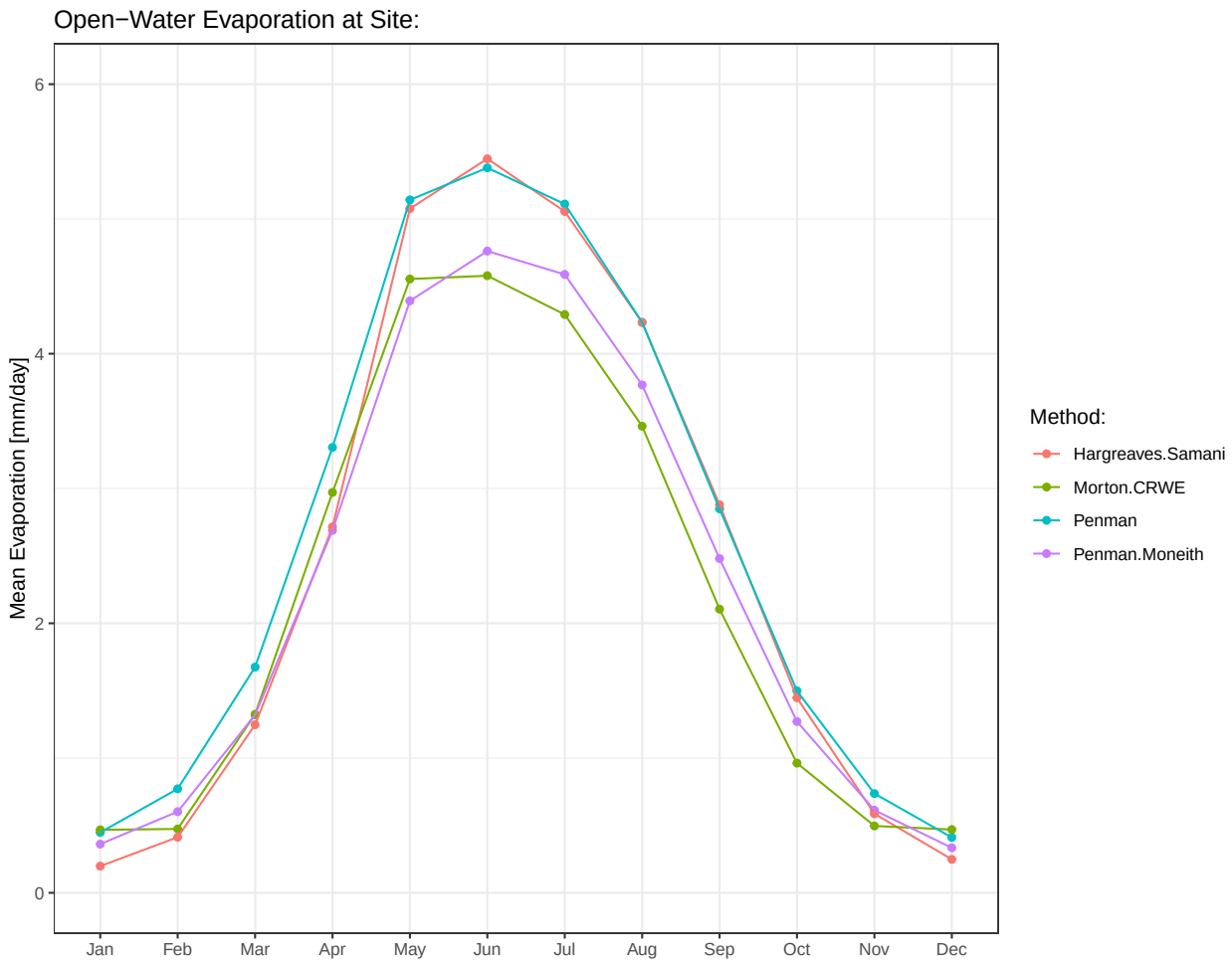
Evaporation Calculations

Surface water evaporation or lake evaporation can be estimated based on other climatic parameters. In this section, evaporation was calculated for site based on the Project climate timeseries that have been defined in the previous analysis.

The following methods have been assessed:

- Hargreaves-Samani (George H. Hargreaves and Zohrab A. Samani 1985): The method is based on an empirical relationship where reference evapotranspiration was regressed with solar radiation and air temperature data. It only requires temperature as an input. For bodies of water, reference evapotranspiration can be considered equal to open water evaporation.
- Penman (Penman 1948): the Penman equation describes evaporation (E) from an open water surface.
- Penman-Monteith (Allen 1998): The Penman-Monteith equation approximates net evapotranspiration (ET) from meteorological data as a replacement for direct measurement of evapotranspiration. The equation is widely used, and was derived by the United Nations Food and Agriculture Organization for modeling reference evapotranspiration ET0. The reference evaptranspiration obtained by this method is then multiplied by a crop coefficient to obtain actual evaporation values. The crop coefficient of K = 1.25 corresponding to open water with a depth of more than 2m was used in this analysis.
- Morton-CRWE (Morton 1983): the Morton CRWE formulation was developed in Canada for estimating potential evapotranspiration or shallow lake evaporation.

The results of the evaporation calculations for site are summarized in the following figure. Evaporation during the winter months (December, January and, February) was considered negligible.



All methods are consistent.

Chapter 4

Site Timeseries Selection and Results

Measured evaporation records are unavailable in the project region, and all the evaporation calculation methods that were consistent and can be considered equally representative of site. The average of these methods was selected as the open water evaporation result for the project. Note that the Morton CRWE method only offers monthly results and was not considered for the average calculation.

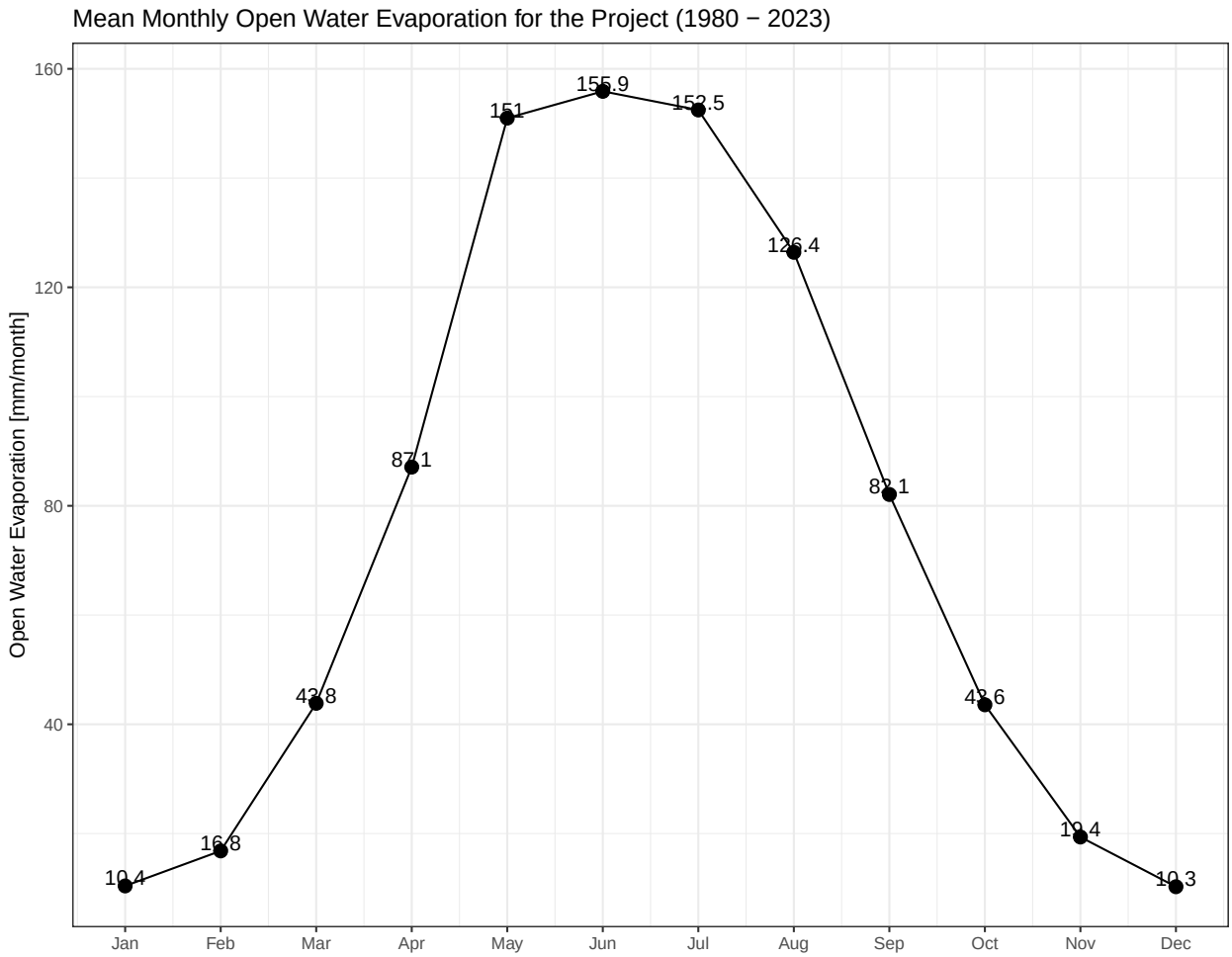


Table 4.1: Cimate Normals (1994-2023) for the Project

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Prcp	73.4	59.2	72	83.7	93.3	120.5	113.5	104	111.4	106.6	81.5	86.6	1106
Rain	9.1	3.8	20.4	63.1	92.1	120.5	113.5	104	111.4	98.6	40.6	16.7	793.9
Snow	64.3	55.4	51.5	20.5	1.2	0	0	0	0	8.1	40.9	69.8	311.8
SSRD	169.2	271	472.6	640.6	792.8	677.1	613.2	533.8	386.2	240.4	151.3	129.3	5078
Evap	10.4	16.9	44	86.7	152.3	157.1	151.1	127.4	84.2	44.4	19.5	10.2	904.1
Tmax	-7.7	-5.4	0.6	7.6	16.4	21.4	23.5	22.4	18	10.2	2.2	-4.5	8.7
Tmin	-19.9	-19.3	-12.6	-4.5	2.6	8.3	11	10	5.9	0.3	-6.4	-14.2	-3.2
Tavg	-13.8	-12.4	-6	1.6	9.5	14.9	17.3	16.2	12	5.2	-2.1	-9.3	2.7
Wspd	1.5	1.6	1.7	1.8	1.6	1.4	1.4	1.3	1.5	1.7	1.7	1.5	1.6
Tdew	-16.4	-15.2	-9.9	-3.6	3.2	9	11.7	11.1	8	2.2	-4.3	-10.8	-1.2
Tdewmax	-11.7	-10.5	-5.9	-0.1	6.6	11.9	14.2	13.7	11.1	5.2	-0.9	-6.7	2.2
Tdewmin	-20.5	-19.3	-13.4	-6.6	-0.1	6.3	9.4	8.8	5.4	-0.4	-7.3	-14.5	-4.4
RH	80.4	79.3	75	70	66.3	68.7	70.1	72.2	77.4	81.3	84.8	87.6	76.1
RHmax	94.6	94.6	91.1	85.1	81.1	82	82.4	84.6	90.6	92.5	95	97.3	89.2
RHmin	58.9	57.9	57.5	56.3	52.9	57.5	60.3	62	64.8	67.9	68.5	67.7	61

Table 4.2: Climate Normals (1985-2014) for the Project

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Prcp	73.3	53	66.2	74.6	93.8	116.2	112.7	103	114.1	101	83.5	78	1069
Rain	9.1	3	18.4	56.5	92.7	116.2	112.7	103	113.9	93.9	41.7	10.7	771.9
Snow	64.2	50	47.8	18.1	1.2	0	0	0	0.1	7.1	41.8	67.4	297.6
SSRD	168.1	269.5	469.4	631.6	768.9	670.4	615.2	531.1	375.4	239.3	150.5	132.2	5022
Evap	10.6	16.7	44.5	89.5	151.4	157.4	153.1	128.2	82.2	43.6	19.5	10	906.8
Tmax	-7.8	-5.5	0.7	8.2	16.4	21.2	23.4	22.2	17.3	9.6	2.1	-5.1	8.5
Tmin	-20.5	-19.9	-13.2	-4.1	2.6	8	10.6	9.5	5.3	-0.2	-6.7	-15.8	-3.7
Tavg	-14.2	-12.7	-6.3	2	9.5	14.6	17	15.8	11.3	4.7	-2.3	-10.4	2.4
Wspd	1.6	1.6	1.7	1.7	1.6	1.5	1.4	1.3	1.5	1.7	1.7	1.5	1.6
Tdew	-16.8	-15.7	-10.1	-3.2	3.3	8.7	11.4	10.8	7.5	1.5	-4.7	-12	-1.6
Tdewmax	-12	-11.2	-6.1	0.1	6.8	11.7	13.9	13.3	10.6	4.6	-1.2	-7.7	1.9
Tdewmin	-21.1	-19.8	-13.6	-6.3	0.1	5.9	9	8.4	4.8	-1.2	-7.9	-16	-4.8
RH	79.8	78.4	75	69.6	66.7	68.6	70	72.2	77.7	80.6	83.8	86.5	75.8
RHmax	94.2	94	90.9	84.4	81.9	82.1	82.2	84.6	90.9	92.3	94.7	96.9	89.1
RHmin	57.6	56.9	57.2	56.1	53.5	57.1	60.2	61.9	64.7	66.8	67	65.4	60.4

Chapter 5

Outputs

Output of this code has been backed up and saved as an rds file in the **/01_Data/rds** project folder.

References

Allen, Pereira, R. G. 1998. *Crop Evapotranspiration - Guidelines for Computing Crop Water Requirements - FAO Irrigation and Drainage Paper 56*. Rome: FAO.

Gelaro, Ronald, Will McCarty, Max J. Suárez, Ricardo Todling, Andrea Molod, Lawrence Takacs, Cynthia A. Randles, et al. 2017. "The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2)." *Journal of Climate* 30 (14): 5419–54. https://doi.org/10.1175/jcli-d-16-0758.1.

George H. Hargreaves, and Zohrab A. Samani. 1985. "Reference Crop Evapotranspiration from Temperature." *Applied Engineering in Agriculture* 1 (2): 96–99. https://doi.org/10.13031/2013.26773.

Hersbach, Hans, Bill Bell, Paul Berrisford, Shoji Hirahara, András Horányi, Joaquín Muñoz-Sabater, Julien Nicolas, et al. 2020. "The ERA5 Global Reanalysis." *Quarterly Journal of the Royal Meteorological Society* 146 (730): 1999–2049. https://doi.org/10.1002/qj.3803.

Morton, F. I. 1983. "Operational Estimates of Lake Evaporation." *Journal of Hydrology* 66 (1-4): 77–100. https://doi.org/10.1016/0022-1694(83)90178-6.

Muñoz-Sabater, Joaquín, Emanuel Dutra, Anna Agustí-Panareda, Clément Albergel, Gabriele Arduini, Gianpaolo Balsamo, Souhail Boussetta, et al. 2021. "ERA5-Land: A State-of-the-Art Global Reanalysis Dataset for Land Applications." *Earth System Science Data* 13 (9): 4349–83. https://doi.org/10.5194/essd-13-4349-2021.

Penman, H. L. 1948. "Natural Evaporation from Open Water, Bare Soil and Grass." *Proceedings of the Royal Society of London. Series A. Mathematical and Physical Sciences* 193 (1032): 120–45. https://doi.org/10.1098/rspa.1948.0037.

Thornton, M. M., R. Shrestha, Y. Wei, P. E. Thornton, and S-C. Kao. 2022. "Daymet: Daily Surface Weather Data on a 1-Km Grid for North America, Version 4 R1," November. https://doi.org/10.3334/ORNLDAAC/2129.

Appendix A Temperature Detailed Analysis

1. NMG - Matawinie Air Temperature Analysis

CAPR003306

Camilo Gallard

February 12, 2025

Abstract

This report compiles the temperature anlaysis that was carried out by SRK Consulting (Canada) Inc. for the Nouveau Monde Graphite Matawinie Site in 2024 to support Engineering Design. The data compilation and subsequent analysis was conducted in the R Software environment.

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Chapter 1

Glossary

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- **MAAT**: Mean Annual Air Temperature.
- **MAP**: Mean Annual Precipitation.
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- **PMP**: Probable Maximum Precipitation.
- **RH**: Relative Humidity.

- **SRAD**: Shortwave (solar) radiation. Incident shortwave radiation flux density in watts per square meter.
- **SRK**: SRK Consulting (Canada) Inc.
- **SSR**: Surface net shortwave (solar) radiation. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth (both direct and diffuse) minus the amount reflected by the Earth's surface (which is governed by the albedo).
- **SSRD**: Surface short-wave (solar) radiation downwards. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth. This parameter comprises both direct and diffuse solar radiation.
- **Tavg**: Mean or Average Air Temperature over a given temporal unit (day, month, year…).
- **Tdew**: Mean or Average Dew Point Temperature over a given temporal unit (day, month, year…).
- **Tmax**: Maximum Air Temperature over a given temporal unit (day, month, year…).
- **Tmin**: Minimum Air Temperature over a given temporal unit (day, month, year…).

Chapter 2

General Parameters

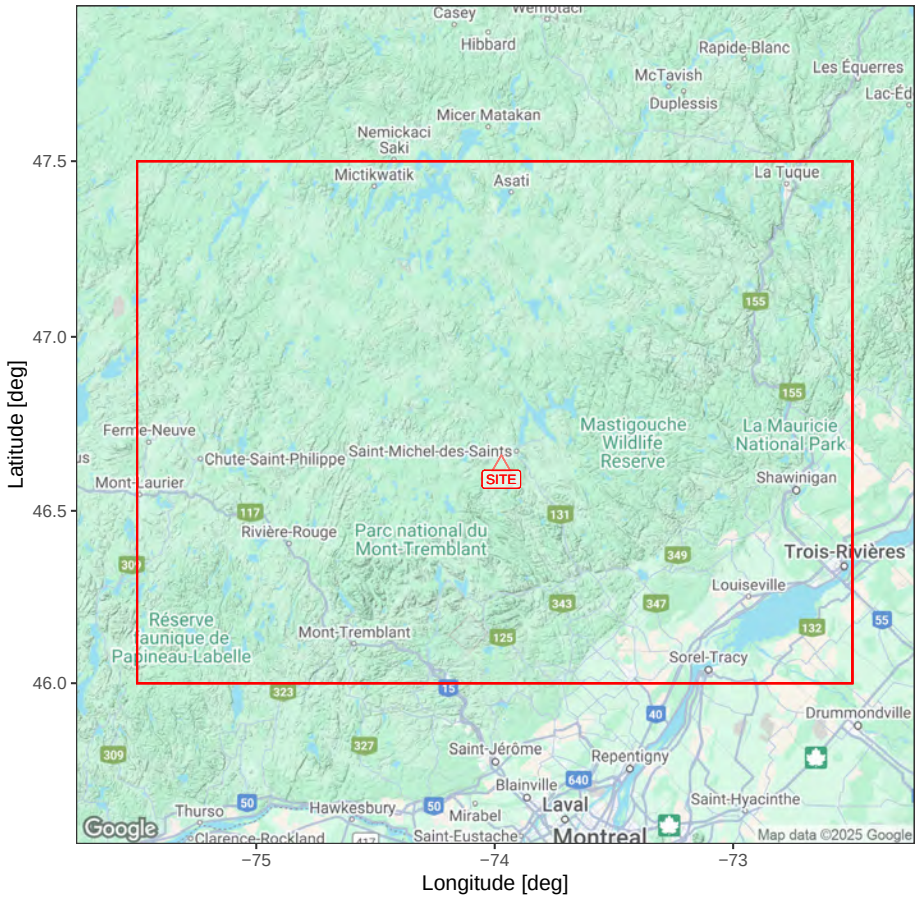
The NMG Matawinie site is located in southern Quebec, 125 km north of Montreal. Site latitude is 46.63 degrees, and longitude is -73.97 degrees, at an elevation of 562 masl. These coordinates were selected to match the location of the meteorological station on site.

For the purpose of this meteorological analysis, an area of interest was defined around site to capture regional data and climate trends, and was defined as the region between:

- 46° and 47.5° Latitude
- -75.5° and -72.5° Longitude

Site Location and Area of Interest for this Study

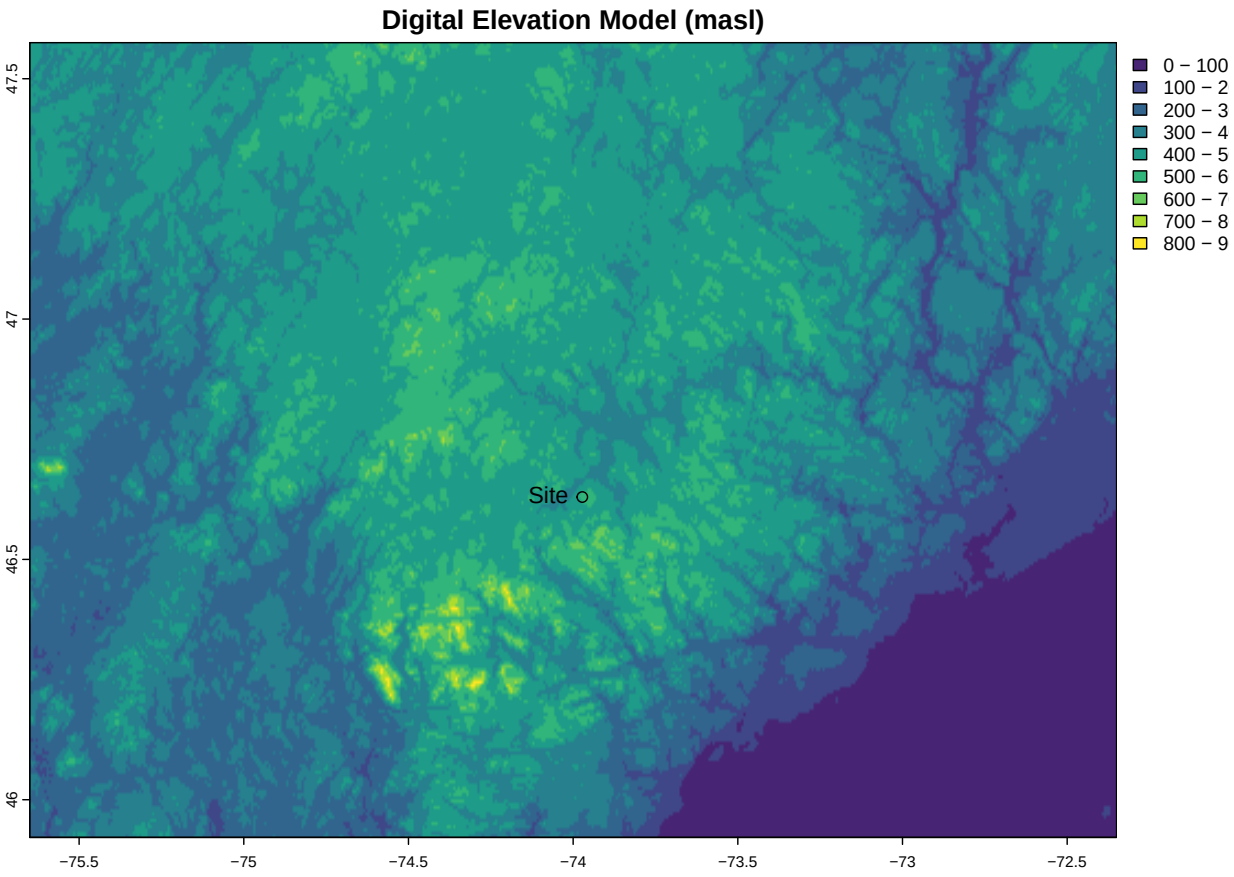
Area of interest covers a distance of up to 125km from Site



Chapter 3

Digital Elevation Model

Digital elevation model from the region was downloaded from the Shuttle Radar Topography Mission (SRTM) dataset (NASA, 2013). The SRTM database contains global elevation data with 3 arc-second (90 m) spatial resolution, which is deemed sufficient for climate analysis.

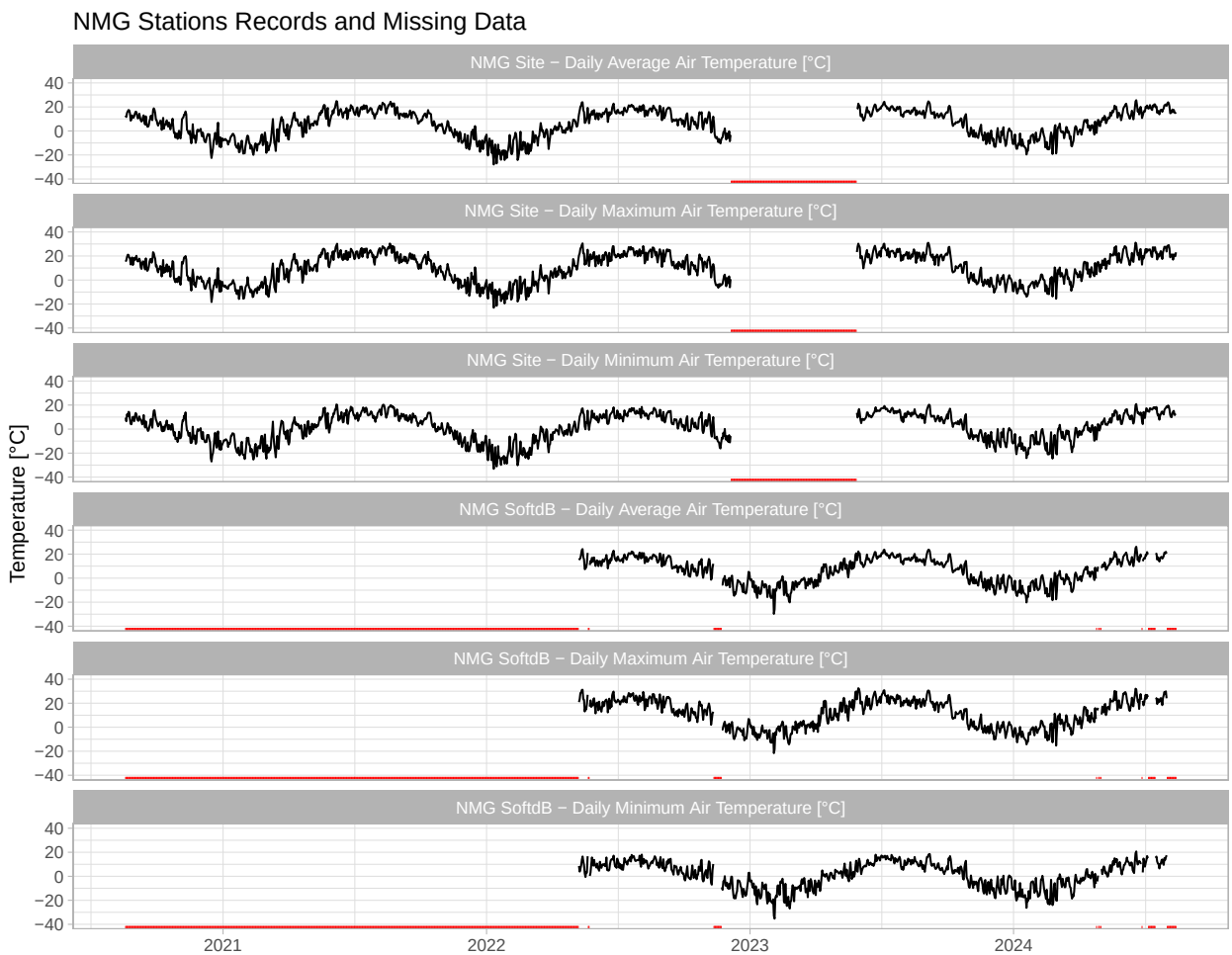


Chapter 4

NMG Air Temperature Data

Site data is collected by NMG from two meteorological stations. The first station is located on Site, and the second station, called SoftdB, is located 1.5 km north at the following address: 200 Chemin des Hauteurs, Saint-Michel-des-Saints.

Note: SoftdB data is different from ECCC station 48188 data, so both records were kept.



Chapter 5

Regional Air Temperature Analysis

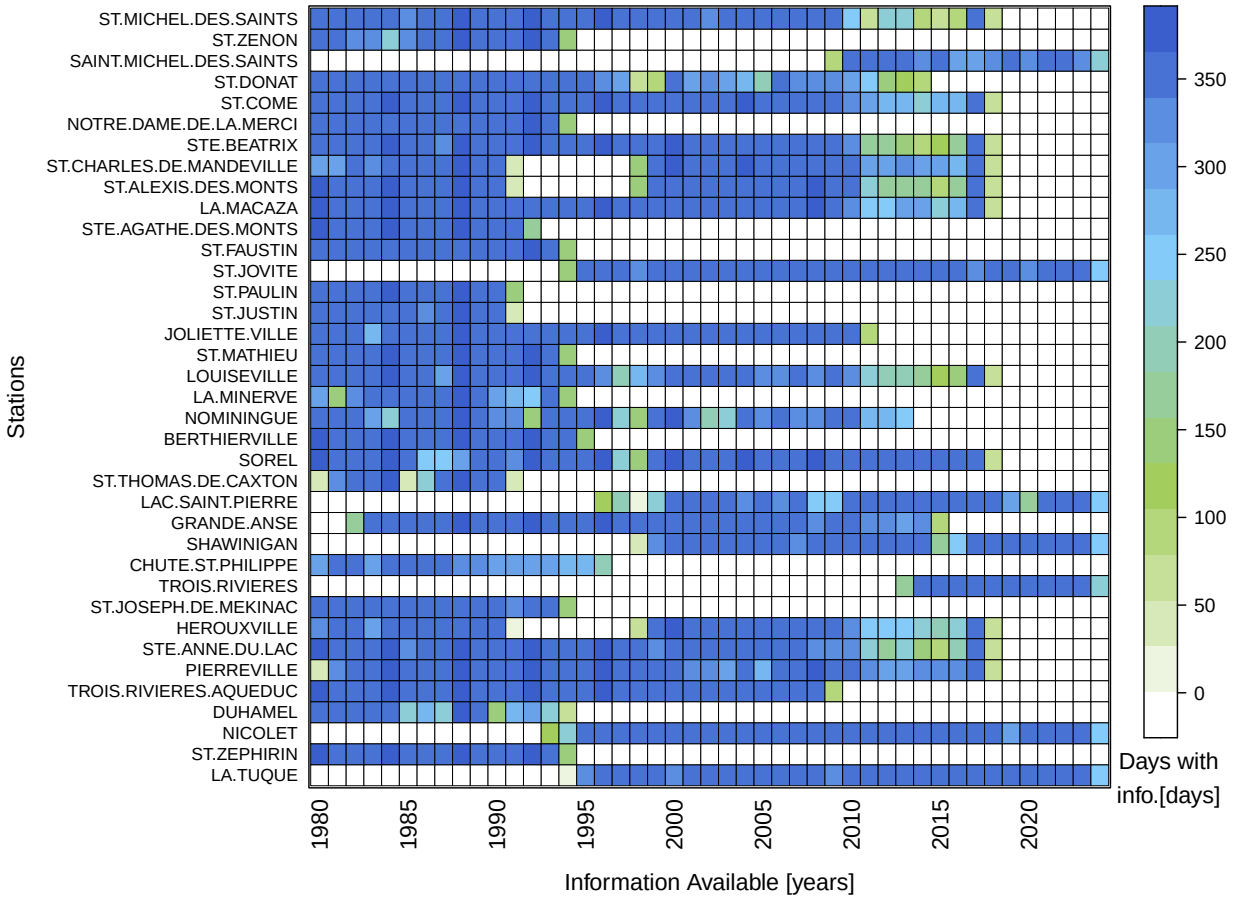
5.1 ECCC Temperature Data

Environment and Climate Change Canada (ECCC) data was downloaded and prepared for analysis . The information is captured on a daily or hourly timestep when available. No complementary/redundant stations were detected so patching was not required for stations within the area of interest.

The following figures show:

1. Data availability over time at each station (only records from 1980 to 2023 were considered for this analysis).
2. Selected ECCC stations location and elevation.

Refer to the "eccc_read.r" for pre-processing details.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STE.BEATRIX
ST.CHARLES.DE.MANDEVILLE
ST.ALEXIS.DES.MONTS
LA.MACAZA
STE.AGATHE.DES.MONTS
ST.FAUSTIN
ST.JOVITE
ST.PAULIN
ST.JUSTIN
JOLIETTE.VILLE
ST.MATHIEU
LOUISEVILLE
LA.MINERVE
NOMININGUE
BERTHIERVILLE
SOREL
ST.THOMAS.DE.CAXTON
LAC.SAINT.PIERRE
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SHAWINIGAN
CHUTE.ST.PHILIPPE
TROIS.RIVIERES
ST.JOSEPH.DE.MEKINAC
HEROUXVILLE
STE.ANNE.DU.LAC
PIERREVILLE
TROIS.RIVIERES.AQUEDUC
DUHAMEL
NICOLET
ST.ZEPHIRIN
LA.TUQUE
Stations
1980
1985
1990
1995
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2005
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50
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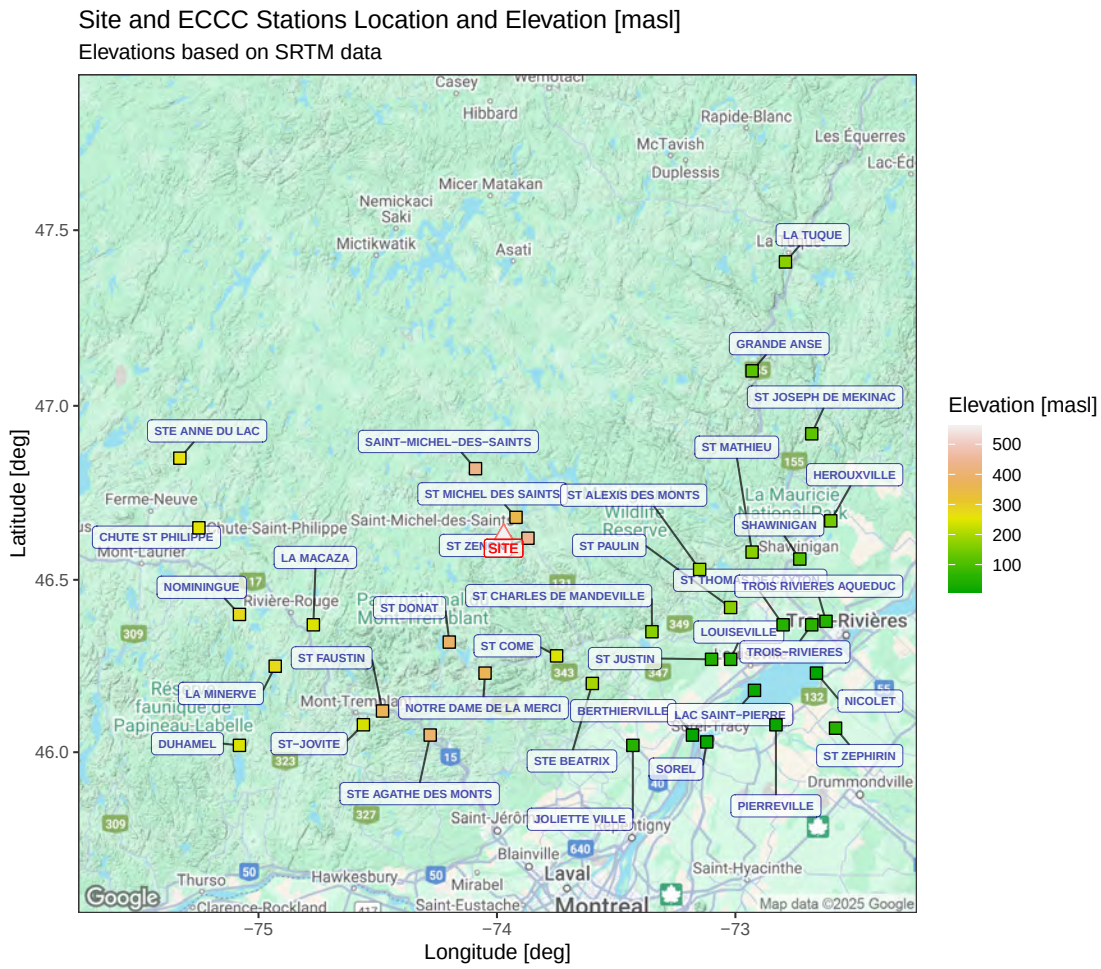
Days with
info.[days]



5.2 Reanalysis Regional Overview

Climate reanalysis combines gridded global models with observed historical data to produce historical climate and to incorporate adjustments based on developed relationships. Multiple reanalysis datasets are available in different spatio-temporal resolutions.

For this project four reanalysis datasets were evaluated. These are presented as gridded climate models and cover an area of interest defined between

5.2.1 Temperature Gridded Dataset Analysis Function

A general function is created to review each selected gridded dataset and compare it to station records. Four graphs are presented as outputs including:

- Graph 1: Mean Annual Air Temperature (MAAT) as a gridded map over the analysis extents, compared to station results. This aims to help visualize any regional trends in mean temperature.
- Graph 2: MAAT Elevation gradient over the analysis extents and regression, compared to station results.
- Graph 3: Mean Monthly Air Temperature Elevation gradient over the analysis extents, compared to station results. Results and regressions split by month.

- Graph 4: Mean Annual Air Temperature Elevation gradient and regression, compared to station results, split by location by latitude and longitude increments of 0.5 degrees. This graph offers a visualization of any local trends that might be more significant than regional trends.

5.2.2 Daymet Regional Overview for Mean Air Temperature

Daymet is a reanalysis tool developed by the Oak Ridge National Laboratory and supported by NASA, Daymet provides long-term, continuous, gridded estimates of daily weather and climatology in North America (Thornton et al. 2022) including variables such as daily maximum and minimum temperatures, precipitation, and shortwave radiation.

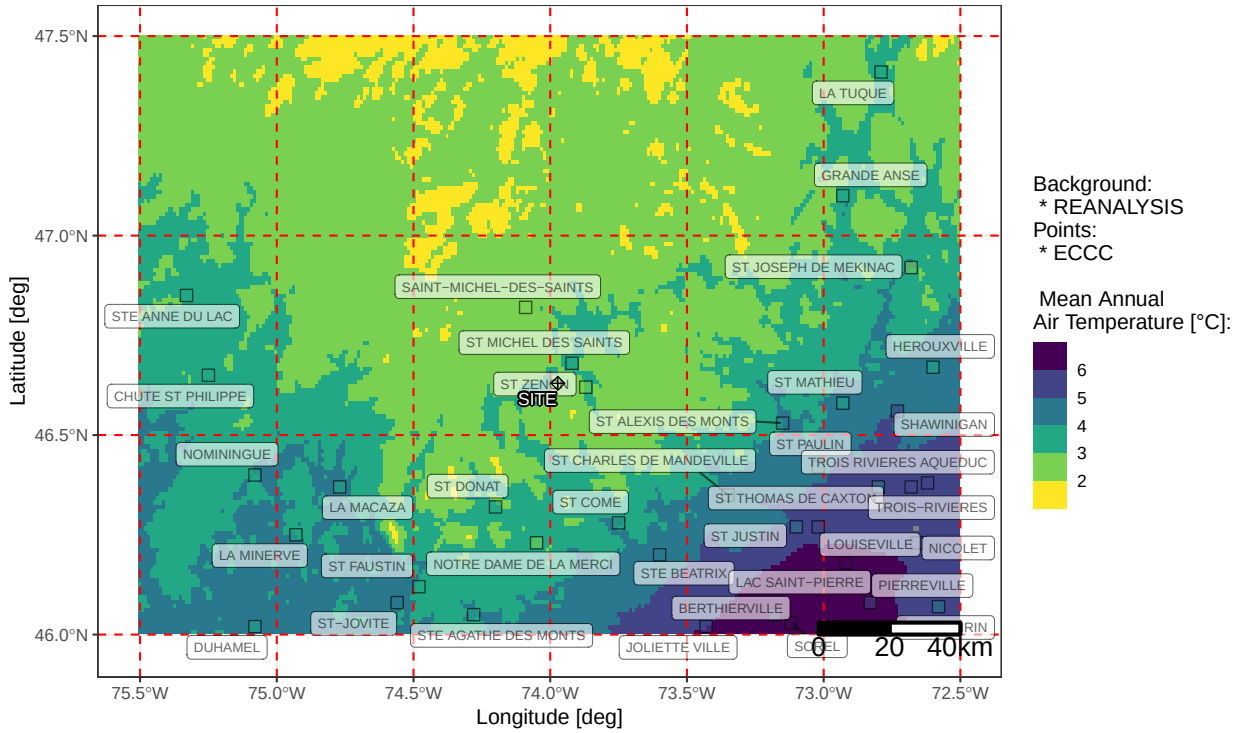
Daymet uses a set of spatial interpolation algorithms to estimate weather and climate patterns at a 1 km spatial resolution. Daymet is particularly useful for ecological and hydrological modeling. It offers high spatial resolution data covering an extended time period, making it suitable for analyzing long-term climate trends and their impacts on various environmental processes.

The main findings of the Daymet regional overview are listed below (the corresponding figures follow):

- Results are similar for the analysis of average maximum, and minimum temperature.
- On a regional scale, Daymet is consistent with ECCC in terms of spatial trends on all annual air temperature parameters (average, maximum, and minimum) (Graphs 1).
- The temperature versus elevation gradients (Graphs 2) show good correlation for Daymet on a regional scale. This observation is consistent with the monthly breakdowns of this data (Graphs 3), although the R^2_{adj} factor decreases slightly for the winter months.
- The localized breakdowns of temperature vs Elevation (Graphs 4) also show good correlations between elevation and temperature. ECCC stations temperature is also consistent with Daymet near the project area.

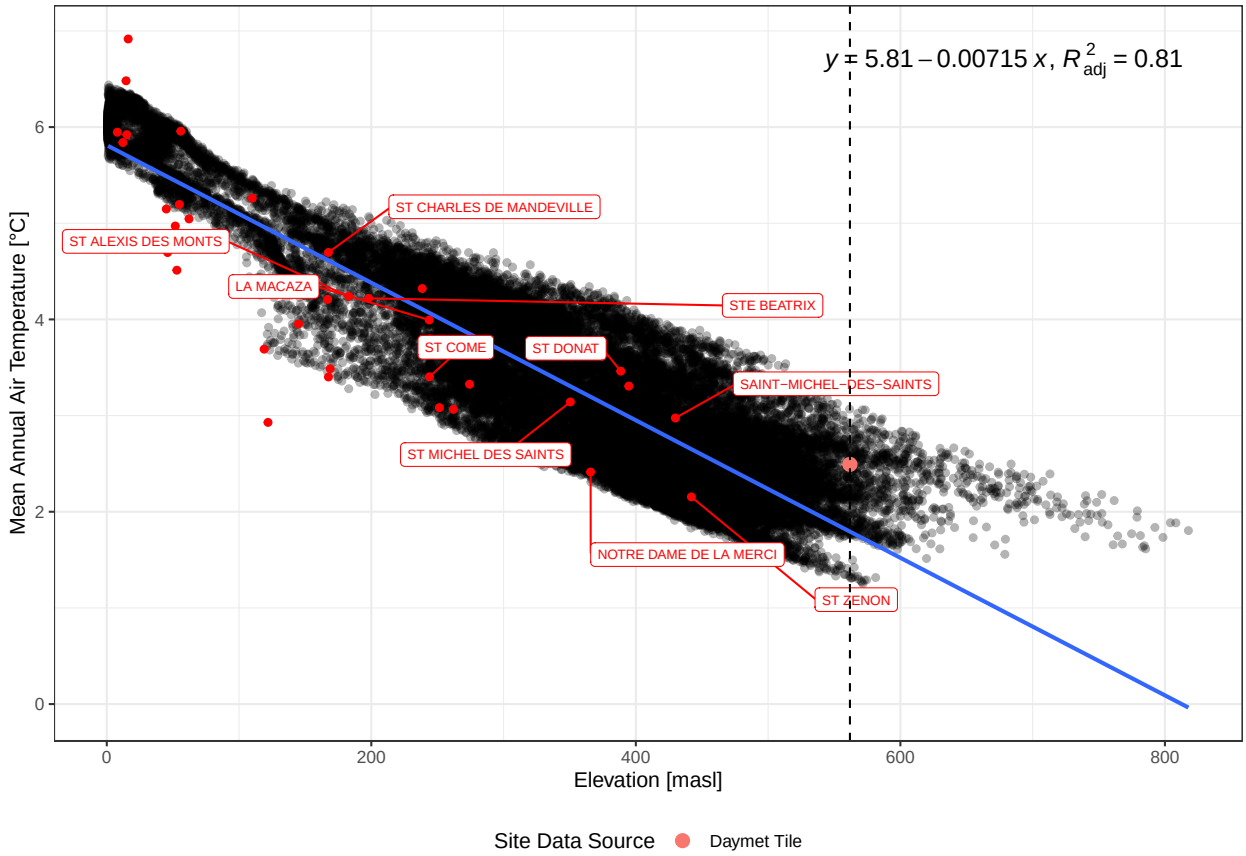
5.2.2.1 Daymet Tavg Regional Overview

Graph 1: Mean Annual Air Temperature [°C]:
(1980 – 2023)



Graph 2: Regional Elevation Gradient

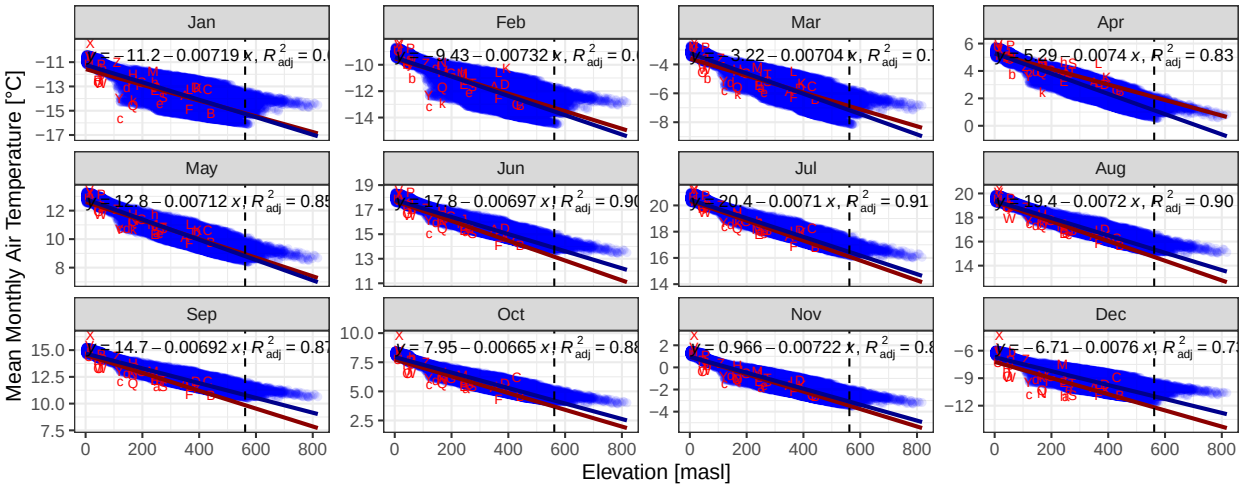
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

Reanalsis source as background: 1980 to 2023 (distance 125 km from site)

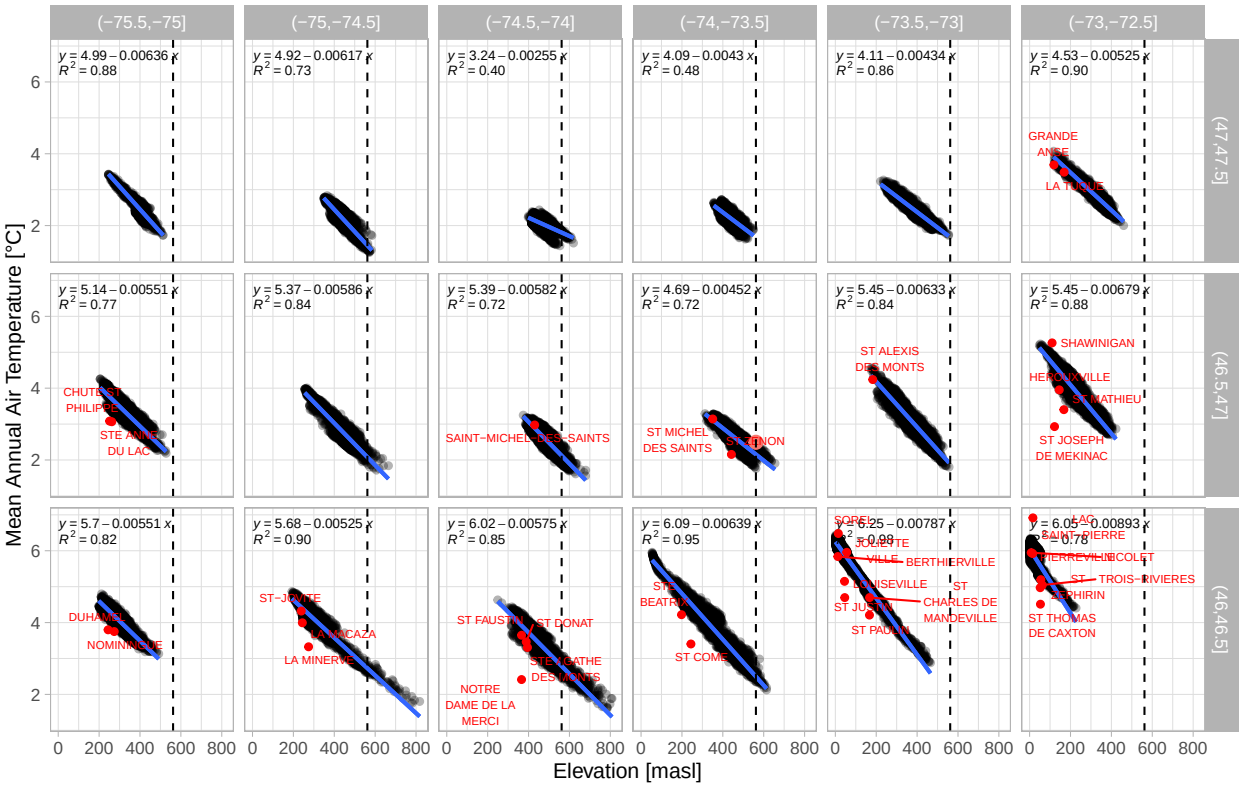


A	ST MICHEL DES SAINTS	I	ST ALEXIS DES MONTS	Q	ST MATHIEU	Y	GRANDE ANSE	g	TROIS RIVI
B	ST ZENON	J	LA MACAZA	R	LOUISEVILLE	Z	SHAWINIGAN	h	DUHAMEL
C	SAINT−MICHEL−DES−SAINTS	K	STE AGATHE DES MONTS	S	LA MINERVE	a	CHUTE ST PHILIPPE	i	NICOLET
D	ST DONAT	L	ST FAUSTIN	T	NOMININGUE	b	TROIS−RIVIERES	j	ST ZEPHIRI
E	ST COME	M	ST−JOVITE	U	BERTHIERVILLE	c	ST JOSEPH DE MEKINAC	k	LA TUQUE
F	NOTRE DAME DE LA MERCI	N	ST PAULIN	V	SOREL	d	HEROUXVILLE		
G	STE BEATRIX	O	ST JUSTIN	W	ST THOMAS DE CAXTON	e	STE ANNE DU LAC		
H	ST CHARLES DE MANDEVILLE	P	JOLIETTE VILLE	X	LAC SAINT−PIERRE	f	PIERREVILLE		

Note: black dotted line represents site elevation

Graph 4: Mean Annual Air Temperature [°C] versus Elevation [masl] (1980 − 2023)

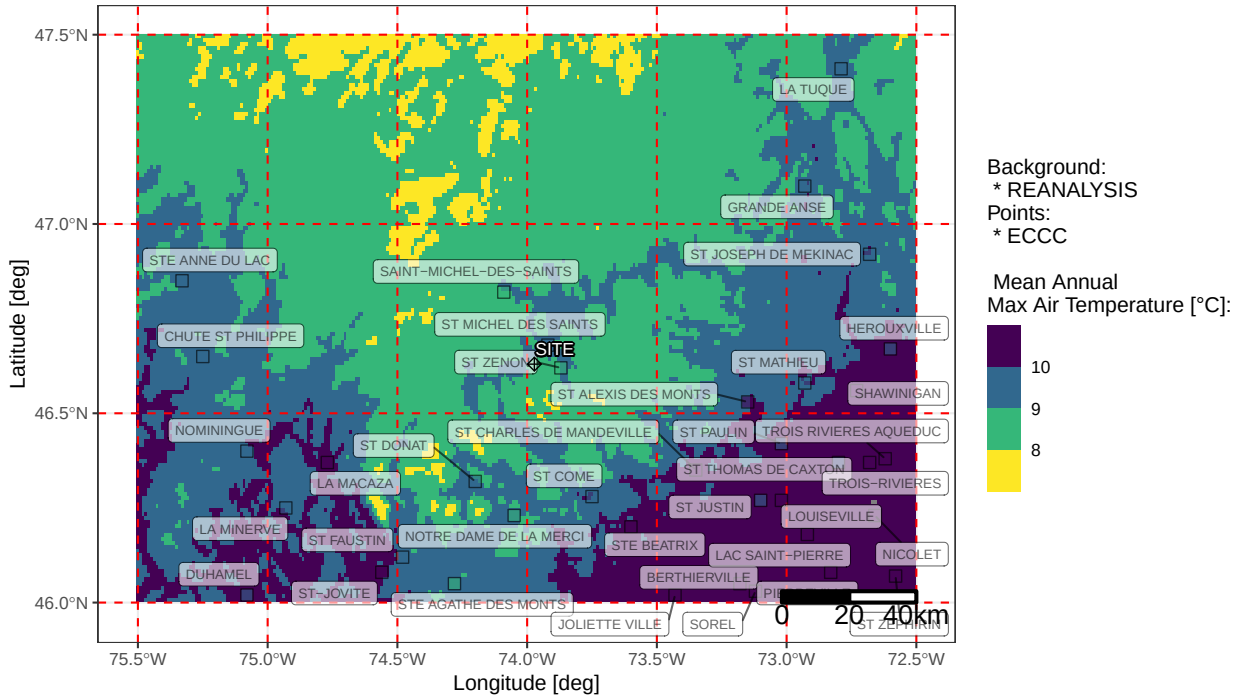
Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



Note: black dotted line represents site elevation

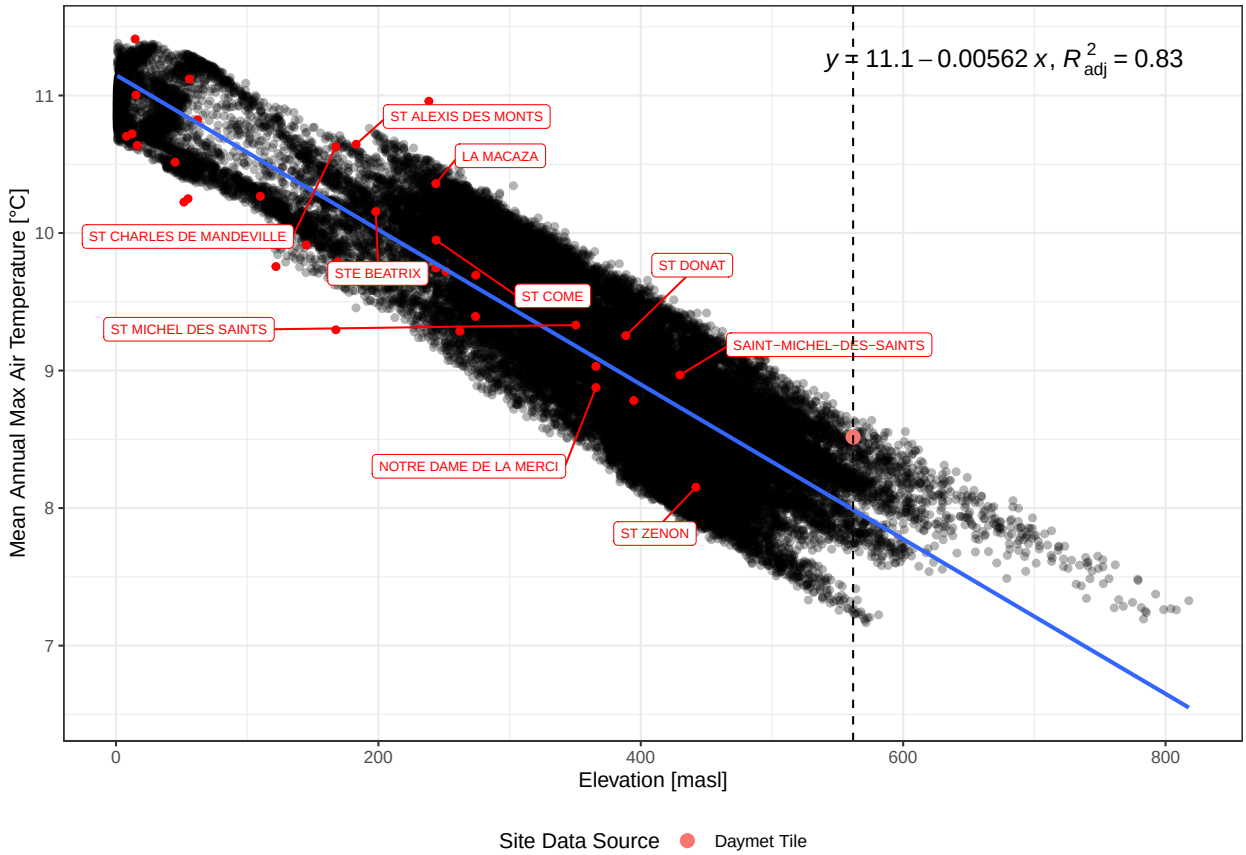
5.2.2.2 Daymet Tmax Regional Overview

Graph 1: Mean Annual Max Air Temperature [°C]:
(1980 – 2023)



Graph 2: Regional Elevation Gradient

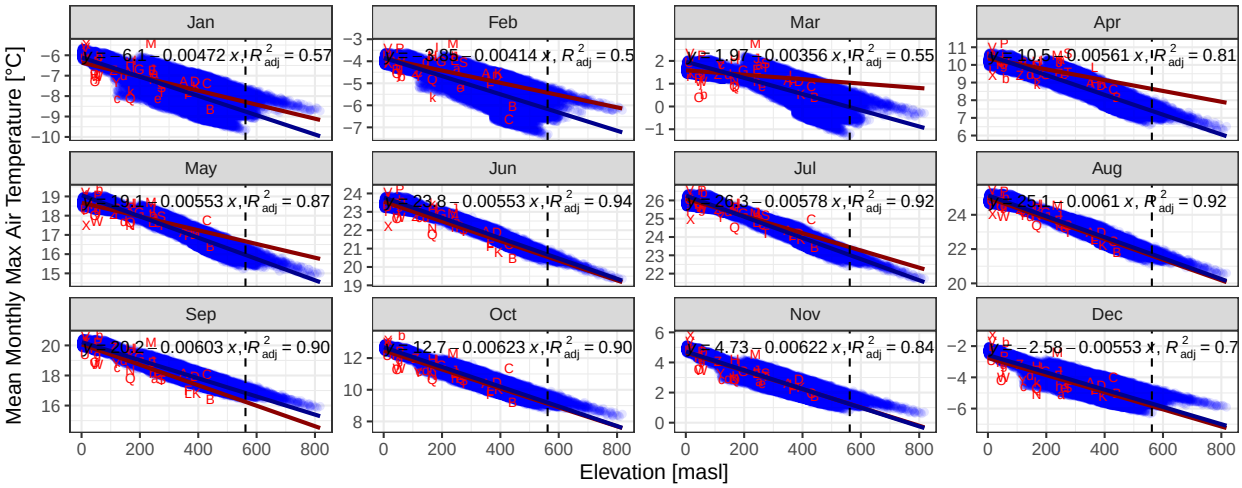
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

Reanalsis source as background: 1980 to 2023 (distance 125 km from site)

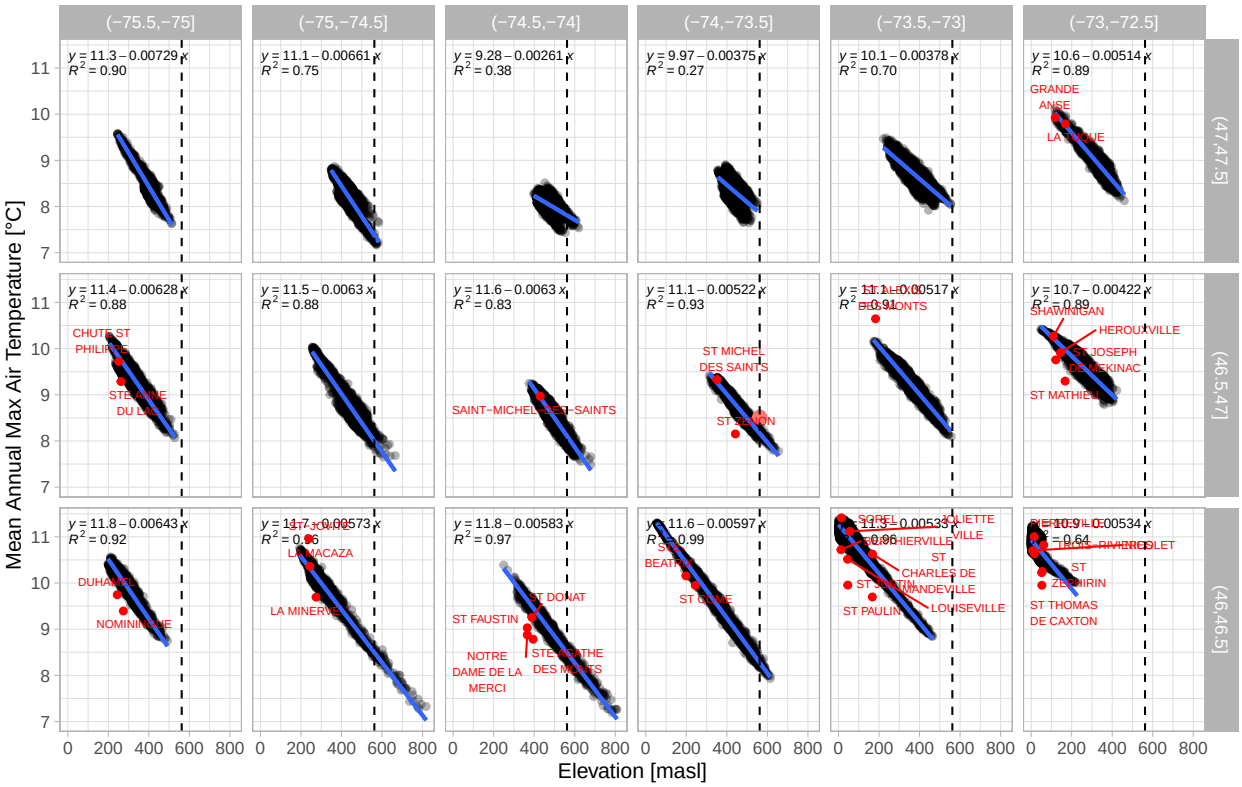


A	ST MICHEL DES SAINTS	I	ST ALEXIS DES MONTS	Q	ST MATHIEU	Y	GRANDE ANSE	g	TROIS RIVIE
B	ST ZENON	J	LA MACAZA	R	LOUISEVILLE	Z	SHAWINIGAN	h	DUHAMEL
C	SAINT−MICHEL−DES−SAINTS	K	STE AGATHE DES MONTS	S	LA MINERVE	a	CHUTE ST PHILIPPE	i	NICOLET
D	ST DONAT	L	ST FAUSTIN	T	NOMININGUE	b	TROIS−RIVIERES	j	ST ZEPHIRI
E	ST COME	M	ST−JOVITE	U	BERTHIERVILLE	c	ST JOSEPH DE MEKINAC	k	LA TUQUE
F	NOTRE DAME DE LA MERCI	N	ST PAULIN	V	SOREL	d	HEROUXVILLE		
G	STE BEATRIX	O	ST JUSTIN	W	ST THOMAS DE CAXTON	e	STE ANNE DU LAC		
H	ST CHARLES DE MANDEVILLE	P	JOLIETTE VILLE	X	LAC SAINT−PIERRE	f	PIERREVILLE		

Note: black dotted line represents site elevation

Graph 4: Mean Annual Max Air Temperature [°C] versus Elevation [masl] (1980 − 2023)

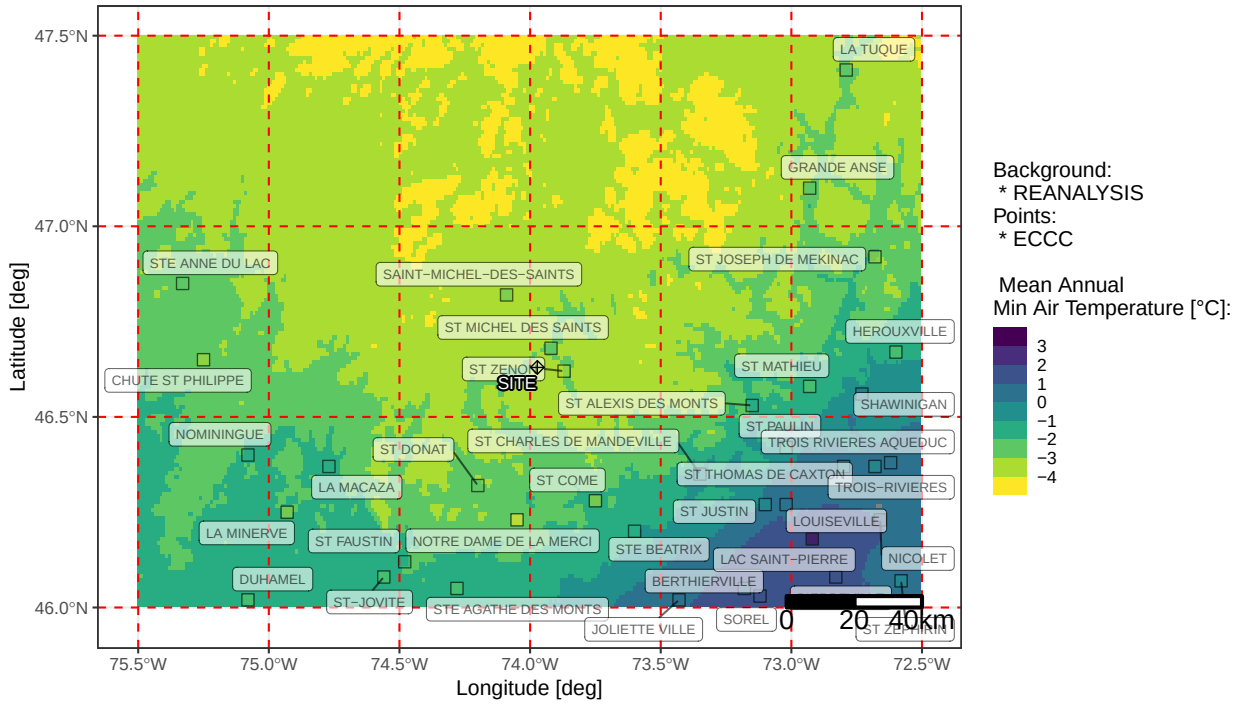
Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



Note: black dotted line represents site elevation

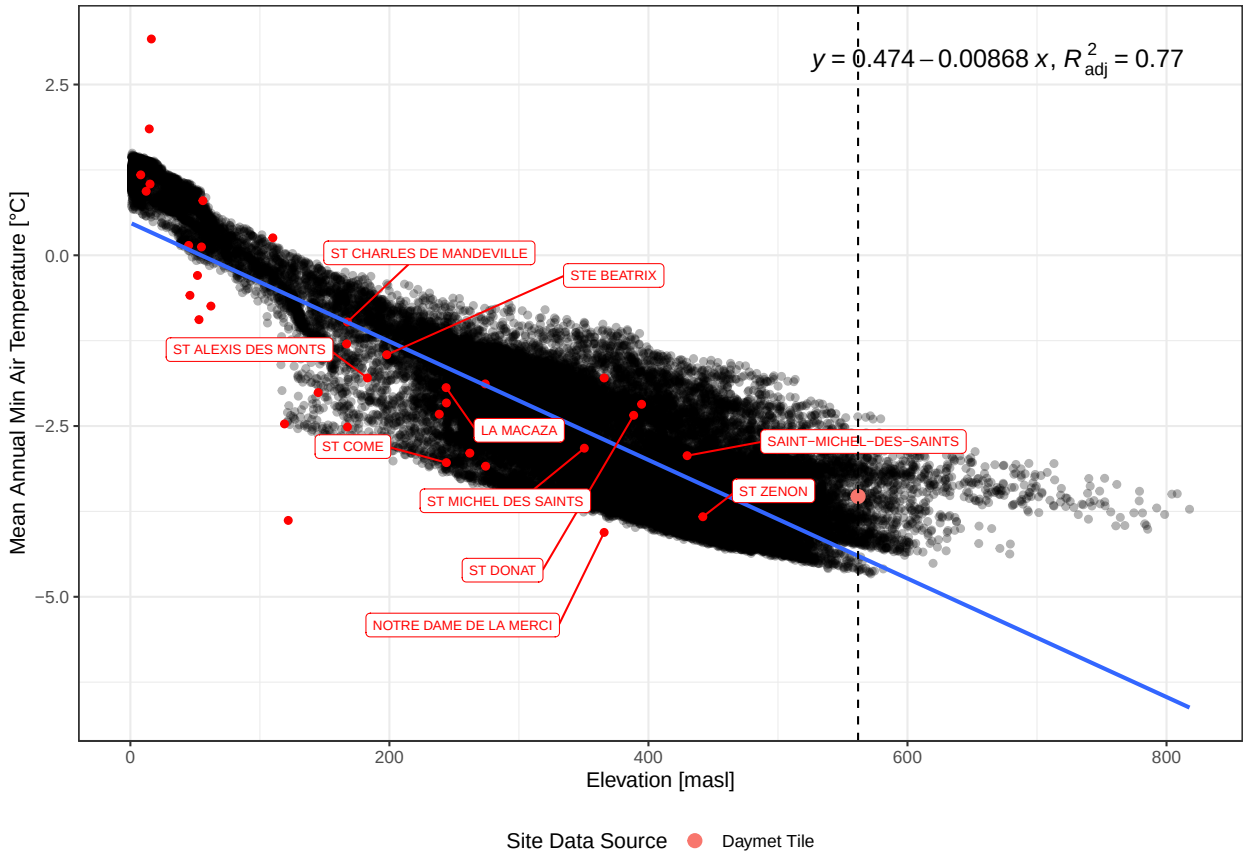
5.2.2.3 Daymet Tmin Regional Overview

Graph 1: Mean Annual Min Air Temperature [°C]:
(1980 − 2023)



Graph 2: Regional Elevation Gradient

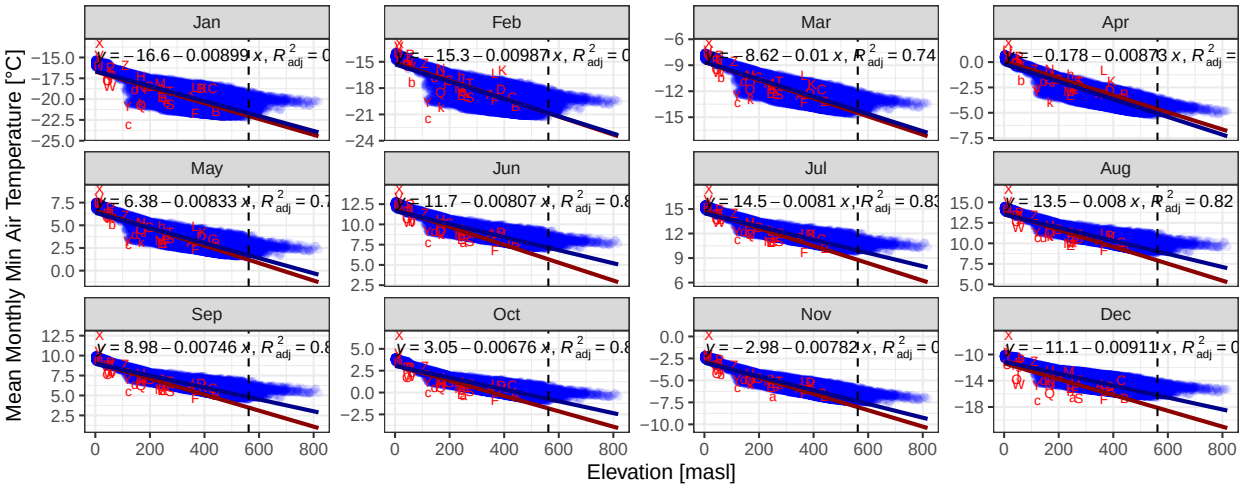
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

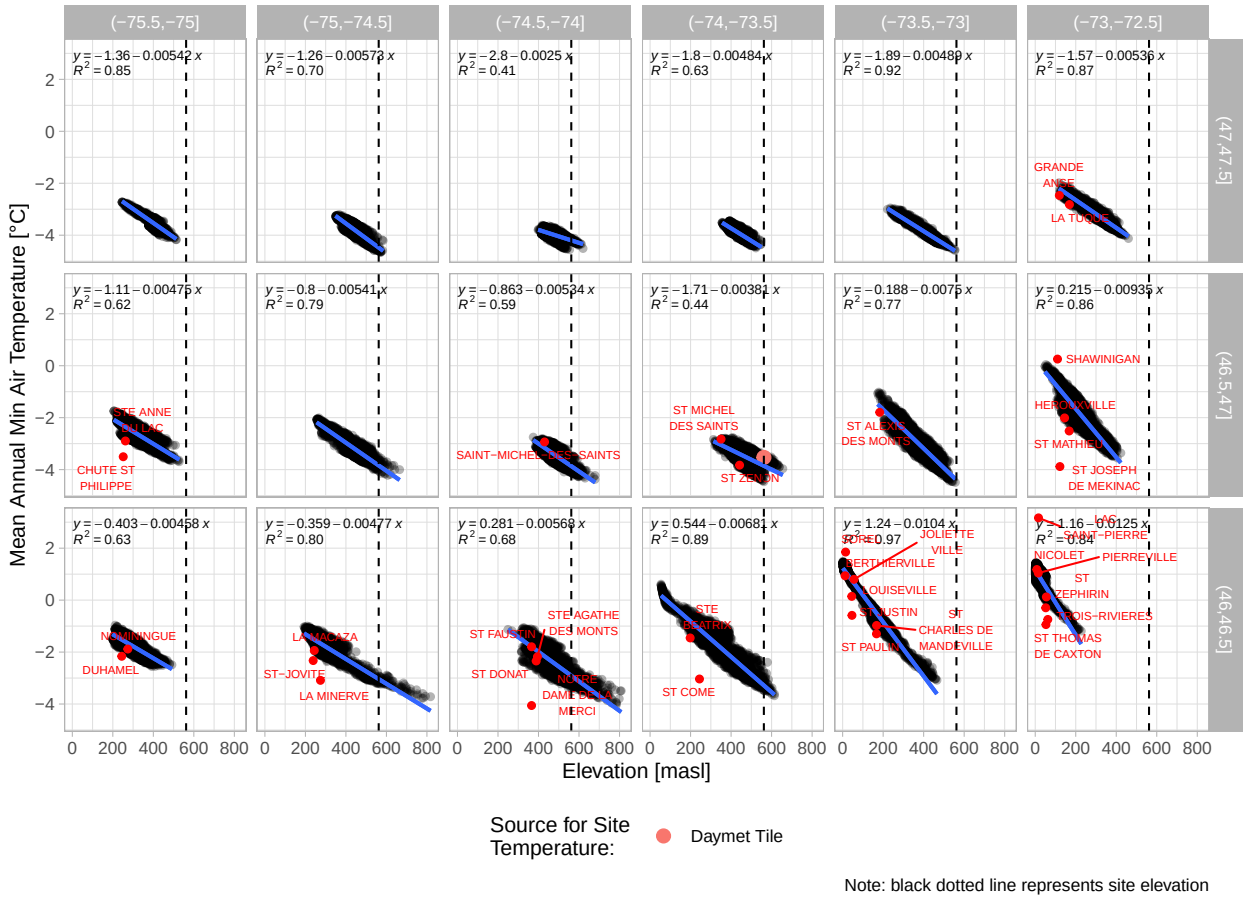
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



A	ST MICHEL DES SAINTS	I	ST ALEXIS DES MONTS	Q	ST MATHIEU	Y	GRANDE ANSE	g	TROIS RIVI
B	ST ZENON	J	LA MACAZA	R	LOUISEVILLE	Z	SHAWINIGAN	h	DUHAMEL
C	SAINT−MICHEL−DES−SAINTS	K	STE AGATHE DES MONTS	S	LA MINERVE	a	CHUTE ST PHILIPPE	i	NICOLET
D	ST DONAT	L	ST FAUSTIN	T	NOMININGUE	b	TROIS−RIVIERES	j	ST ZEPHIR
E	ST COME	M	ST−JOVITE	U	BERTHIERVILLE	c	ST JOSEPH DE MEKINAC	k	LA TUQUE
F	NOTRE DAME DE LA MERCI	N	ST PAULIN	V	SOREL	d	HEROUXVILLE		
G	STE BEATRIX	O	ST JUSTIN	W	ST THOMAS DE CAXTON	e	STE ANNE DU LAC		
H	ST CHARLES DE MANDEVILLE	P	JOLIETTE VILLE	X	LAC SAINT−PIERRE	f	PIERREVILLE		

Note: black dotted line represents site elevation

Graph 4: Mean Annual Min Air Temperature [°C] versus Elevation [masl] (1980 − 2023)
Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



5.2.3 ERA5 Regional Overview for Mean Air Temperature

ERA5 is the fifth generation ECMWF atmospheric reanalysis of the global climate covering the period from January 1940 to present (Hersbach et al. 2020). ERA5 is produced by the Copernicus Climate Change Service (C3S) at the European Centre for Medium-Range Weather Forecasts (ECMWF). It offers information about multiple meteorological parameters.

ERA5 provides hourly estimates of a large number of atmospheric, land and oceanic climate variables. The data cover the Earth on a 31km grid and resolve the atmosphere using 137 levels from the surface up to a height of 80km. Surface level parameters were evaluated in this analysis.

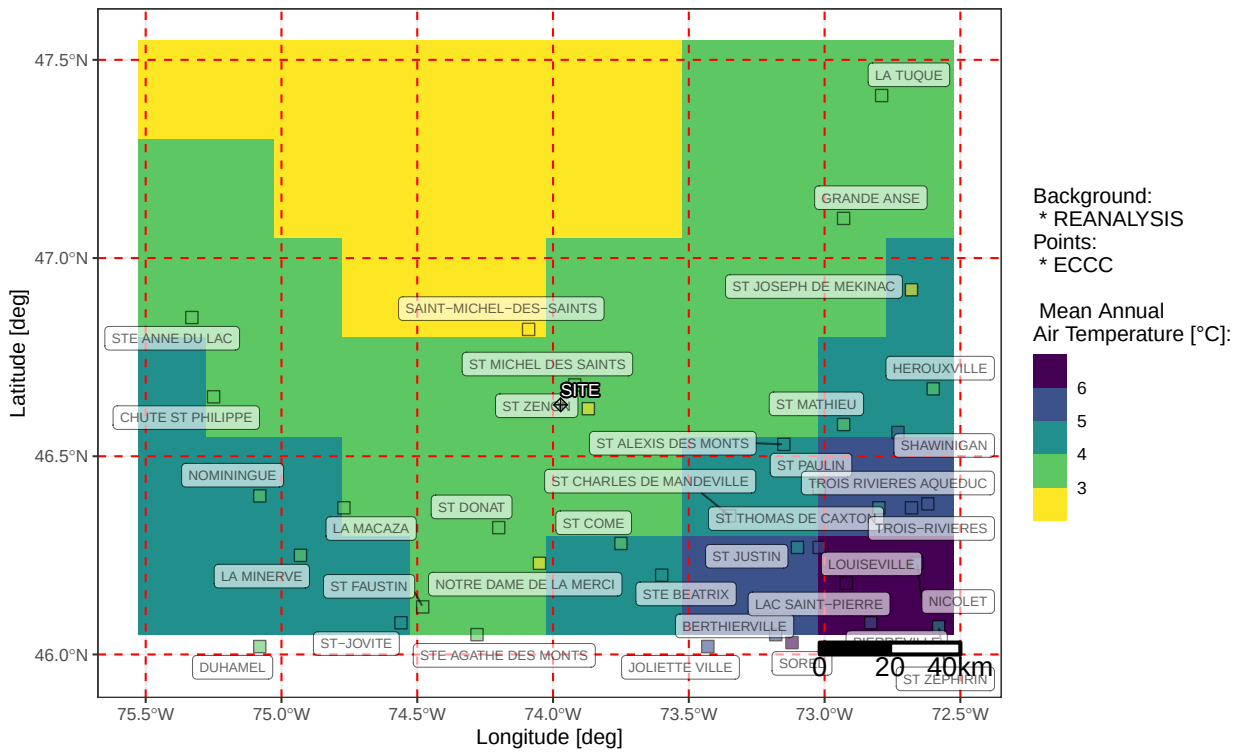
The main findings of the ERA5 regional overview are listed below (the corresponding figures follow):

- Results are generally similar for the analysis of average maximum, and minimum temperature.
- On a regional scale, ERA5 is consistent with ECCC in terms of spatial trends on temperature (Graphs 1).
- The temperature versus elevation gradients (Graphs 2) show a slight overprediction of temperature for ERA5 on a regional scale. This appears to be mostly due to an overprediction of low temperatures (see Tmin graphs), as Tmax results are mostly aligned with ECCC station data. This observation is generally consistent with the monthly breakdowns of this data (Graphs 3). Note that the R^2_{adj} factor decreases slightly for the winter months.
- The localized breakdowns of temperature versus elevation (Graphs 4) are not relevant for

temperature analysis due to the lower resolution of the ERA5 dataset. Note that mean grid elevation is generally higher than the stations elevation due to the mountainous nature of the region, and stations generally being located in the valleys.

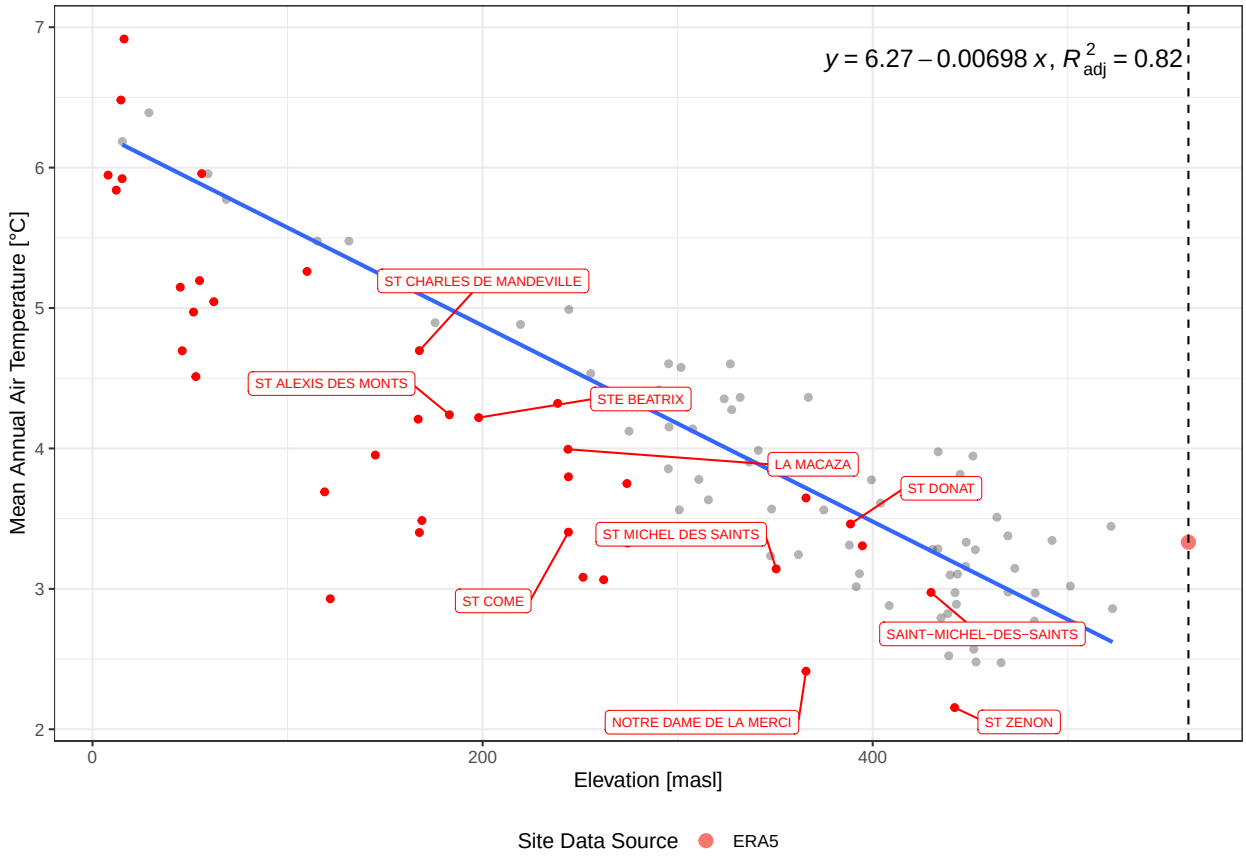
5.2.3.1 ERA5 Tavg Regional Overview

Graph 1: Mean Annual Air Temperature [°C]:
(1980 – 2023)



Graph 2: Regional Elevation Gradient

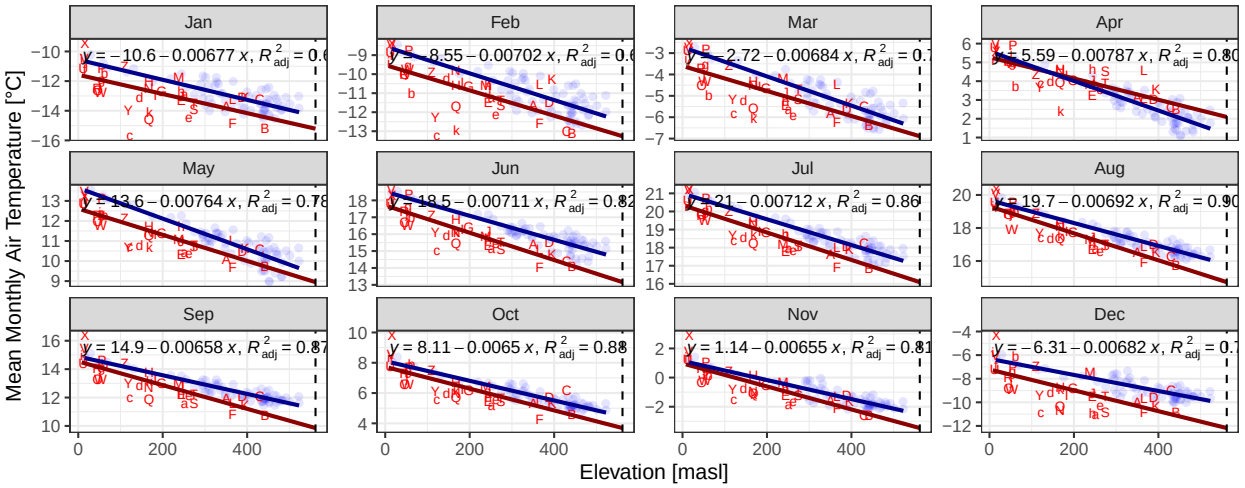
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

Reanalsis source as background: 1980 to 2023 (distance 125 km from site)

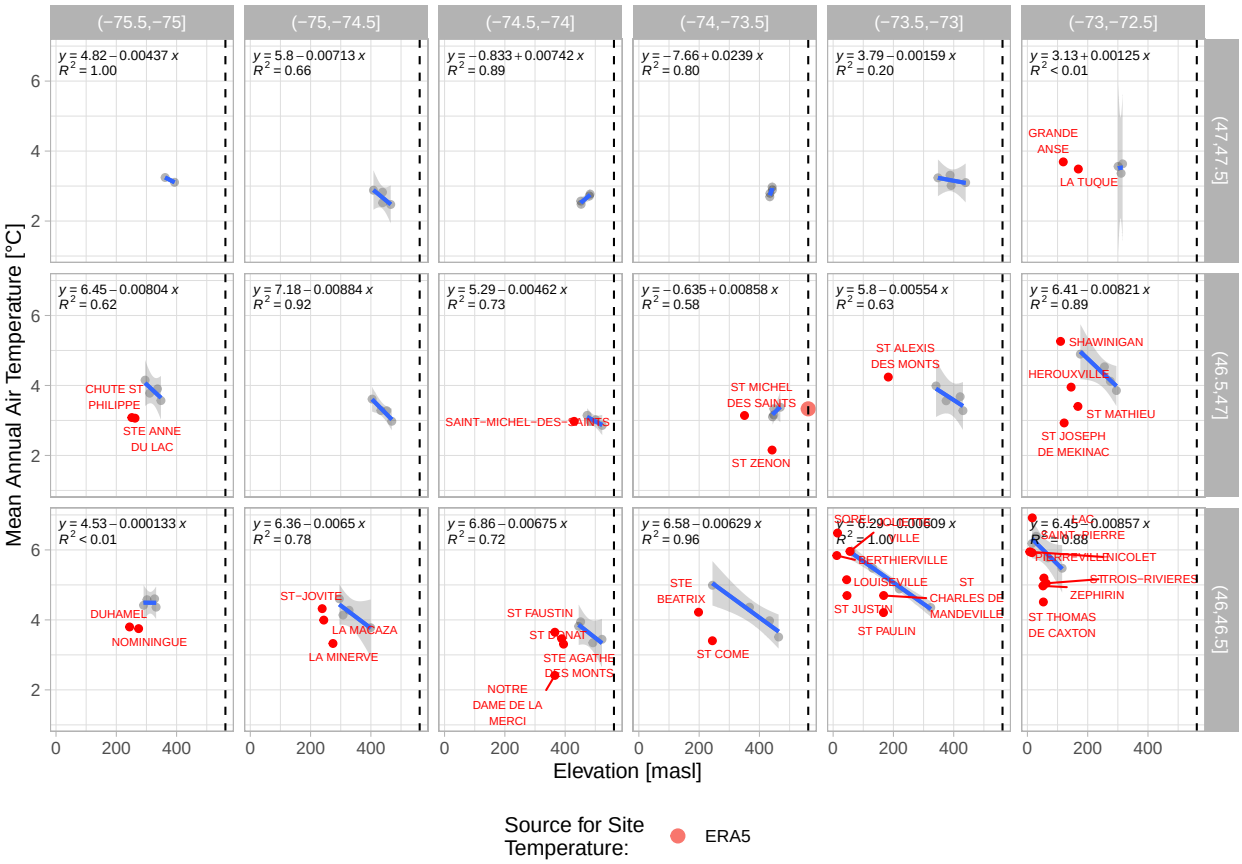


A	ST MICHEL DES SAINTS	I	ST ALEXIS DES MONTS	Q	ST MATHIEU	Y	GRANDE ANSE	g	TROIS RIVIE
B	ST ZENON	J	LA MACAZA	R	LOUISEVILLE	Z	SHAWINIGAN	h	DUHAMEL
C	SAINT−MICHEL−DES−SAINTS	K	STE AGATHE DES MONTS	S	LA MINERVE	a	CHUTE ST PHILIPPE	i	NICOLET
D	ST DONAT	L	ST FAUSTIN	T	NOMININGUE	b	TROIS−RIVIERES	j	ST ZEPHIRI
E	ST COME	M	ST−JOVITE	U	BERTHIERVILLE	c	ST JOSEPH DE MEKINAC	k	LA TUQUE
F	NOTRE DAME DE LA MERCI	N	ST PAULIN	V	SOREL	d	HEROUXVILLE		
G	STE BEATRIX	O	ST JUSTIN	W	ST THOMAS DE CAXTON	e	STE ANNE DU LAC		
H	ST CHARLES DE MANDEVILLE	P	JOLIETTE VILLE	X	LAC SAINT−PIERRE	f	PIERREVILLE		

Note: black dotted line represents site elevation

Graph 4: Mean Annual Air Temperature [°C] versus Elevation [masl] (1980 − 2023)

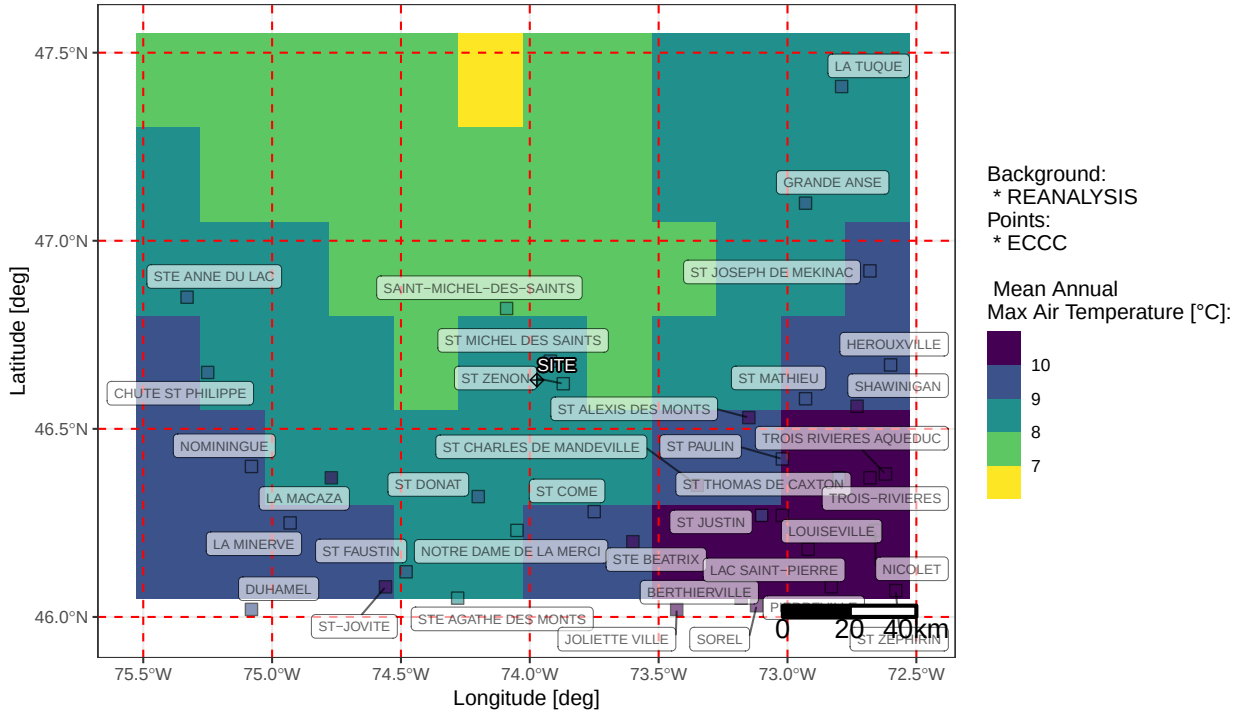
Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



Note: black dotted line represents site elevation

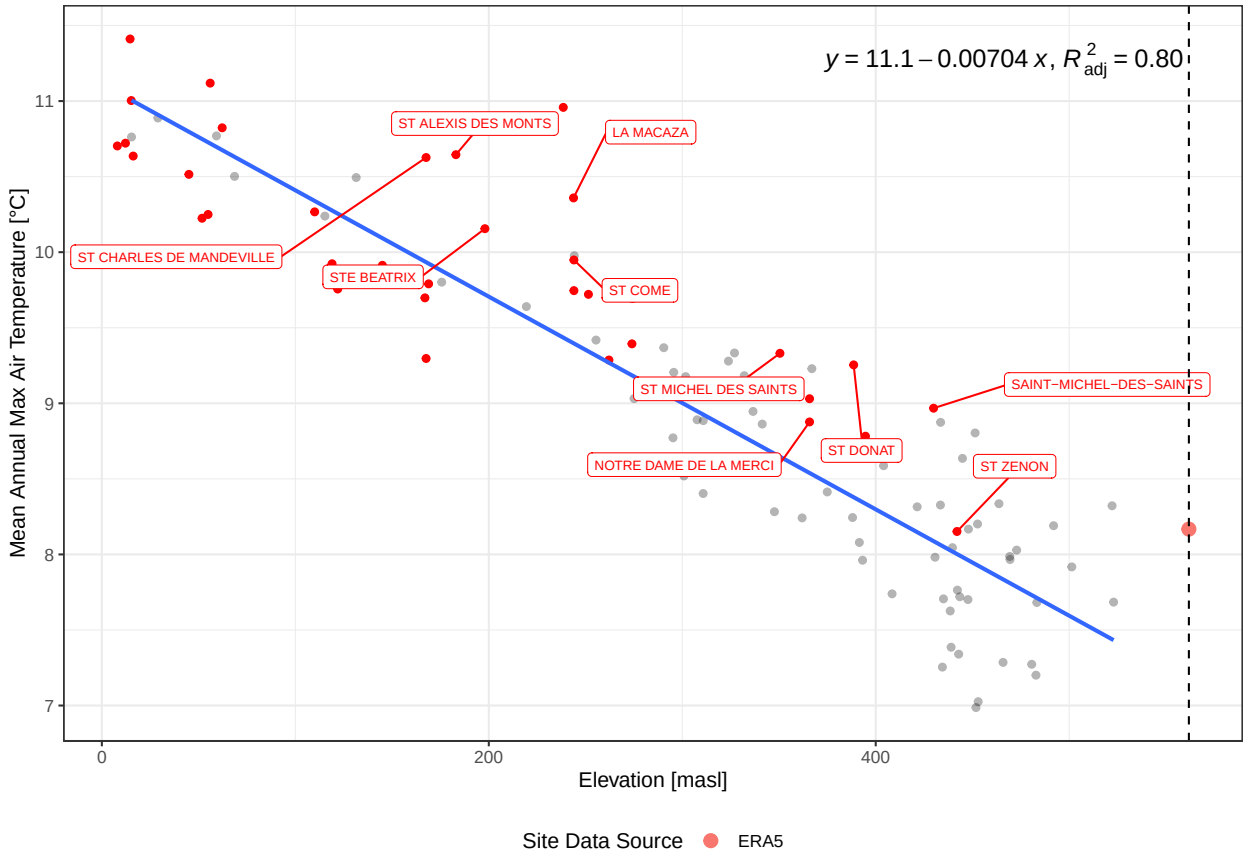
5.2.3.2 ERA5 Tmax Regional Overview

Graph 1: Mean Annual Max Air Temperature [°C]:
(1980 – 2023)



Graph 2: Regional Elevation Gradient

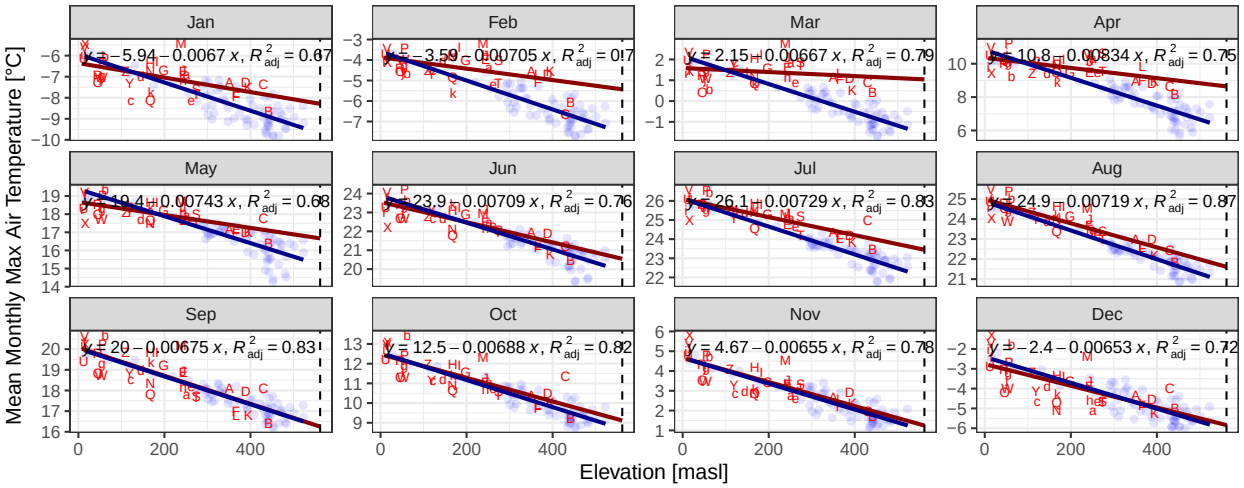
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

Reanalsis source as background: 1980 to 2023 (distance 125 km from site)

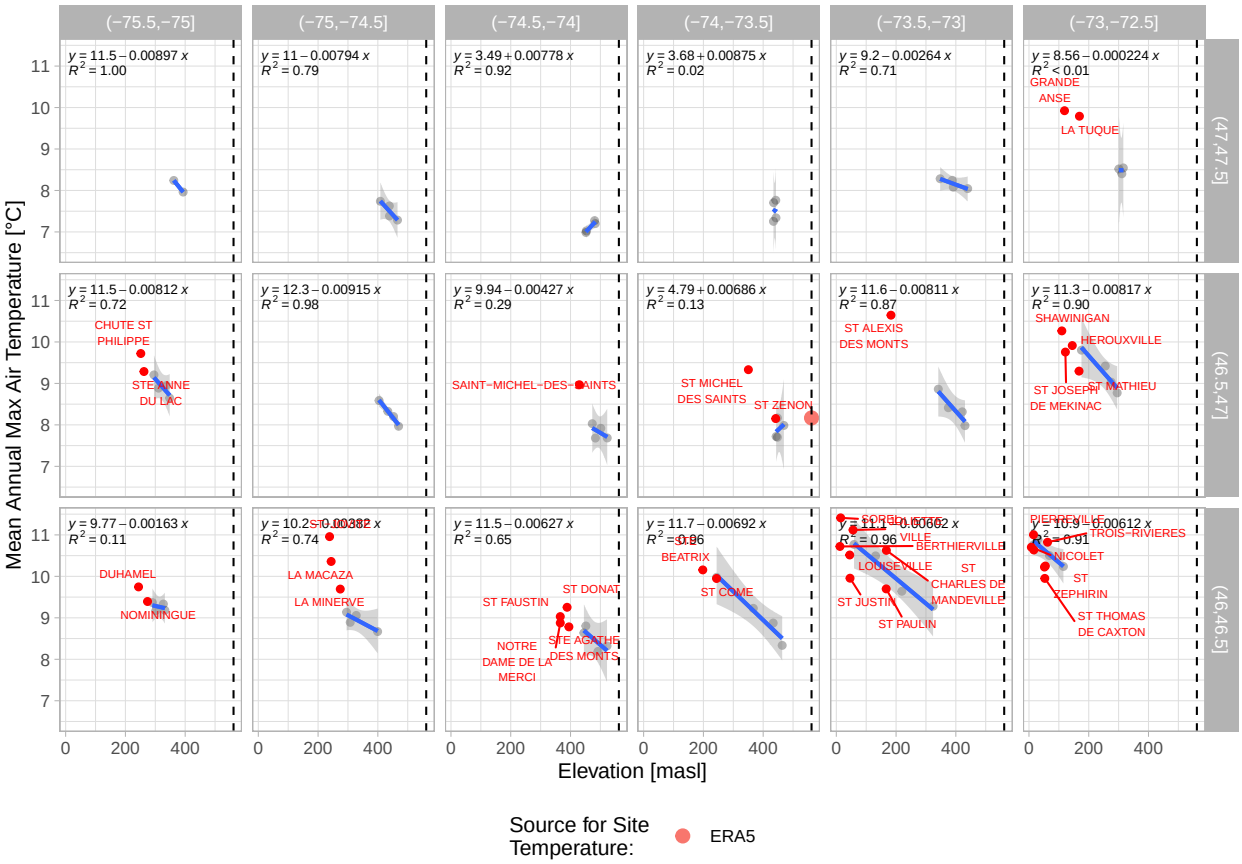


A	ST MICHEL DES SAINTS	I	ST ALEXIS DES MONTS	Q	ST MATHIEU	Y	GRANDE ANSE	g	TROIS RIVIE
B	ST ZENON	J	LA MACAZA	R	LOUISEVILLE	Z	SHAWINIGAN	h	DUHAMEL
C	SAINT−MICHEL−DES−SAINTS	K	STE AGATHE DES MONTS	S	LA MINERVE	a	CHUTE ST PHILIPPE	i	NICOLET
D	ST DONAT	L	ST FAUSTIN	T	NOMININGUE	b	TROIS−RIVIERES	j	ST ZEPHIRI
E	ST COME	M	ST−JOVITE	U	BERTHIERVILLE	c	ST JOSEPH DE MEKINAC	k	LA TUQUE
F	NOTRE DAME DE LA MERCI	N	ST PAULIN	V	SOREL	d	HEROUXVILLE		
G	STE BEATRIX	O	ST JUSTIN	W	ST THOMAS DE CAXTON	e	STE ANNE DU LAC		
H	ST CHARLES DE MANDEVILLE	P	JOLIETTE VILLE	X	LAC SAINT−PIERRE	f	PIERREVILLE		

Note: black dotted line represents site elevation

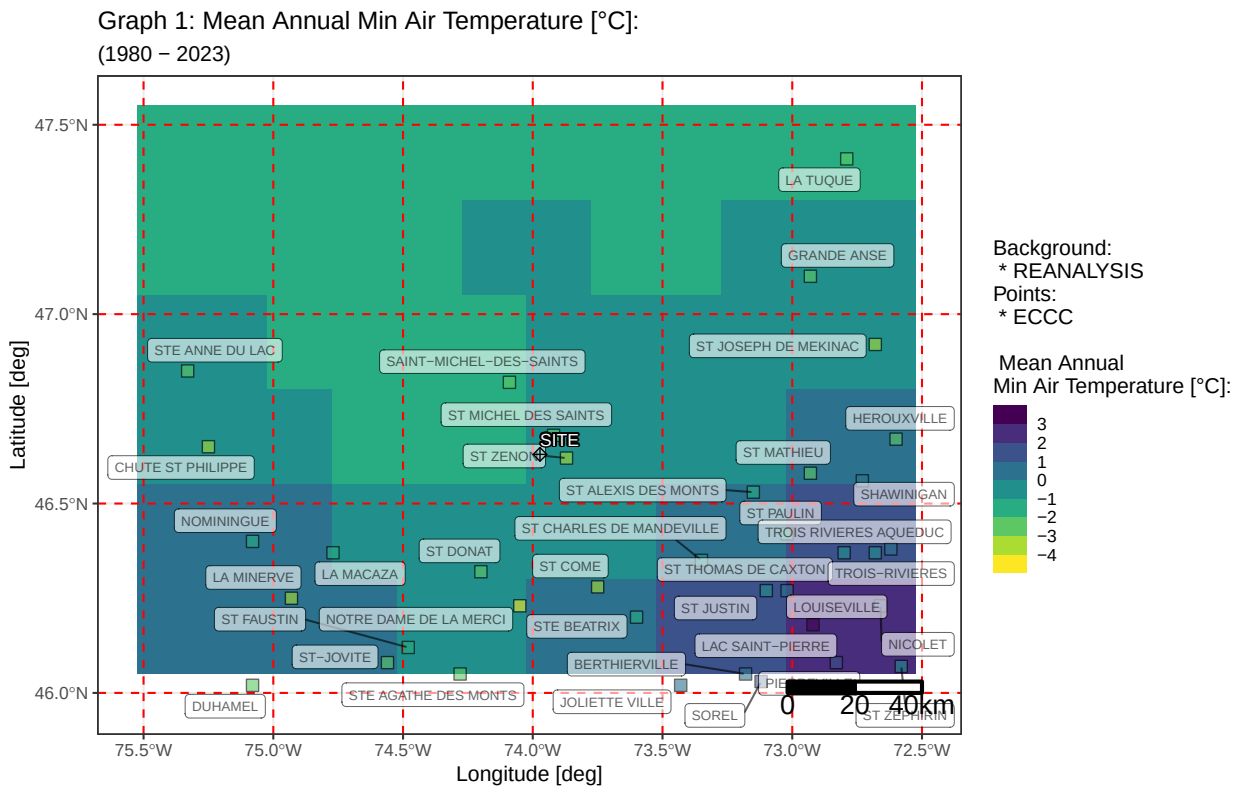
Graph 4: Mean Annual Max Air Temperature [°C] versus Elevation [masl] (1980 − 2023)

Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



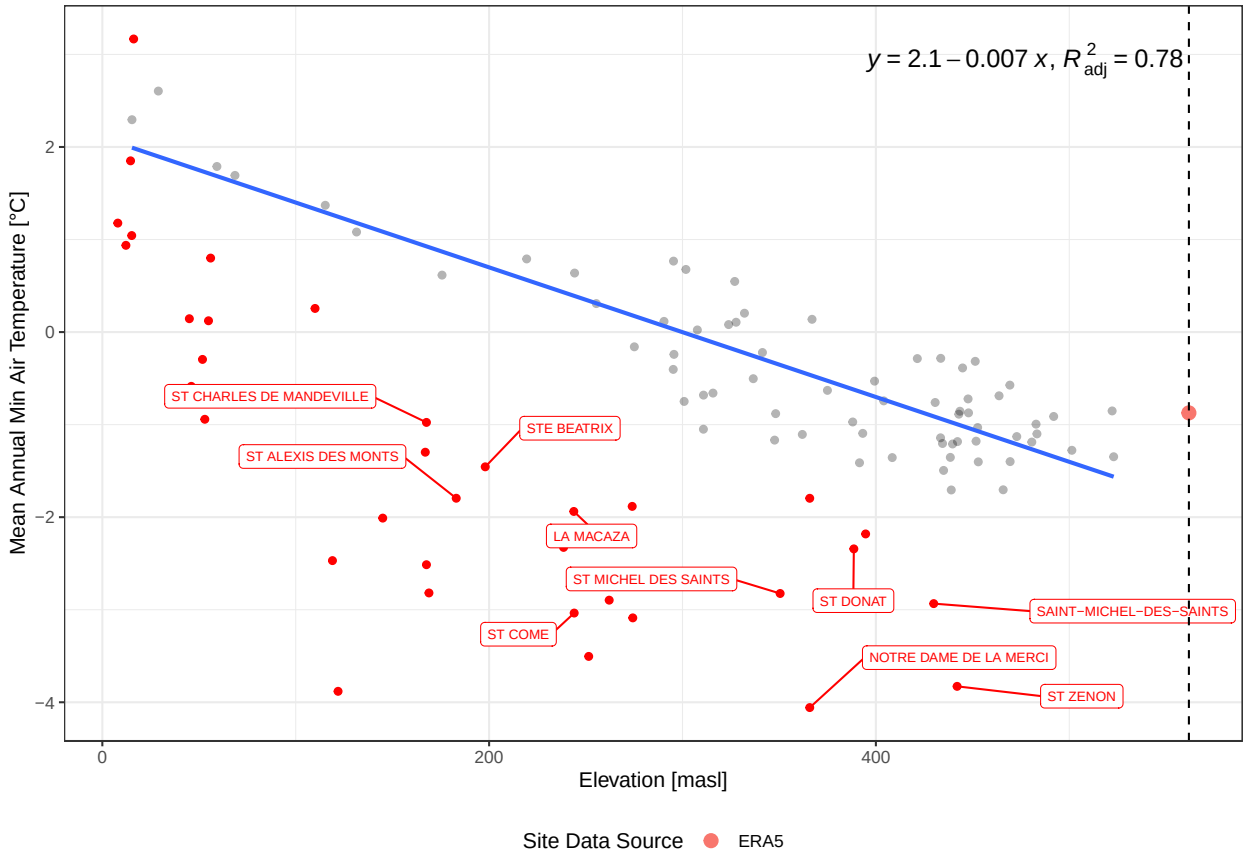
Note: black dotted line represents site elevation

5.2.3.3 ERA5 Tmin Regional Overview



Graph 2: Regional Elevation Gradient

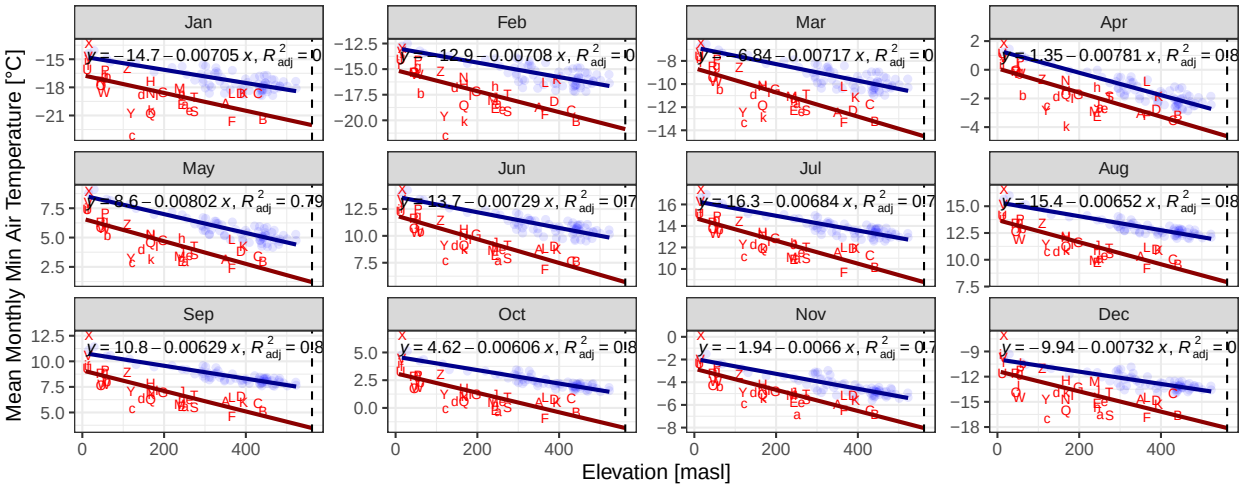
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

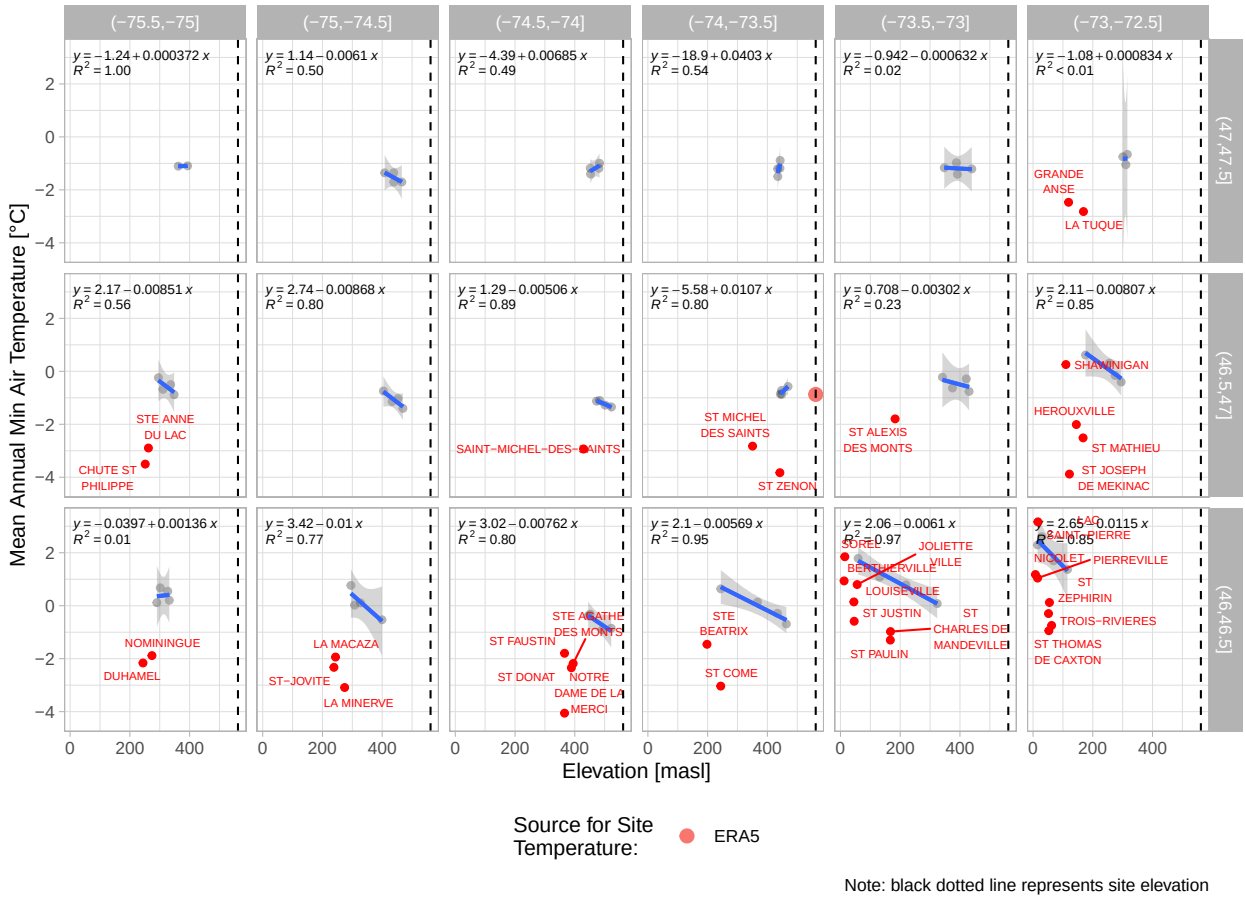
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



A	ST MICHEL DES SAINTS	I	ST ALEXIS DES MONTS	Q	ST MATHIEU	Y	GRANDE ANSE	g	TROIS RIVI
B	ST ZENON	J	LA MACAZA	R	LOUISEVILLE	Z	SHAWINIGAN	h	DUHAMEL
C	SAINT−MICHEL−DES−SAINTS	K	STE AGATHE DES MONTS	S	LA MINERVE	a	CHUTE ST PHILIPPE	i	NICOLET
D	ST DONAT	L	ST FAUSTIN	T	NOMININGUE	b	TROIS−RIVIERES	j	ST ZEPHIRI
E	ST COME	M	ST−JOVITE	U	BERTHIERVILLE	c	ST JOSEPH DE MEKINAC	k	LA TUQUE
F	NOTRE DAME DE LA MERCI	N	ST PAULIN	V	SOREL	d	HEROUXVILLE		
G	STE BEATRIX	O	ST JUSTIN	W	ST THOMAS DE CAXTON	e	STE ANNE DU LAC		
H	ST CHARLES DE MANDEVILLE	P	JOLIETTE VILLE	X	LAC SAINT−PIERRE	f	PIERREVILLE		

Note: black dotted line represents site elevation

Graph 4: Mean Annual Min Air Temperature [°C] versus Elevation [masl] (1980 − 2023)
Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



Note: black dotted line represents site elevation

5.2.4 ERA5-Land Regional Overview for Mean Air Temperature

ERA5-Land is a higher spatial and temporal resolution reanalysis dataset produced by the European Centre for Medium-Range Weather Forecasts (ECMWF) (Muñoz-Sabater et al. 2021). It offers detailed information about a large number of atmospheric, land and oceanic climate variables.

ERA5-Land operates at a spatial resolution of approximately 9 km and provides data at hourly intervals, making it particularly useful for hydrological and environmental studies. This dataset is widely used in research and operational applications due to its comprehensive coverage and high accuracy in representing land-surface conditions.

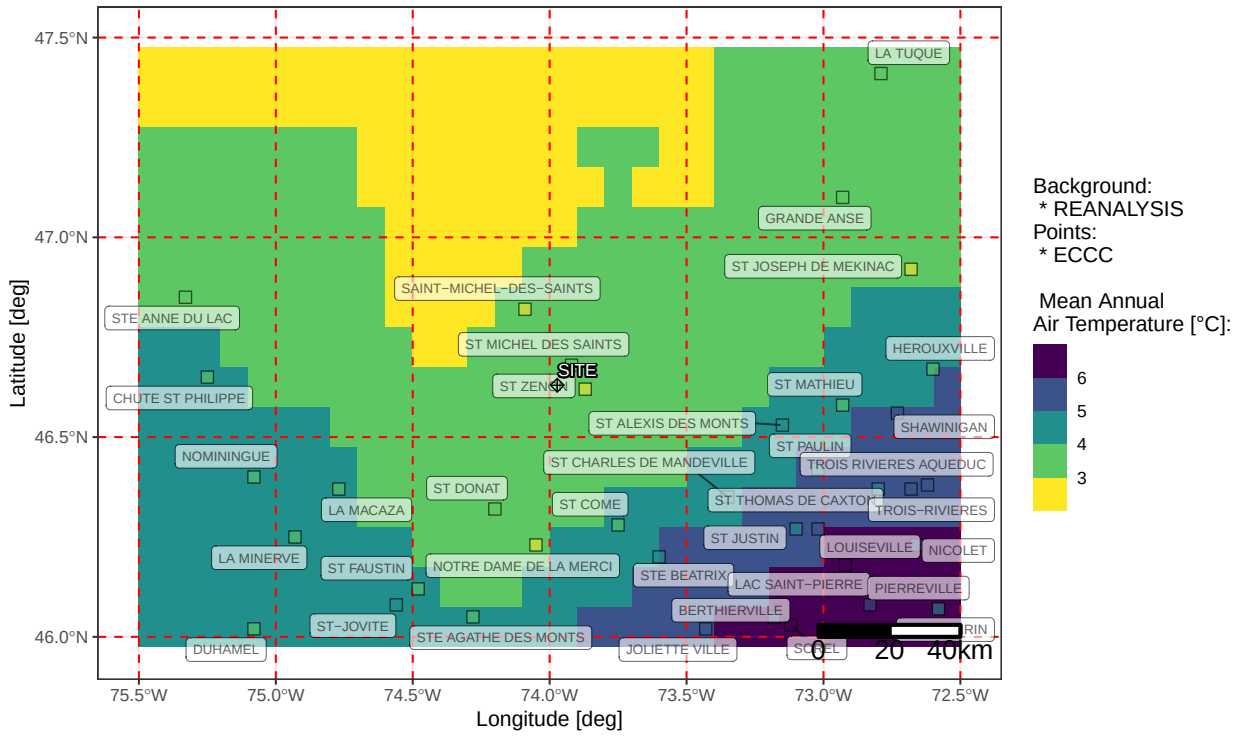
The main findings of the ERA5-Land regional overview are listed below (the corresponding figures follow):

- On a regional scale, ERA5-Land is consistent with ECCC in terms of spatial trends on temperature (Graphs 1).
- Similarly to ERA5, the temperature versus elevation gradients (Graphs 2) show a slight overprediction of temperature for ERA5-Land on a regional scale. This appears to be mostly due to an overprediction of low temperatures (see Tmin graphs), as Tmax results are mostly aligned with ECCC station data. This observation is generally consistent with the monthly breakdowns of this data (Graphs 3). Note that the R^2_{adj} factor decreases slightly for the winter months.

- The localized breakdowns of temperature versus Elevation (Graphs 4) show improved correlations between elevation and temperature in the subdivisions with wider elevation spread, although results are not always consistent with temperature from ECCC stations.

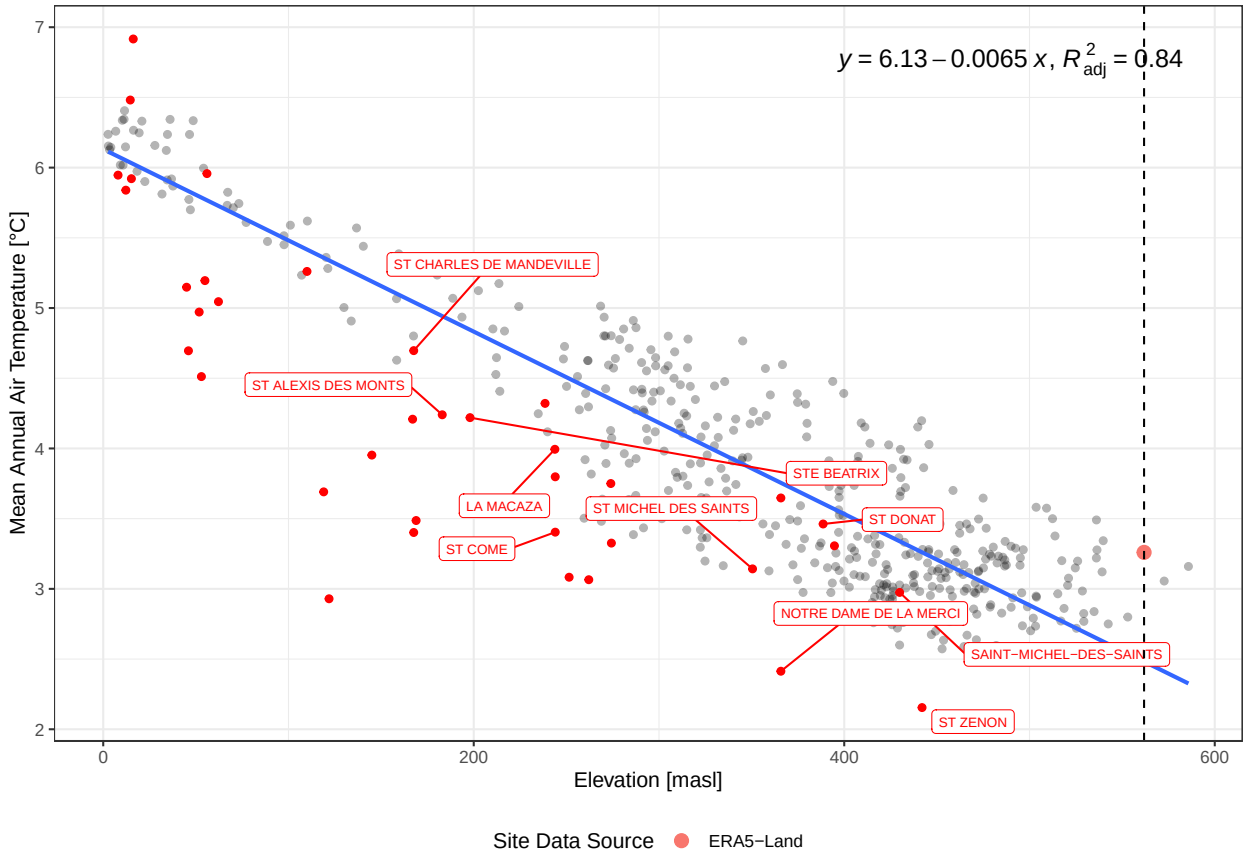
5.2.4.1 ERA5-Land Tavg Regional Overview

Graph 1: Mean Annual Air Temperature [°C]:
(1980 – 2023)



Graph 2: Regional Elevation Gradient

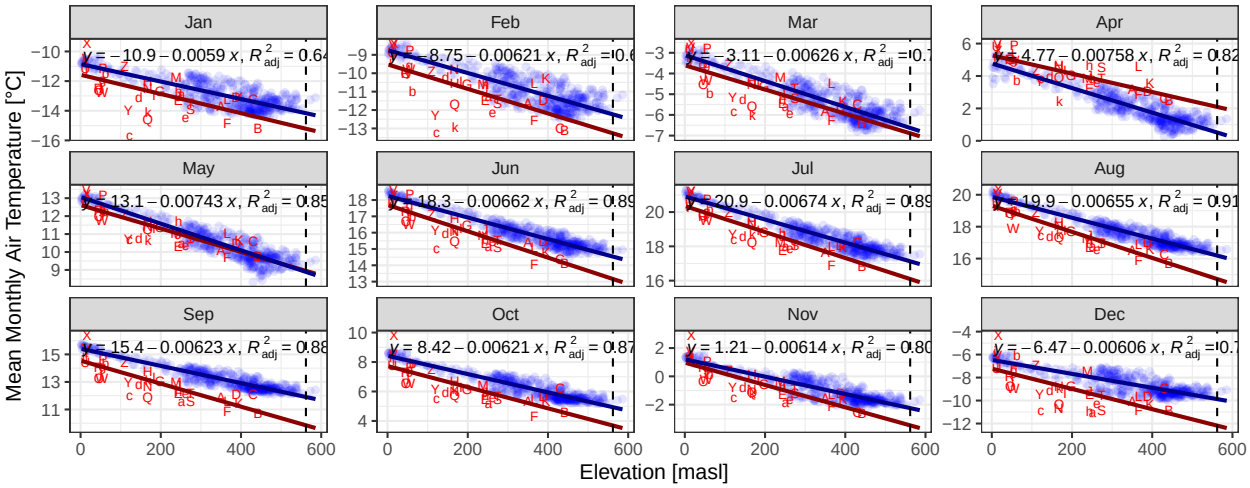
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

Reanalsis source as background: 1980 to 2023 (distance 125 km from site)

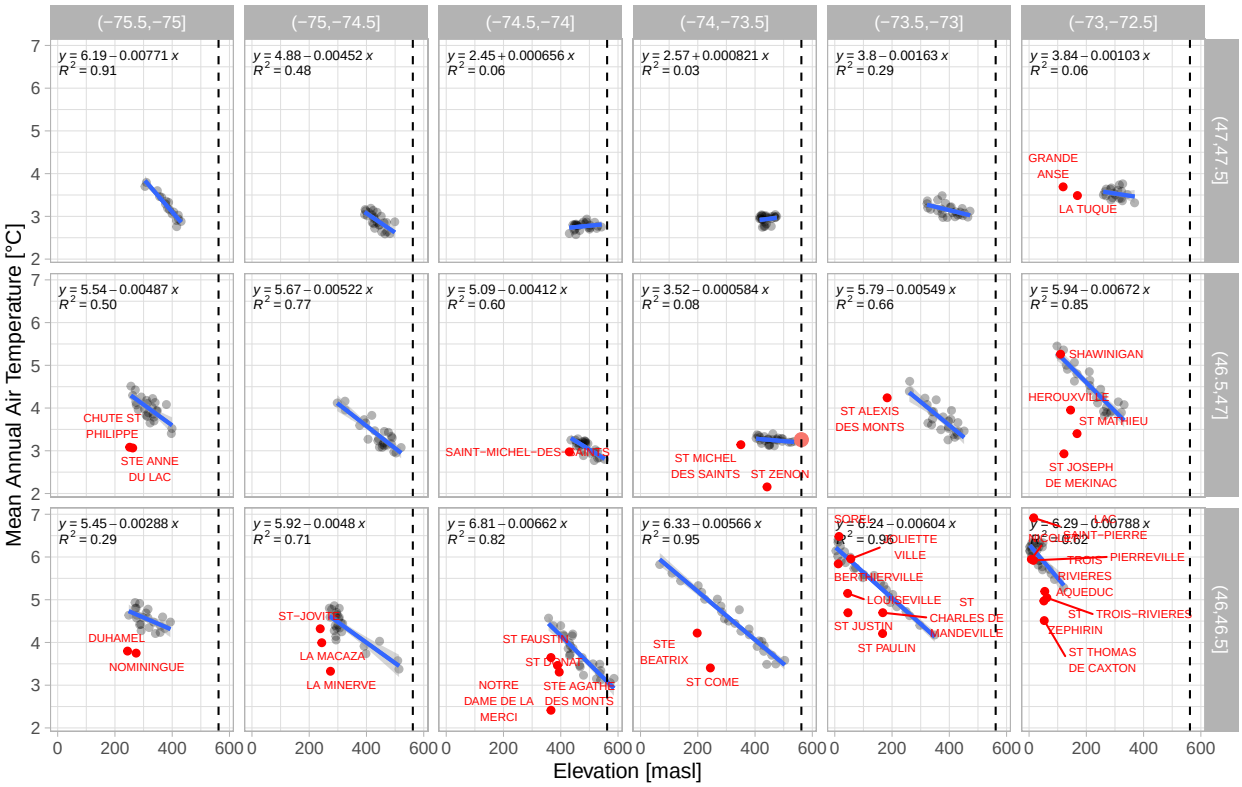


A	ST MICHEL DES SAINTS	I	ST ALEXIS DES MONTS	Q	ST MATHIEU	Y	GRANDE ANSE	g	TROIS RIVIE
B	ST ZENON	J	LA MACAZA	R	LOUISEVILLE	Z	SHAWINIGAN	h	DUHAMEL
C	SAINT−MICHEL−DES−SAINTS	K	STE AGATHE DES MONTS	S	LA MINERVE	a	CHUTE ST PHILIPPE	i	NICOLET
D	ST DONAT	L	ST FAUSTIN	T	NOMININGUE	b	TROIS−RIVIERES	j	ST ZEPHIRI
E	ST COME	M	ST−JOVITE	U	BERTHIERVILLE	c	ST JOSEPH DE MEKINAC	k	LA TUQUE
F	NOTRE DAME DE LA MERCI	N	ST PAULIN	V	SOREL	d	HEROUXVILLE		
G	STE BEATRIX	O	ST JUSTIN	W	ST THOMAS DE CAXTON	e	STE ANNE DU LAC		
H	ST CHARLES DE MANDEVILLE	P	JOLIETTE VILLE	X	LAC SAINT−PIERRE	f	PIERREVILLE		

Note: black dotted line represents site elevation

Graph 4: Mean Annual Air Temperature [°C] versus Elevation [masl] (1980 − 2023)

Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC

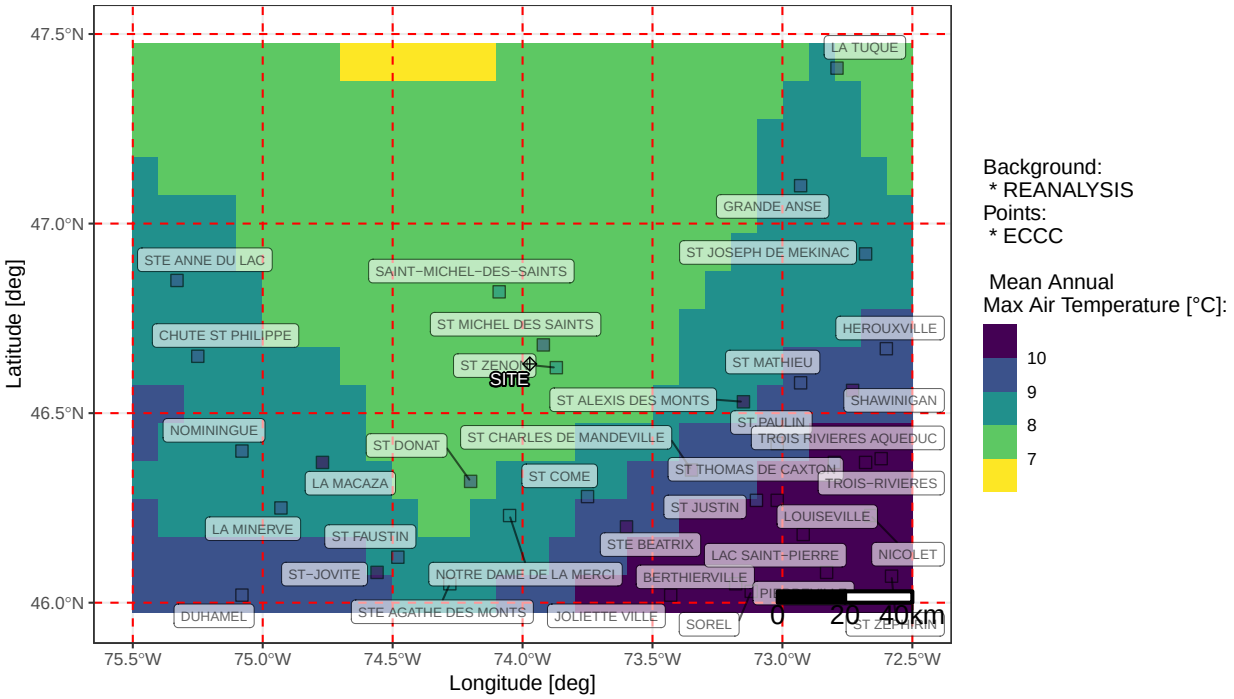


Source for Site Temperature: ● ERA5−Land

Note: black dotted line represents site elevation

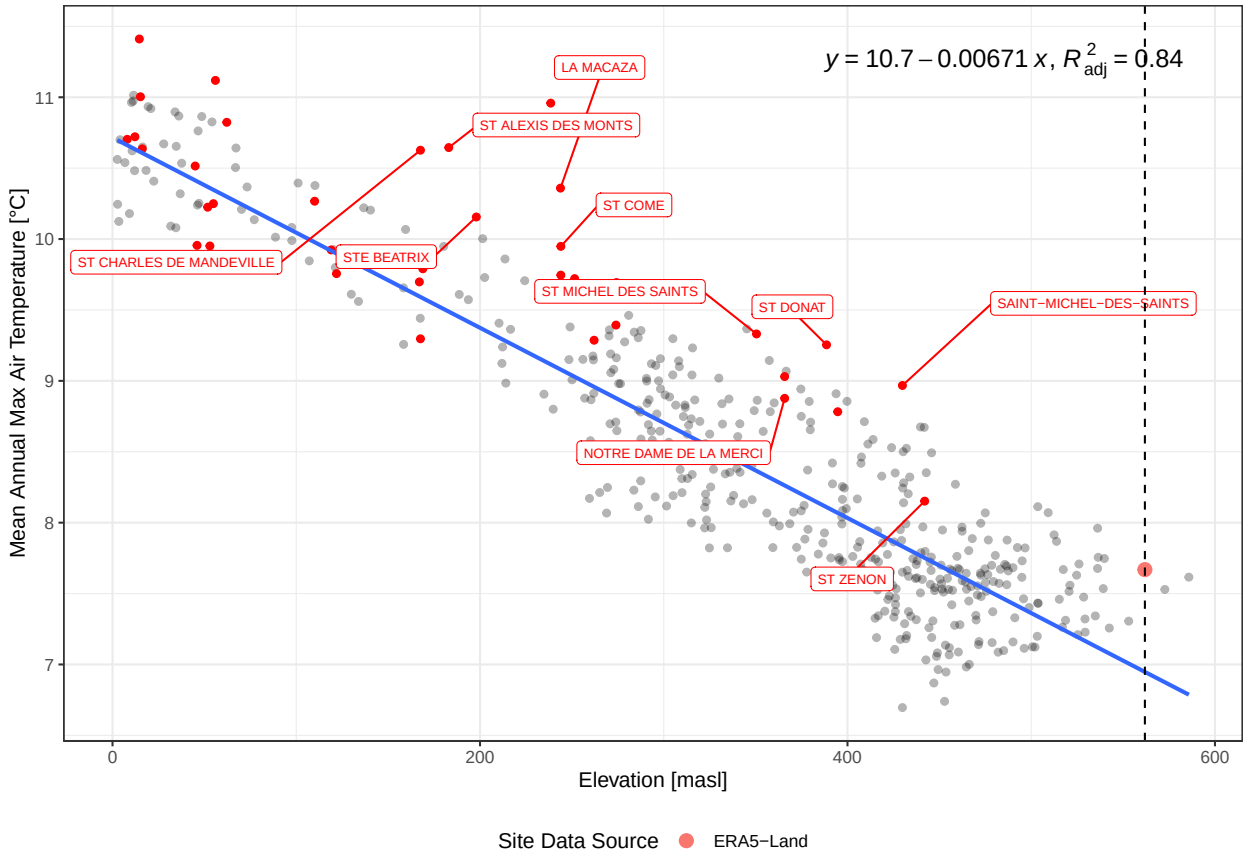
5.2.4.2 ERA5-Land Tmax Regional Overview

Graph 1: Mean Annual Max Air Temperature [°C]:
(1980 – 2023)



Graph 2: Regional Elevation Gradient

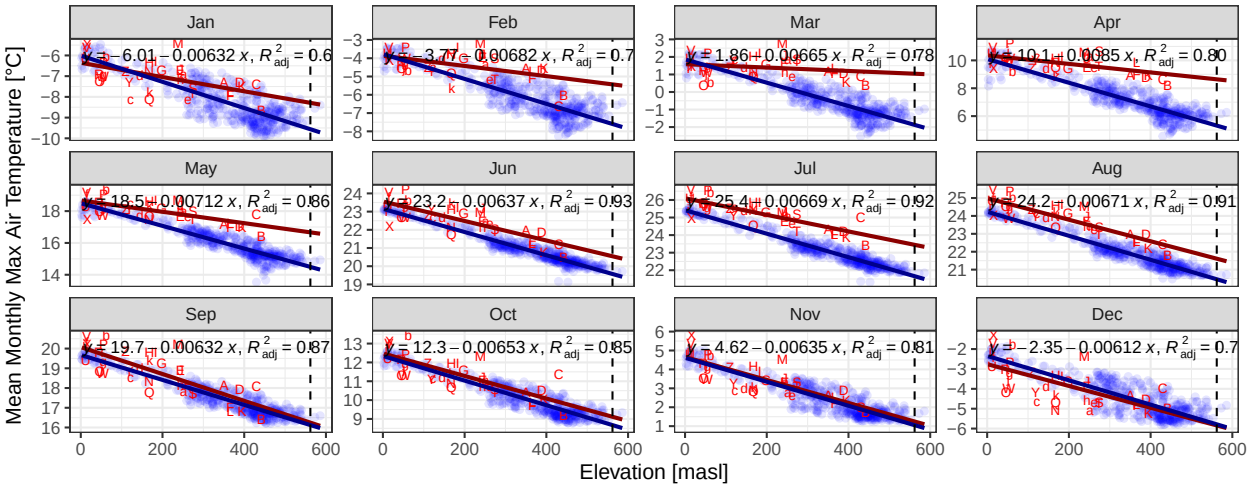
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

Reanalsis source as background: 1980 to 2023 (distance 125 km from site)

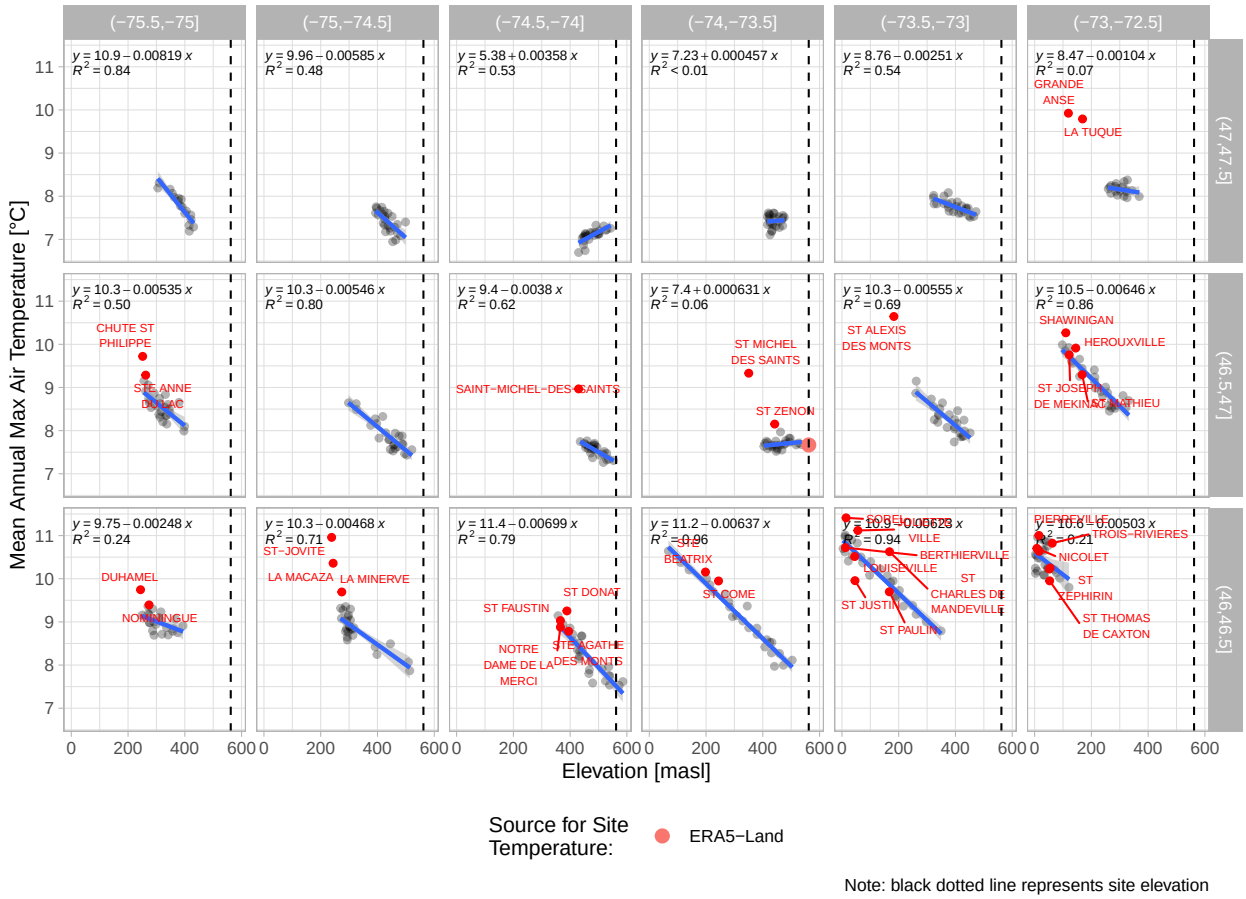


A	ST MICHEL DES SAINTS	I	ST ALEXIS DES MONTS	Q	ST MATHIEU	Y	GRANDE ANSE	g	TROIS RIVIE
B	ST ZENON	J	LA MACAZA	R	LOUISEVILLE	Z	SHAWINIGAN	h	DUHAMEL
C	SAINT−MICHEL−DES−SAINTS	K	STE AGATHE DES MONTS	S	LA MINERVE	a	CHUTE ST PHILIPPE	i	NICOLET
D	ST DONAT	L	ST FAUSTIN	T	NOMININGUE	b	TROIS−RIVIERES	j	ST ZEPHIRI
E	ST COME	M	ST−JOVITE	U	BERTHIERVILLE	c	ST JOSEPH DE MEKINAC	k	LA TUQUE
F	NOTRE DAME DE LA MERCI	N	ST PAULIN	V	SOREL	d	HEROUXVILLE		
G	STE BEATRIX	O	ST JUSTIN	W	ST THOMAS DE CAXTON	e	STE ANNE DU LAC		
H	ST CHARLES DE MANDEVILLE	P	JOLIETTE VILLE	X	LAC SAINT−PIERRE	f	PIERREVILLE		

Note: black dotted line represents site elevation

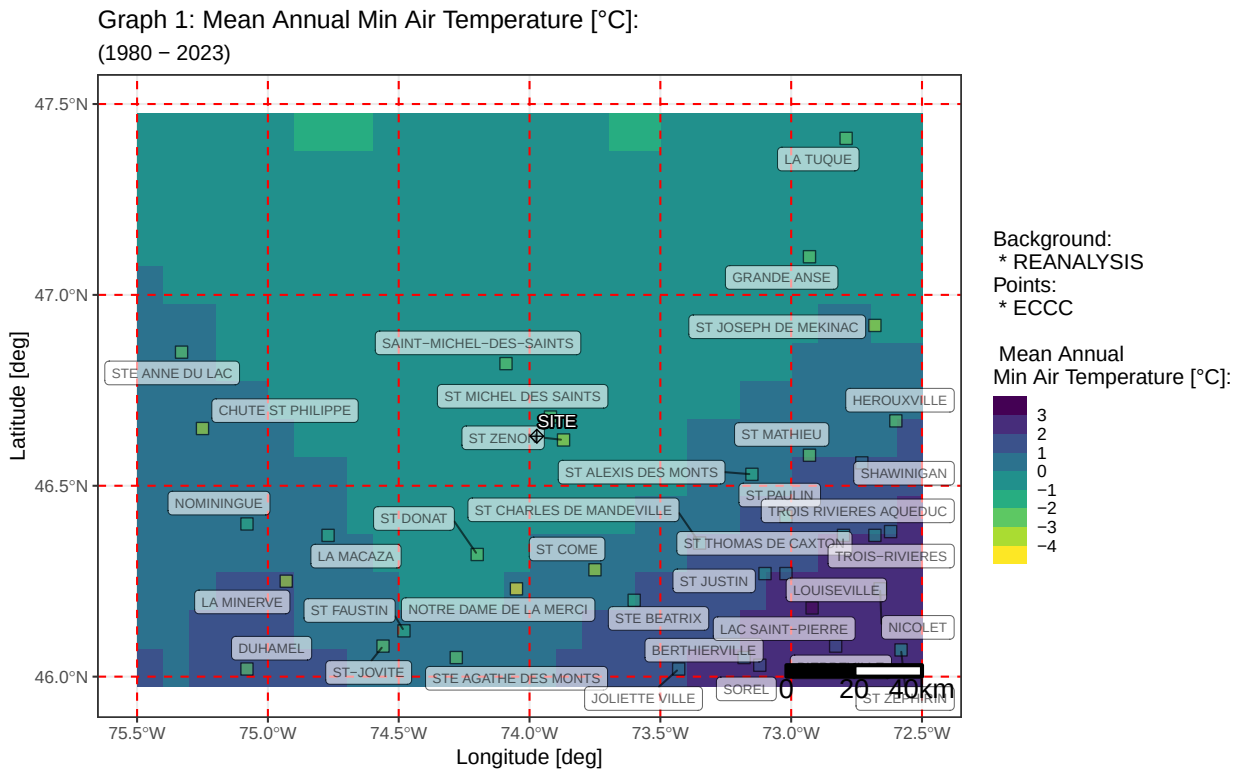
Graph 4: Mean Annual Max Air Temperature [°C] versus Elevation [masl] (1980 − 2023)

Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



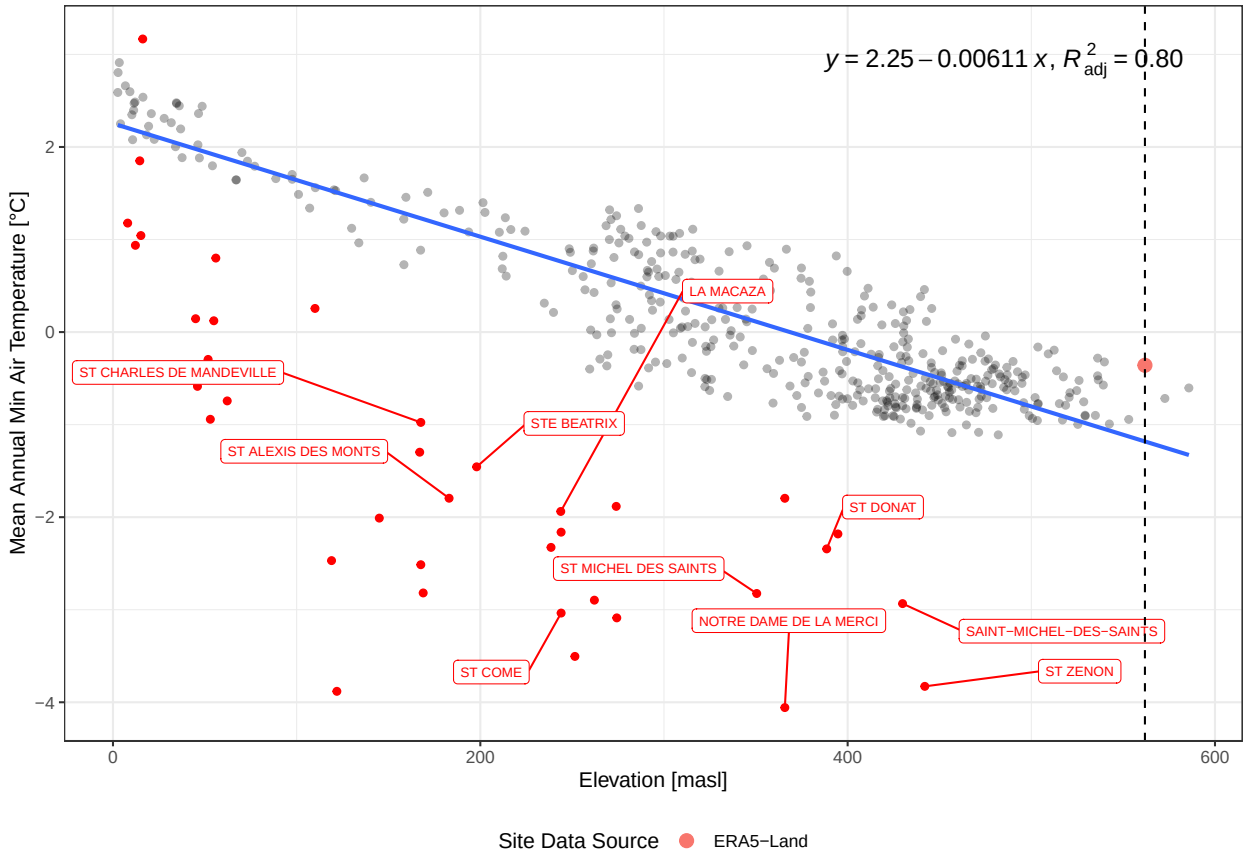
Note: black dotted line represents site elevation

5.2.4.3 ERA5-Land Tmin Regional Overview



Graph 2: Regional Elevation Gradient

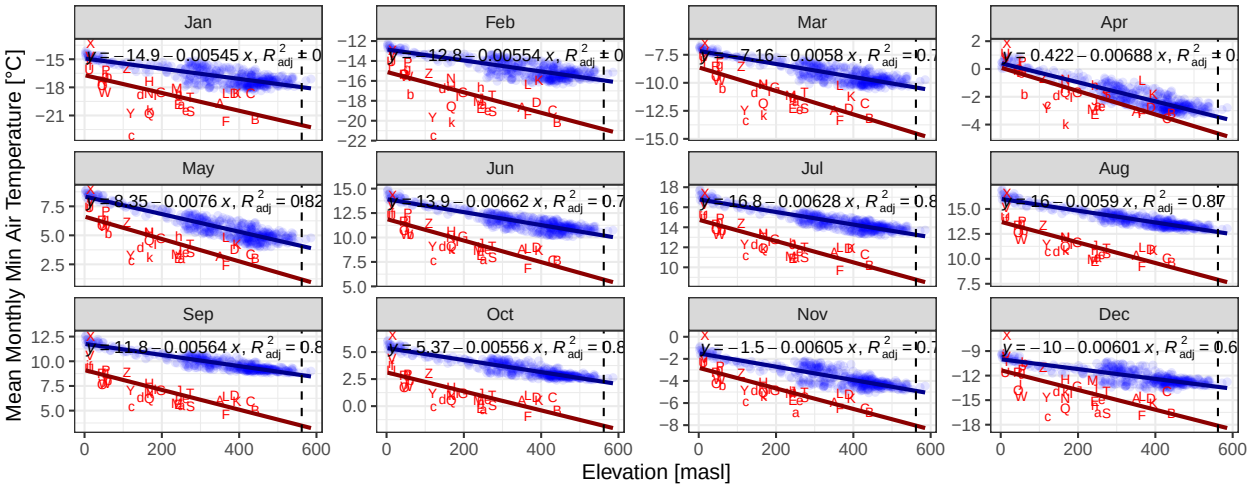
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

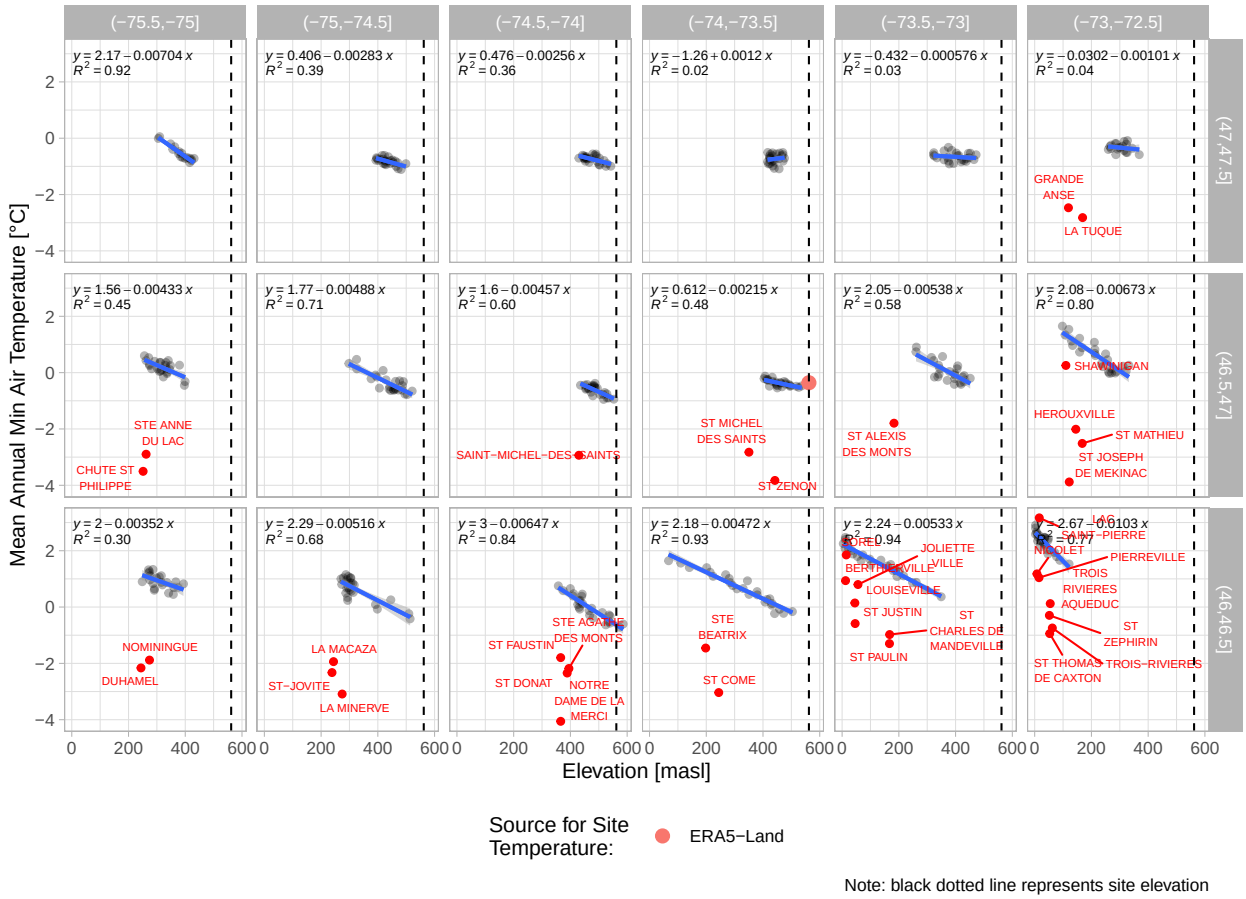
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



A	ST MICHEL DES SAINTS	I	ST ALEXIS DES MONTS	Q	ST MATHIEU	Y	GRANDE ANSE	g	TROIS RIVI
B	ST ZENON	J	LA MACAZA	R	LOUISEVILLE	Z	SHAWINIGAN	h	DUHAMEL
C	SAINT−MICHEL−DES−SAINTS	K	STE AGATHE DES MONTS	S	LA MINERVE	a	CHUTE ST PHILIPPE	i	NICOLET
D	ST DONAT	L	ST FAUSTIN	T	NOMININGUE	b	TROIS−RIVIERES	j	ST ZEPHIRI
E	ST COME	M	ST−JOVITE	U	BERTHIERVILLE	c	ST JOSEPH DE MEKINAC	k	LA TUQUE
F	NOTRE DAME DE LA MERCI	N	ST PAULIN	V	SOREL	d	HEROUXVILLE		
G	STE BEATRIX	O	ST JUSTIN	W	ST THOMAS DE CAXTON	e	STE ANNE DU LAC		
H	ST CHARLES DE MANDEVILLE	P	JOLIETTE VILLE	X	LAC SAINT−PIERRE	f	PIERREVILLE		

Note: black dotted line represents site elevation

Graph 4: Mean Annual Min Air Temperature [°C] versus Elevation [masl] (1980 − 2023)
Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



5.2.5 MERRA2 Regional Overview for Mean Air Temperature

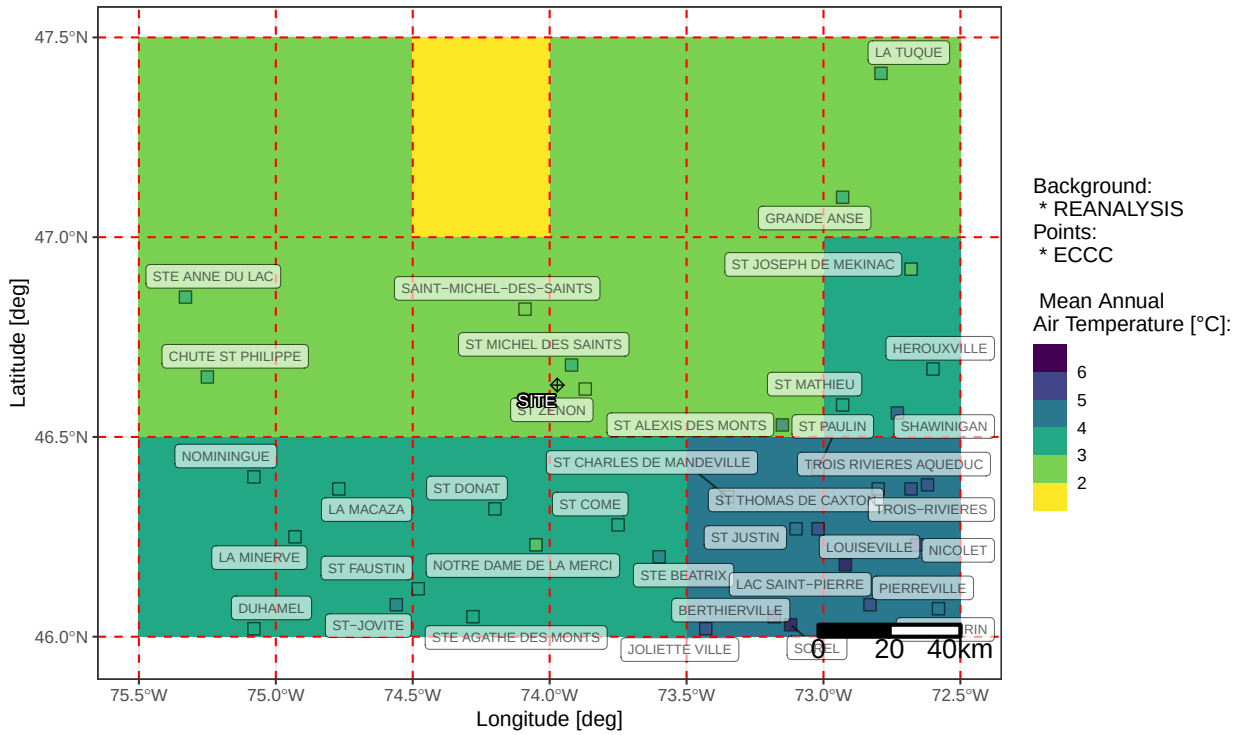
MERRA2 (Modern-Era Retrospective analysis from Research and Applications, Version 2) is a global climate reanalysis model from the U.S. National Aeronautics and Space Administration (NASA) (Gelaro et al. 2017). MERRA2 offers daily data from 1981 to present (2024) on a grid of 0.5 degrees latitude by 0.5 degrees longitude covering the entire globe.

The main findings of the MERRA2 regional overview are listed below (the corresponding figures follow):

- On a regional scale, MERRA2 is consistent with ECCC in terms of spatial trends on temperature (Graphs 1).
- The temperature versus elevation gradients (Graphs 2) show temperature predictions within the range of station data for MERRA2 on a regional scale, although Tmax seems to be underpredicted. This observation is consistent with the monthly breakdowns of this data (Graphs 3).
- The localized breakdowns of temperature versus elevation (Graphs 4) are not relevant for temperature analysis due to the lower resolution of the MERRA2 dataset. Note that mean grid elevation is generally higher than the stations elevation due to the mountainous nature of the region, and stations generally being located in the valleys.

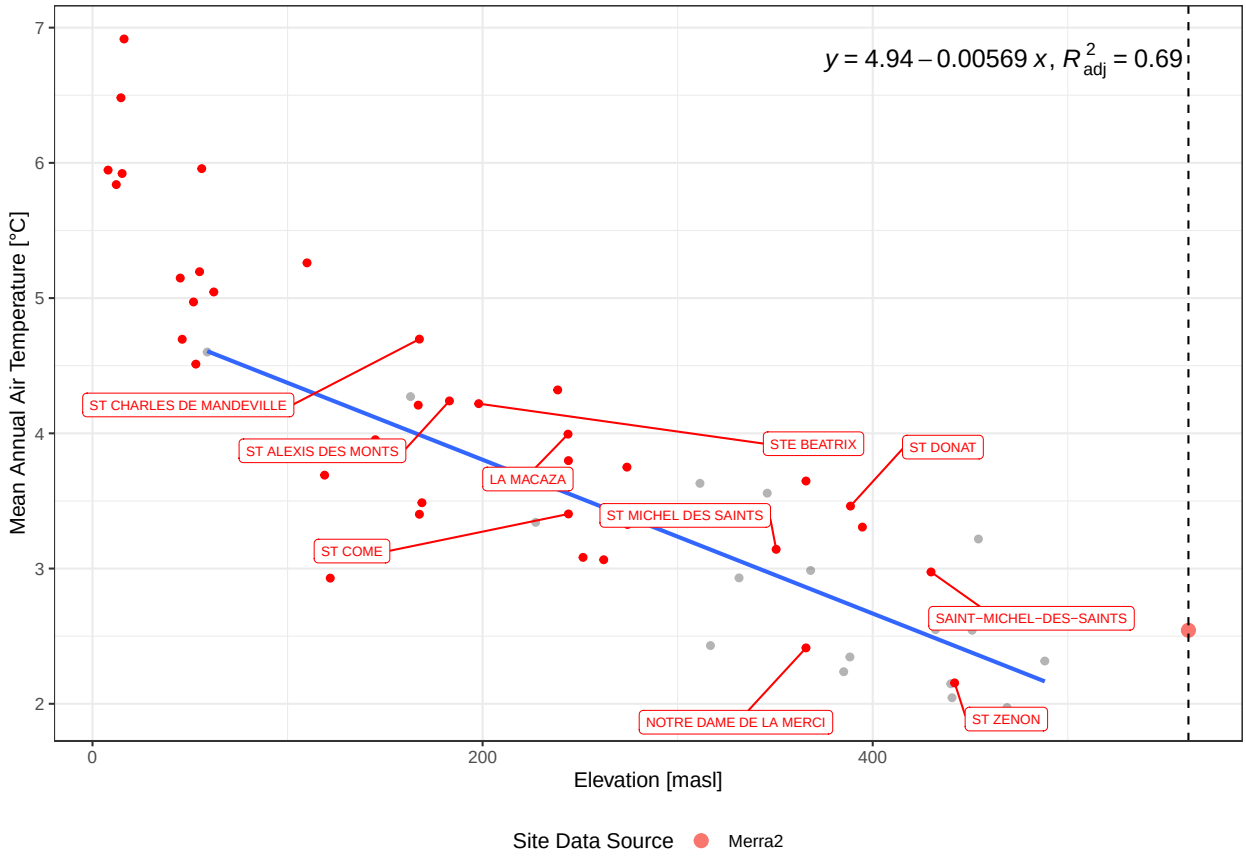
5.2.5.1 MERRA2 Tavg Regional Overview

Graph 1: Mean Annual Air Temperature [°C]:
(1980 – 2023)



Graph 2: Regional Elevation Gradient

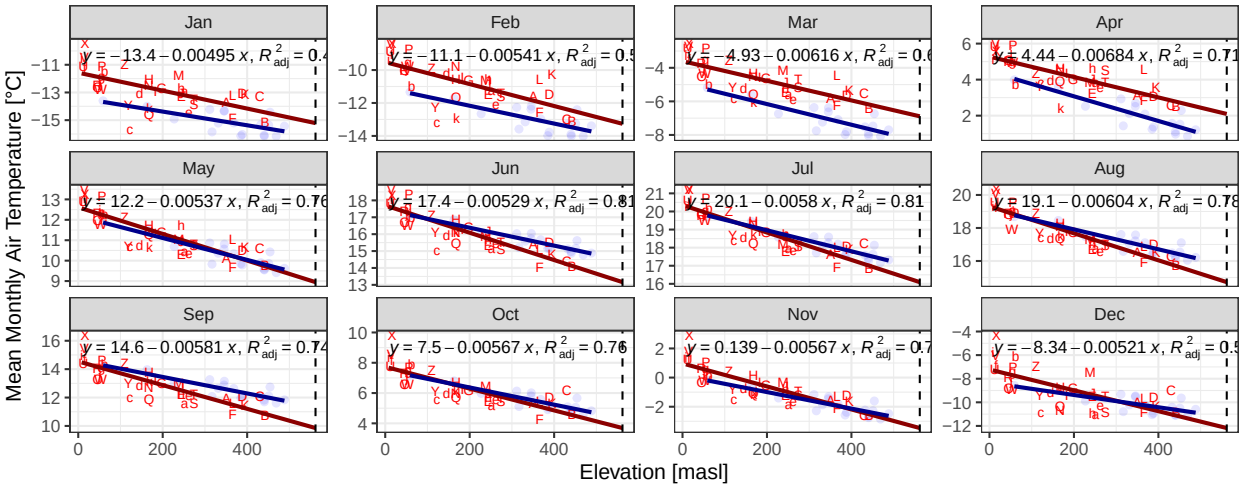
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

Reanalsis source as background: 1980 to 2023 (distance 125 km from site)

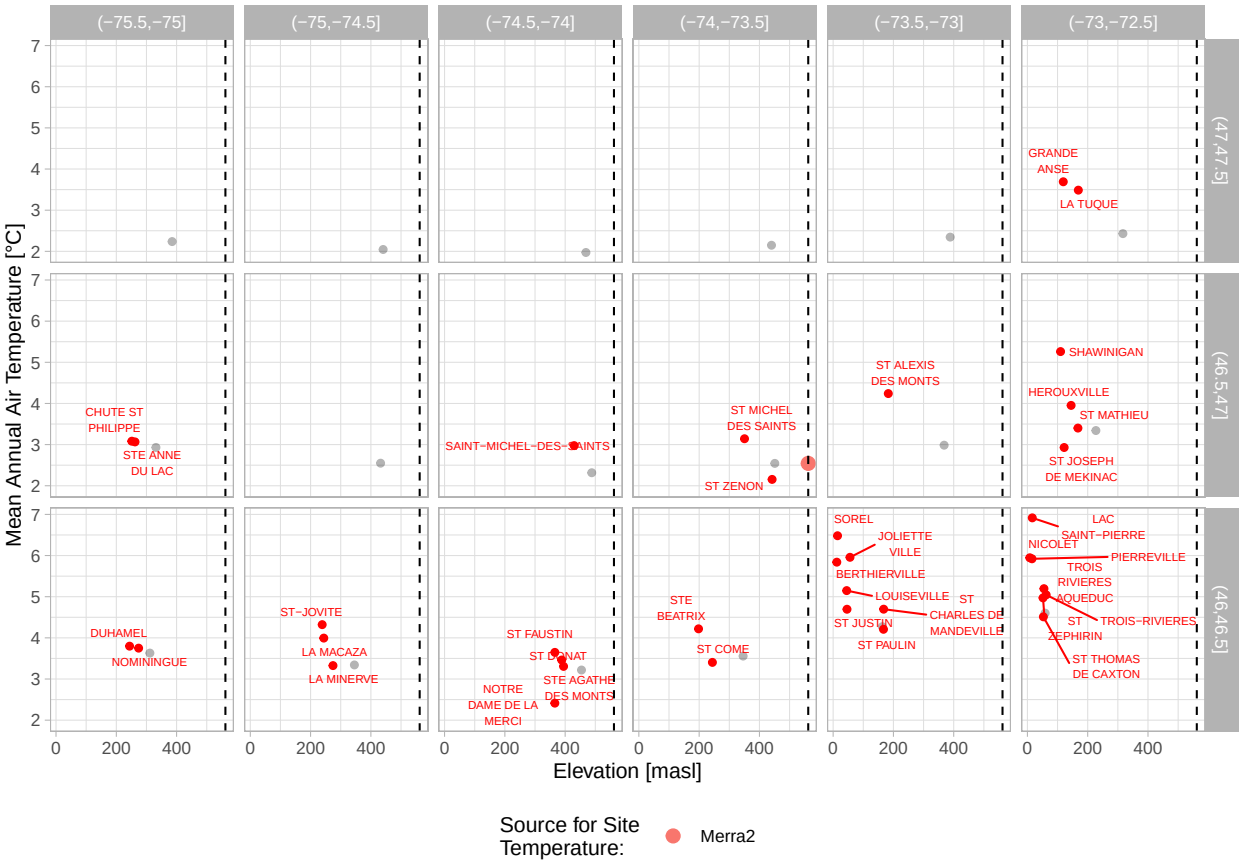


A	ST MICHEL DES SAINTS	I	ST ALEXIS DES MONTS	Q	ST MATHIEU	Y	GRANDE ANSE	g	TROIS RIVIE
B	ST ZENON	J	LA MACAZA	R	LOUISEVILLE	Z	SHAWINIGAN	h	DUHAMEL
C	SAINT−MICHEL−DES−SAINTS	K	STE AGATHE DES MONTS	S	LA MINERVE	a	CHUTE ST PHILIPPE	i	NICOLET
D	ST DONAT	L	ST FAUSTIN	T	NOMININGUE	b	TROIS−RIVIERES	j	ST ZEPHIRI
E	ST COME	M	ST−JOVITE	U	BERTHIERVILLE	c	ST JOSEPH DE MEKINAC	k	LA TUQUE
F	NOTRE DAME DE LA MERCI	N	ST PAULIN	V	SOREL	d	HEROUXVILLE		
G	STE BEATRIX	O	ST JUSTIN	W	ST THOMAS DE CAXTON	e	STE ANNE DU LAC		
H	ST CHARLES DE MANDEVILLE	P	JOLIETTE VILLE	X	LAC SAINT−PIERRE	f	PIERREVILLE		

Note: black dotted line represents site elevation

Graph 4: Mean Annual Air Temperature [°C] versus Elevation [masl] (1980 − 2023)

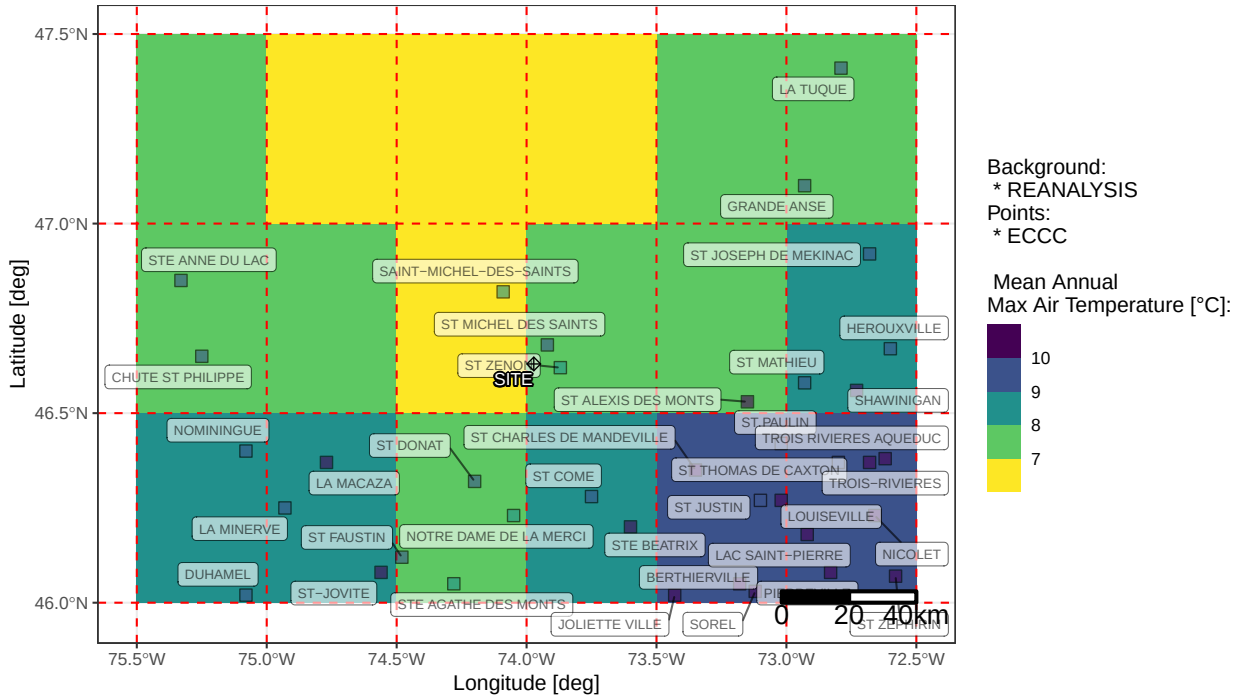
Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



Note: black dotted line represents site elevation

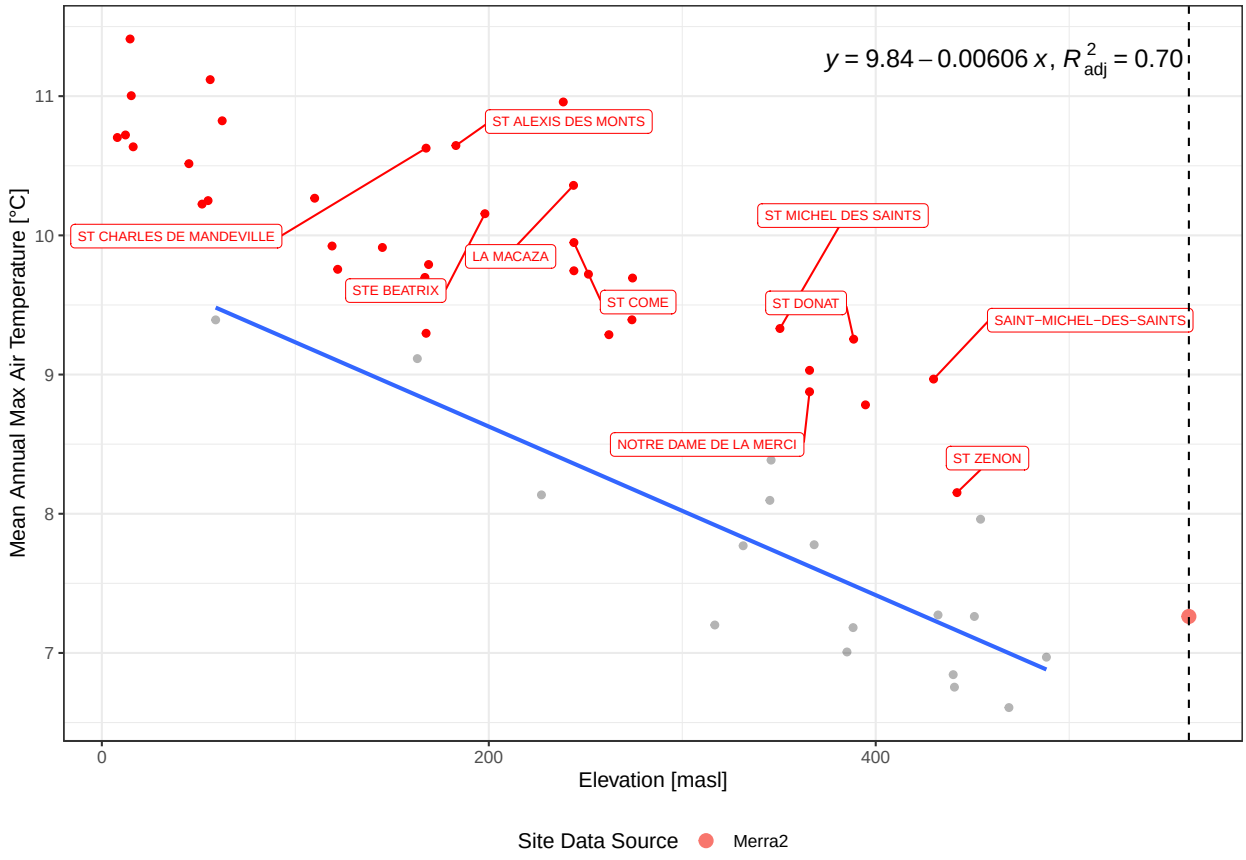
5.2.5.2 MERRA2 Tmax Regional Overview

Graph 1: Mean Annual Max Air Temperature [°C]:
(1980 – 2023)



Graph 2: Regional Elevation Gradient

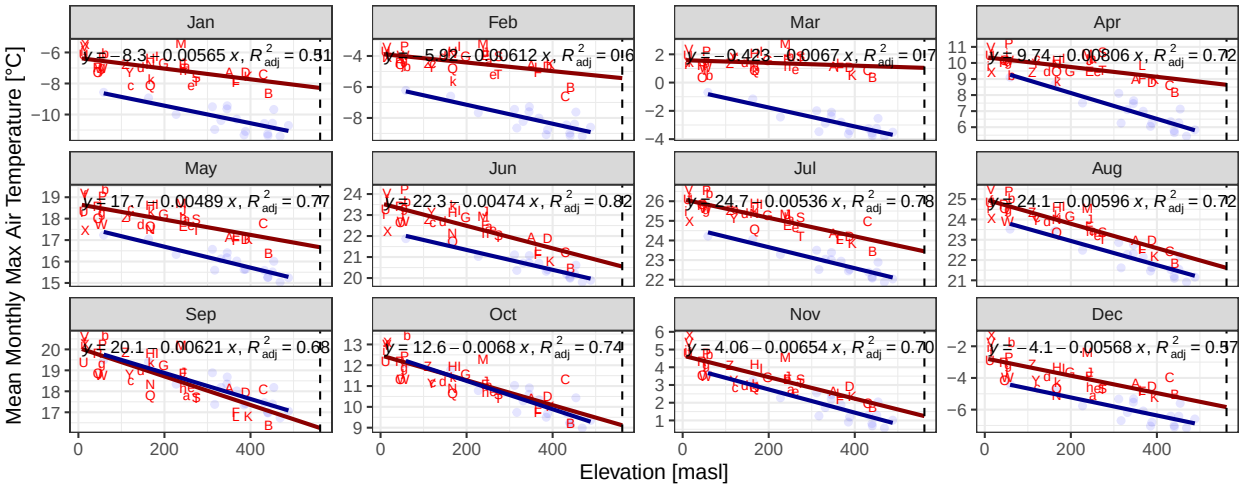
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

Reanalsis source as background: 1980 to 2023 (distance 125 km from site)

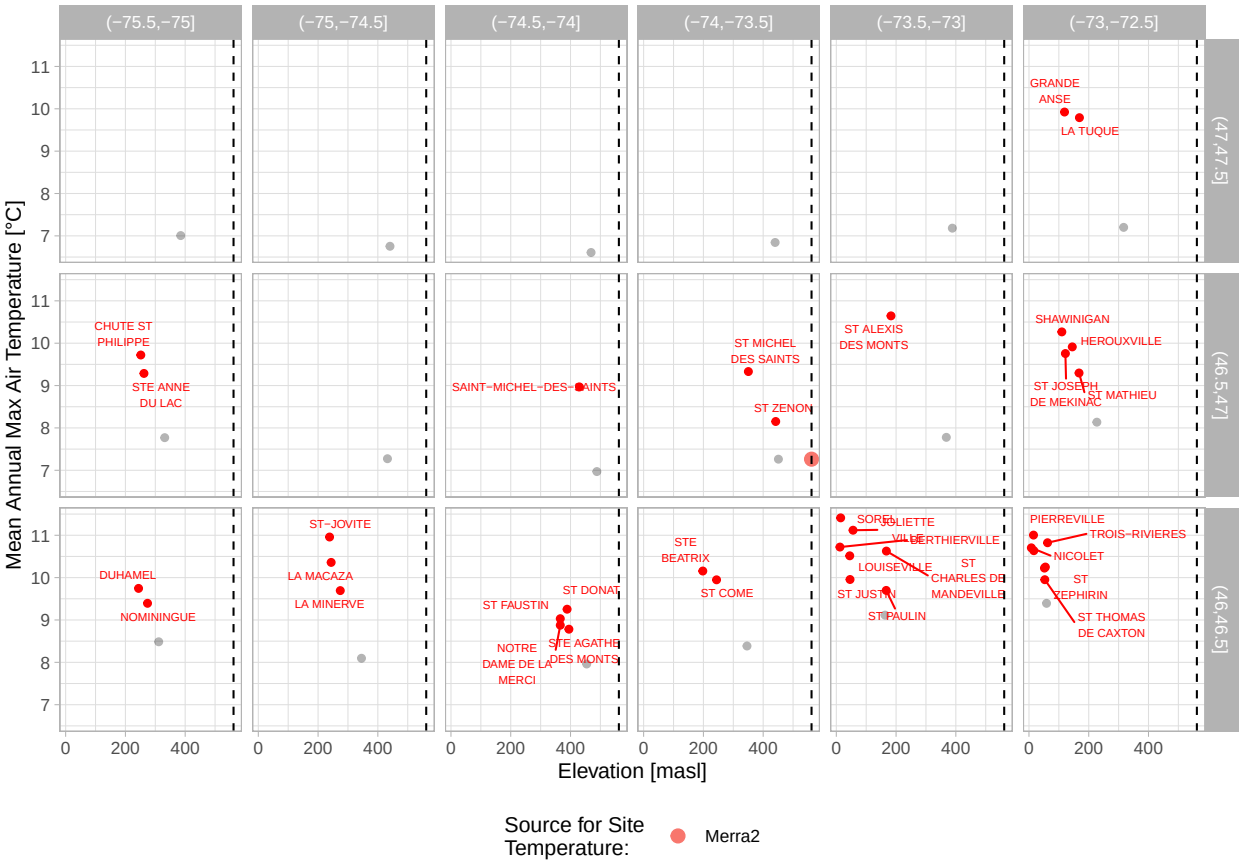


A	ST MICHEL DES SAINTS	I	ST ALEXIS DES MONTS	Q	ST MATHIEU	Y	GRANDE ANSE	g	TROIS RIVIE
B	ST ZENON	J	LA MACAZA	R	LOUISEVILLE	Z	SHAWINIGAN	h	DUHAMEL
C	SAINT−MICHEL−DES−SAINTS	K	STE AGATHE DES MONTS	S	LA MINERVE	a	CHUTE ST PHILIPPE	i	NICOLET
D	ST DONAT	L	ST FAUSTIN	T	NOMININGUE	b	TROIS−RIVIERES	j	ST ZEPHIRI
E	ST COME	M	ST−JOVITE	U	BERTHIERVILLE	c	ST JOSEPH DE MEKINAC	k	LA TUQUE
F	NOTRE DAME DE LA MERCI	N	ST PAULIN	V	SOREL	d	HEROUXVILLE		
G	STE BEATRIX	O	ST JUSTIN	W	ST THOMAS DE CAXTON	e	STE ANNE DU LAC		
H	ST CHARLES DE MANDEVILLE	P	JOLIETTE VILLE	X	LAC SAINT−PIERRE	f	PIERREVILLE		

Note: black dotted line represents site elevation

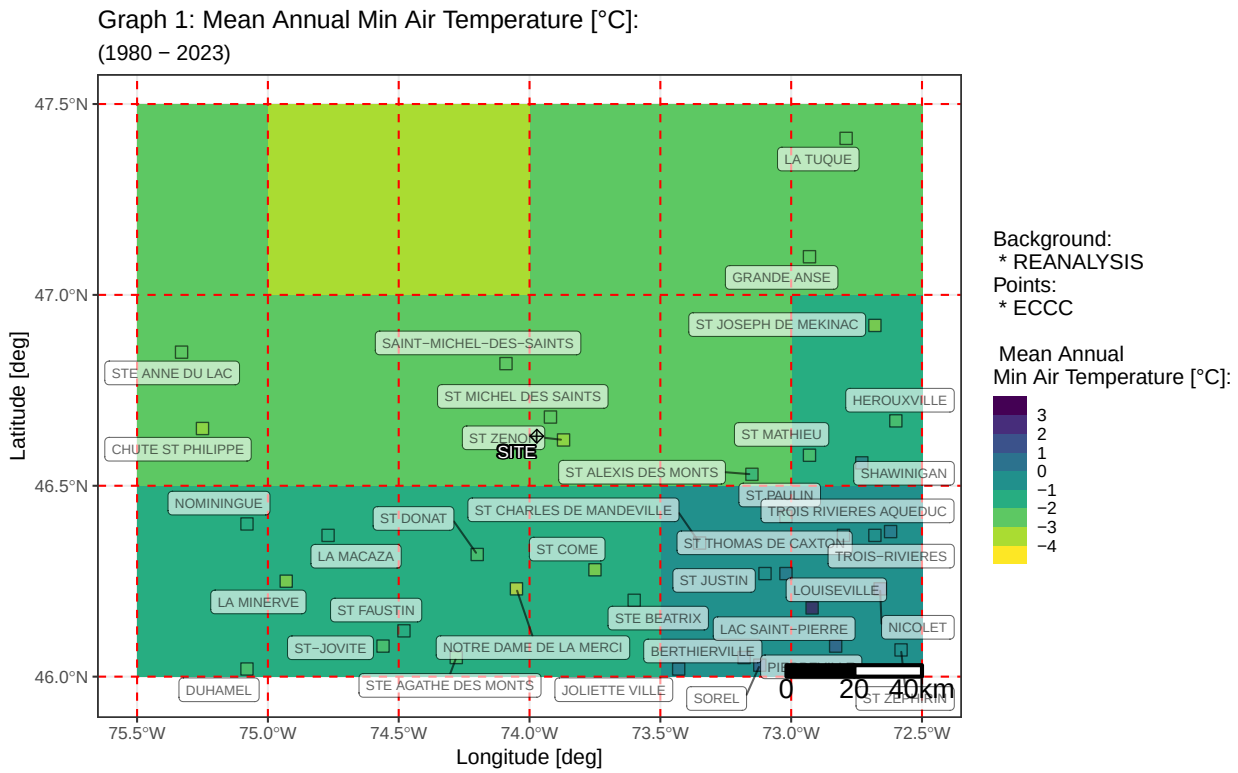
Graph 4: Mean Annual Max Air Temperature [°C] versus Elevation [masl] (1980 − 2023)

Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



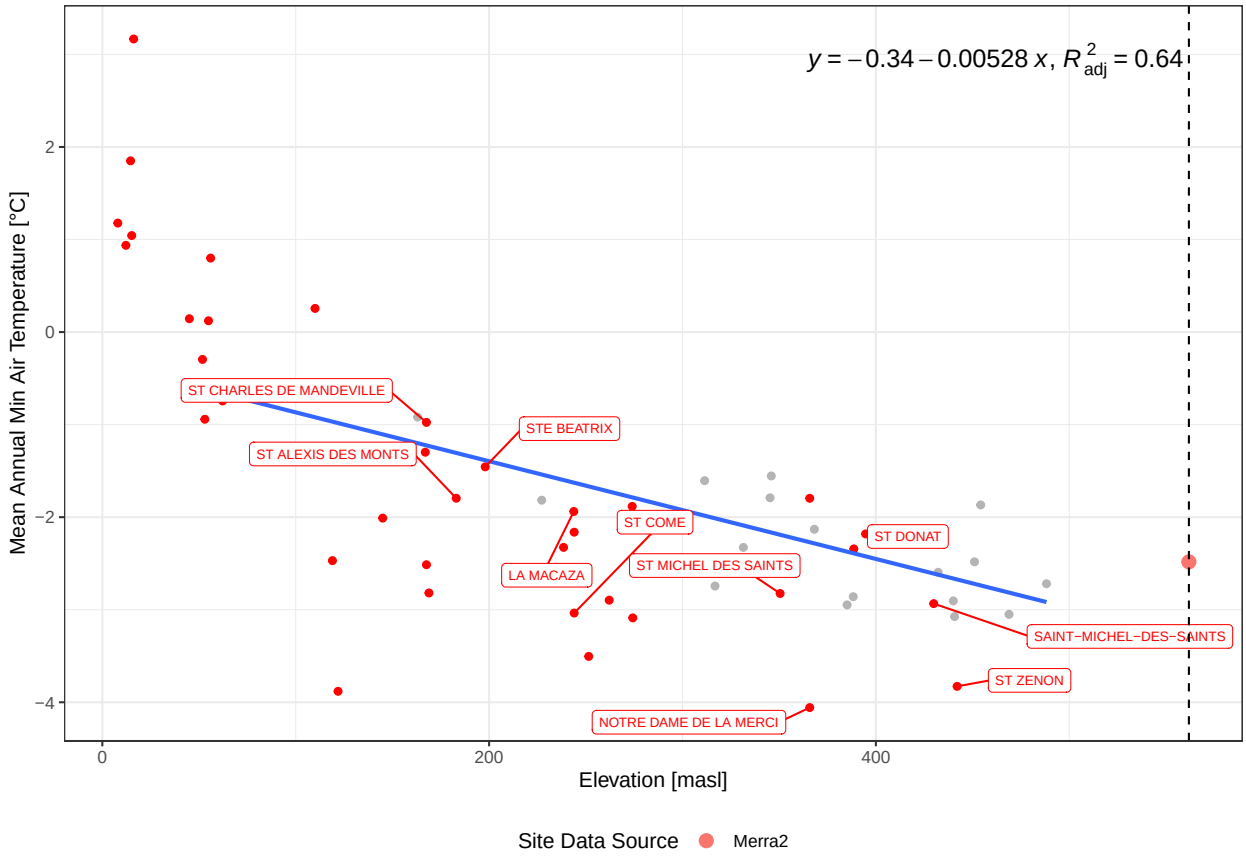
Note: black dotted line represents site elevation

5.2.5.3 MERRA2 Tmin Regional Overview



Graph 2: Regional Elevation Gradient

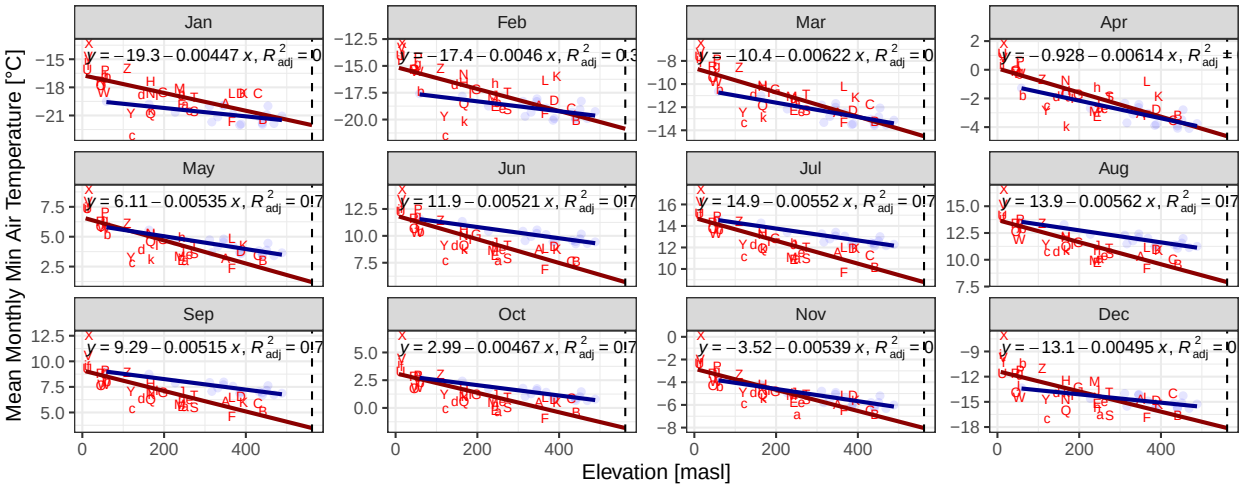
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

Reanalsis source as background: 1980 to 2023 (distance 125 km from site)

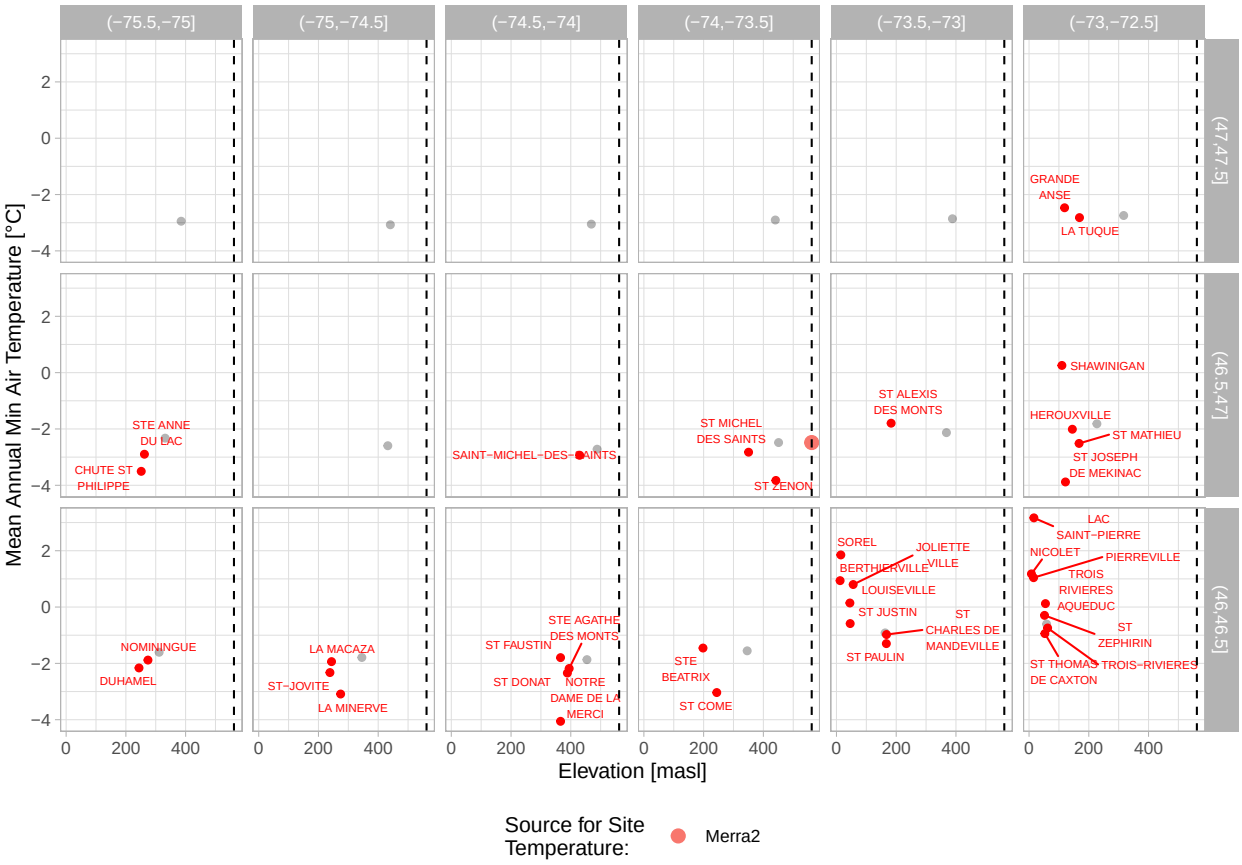


A	ST MICHEL DES SAINTS	I	ST ALEXIS DES MONTS	Q	ST MATHIEU	Y	GRANDE ANSE	g	TROIS RIVI
B	ST ZENON	J	LA MACAZA	R	LOUISEVILLE	Z	SHAWINIGAN	h	DUHAMEL
C	SAINT−MICHEL−DES−SAINTS	K	STE AGATHE DES MONTS	S	LA MINERVE	a	CHUTE ST PHILIPPE	i	NICOLET
D	ST DONAT	L	ST FAUSTIN	T	NOMININGUE	b	TROIS−RIVIERES	j	ST ZEPHIRI
E	ST COME	M	ST−JOVITE	U	BERTHIERVILLE	c	ST JOSEPH DE MEKINAC	k	LA TUQUE
F	NOTRE DAME DE LA MERCI	N	ST PAULIN	V	SOREL	d	HEROUXVILLE		
G	STE BEATRIX	O	ST JUSTIN	W	ST THOMAS DE CAXTON	e	STE ANNE DU LAC		
H	ST CHARLES DE MANDEVILLE	P	JOLIETTE VILLE	X	LAC SAINT−PIERRE	f	PIERREVILLE		

Note: black dotted line represents site elevation

Graph 4: Mean Annual Min Air Temperature [°C] versus Elevation [masl] (1980 − 2023)

Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



Note: black dotted line represents site elevation

Chapter 6

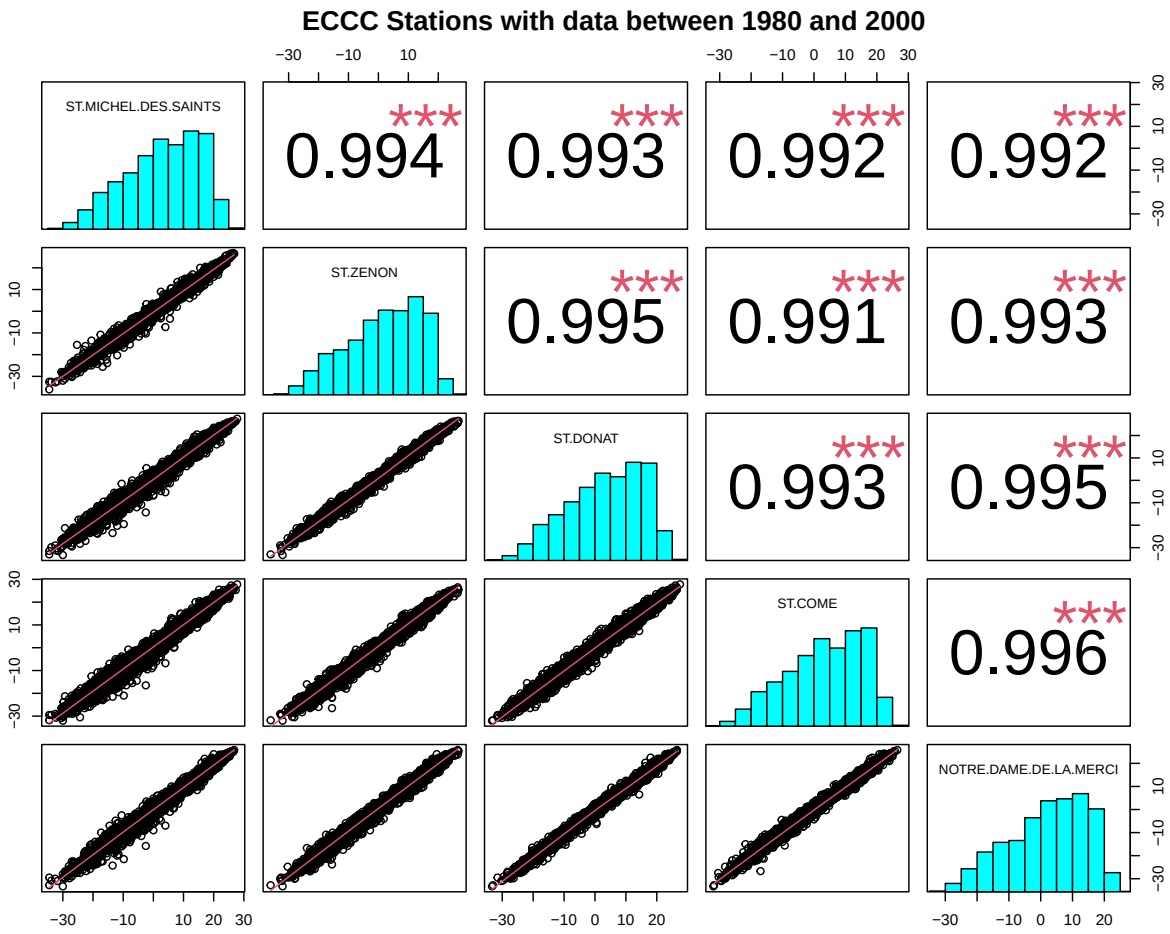
Local Analysis

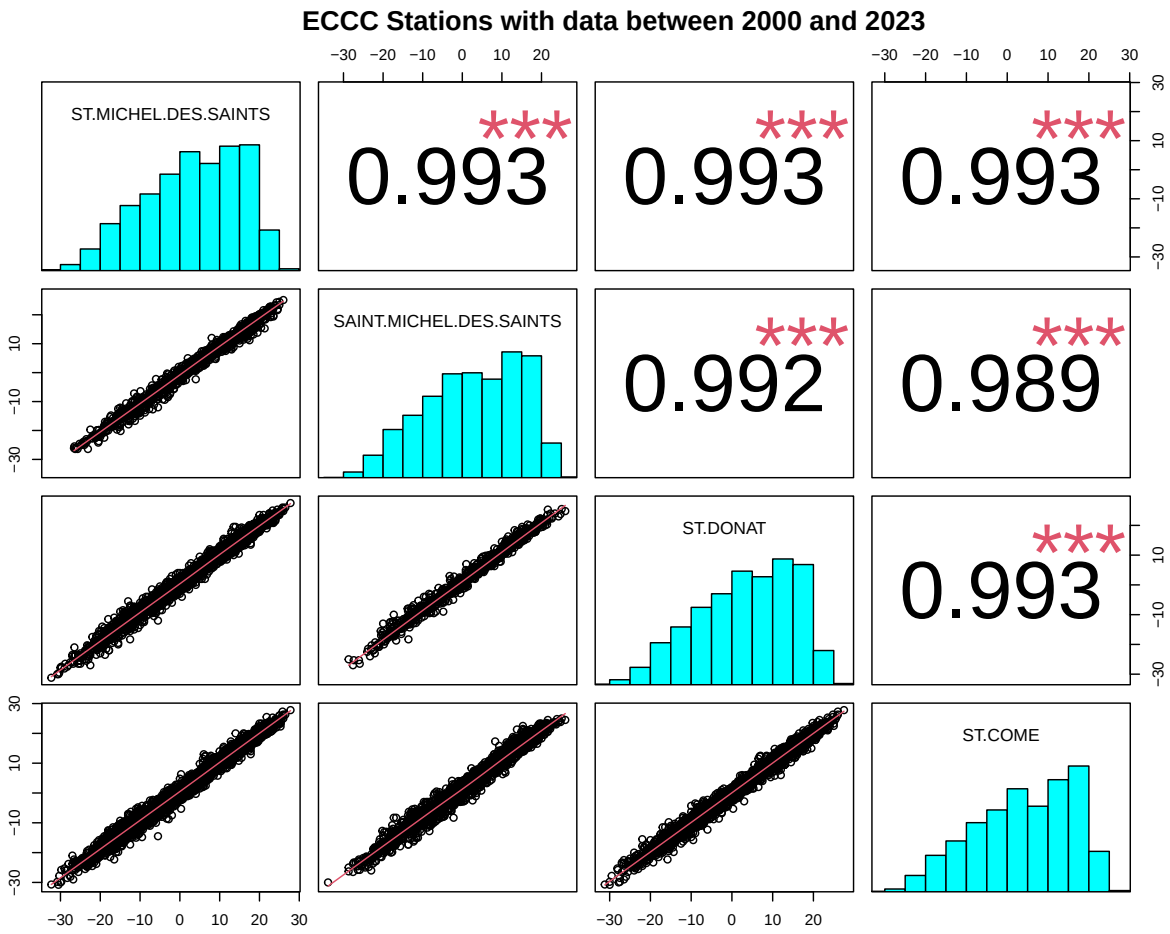
The regional analysis shows that spatial temperature gradient effect exists in the region, therefore a smaller area around Site should be more representative of its climate. The following analysis only considers data within 50km of the Matawinie Site.

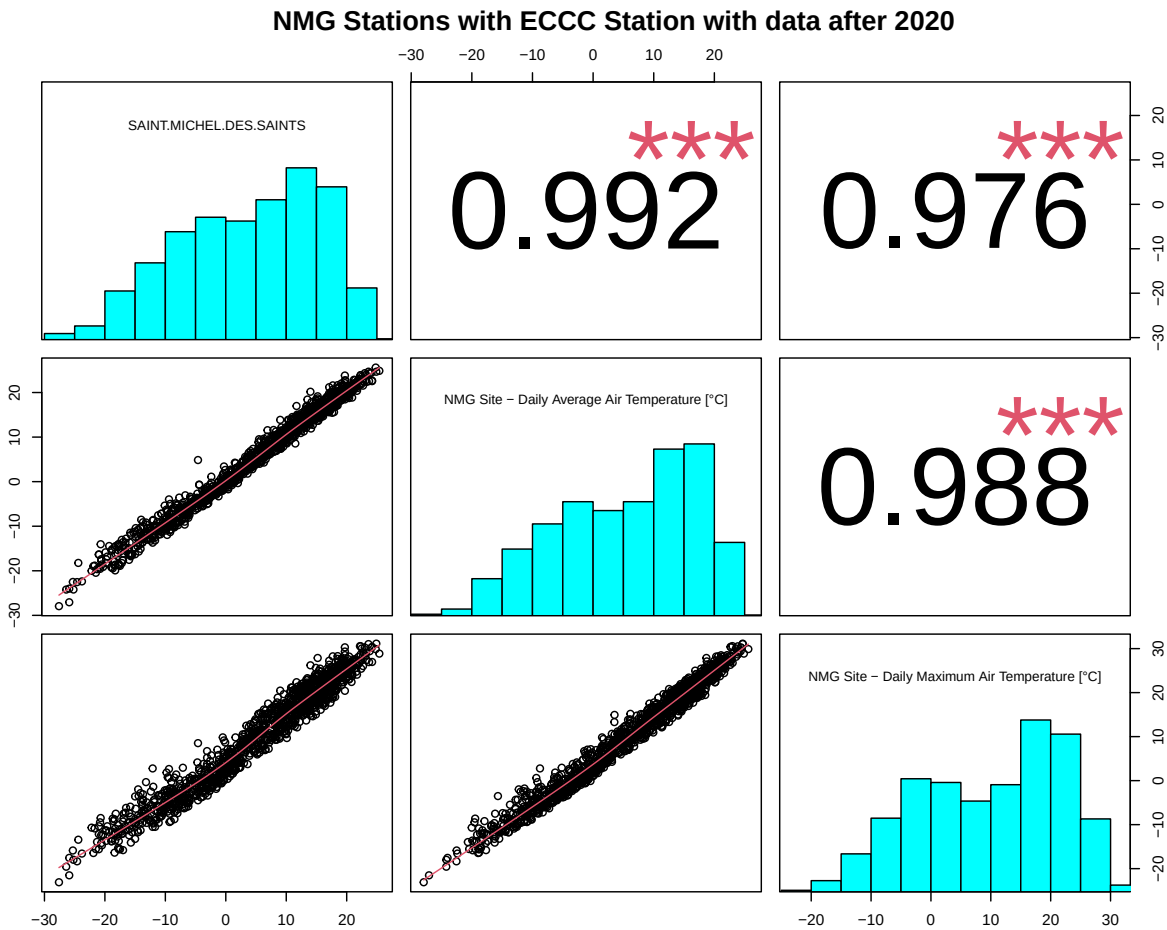
6.1 ECCC and NMG Stations data correlations

The following visualization is a correlation matrix between daily average air temperature records from stations close to site. On the top right quadrant, the (absolute) value of the correlation is presented together with the result of the Pearson's product moment correlation coefficient as stars. On bottom-left quadrant the bivariate scatterplots, with a fitted line are presented. On the diagonal there is an histogram of each variable.

All daily average air temperature records have excellent correlation between each other.


ECCC Stations with data between 1980 and 2000
ST.MICHEL.DES.SAINTS
0.994 ***
0.993 ***
0.992 ***
0.992 ***
ST.ZENON
0.995 ***
0.991 ***
0.993 ***
ST.DONAT
0.993 ***
0.995 ***
ST.COME
0.996 ***
NOTRE.DAME.DE.LA.MERCI


ECCC Stations with data between 2000 and 2023
ST.MICHEL.DES.SAINTS
SAINT.MICHEL.DES.SAINTS
ST.DONAT
ST.COME
0.993 ***
0.993 ***
0.993 ***
0.992 ***
0.989 ***
0.993 ***



6.2 Reanalysis Evaluation Against Station Records

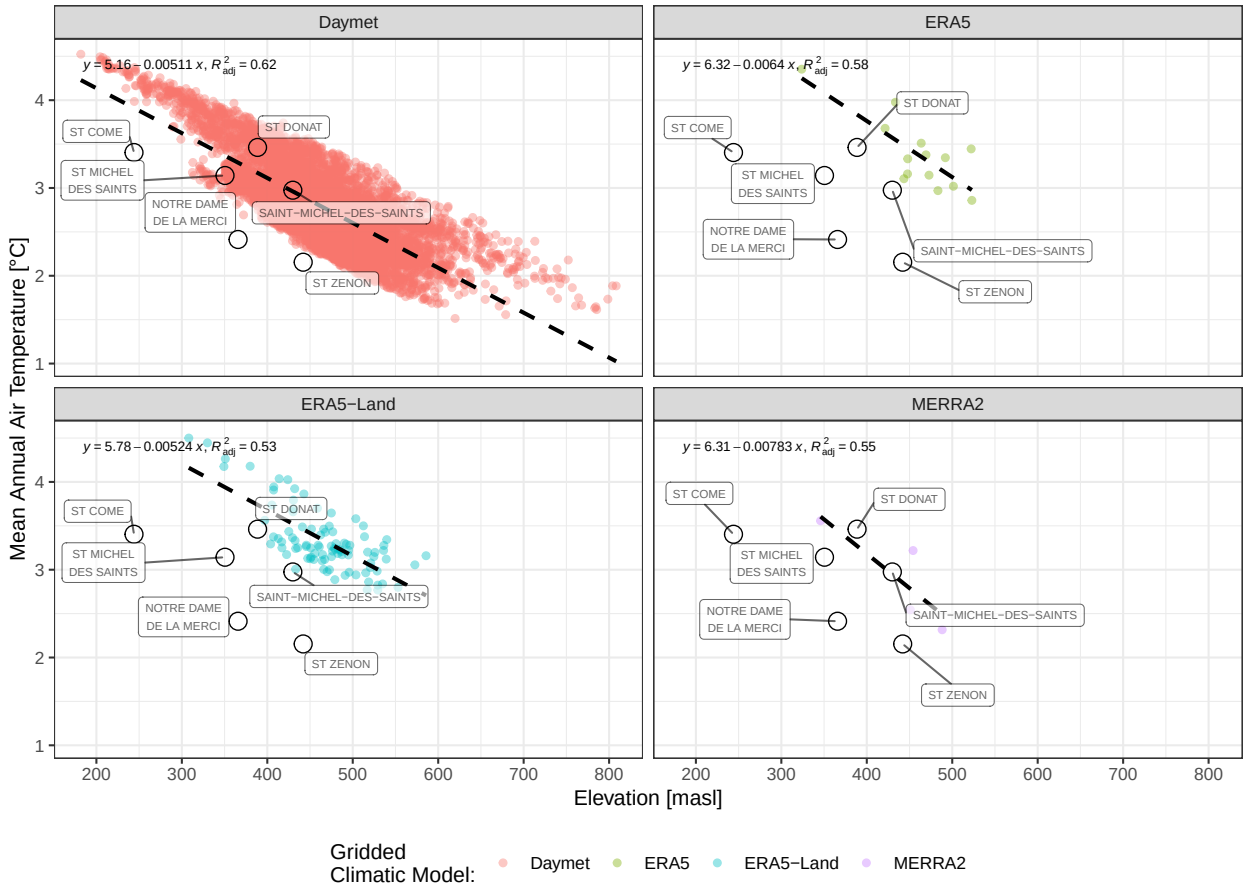
6.2.1 Local Annual Temperature Elevation Gradient Comparison

A local annual temperature to elevation regression is generated with data available within 50km, 30km and 10km from site. All the gridded climate models from the previous analysis were kept for reference.

- At an analysis distance of 50km, MAAT correlations to elevation for all climate models are fair (0.53 R^2 0.62). An inverse correlation relationship is apparent between Elevation and MAAT.
- At an analysis distance of 30km, MAAT correlations to elevation increases for Daymet. ERA5, ERA5-Land and MERRA2 have their data population considerably reduced at this distance so the variability at this scale is not relevant. Only three selected ECCC stations exist within this range.
- At an analysis distance of 10km, Daymet is the only climate model with a data population large enough (i.e. grid size small enough) to be relevant. Daymet shows a clear MAP to Elevation gradient at this scale. Only two selected ECCC stations exist within this range.

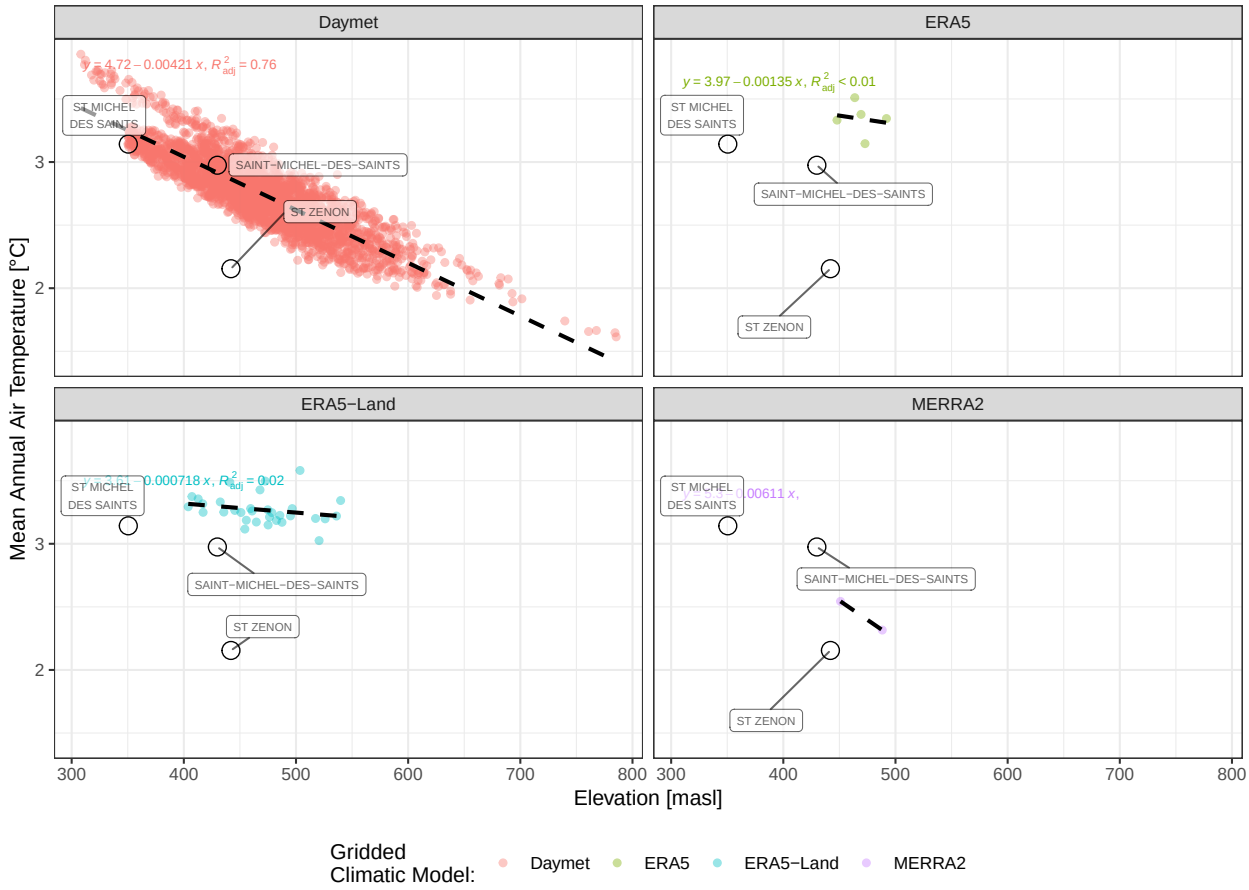
Graph 1: Elevation Gradient for MAAT within 50km of Site (1980 to 2023)

Near site comparison of Gridded Climatic Models and ECCC Stations

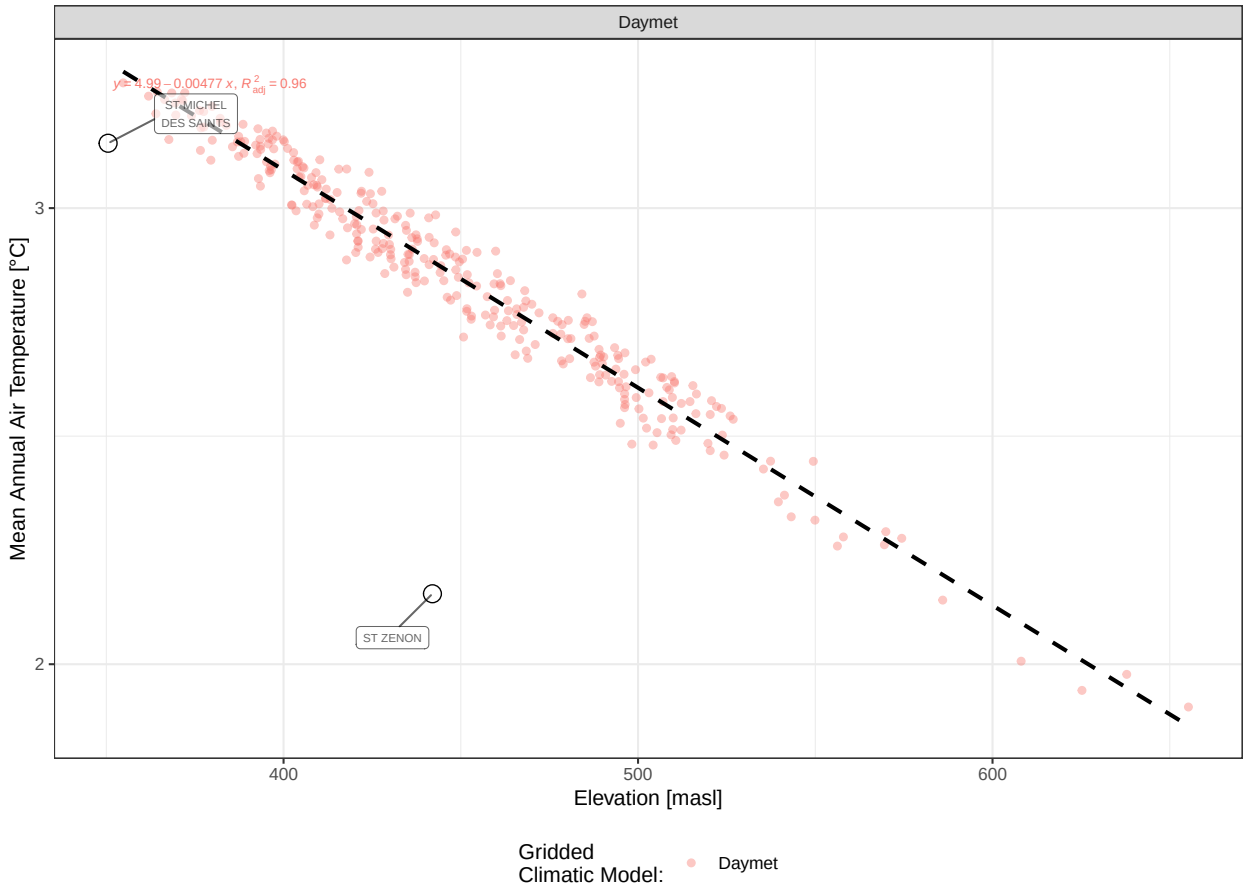


Graph 2: Elevation Gradient for MAAT within 30km of Site (1980 to 2023)

Near site comparison of Gridded Climatic Models and ECCC Stations



Graph 3: Elevation Gradient for MAAT within 10km of Site (1980 to 2023)
Near site comparison of Daymet and ECCC Stations



6.2.2 Station to Climate Model - Monthly Correlations

Monthly correlations between station and climate model data at each location help comparing model coherence with measured data and highlight seasonal bias. Monthly analysis allows inclusion of the NMG stations records. The ECCC stations within 50km of site were kept for this analysis.

The main findings of this section are summarized below:

- All the climate models present strong correlation with ECCC station data. The strongest appear to ERA5-Land and Daymet.
- NMG station records are short, but have excellent correlation with all the climate models.

6.2.2.1 Functions Definition

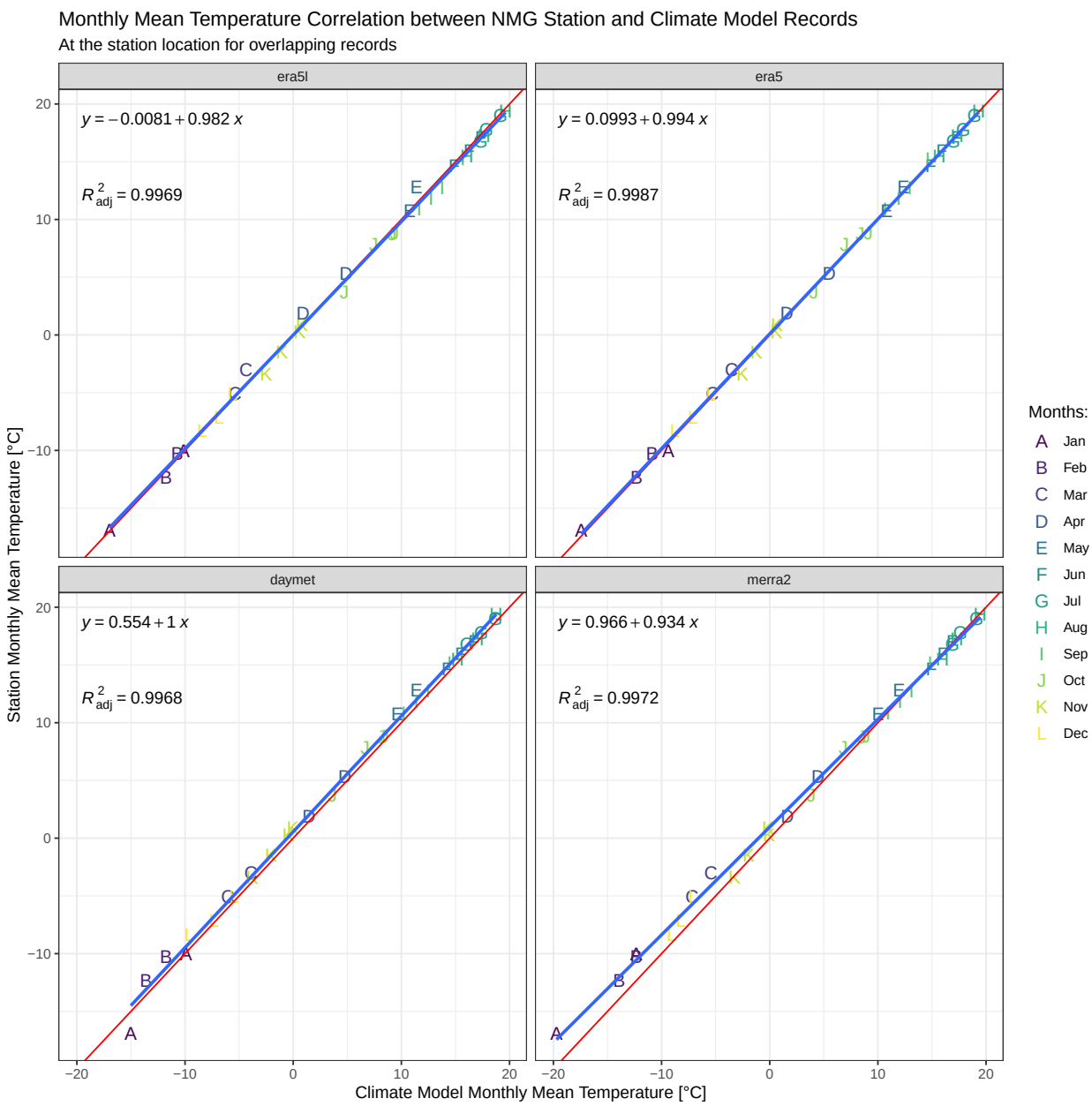
A function is defined to compare monthly station records against data produced for the same location by all four climate models included in this study.

- Monthly temperature results are summarized in a table comparing climate model results to station records for the same overlapping record period.
- The plot shows correlation between each station monthly data and all four climate models for the same overlapping record period.

6.2.2.2 Monthly Correlations for NMG Site

Table 6.1: Monthly Summary of Reanalysis Data matching Observed Data at NMG Site

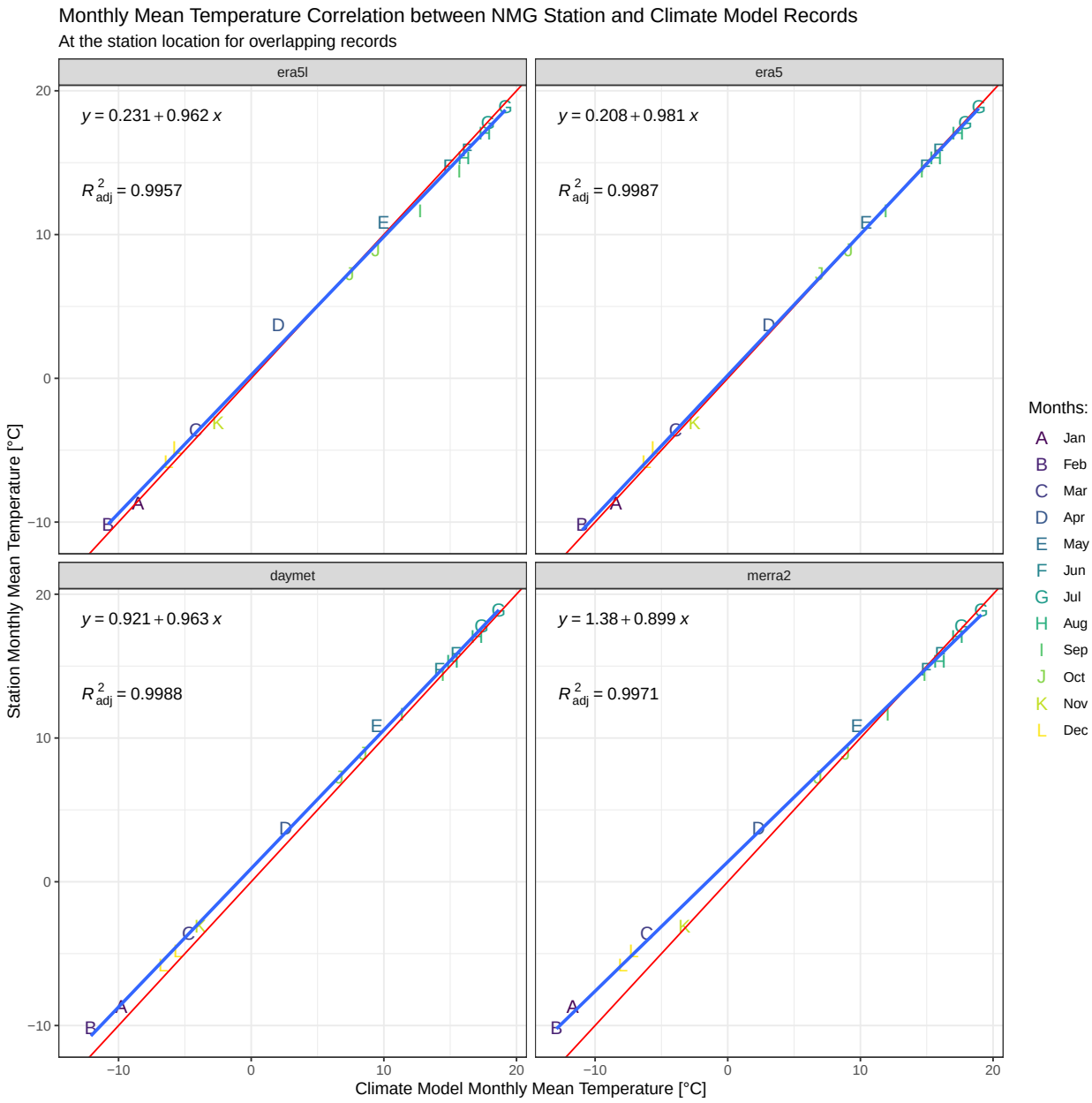
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-13.5	-11.2	-4.9	2.9	11.1	16.2	18.1	17.8	13.5	7.7	-0.5	-6.9	4.2
era5	-13.4	-11.6	-4.4	3.5	11.6	16	17.9	17.5	12.6	7.1	-0.6	-7.1	4.1
daymet	-12.5	-12.7	-5	3.1	10.5	15.5	17.4	17	12.1	6.7	-1.6	-7.4	3.6
merra2	-16	-13.1	-6.3	3.1	11	16	17.9	17.6	12.7	7	-1.4	-8.1	3.4
station	-12.3	-9.8	-3.3	3.6	12.1	16.1	18.1	17.4	12.7	7.3	-0.9	-6.8	4.5



6.2.2.3 Monthly Correlations for NMG SoftdB

Table 6.2: Monthly Summary of Reanalysis Data matching Observed Data at NMG SoftdB

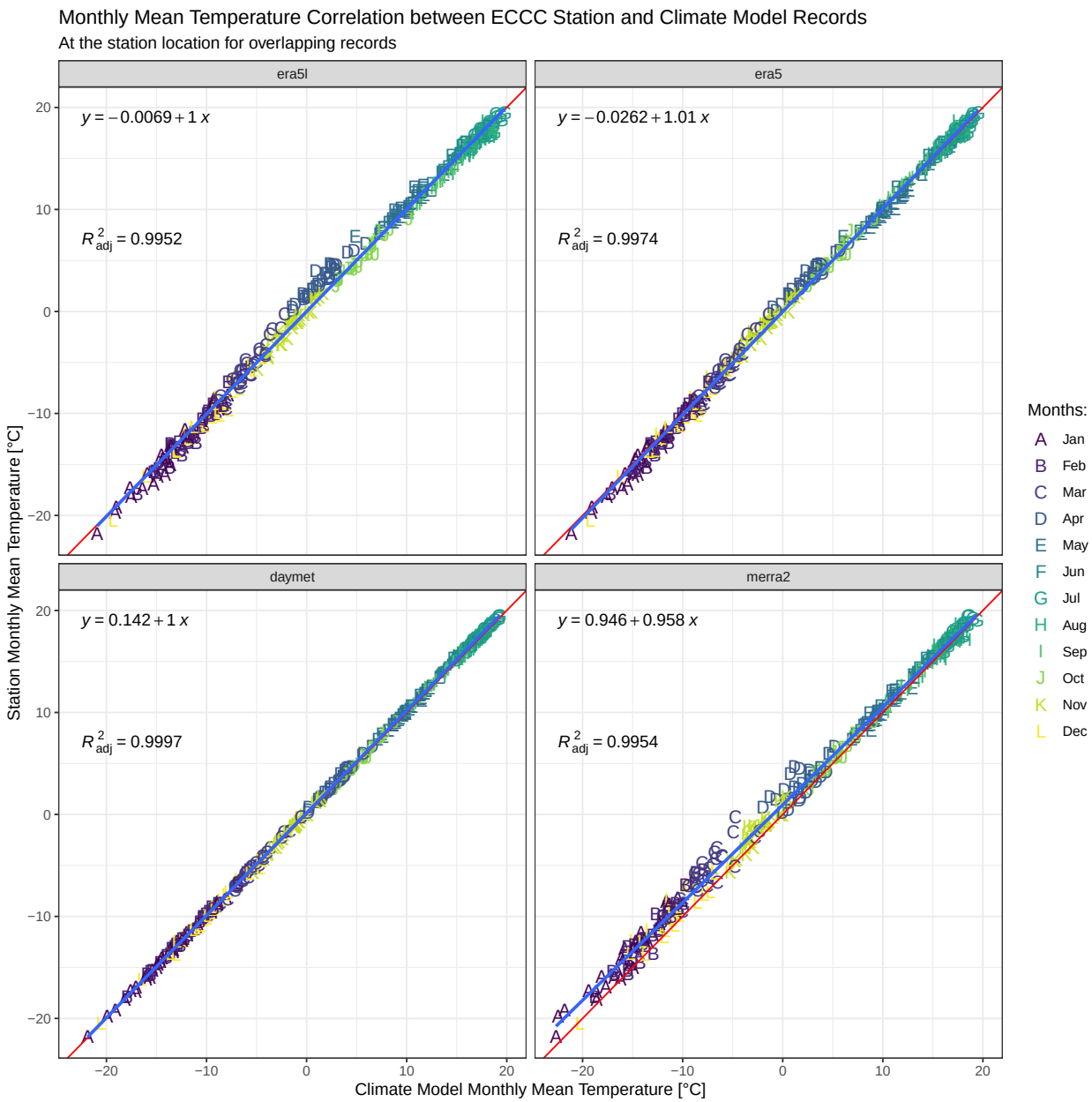
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-8.5	-10.8	-4.2	2	10	15.6	18.5	16.8	14.2	8.4	-2.5	-5.9	4.5
era5	-8.4	-11	-3.9	3.1	10.4	15.4	18.4	16.5	13.3	8	-2.5	-5.8	4.5
daymet	-9.8	-12.1	-4.7	2.6	9.5	14.8	18	16.1	12.9	7.5	-3.8	-6.1	3.7
merra2	-11.7	-12.9	-6.1	2.3	9.7	15.5	18.4	16.6	13.5	7.9	-3.3	-7.5	3.5
station	-9.1	-8.5	-2.6	3.8	12.1	15.9	18.4	16.2	13.1	8.1	-3.1	-5.3	4.9



6.2.2.4 Monthly Correlations for ST MICHEL DES SAINTS

Table 6.3: Monthly Summary of Reanalysis Data matching Observed Data at ST MICHEL DES SAINTS

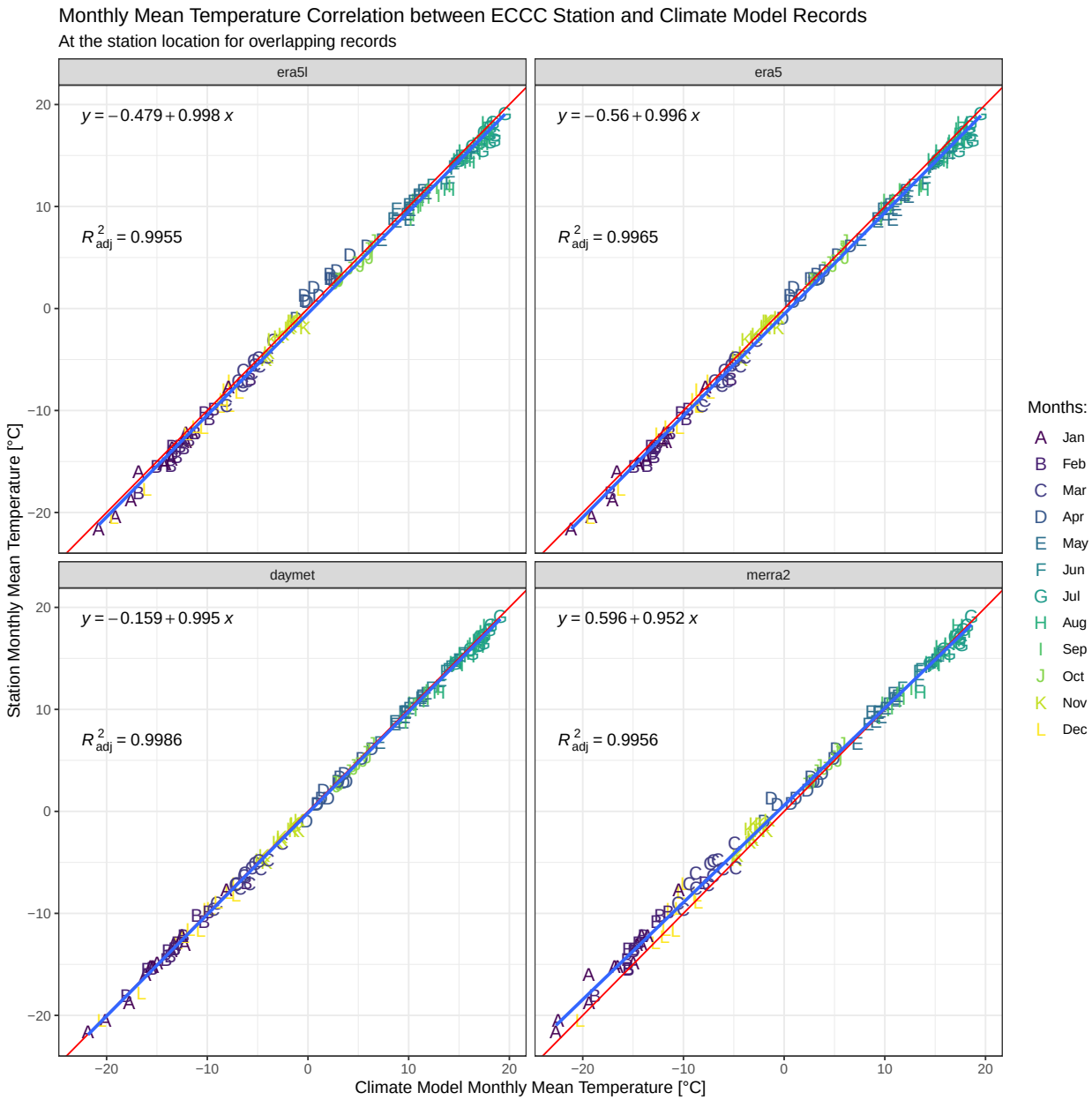
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-13.4	-11.2	-6	1.6	9.7	15.4	17.9	16.9	12.5	5.4	-1.5	-9.7	3.1
era5	-13.4	-11.2	-5.7	2.4	10.3	15.5	17.8	16.5	11.8	5	-1.8	-9.8	3.1
daymet	-13.9	-11.8	-5.8	2.9	10	15.1	17.5	16.4	11.9	5.2	-1.6	-10.1	3
merra2	-15.4	-13.1	-7.6	2	9.7	15.1	17.4	16.3	11.9	4.8	-2.2	-11	2.3
station	-14.1	-12.1	-5.8	2.8	10	15.3	17.6	16.4	11.8	5.3	-1.6	-10.3	2.9



6.2.2.5 Monthly Correlations for ST ZENON

Table 6.4: Monthly Summary of Reanalysis Data matching Observed Data at ST ZENON

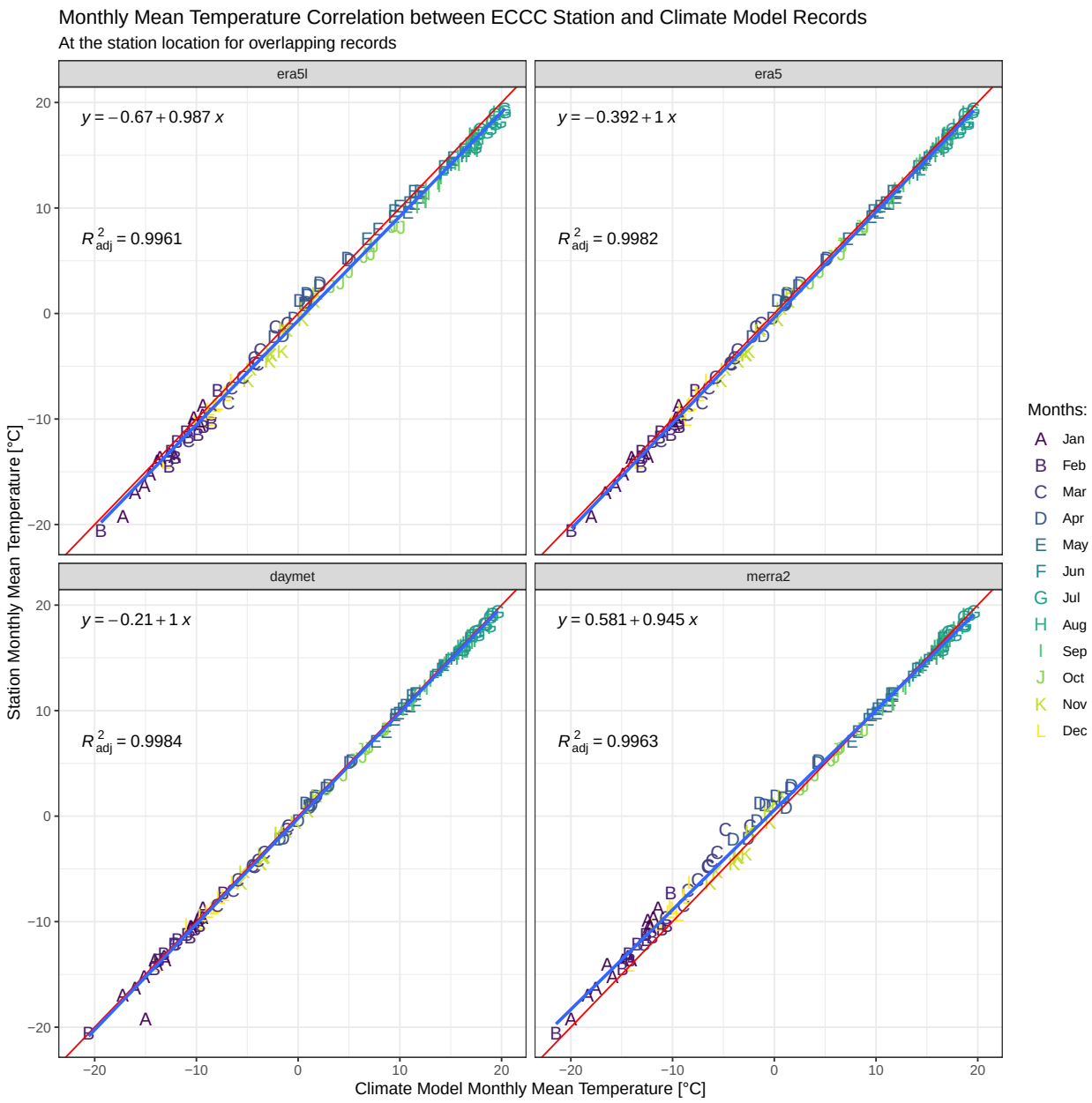
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-14.3	-12	-5.9	1.8	9.9	14.8	17.7	16.6	11.5	4.6	-2.2	-10.7	2.7
era5	-14.2	-12	-5.6	2.6	10.6	15.1	17.9	16.4	11	4.4	-2.4	-10.9	2.7
daymet	-14.9	-12.9	-6.1	2.8	9.9	14.2	17.2	16	10.9	4.4	-2.3	-11.3	2.3
merra2	-16.6	-14.1	-7.6	2	9.7	14.4	17.1	15.9	10.8	3.9	-2.9	-11.5	1.8
station	-15.2	-13.2	-6.1	2.3	10	14.1	16.9	15.4	10.3	4	-2.6	-11.5	2



6.2.2.6 Monthly Correlations for SAINT-MICHEL-DES-SAINTS

Table 6.5: Monthly Summary of Reanalysis Data matching Observed Data at SAINT-MICHEL-DES-SAINTS

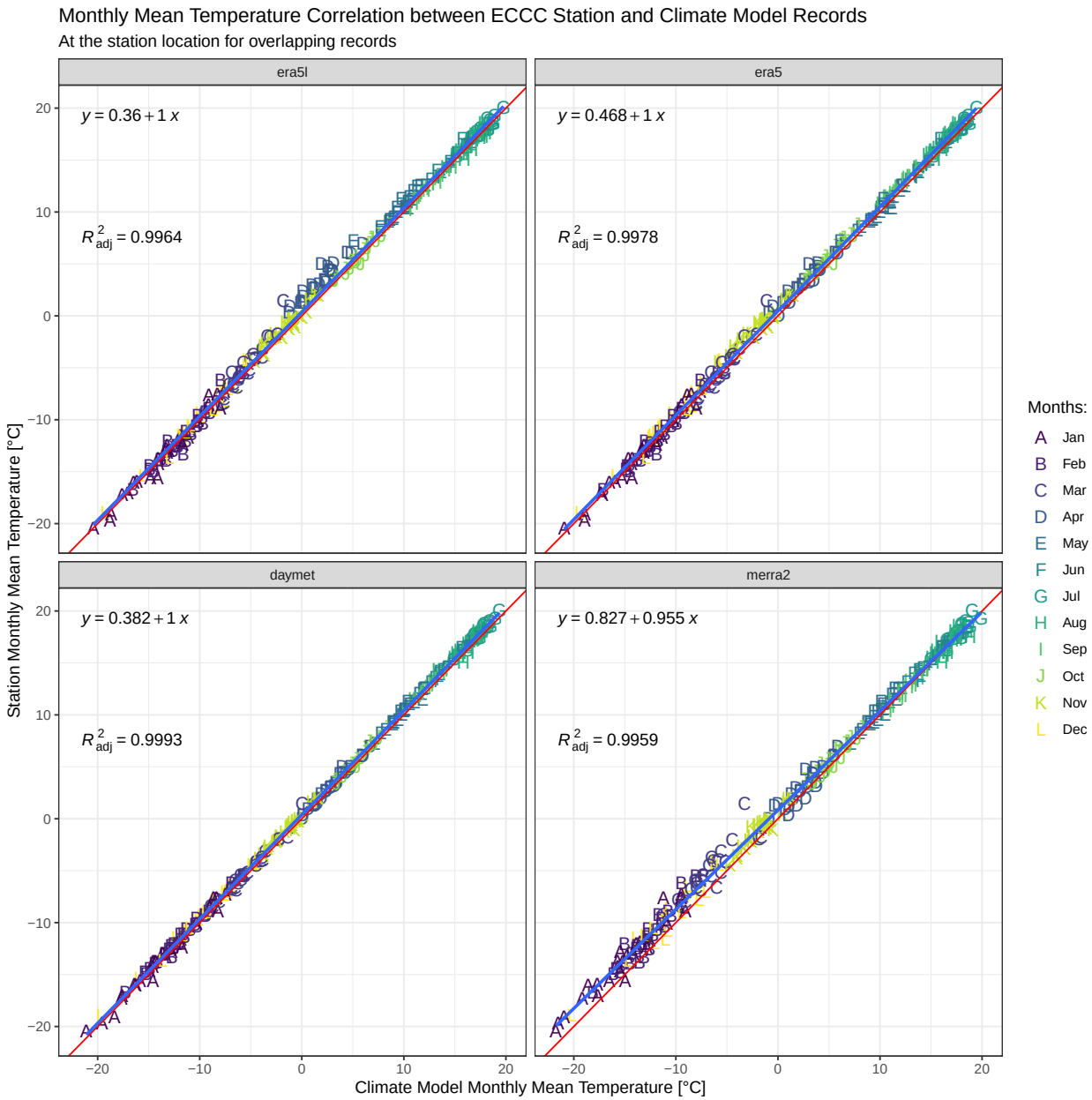
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-12.6	-11.4	-5.2	1.1	10.3	15.4	18.9	17.5	13.5	7	-1.4	-8.6	3.7
era5	-12.8	-11.8	-5.3	1.4	10.5	15.1	18.3	16.8	12.5	6.2	-1.7	-8.8	3.4
daymet	-12.9	-12.2	-5.5	1.6	10.2	14.7	18	16.7	12.3	6.1	-2	-9	3.2
merra2	-14.7	-13.4	-7.3	0.3	10.2	14.9	18	16.7	12.5	6	-2.5	-10.3	2.5
station	-13.2	-12.1	-5.3	1.6	10.2	14.6	17.8	16.5	12.1	5.9	-2.3	-9.2	3.1



6.2.2.7 Monthly Correlations for ST DONAT

Table 6.6: Monthly Summary of Reanalysis Data matching Observed Data at ST DONAT

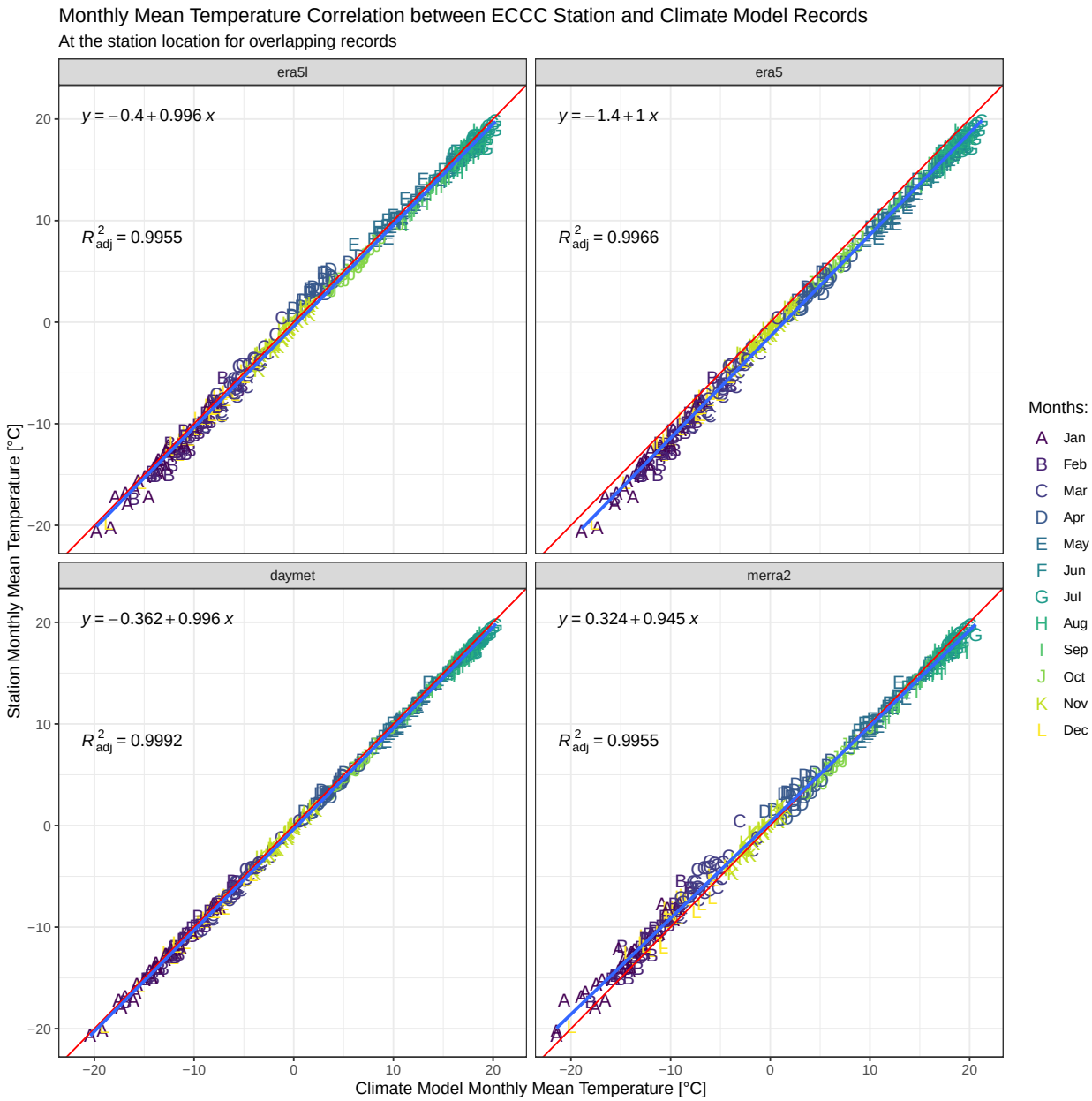
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-13.4	-11.3	-5.6	1.7	9.6	15.3	17.8	16.8	12.3	5.3	-1.5	-9.8	3.1
era5	-13.5	-11.5	-5.5	2.5	10.2	15.4	17.7	16.3	11.6	4.8	-1.9	-10.2	3
daymet	-13.6	-11.7	-5.4	2.9	10	15.1	17.5	16.4	11.8	5.3	-1.5	-10	3.1
merra2	-14.8	-12.7	-6.7	2.6	10	15.5	17.8	16.7	12.3	5.2	-1.7	-10.5	2.8
station	-13.4	-11.7	-5.1	2.8	10.1	15.5	17.9	16.7	12.1	5.7	-1.1	-9.6	3.3



6.2.2.8 Monthly Correlations for ST COME

Table 6.7: Monthly Summary of Reanalysis Data matching Observed Data at ST COME

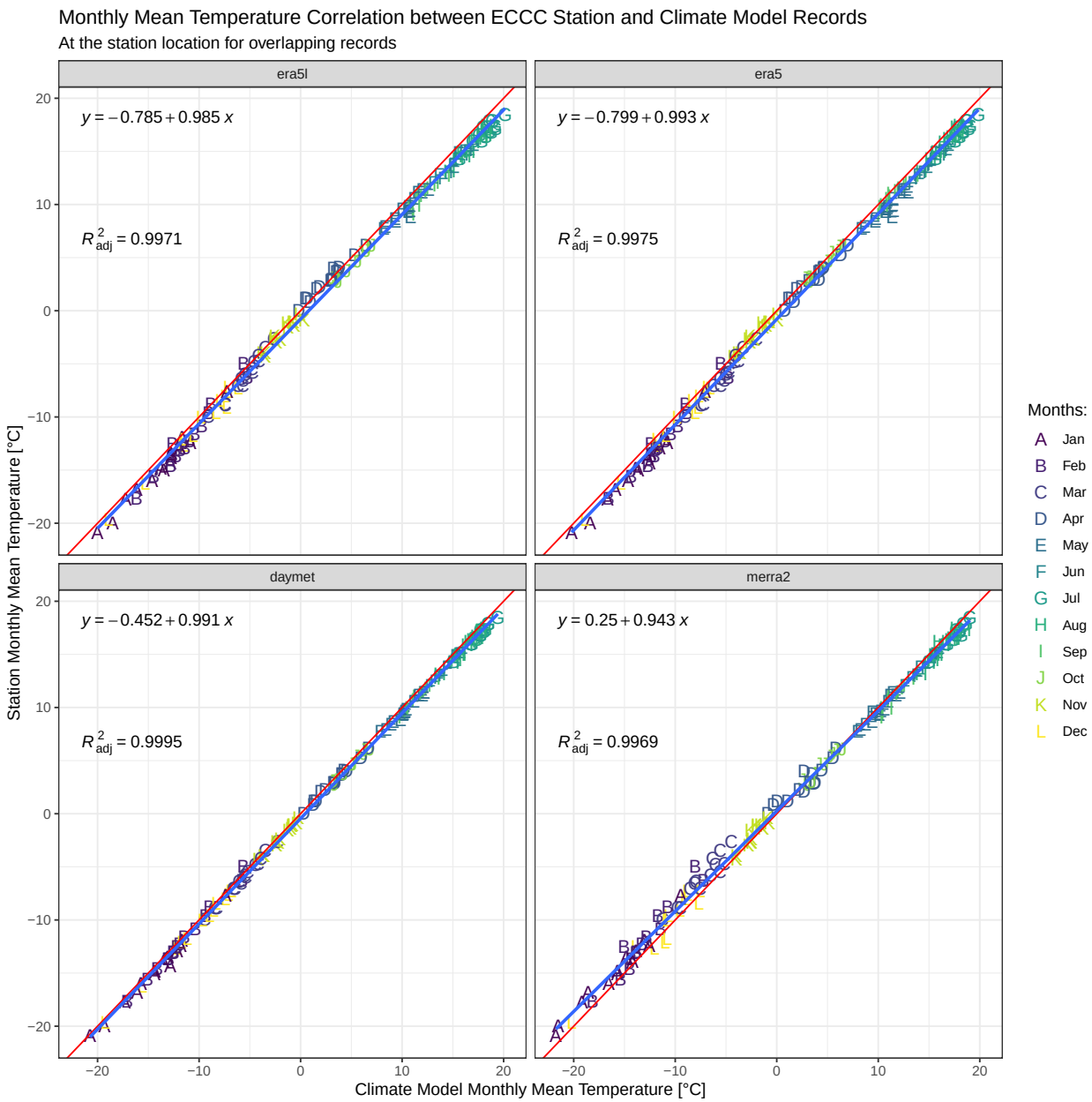
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-12.8	-10.3	-5.1	2.5	10.6	16	18.4	17.5	13.1	6	-1	-9	3.8
era5	-11.7	-9.4	-3.9	4.5	12.2	17.2	19.4	18.1	13.4	6.4	-0.3	-8.1	4.8
daymet	-13	-10.9	-5	3.5	10.9	15.9	18.3	17.2	12.7	5.9	-0.9	-9.1	3.8
merra2	-14.5	-12.1	-6.5	2.9	10.7	16	18.3	17.3	13	5.7	-1.3	-10	3.3
station	-13.1	-11.4	-5.4	3	10.4	15.5	17.9	16.6	12.1	5.7	-1.1	-9.5	3.4



6.2.2.9 Monthly Correlations for NOTRE DAME DE LA MERCI

Table 6.8: Monthly Summary of Reanalysis Data matching Observed Data at NOTRE DAME DE LA MERCI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-13.8	-10.9	-5.4	2.7	10.5	15.3	18.3	17.2	12	5	-1.8	-10	3.3
era5	-13.7	-10.9	-5.2	3.4	11	15.3	18.2	16.7	11.4	4.6	-1.9	-10.2	3.2
daymet	-14.3	-11.5	-5.7	3.2	10.3	14.6	17.6	16.5	11.4	4.8	-1.8	-10.4	2.9
merra2	-15.9	-12.9	-7.3	2.7	10.1	14.8	17.7	16.5	11.5	4.5	-2.3	-10.8	2.4
station	-14.9	-12.3	-5.9	2.7	9.6	14.1	16.6	15.5	10.6	4.4	-2.2	-10.6	2.3

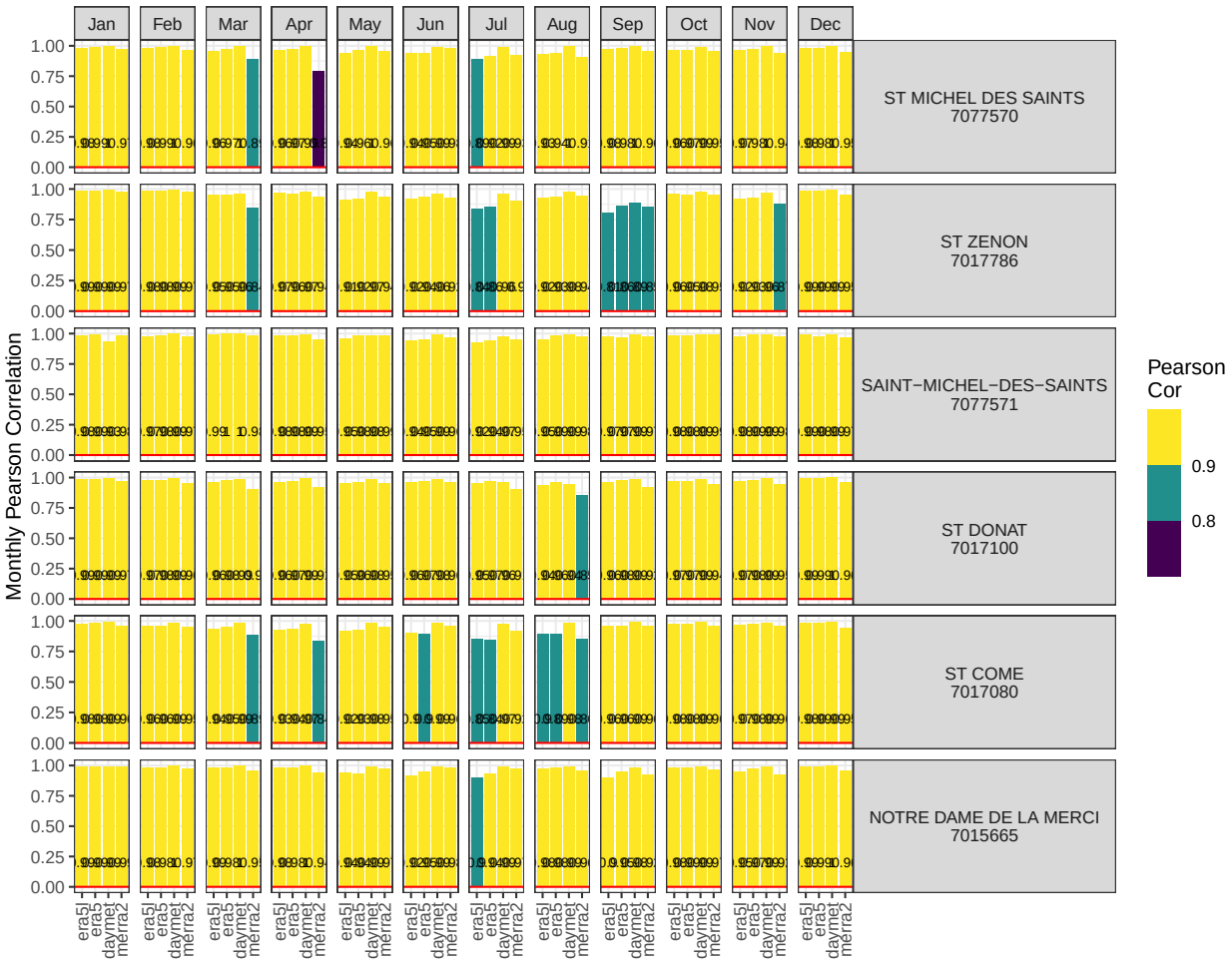


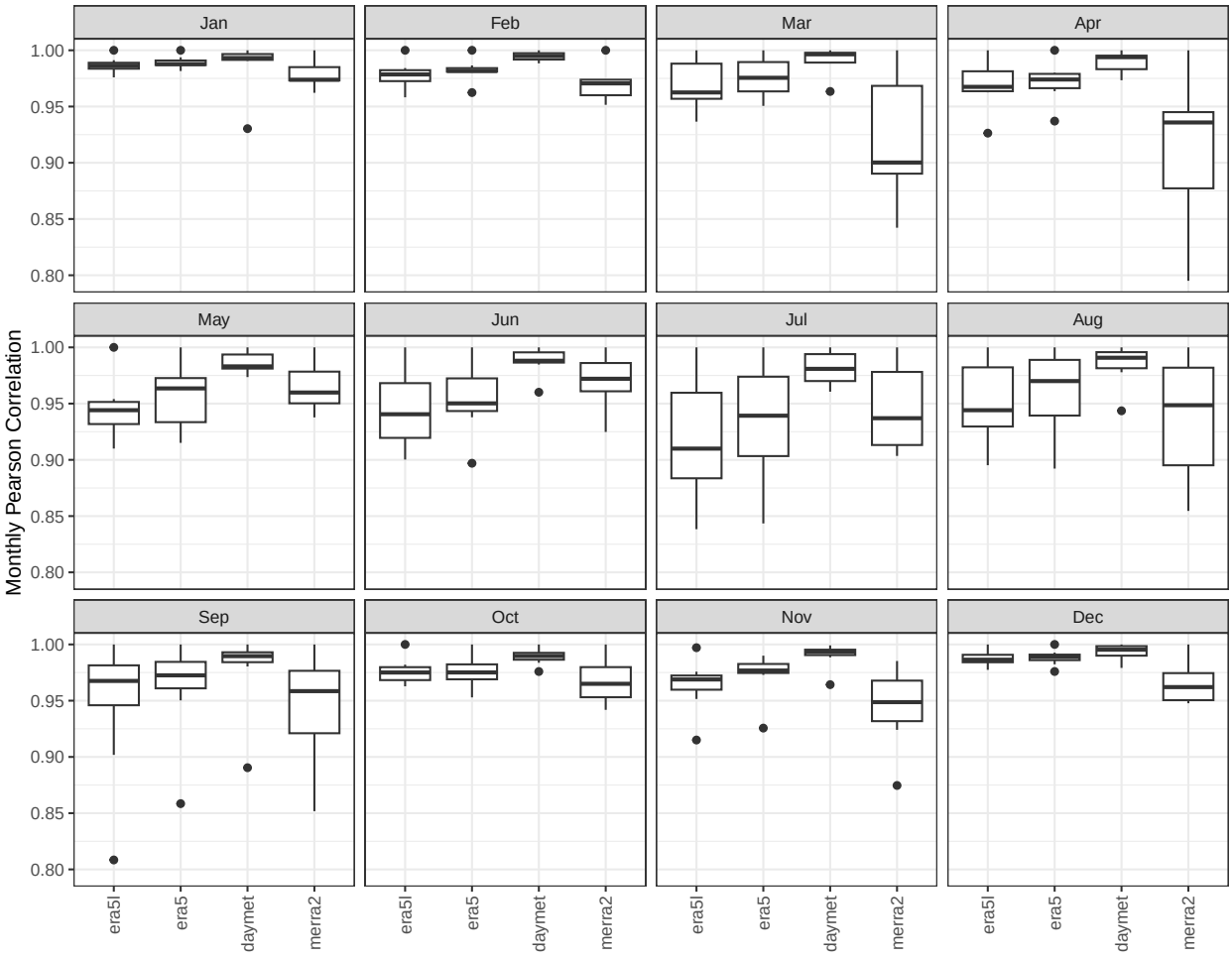
6.2.3 Monthly Pearson Correlation Coefficient

The Pearson correlation coefficient (PCC) is a correlation coefficient that measures linear correlation (and linear only) between two sets of data. It represents a normalized measurement of the covariance, such that the result always has a value between −1 and 1. A value of 0 represents no linear correlation between both datasets. A value of 1 represents perfect positive linear correlation, and a value of -1 perfect negative linear correlation.

Monthly data reviewed in the previous section is summarized in the following figures that represent PCC monhtly for ECCC stations versus climate models comparisons.

Daymet generally presents the better Pearson correlations with station data year round.




Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Monthly Pearson Correlation
1.00
0.95
0.90
0.85
0.80
era5l
era5
daymet
merra2

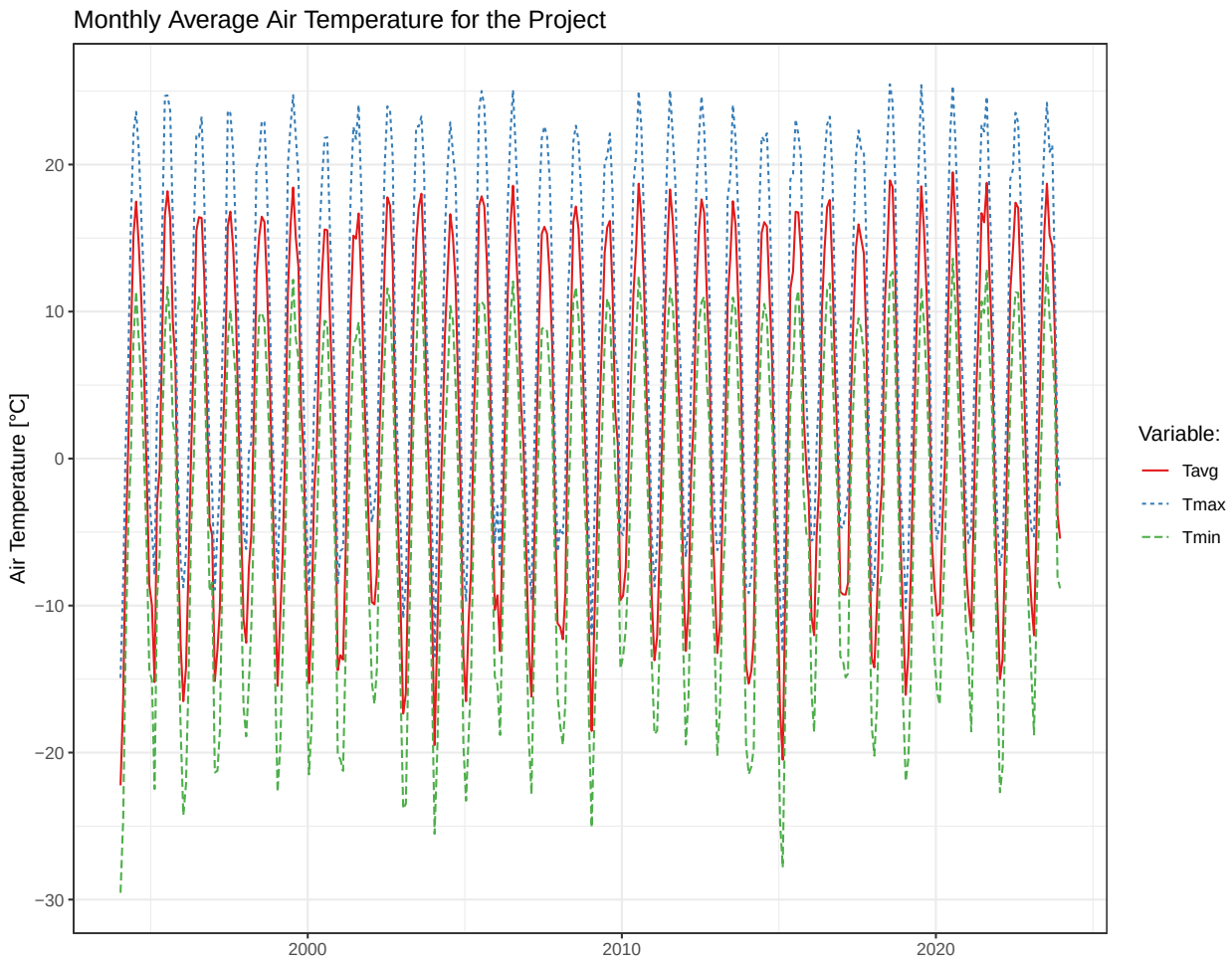
Chapter 7

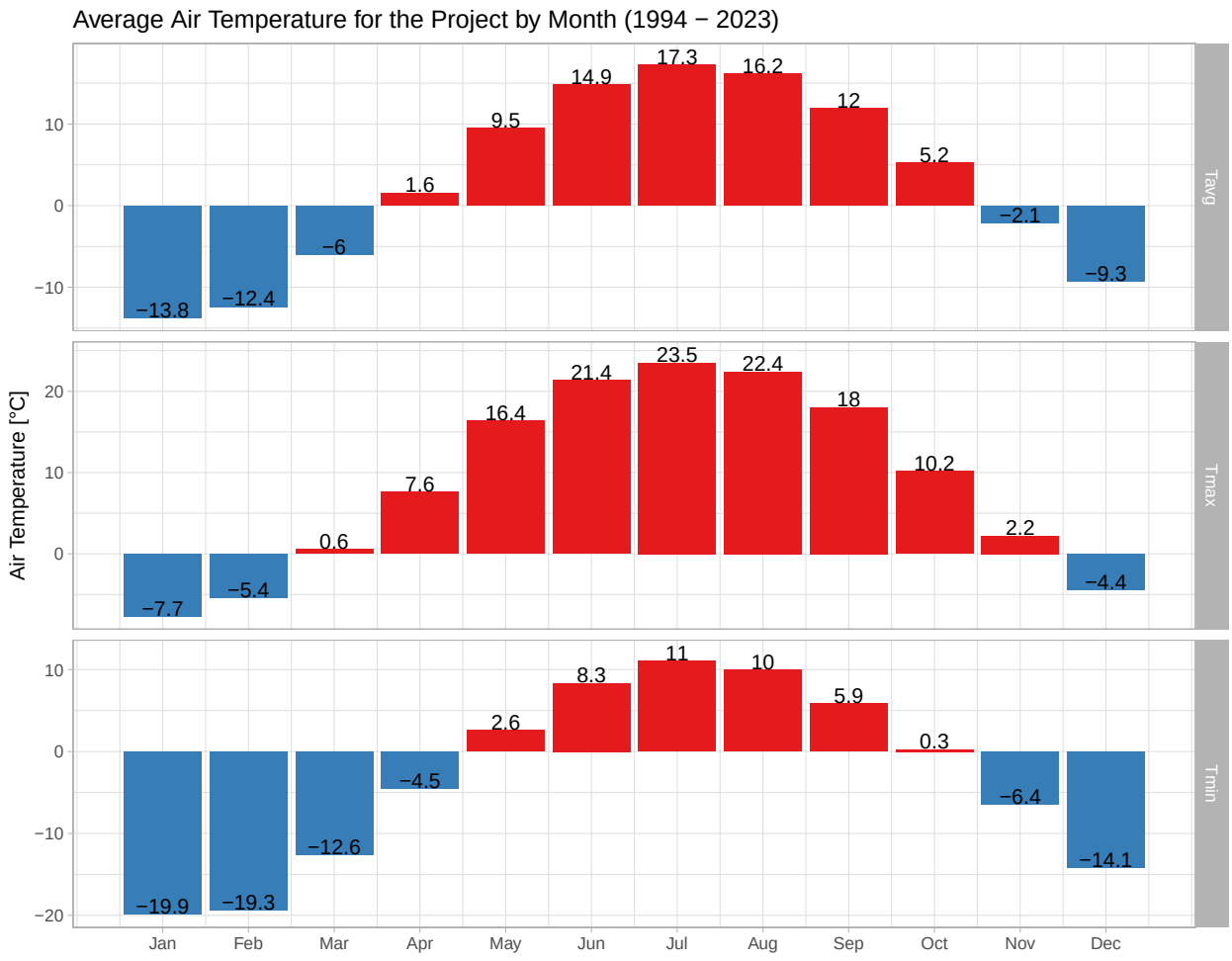
Site Temperature Selection and Results

7.1 Project Temperature Timeseries

Based on the previous analysis, Daymet is the dataset most likely to be the most representative of temperature on site for the analysis period.

Temperature timeseries and normals for the Matawinie Project are summarised in the following figures and tables for the 1994-2023 and 1985-2014 Periods.


Monthly Average Air Temperature for the Project
Air Temperature [°C]
20
10
0
−10
−20
−30
2000
2010
2020
Variable:
Tavg
Tmax
Tmin


Average Air Temperature for the Project by Month (1994 − 2023)
Air Temperature [°C]
Tavg
Tmax
Tmin
−13.8
−12.4
−6
1.6
9.5
14.9
17.3
16.2
12
5.2
−2.1
−9.3
−7.7
−5.4
0.6
7.6
16.4
21.4
23.5
22.4
18
10.2
2.2
−4.4
−19.9
−19.3
−12.6
−4.5
2.6
8.3
11
10
5.9
0.3
−6.4
−14.1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

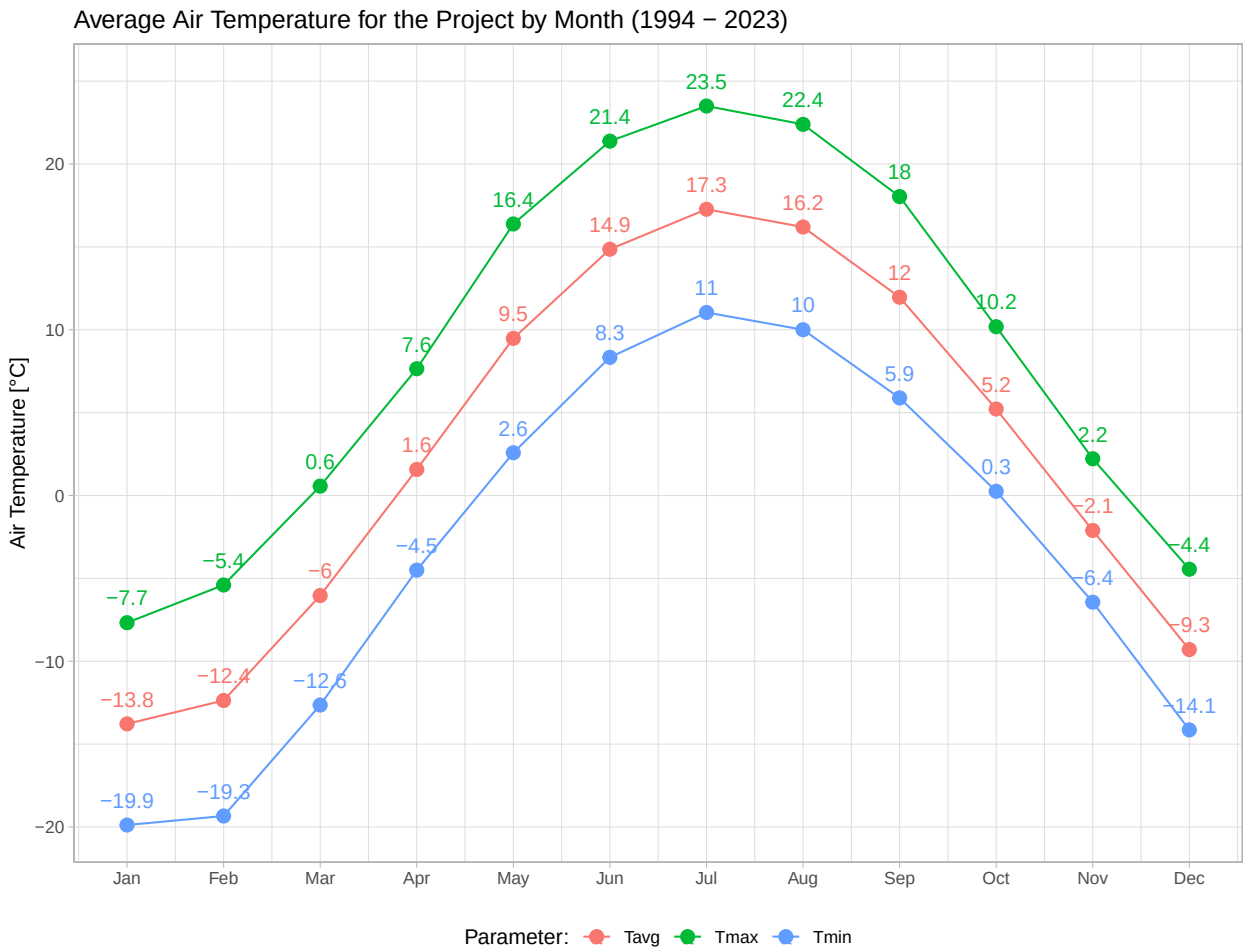


Table 7.1: Air Temperature Normals (1994-2023) for the Project [°C]

Par	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Tmax	-7.7	-5.4	0.6	7.6	16.4	21.4	23.5	22.4	18	10.2	2.2	-4.4	8.7
Tavg	-13.8	-12.4	-6	1.6	9.5	14.9	17.3	16.2	12	5.2	-2.1	-9.3	2.7
Tmin	-19.9	-19.3	-12.6	-4.5	2.6	8.3	11	10	5.9	0.3	-6.4	-14.1	-3.2

Table 7.2: Air Temperature Normals (1985-2014) for the Project [°C]

Par	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Tmax	-7.8	-5.5	0.7	8.2	16.4	21.2	23.4	22.2	17.3	9.6	2.1	-5	8.5
Tavg	-14.2	-12.7	-6.3	2	9.5	14.6	17	15.8	11.3	4.7	-2.3	-10.4	2.4
Tmin	-20.5	-19.9	-13.2	-4.1	2.6	8	10.6	9.5	5.3	-0.2	-6.7	-15.8	-3.7

7.2 Historical Mean Annual Air Temperature Trends

The project MAAT was evaluated to identify statistically significant trends over the historical period. The linear approximation was completed via the ordinary least squares and quantile regression methods. In addition, three trend significance testing mehtods were completed:

- The Theil-Sen method ((Theil 1950), Sen (1968)) to estimate trend, and the Mann-Kendall method ((Mann 1945), (Kendall 1975)) to test for the statistical significance of the estimated trend
- Data pre-whitennig, the Zhang method ((Zhang et al. 2001)) method to estimate trend, and the Mann-Kendall method ((Mann 1945), (Kendall 1975)) to test for the statistical significance of the estimated trend
- Data pre-whitennig, the Yue & Pilon method ((Yue et al. 2002)) to estimate trend, and the Mann-Kendall method ((Mann 1945), (Kendall 1975)) to test for the statistical significance of the estimated trend

All tests identified a significant upward trend in MAAT. The results of the statistical tests are summarized in the figure and table below.

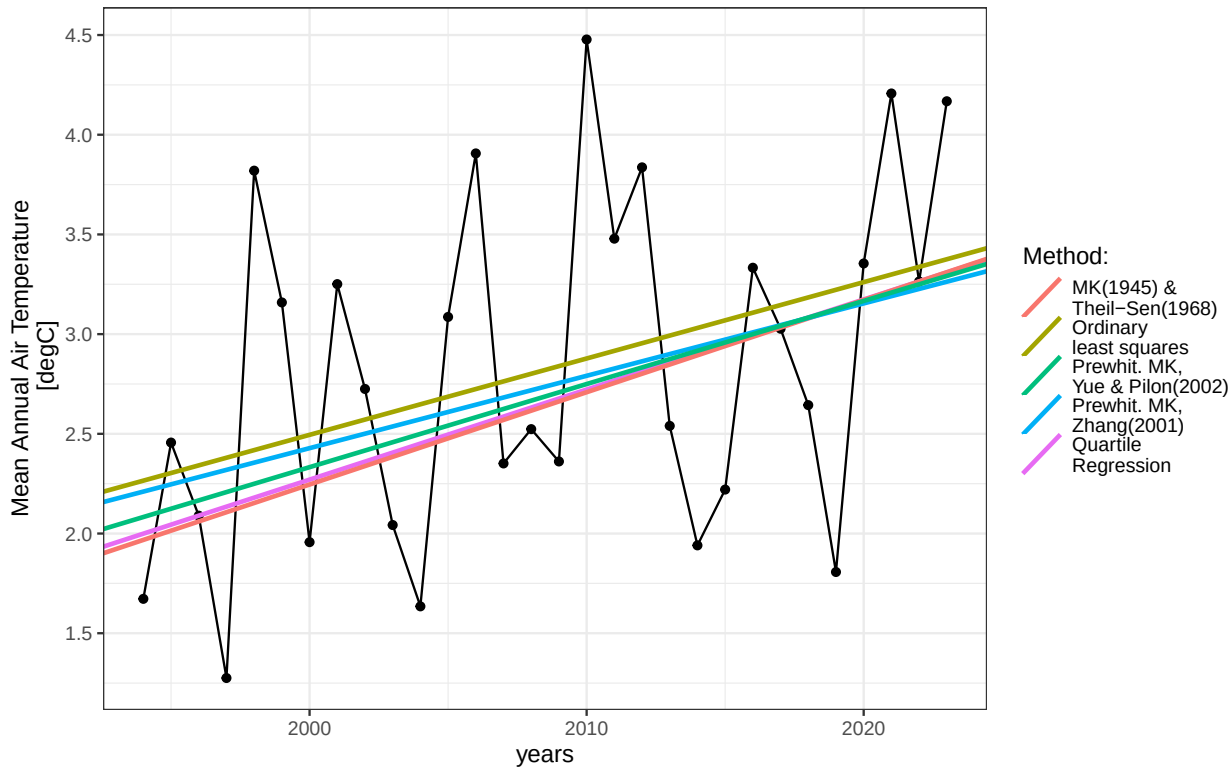


Table 7.3: MAAT Trend Analysis Results

Method	slope	intercept	Comment	Significance
Ordinary least squares	0.03829	-74.08	-	0.9688
Quartile Regression	0.04517	-88.08	-	0.9594
MK(1945) & Theil-Sen(1968)	0.04629	-90.34	Upward Trend, 95% of significance	0.979
Prewhit. MK, Zhang(2001)	0.03629	-70.16	There is no significant	0.979
Prewhit. MK, Yue & Pilon(2002)	0.04168	-81.03	There is no significant	0.979

Chapter 8

Output

Output of this code has been backed up and saved as an rds file in the **/01_Data/rds** project folder.

References

Gelaro, Ronald, Will McCarty, Max J. Suárez, Ricardo Todling, Andrea Molod, Lawrence Takacs, Cynthia A. Randles, et al. 2017. "The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2)." *Journal of Climate* 30 (14): 5419–54. https://doi.org/10.1175/jcli-d-16-0758.1.

Hersbach, Hans, Bill Bell, Paul Berrisford, Shoji Hirahara, András Horányi, Joaquín Muñoz-Sabater, Julien Nicolas, et al. 2020. "The ERA5 Global Reanalysis." *Quarterly Journal of the Royal Meteorological Society* 146 (730): 1999–2049. https://doi.org/10.1002/qj.3803.

Kendall, M. G. 1975. *Rank Correlation Methods (4th Edition)*. London: Griffin.

Mann, Henry B. 1945. "Nonparametric Tests Against Trend." *Econometrica* 13 (3): 245. https://doi.org/10.2307/1907187.

Muñoz-Sabater, Joaquín, Emanuel Dutra, Anna Agustí-Panareda, Clément Albergel, Gabriele Arduini, Gianpaolo Balsamo, Souhail Boussetta, et al. 2021. "ERA5-Land: A State-of-the-Art Global Reanalysis Dataset for Land Applications." *Earth System Science Data* 13 (9): 4349–83. https://doi.org/10.5194/essd-13-4349-2021.

Sen, Pranab Kumar. 1968. "Estimates of the Regression Coefficient Based on Kendall's Tau." *Journal of the American Statistical Association* 63 (324): 1379–89. https://doi.org/10.1080/01621459.1968.10480934.

Theil, H. 1950. "A Rank-Invariant Method of Linear and Polynomial Regression Analysis. I, II, III." Amsterdam: Statistical Department ot the "Mathematisch Oentrum". https://dwc.knaw.nl/DL/publications/PU00018803.pdf.

Thornton, M. M., R. Shrestha, Y. Wei, P. E. Thornton, and S-C. Kao. 2022. "Daymet: Daily Surface Weather Data on a 1-Km Grid for North America, Version 4 R1," November. https://doi.org/10.3334/ORNLDAAC/2129.

Yue, Sheng, Paul Pilon, Bob Phinney, and George Cavadias. 2002. "The Influence of Autocorrelation on the Ability to Detect Trend in Hydrological Series." *Hydrological Processes* 16 (9): 1807–29. https://doi.org/10.1002/hyp.1095.

Zhang, Xuebin, K. David Harvey, W. D. Hogg, and Ted R. Yuzyk. 2001. "Trends in Canadian Streamflow." *Water Resources Research* 37 (4): 987–98. https://doi.org/10.1029/2000wr900357.

Appendix B Wind Detailed Analysis

2. NMG - Matawinie Wind Analysis

CAPR003306

Camilo Gallard

February 12, 2025

Abstract

This report compiles the wind anlaysis that was carried out by SRK Consulting (Canada) Inc. for the Nouveau Monde Graphite Matawinie Site in 2024 to support Engineering Design. The data compilation and subsequent analysis was conducted in the R Software environment.

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Chapter 1

Glossary

- **AMS**: Annual Maximum Series.
- **Daymet**: Reanalysis tool developed by the Oak Ridge National Laboratory and supported by NASA (Thornton et al. 2022).
- **ECCC**: Environment and Climate Change Canada.
- **ERA5**: Reanalysis tool developed by the European Centre for Medium-Range Weather Forecasts (Hersbach et al. 2020).
- **ERA5-Land**: Reanalysis tool based on ERA5 but for Land surfaces and a smaller grid, and developed by the European Centre for Medium-Range Weather Forecasts (Muñoz-Sabater et al. 2021).
- **ET**: Evapotranspiration
- **ET0**: Reference Evapotranspiration
- **IDF**: Intensity-Duration-Frequency (IDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
- **KST**: Kolmogorov–Smirnov Test.
- **MAAT**: Mean Annual Air Temperature.
- **MAP**: Mean Annual Precipitation.
- **MERRA2**: Modern-Era Retrospective analysis from Research and Applications, Version 2, is a global climate reanalysis model from the U.S. National Aeronautics and Space Administration (Gelaro et al. 2017).
- **NMG**: Nouveau Monde Graphite.
- **PCC**: Pearson Correlation Coefficient.
- **PDF**: Precipitation-Duration-Frequency (PDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
- **PMP**: Probable Maximum Precipitation.
- **RH**: Relative Humidity.

- **SRAD**: Shortwave (solar) radiation. Incident shortwave radiation flux density in watts per square meter.
- **SRK**: SRK Consulting (Canada) Inc.
- **SSR**: Surface net shortwave (solar) radiation. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth (both direct and diffuse) minus the amount reflected by the Earth's surface (which is governed by the albedo).
- **SSRD**: Surface short-wave (solar) radiation downwards. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth. This parameter comprises both direct and diffuse solar radiation.
- **Tavg**: Mean or Average Air Temperature over a given temporal unit (day, month, year…).
- **Tdew**: Mean or Average Dew Point Temperature over a given temporal unit (day, month, year…).
- **Tmax**: Maximum Air Temperature over a given temporal unit (day, month, year…).
- **Tmin**: Minimum Air Temperature over a given temporal unit (day, month, year…).

Chapter 2

General Parameters

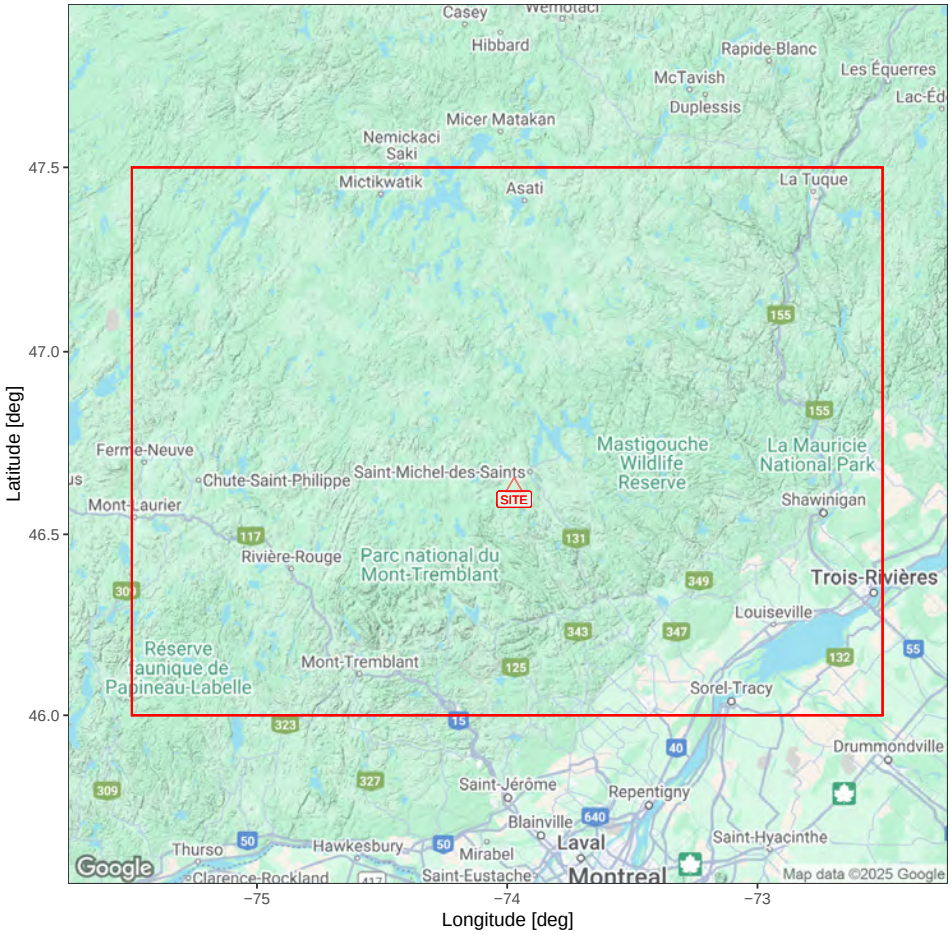
The NMG Matawinie site is located in southern Quebec, 125 km north of Montreal. Site latitude is 46.63 degrees, and longitude is -73.97 degrees, at an elevation of 562 masl. These coordinates were selected to match the location of the meteorological station on site.

For the purpose of this meteorological analysis, an area of interest was defined around site to capture regional data and climate trends, and was defined as the region between:

- 46° and 47.5° Latitude
- -75.5° and -72.5° Longitude

Site Location and Area of Interest for this Study

Area of interest covers a distance of up to 125km from Site

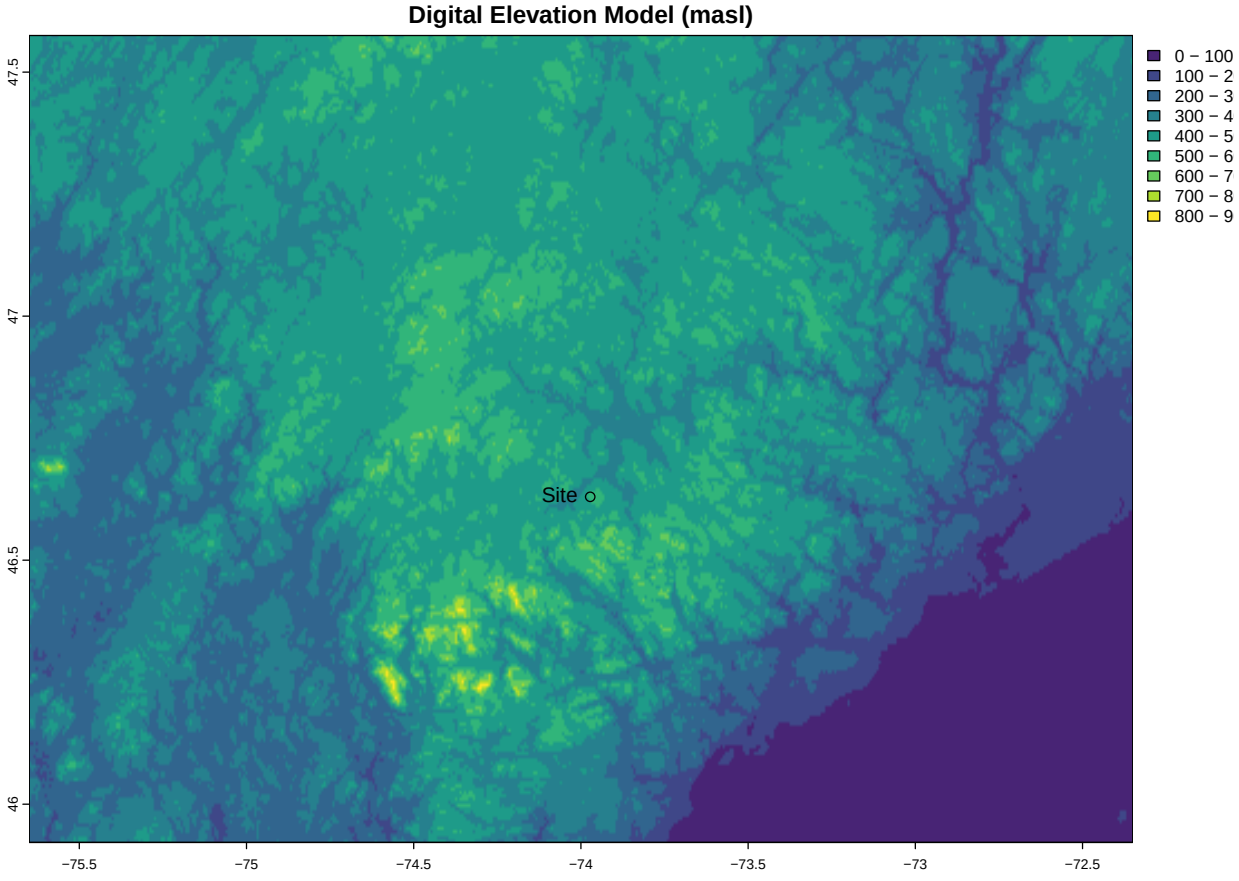


Wind being a quickly shifting parameter, only data based on an hourly timestep is considered in this analysis. Wind roses are presented to illustrate wind direction and speed recorded at different locations. In these figures, direction represents the origin of the winds, and speeds are binned by value and added by frequency (%) by count.

Chapter 3

Digital Elevation Model

Digital elevation model from the region was downloaded from the Shuttle Radar Topography Mission (SRTM) dataset (NASA, 2013). The SRTM database contains global elevation data with 3 arc-second (90 m) spatial resolution, which is deemed sufficient for climate analysis.



Chapter 4

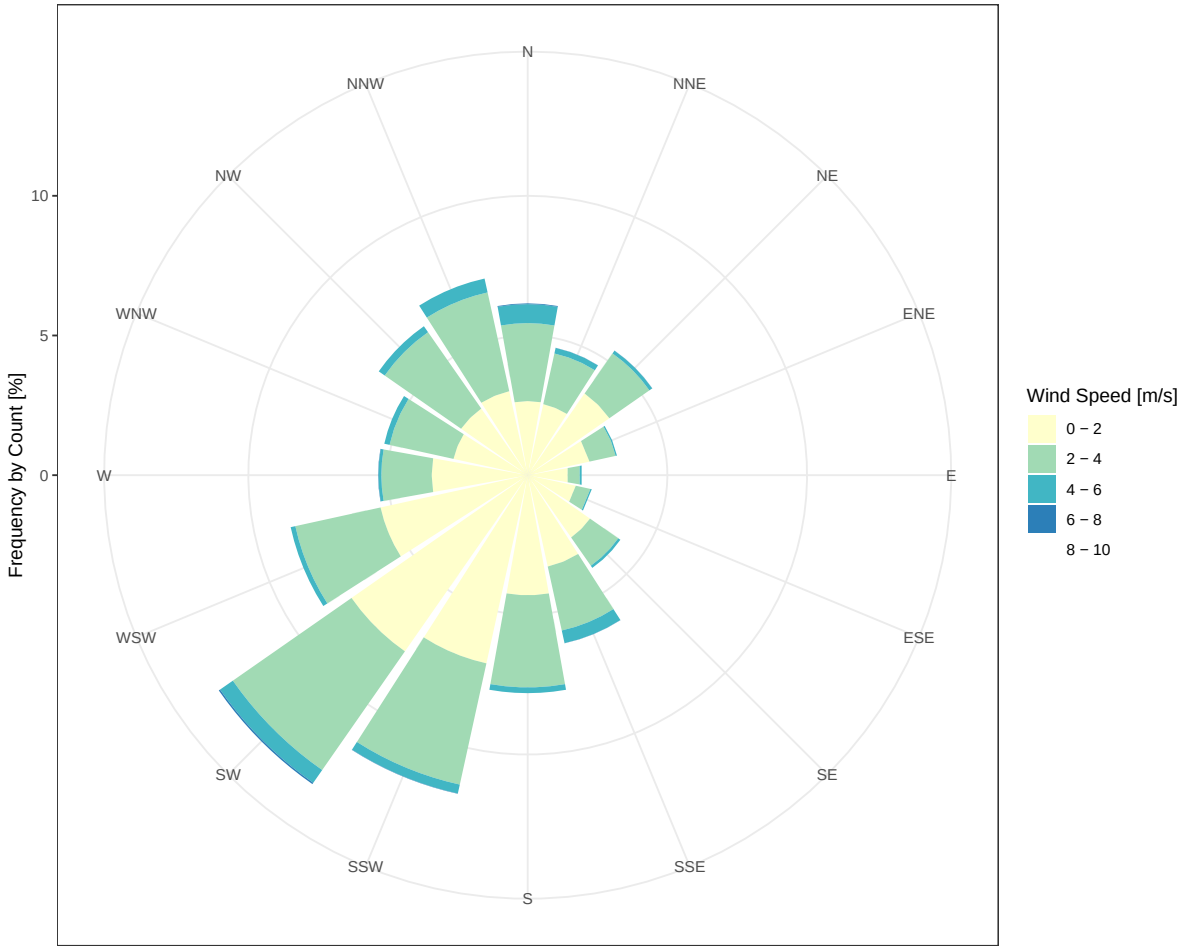
NMG Wind Data

Site data is collected by NMG from two meteorological stations. The first station is located on Site, and the second station, called SoftdB, is located 1.5 km north at the following address: 200 Chemin des Hauteurs, Saint-Michel-des-Saints.

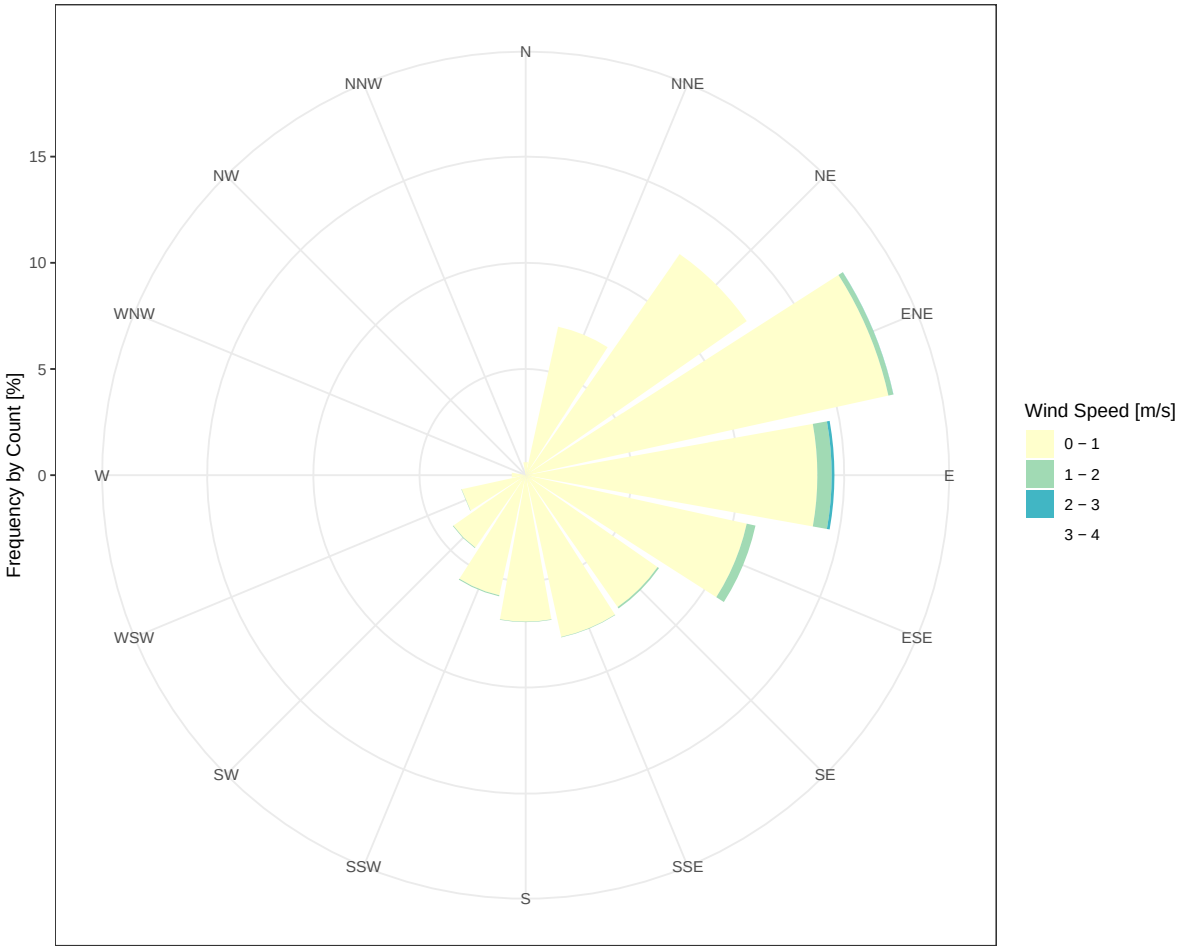
SoftdB station and site station are inconsistent for wind direction. Wind direction can be highly variable even within short distances as it is afected by topography, station setup and tree cover. Both records are short.

The sustained wind speeds recorded at both stations are low (below 4 m/s 97% of the time for Site, always for SoftdB).

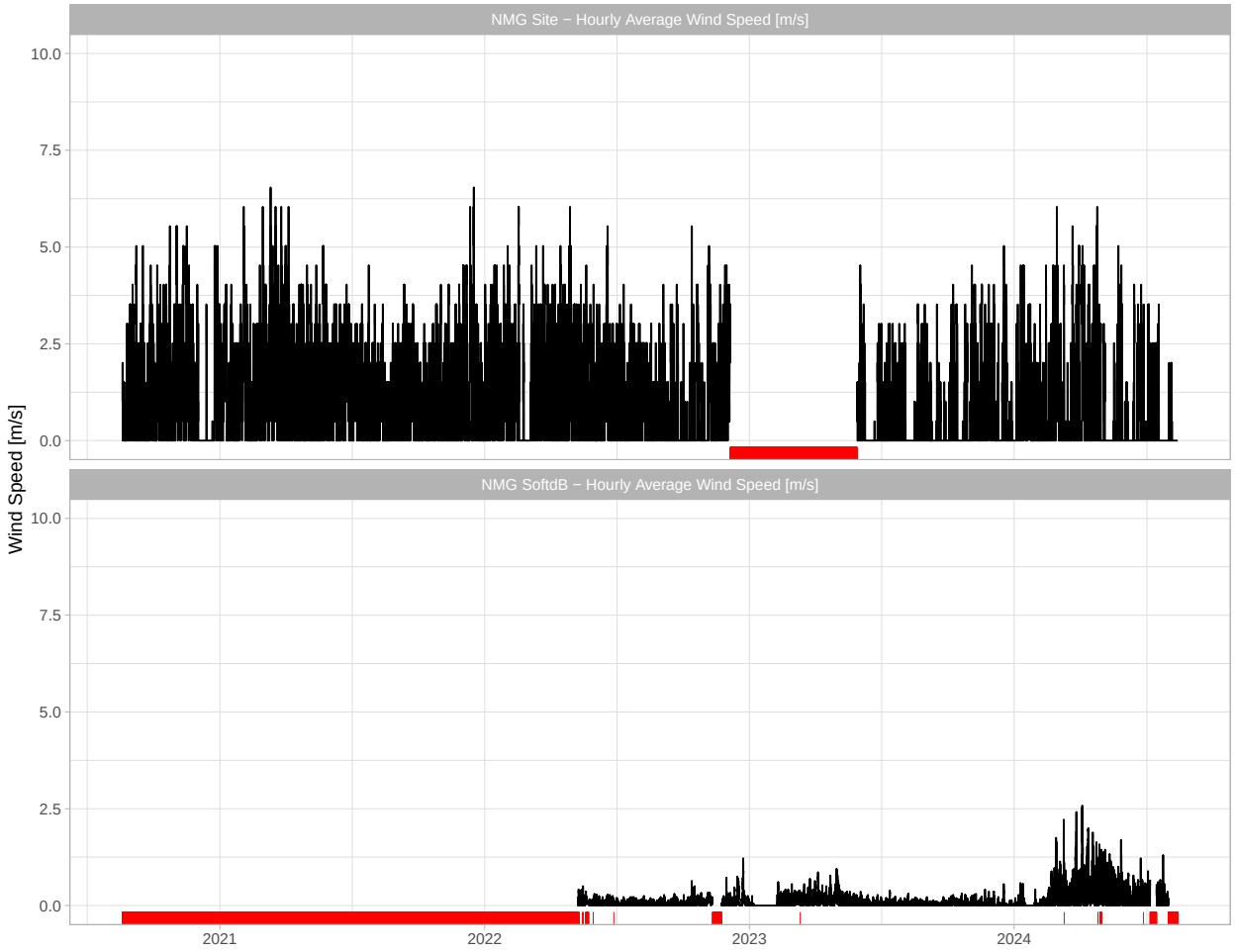
Wind Rose for NMG Site Station



Wind Rose for NMG SoftdB Station



NMG Stations Hourly Records and Missing Data



Chapter 5

Regional Wind Analysis

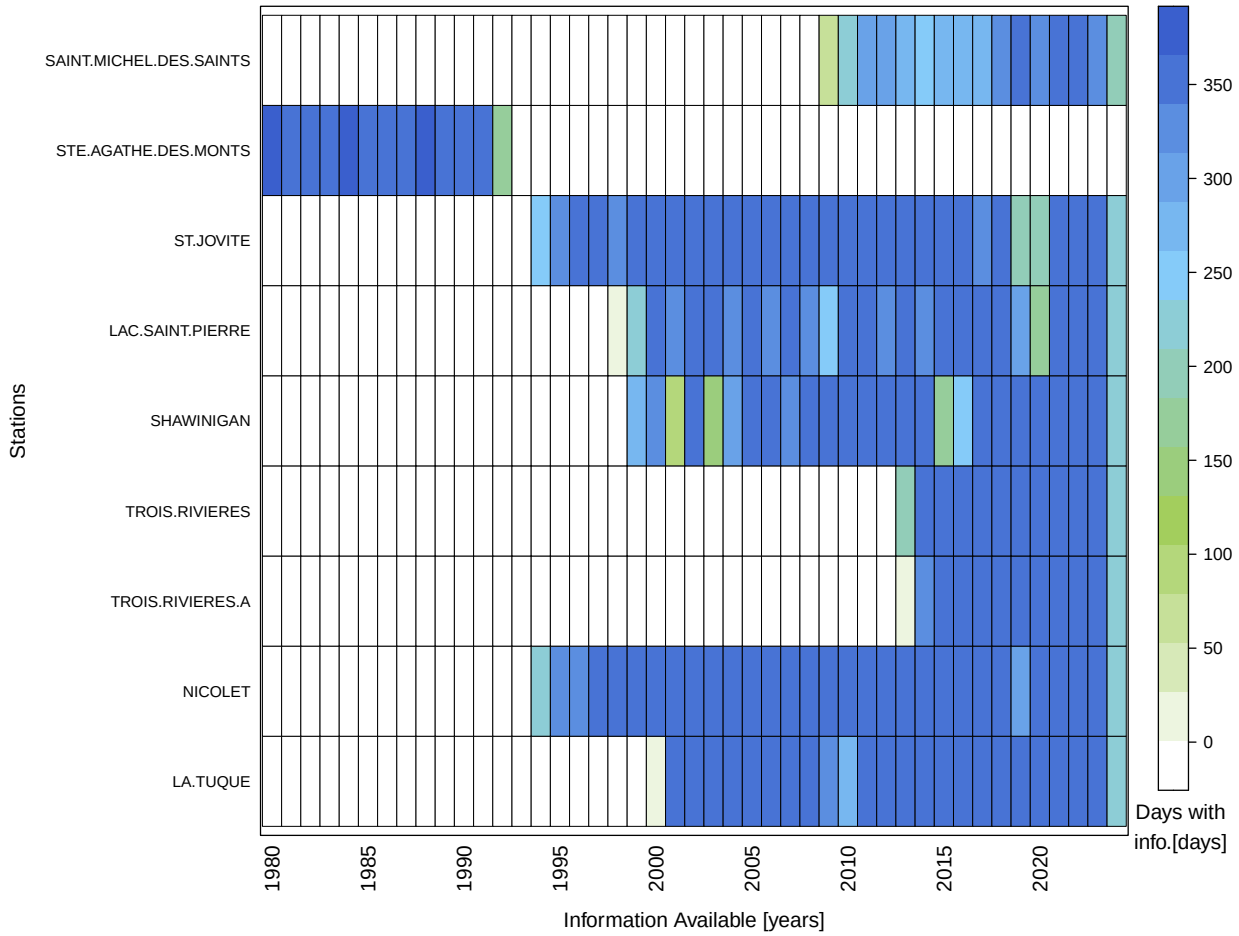
5.1 ECCC Wind Data

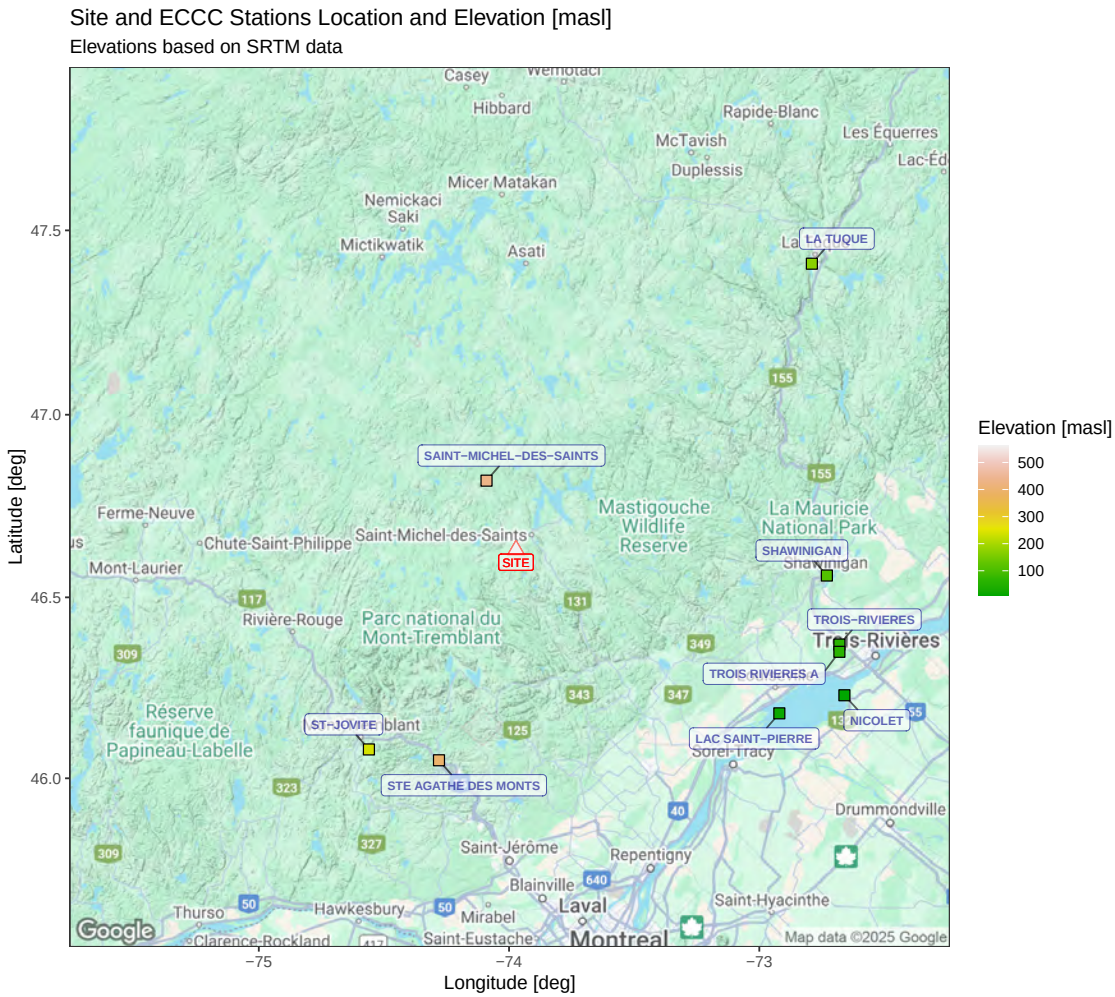
Environment and Climate Change Canada (ECCC) data was downloaded and prepared for analysis . The information is captured on an hourly timestep when available. No complementary/redundant stations were detected so patching was not required for stations within the area of interest.

The following figures show:

1. Data availability over time at each station (only records from 1980 to 2023 were considered for this analysis).
2. Selected ECCC stations location and elevation.

Refer to the "eccc_read.r" for pre-processing details.


SAINT.MICHEL.DES.SAINTS
STE.AGATHE.DES.MONTS
ST.JOVITE
LAC.SAINT.PIERRE
SHAWINIGAN
TROIS.RIVIERES
TROIS.RIVIERES.A
NICOLET
LA.TUQUE
Stations
1980
1985
1990
1995
2000
2005
2010
2015
2020
Information Available [years]
350
300
250
200
150
100
50
0
Days with info.[days]



5.2 Reanalysis Regional Overview

Climate reanalysis combines gridded global models with observed historical data to produce historical climate and to incorporate adjustments based on developed relationships. Multiple reanalysis datasets are available in different spatio-temporal resolutions.

For this project four reanalysis datasets were evaluated. These are presented as gridded climate models and cover an area of interest defined between

5.2.1 Wind Gridded Dataset Analysis Functions

A general function is created to review each selected gridded dataset and compare it to station records. Four Graph are presented as outputs including:

- Graph 1: Mean Annual Wind Speed (MAWS) as a gridded map over the analysis extents, compared to station results. This aims to help visualize any regional trends in wind speed.
- Graph 2: MAWS Elevation gradient over the analysis extents and regression, compared to station results.
- Graph 3: Mean Monthly Wind Speed Elevation gradient over the analysis extents, compared to station results. Results and regressions split by month.

5.2.2 ERA5 Regional Overview for Mean Wind Speed

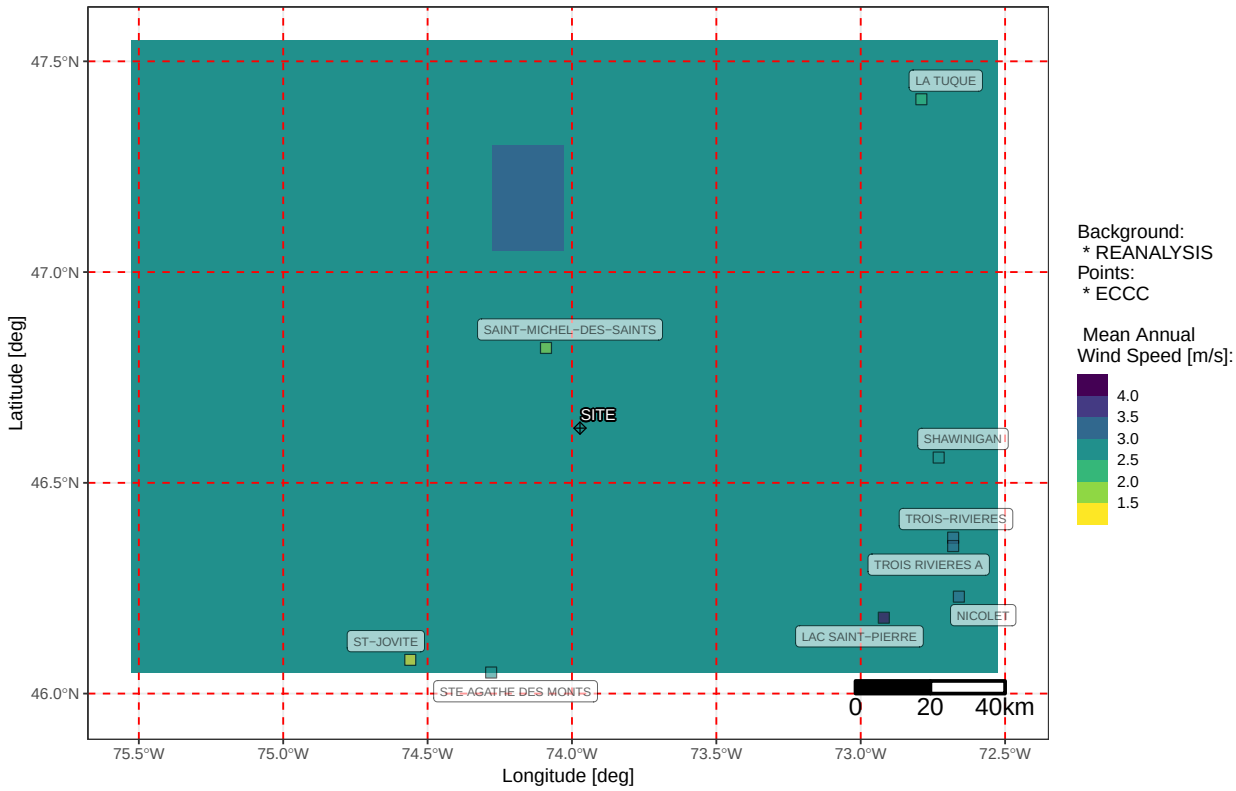
ERA5 is the fifth generation ECMWF atmospheric reanalysis of the global climate covering the period from January 1940 to present (Hersbach et al. 2020). ERA5 is produced by the Copernicus Climate Change Service (C3S) at the European Centre for Medium-Range Weather Forecasts (ECMWF). It offers information about multiple meteorological parameters.

ERA5 provides hourly estimates of a large number of atmospheric, land and oceanic climate variables. The data cover the Earth on a 31km grid and resolve the atmosphere using 137 levels from the surface up to a height of 80km. Surface level parameters were evaluated in this analysis.

The main findings of the ERA5 regional overview are listed below (the corresponding figures follow):

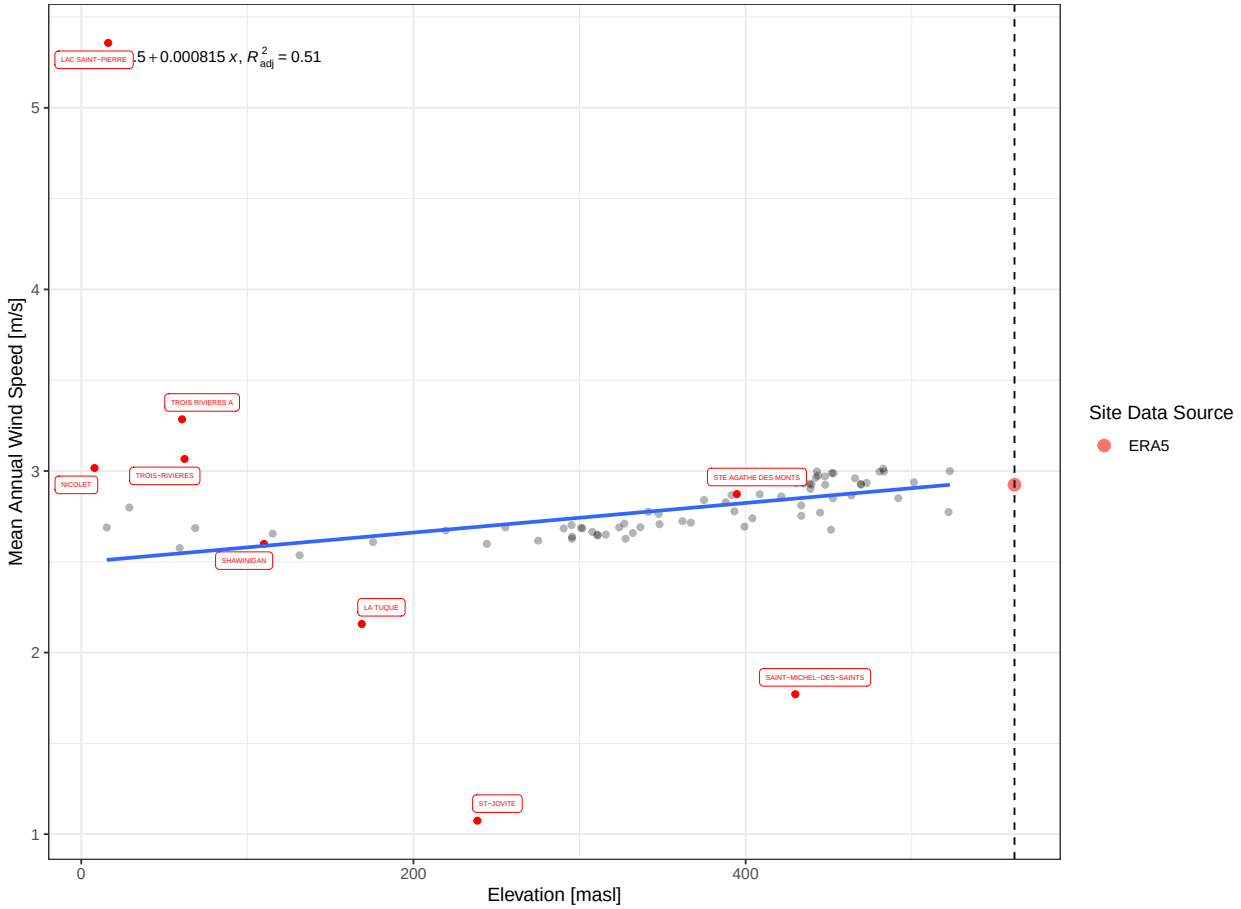
- ERA5 is consistently lower than ECCC data in terms of spatial trends on wind speed, and regional trends are poorly represented by the ERA5 dataset in the project region (Graph 1).
- The wind speed versus elevation gradients (Graphs 2 and 3) are also inconsistent to ECCC data for ERA5 on a regional scale. This could be related to the ERA5 resolution being too large to produce an accurate representation of wind speed near the earth surface at the scale of this analysis.
- Little seasonal variability is apparent for wind speed within the ERA5 dataset and this is consistent with ECCC data (Graph 3).

Graph 1: Mean Annual Wind Speed [m/s]:
(1980 – 2023)



Graph 2: Regional Elevation Gradient

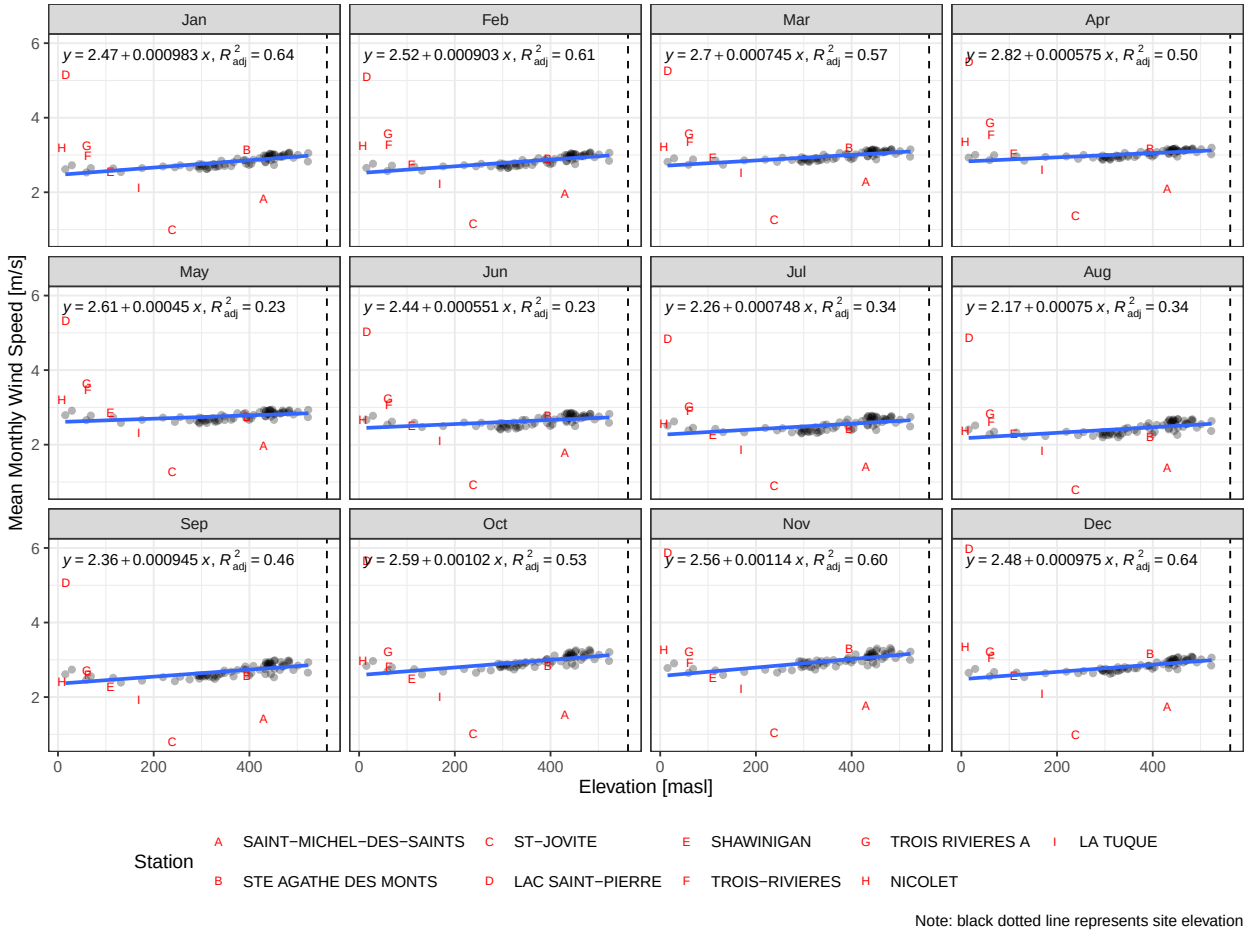
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



5.2.3 ERA5-Land Regional Overview for Mean Wind Speed

ERA5-Land is a higher spatial and temporal resolution reanalysis dataset produced by the European Centre for Medium-Range Weather Forecasts (ECMWF) (Muñoz-Sabater et al. 2021). It offers detailed information about a large number of atmospheric, land and oceanic climate variables.

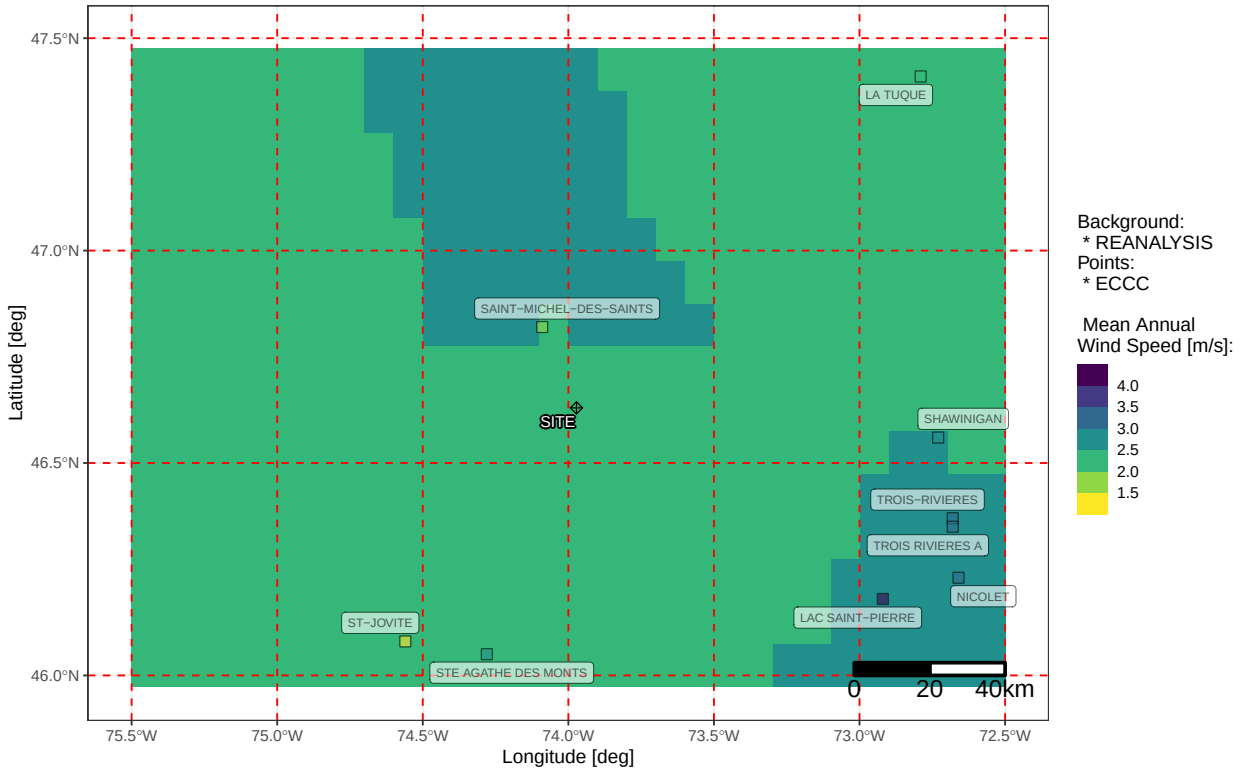
ERA5-Land operates at a spatial resolution of approximately 9 km and provides data at hourly intervals, making it particularly useful for hydrological and environmental studies. This dataset is widely used in research and operational applications due to its comprehensive coverage and high accuracy in representing land-surface conditions.

The main findings of the ERA5-Land regional overview are listed below (the corresponding figures follow):

- ERA5-Land results in the study region are more in line with ECCC data in terms of spatial trends and amplitude of MAWS (Graph 1).
- The wind speed versus elevation gradients (Graphs 2 and 3) for ERA5-Land are not significant. MAWS appears to be well represented regionally by ERA5-Land although significant differences can be observed locally with some of the ECCC stations.
- Little seasonal variability is apparent for wind speed within the ERA5-Land dataset and this is consistent with ECCC data (Graph 3).

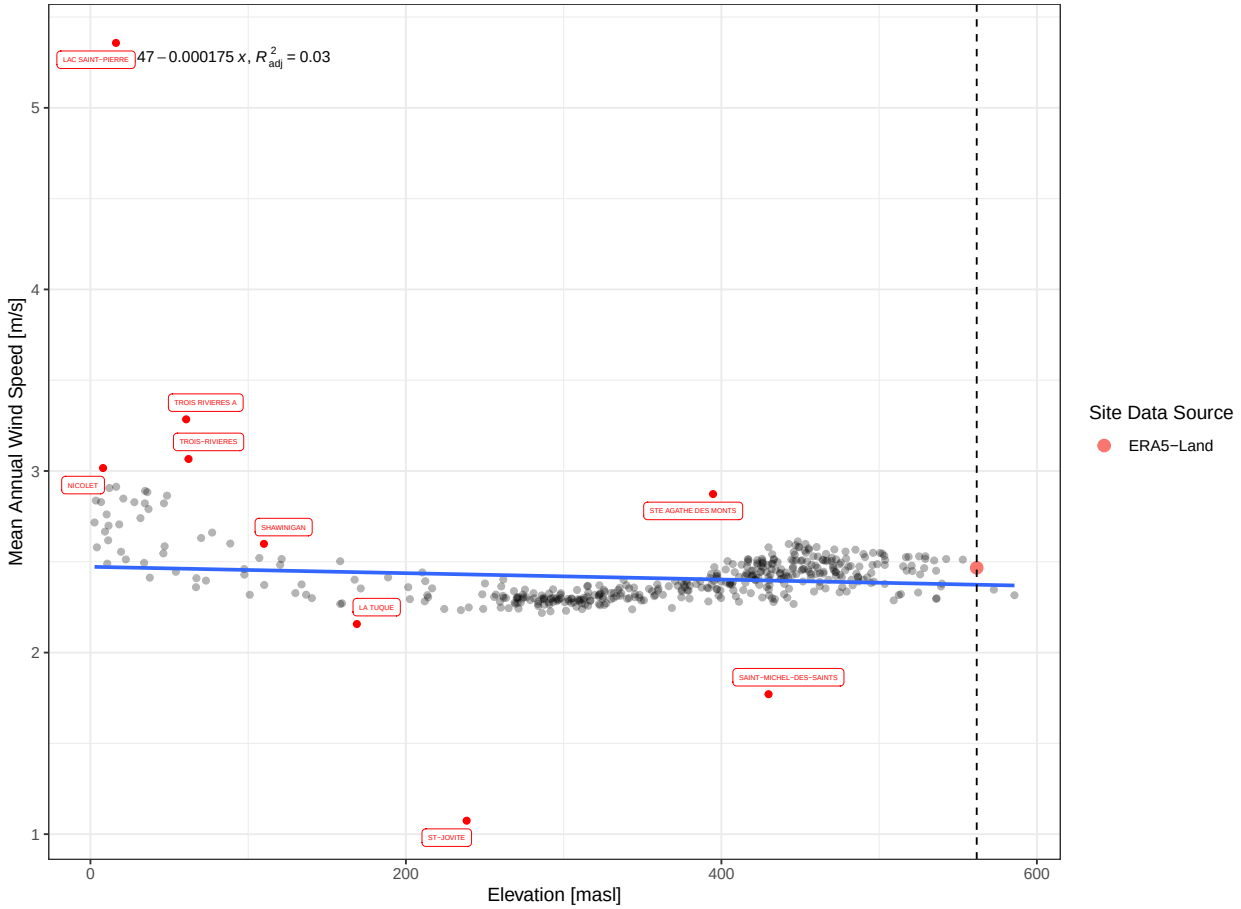
- ERA5-Land is the reanalysis tool that presents the most similar data to ECCC records in this review.

Graph 1: Mean Annual Wind Speed [m/s]:
(1980 – 2023)



Graph 2: Regional Elevation Gradient

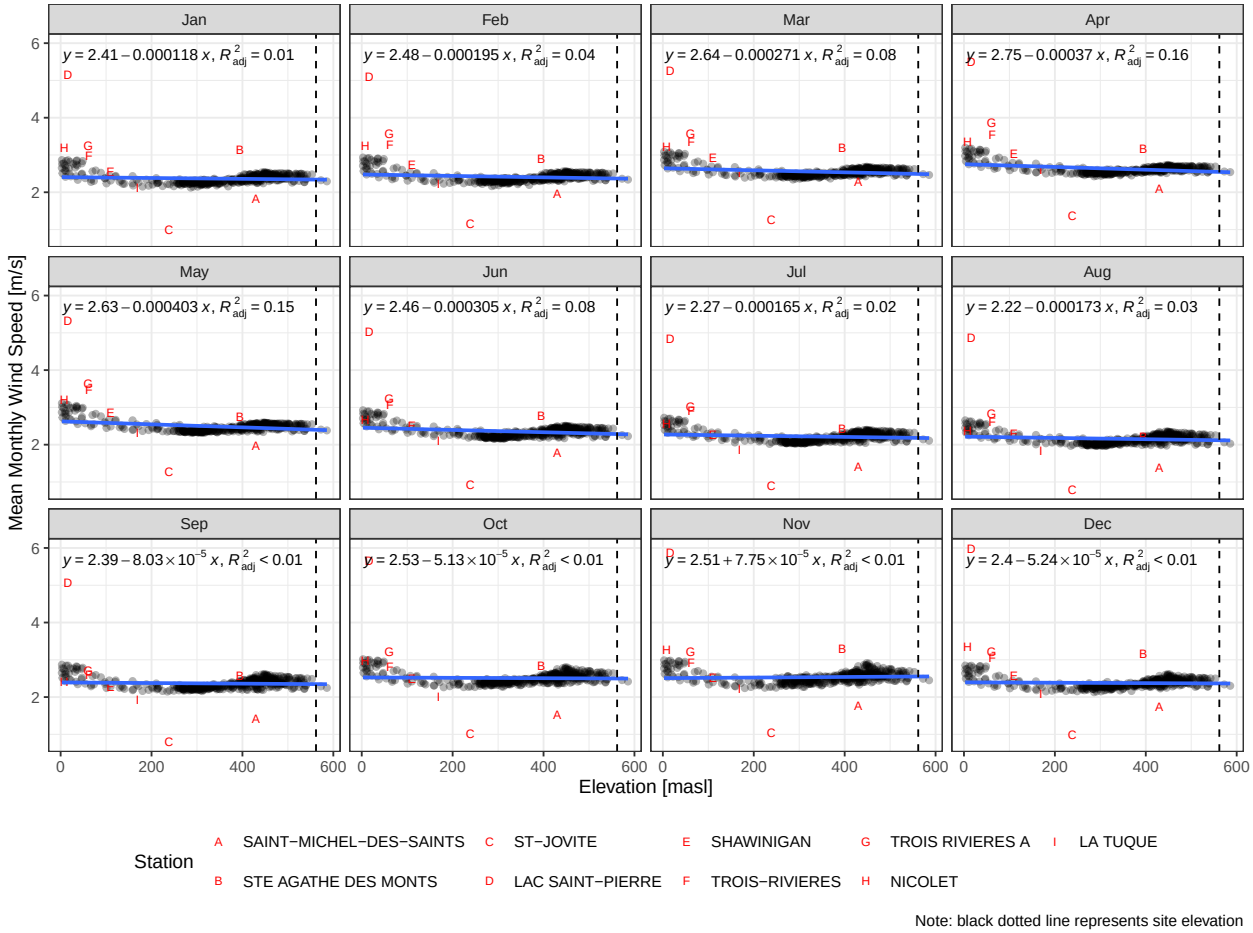
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



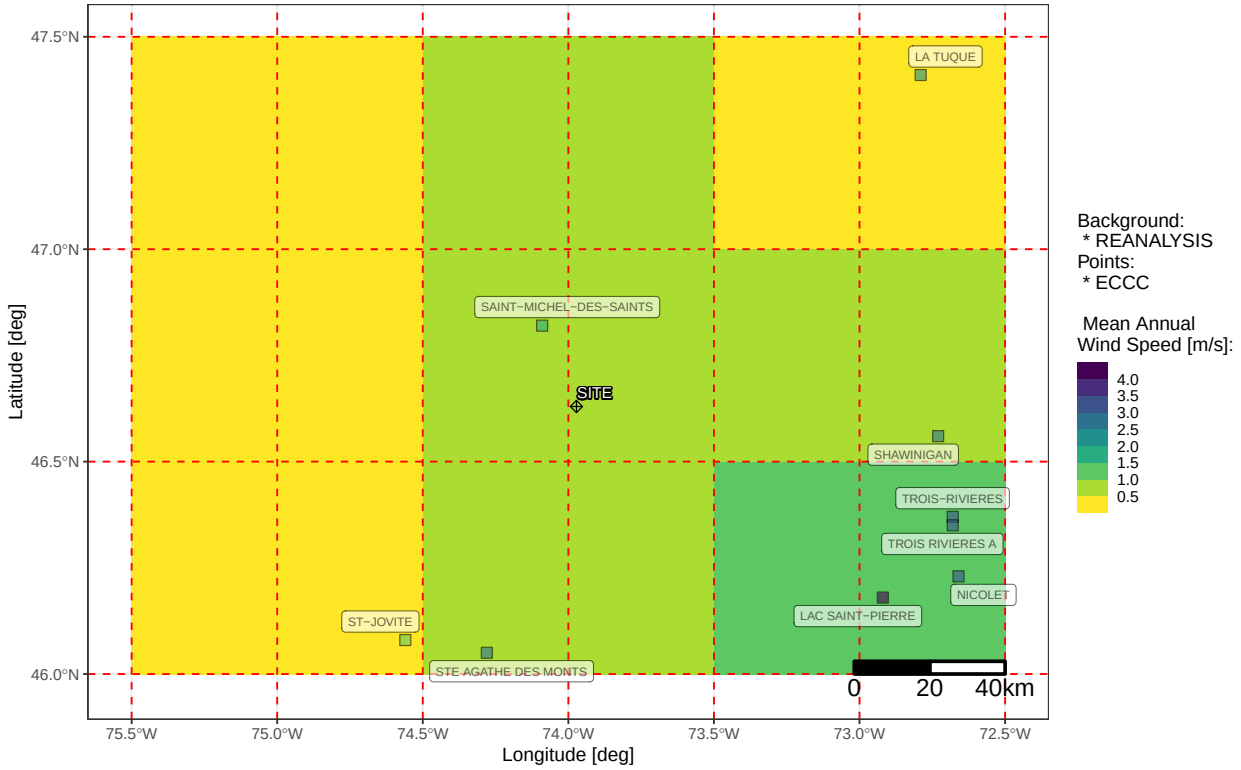
5.2.4 MERRA2 Regional Overview for Mean Wind Speed

MERRA2 (Modern-Era Retrospective analysis from Research and Applications, Version 2) is a global climate reanalysis model from the U.S. National Aeronautics and Space Administration (NASA) (Gelaro et al. 2017). MERRA2 offers daily data from 1981 to present (2024) on a grid of 0.5 degrees latitude by 0.5 degrees longitude covering the entire globe.

The main findings of the MERRA2 regional overview are listed below (the corresponding figures follow):

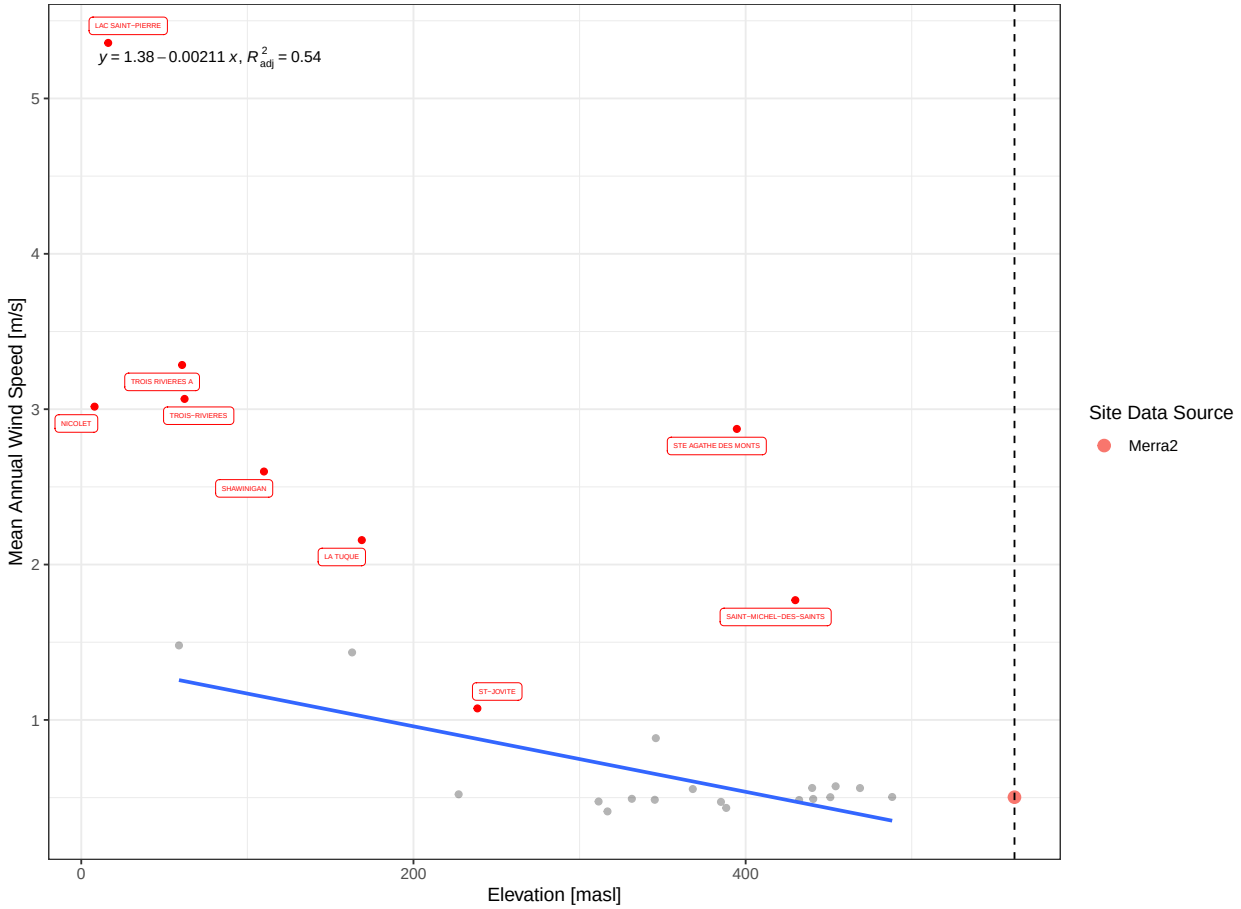
- MERRA2 MAWS is consistently lower than ECCC MAWS over the study region. Regional trends represented by the MERRA2 dataset fit ECCC data trends in the project region (Graph 1).
- The wind speed versus elevation gradients (Graphs 2 and 3) are decreasing within the MERRA2 dataset. This is somewhat consistent with ECCC data on a regional scale, but values are not consistent. MERRA2 is likely too large to produce an accurate representation of wind speed near the earth surface at the scale of this analysis.
- Little seasonal variability is apparent for wind speed within the MERRA2 dataset and this is consistent with ECCC data (Graph 3).

Graph 1: Mean Annual Wind Speed [m/s]:
(1980 – 2023)



Graph 2: Regional Elevation Gradient

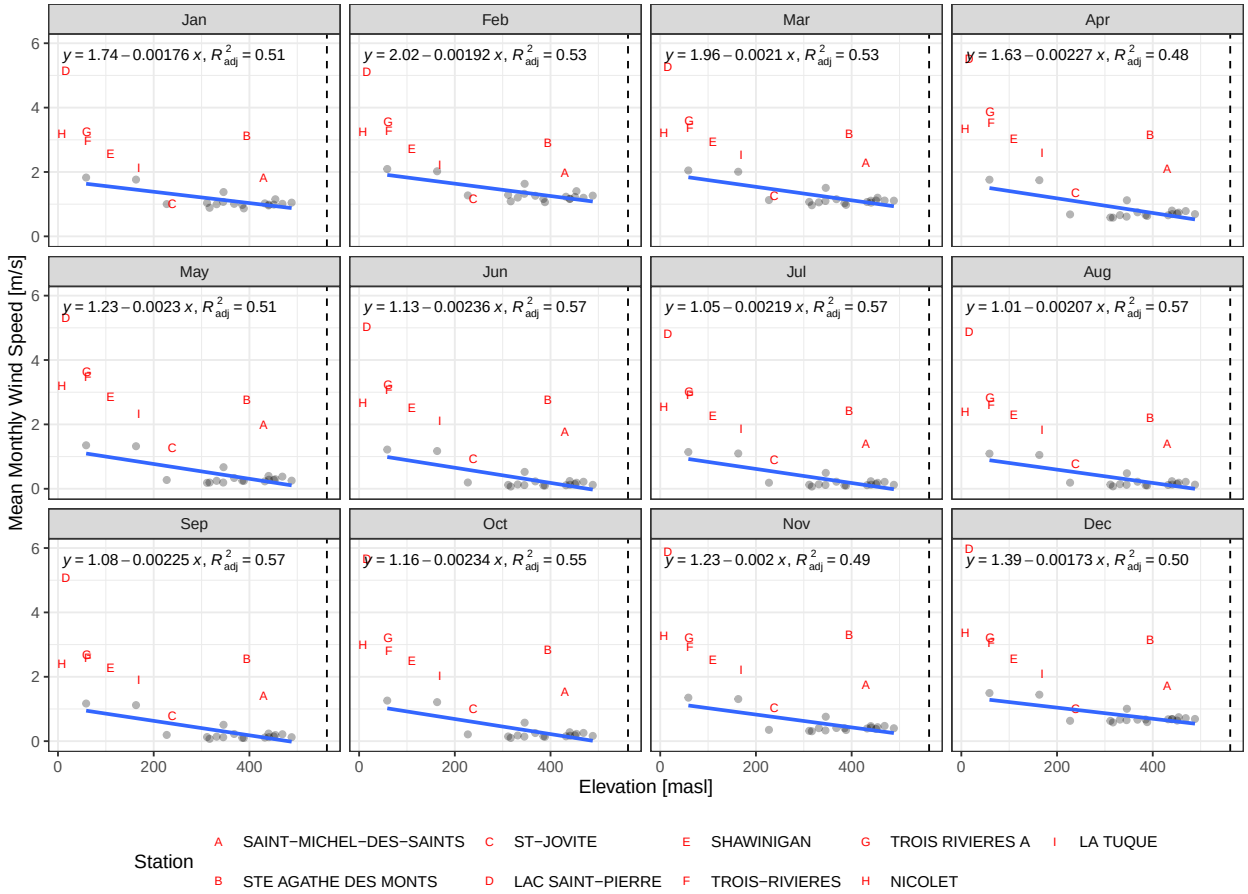
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Chapter 6

Local Analysis

The regional analysis shows that Reanalysis sources are not necessarily accurate locally for wind speed representation. Multiple geographic characteristics of station locations are crucial to wind behavior. The following analysis looks to further review reanalysis data and station data to further assess relevance of these datasets for the project area.

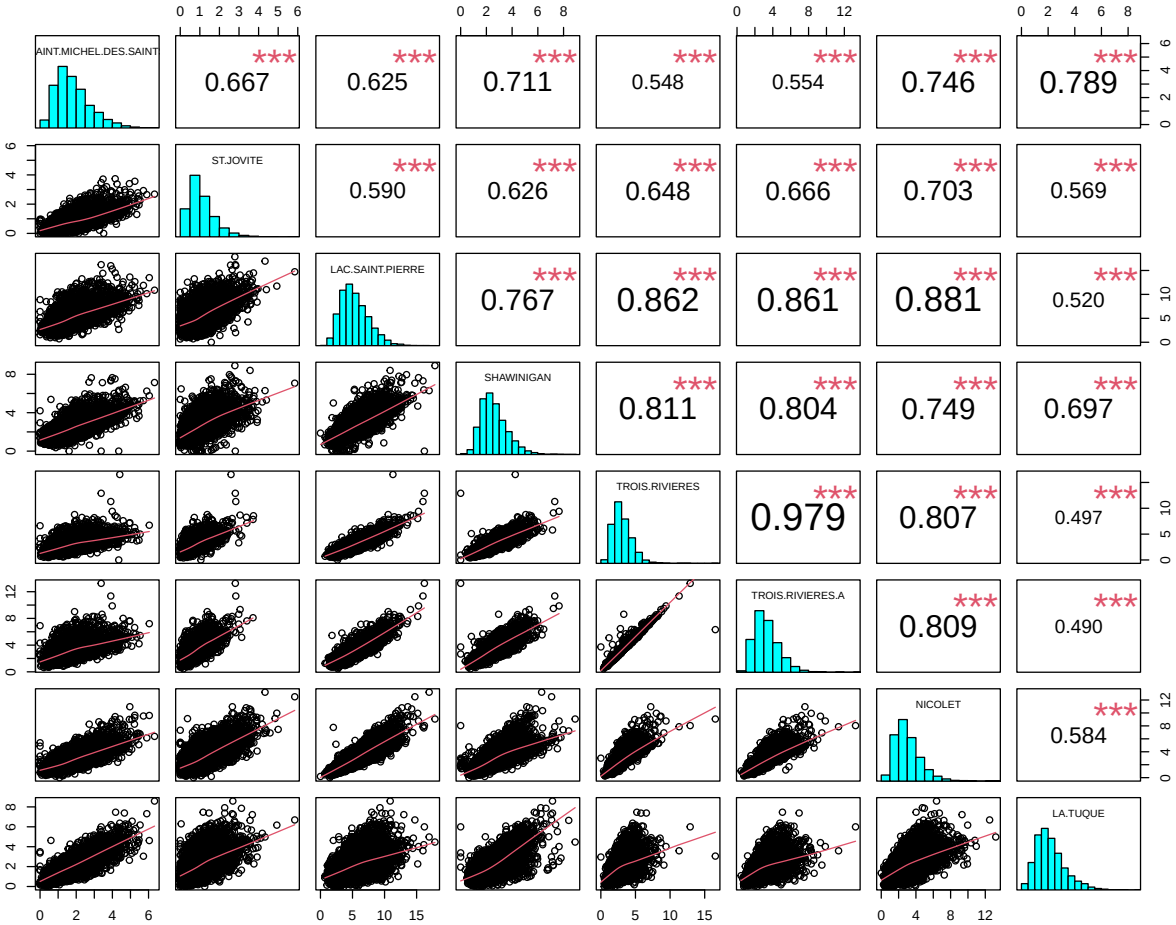
6.1 ECCC and NMG Stations data correlations

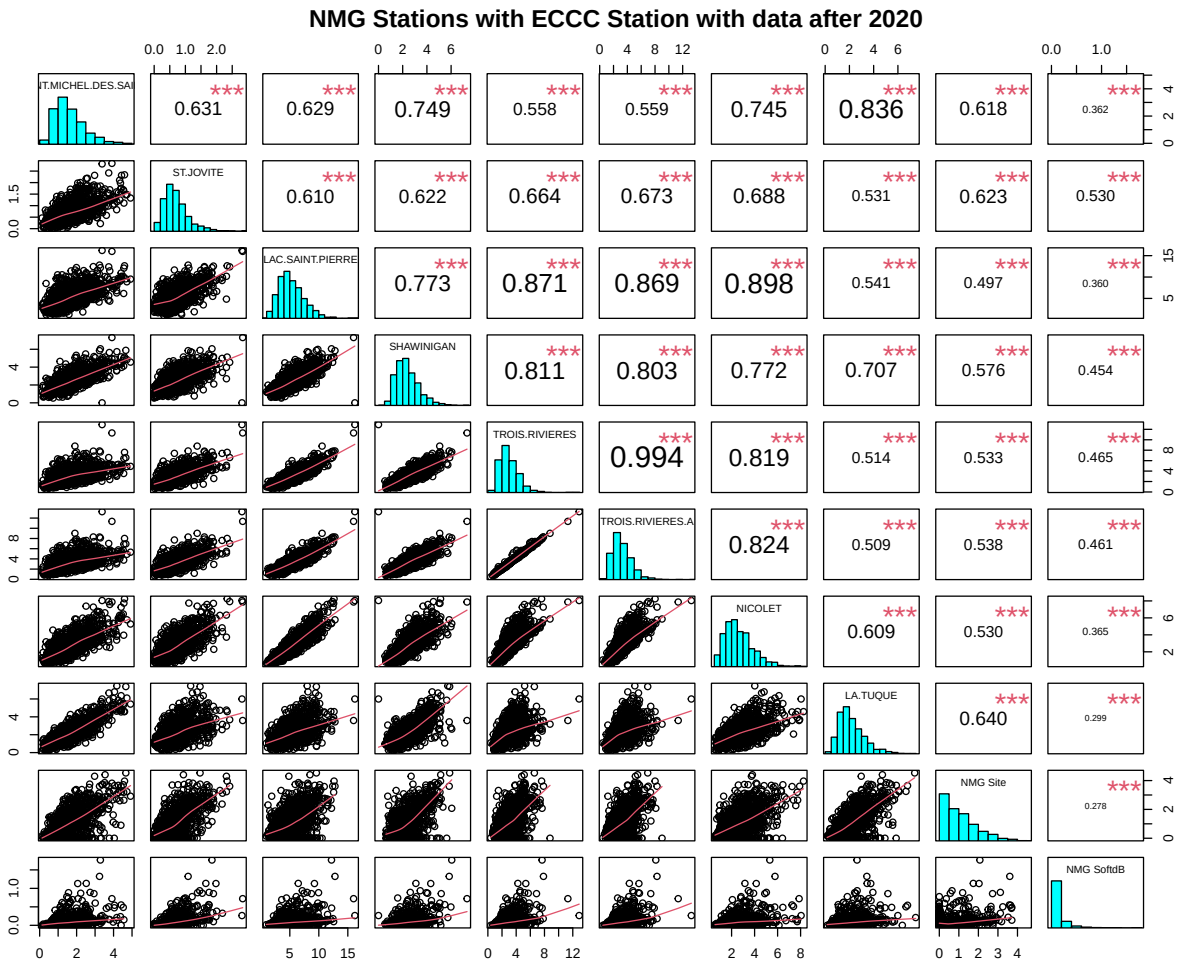
The following visualization is a correlation matrix between daily records from stations close to site. On the top right quadrant, the (absolute) value of the correlation is presented together with the result of the Pearson's product moment correlation coefficient as stars. On bottom-left quadrant the bivariate scatterplots, with a fitted line are presented. On the diagonal there is an histogram of each variable.

Sainte-Agate-des-Monts records were excluded because they don't overlap with any other station. Other daily wind speed records from ECCC have good correlation between each other.

NMG SoftdB station poor correlation with other stations and particularly with NMG Site station for wind speed suggest these records are not significant to this analysis. NMG Site and Saint-Michel-des-Saints station correlate best between each other and with La Tuque and Saint Jovite. These four records are selected for further analysis.

ECCC Stations with data between 1994 and 2024



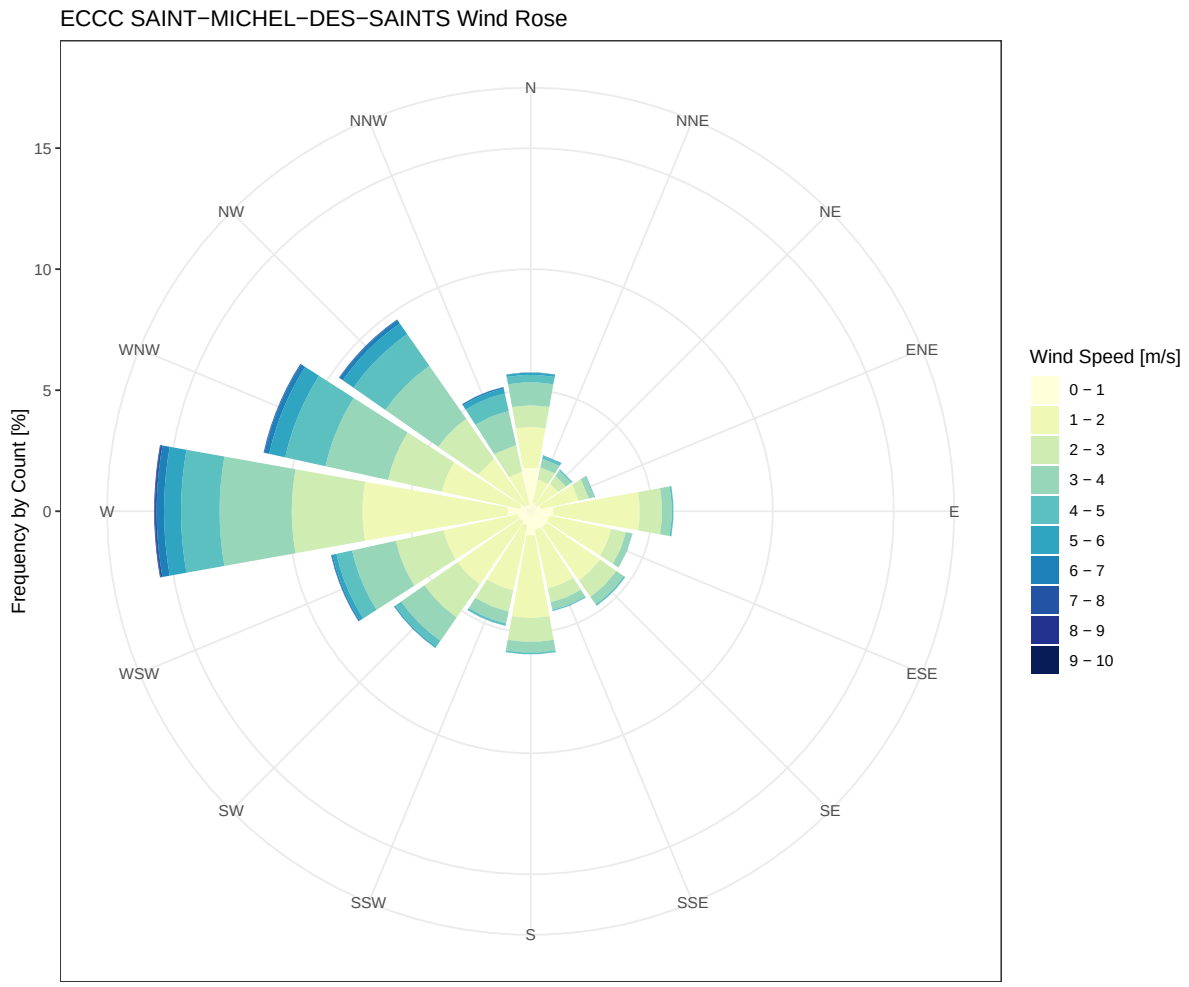


6.2 Reanalysis Evaluation Against Station Records

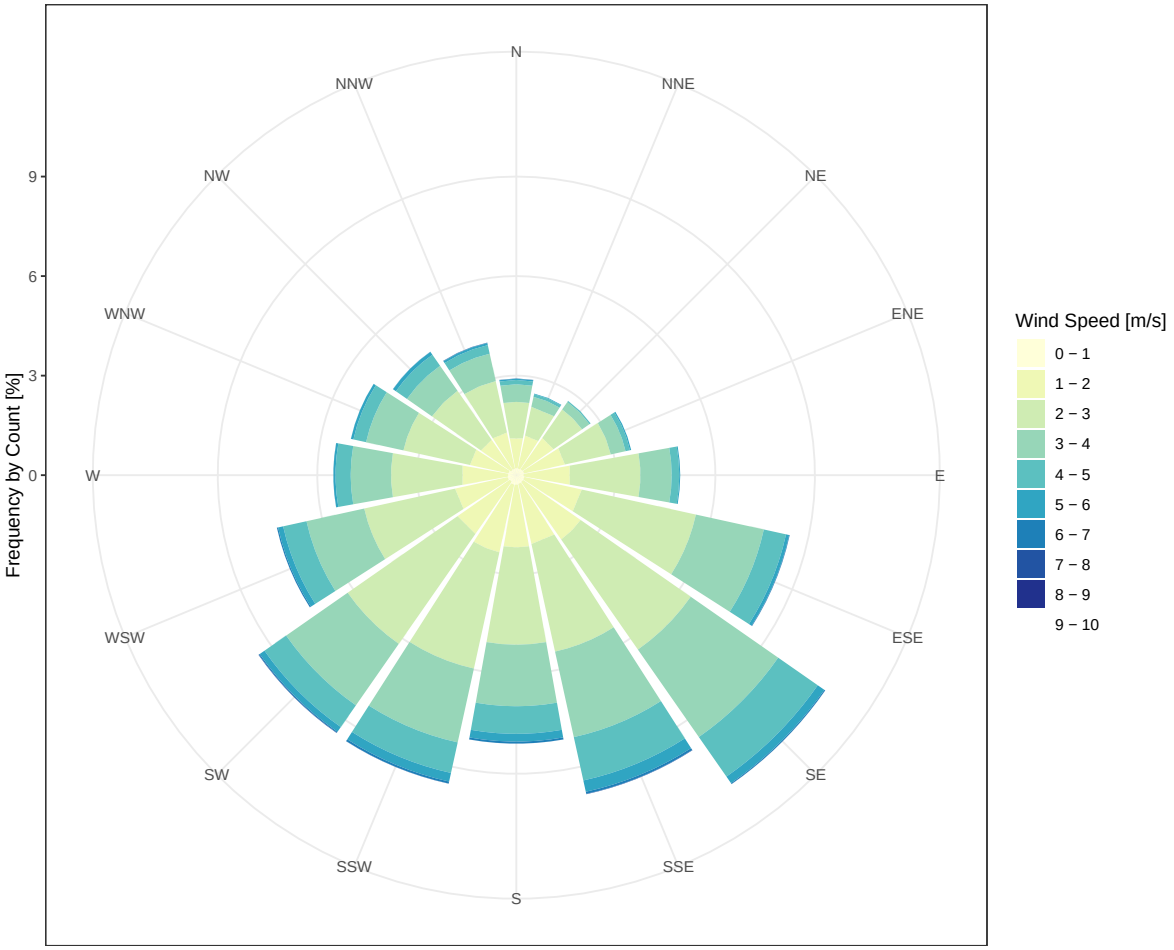
Daily wind speed records and wind roses were compared between ERA5-Land and the four selected stations: Saint-Michel-des-Saints, La Tuque, Saint Jovite and NMG Site. Findings of this section are listed below:

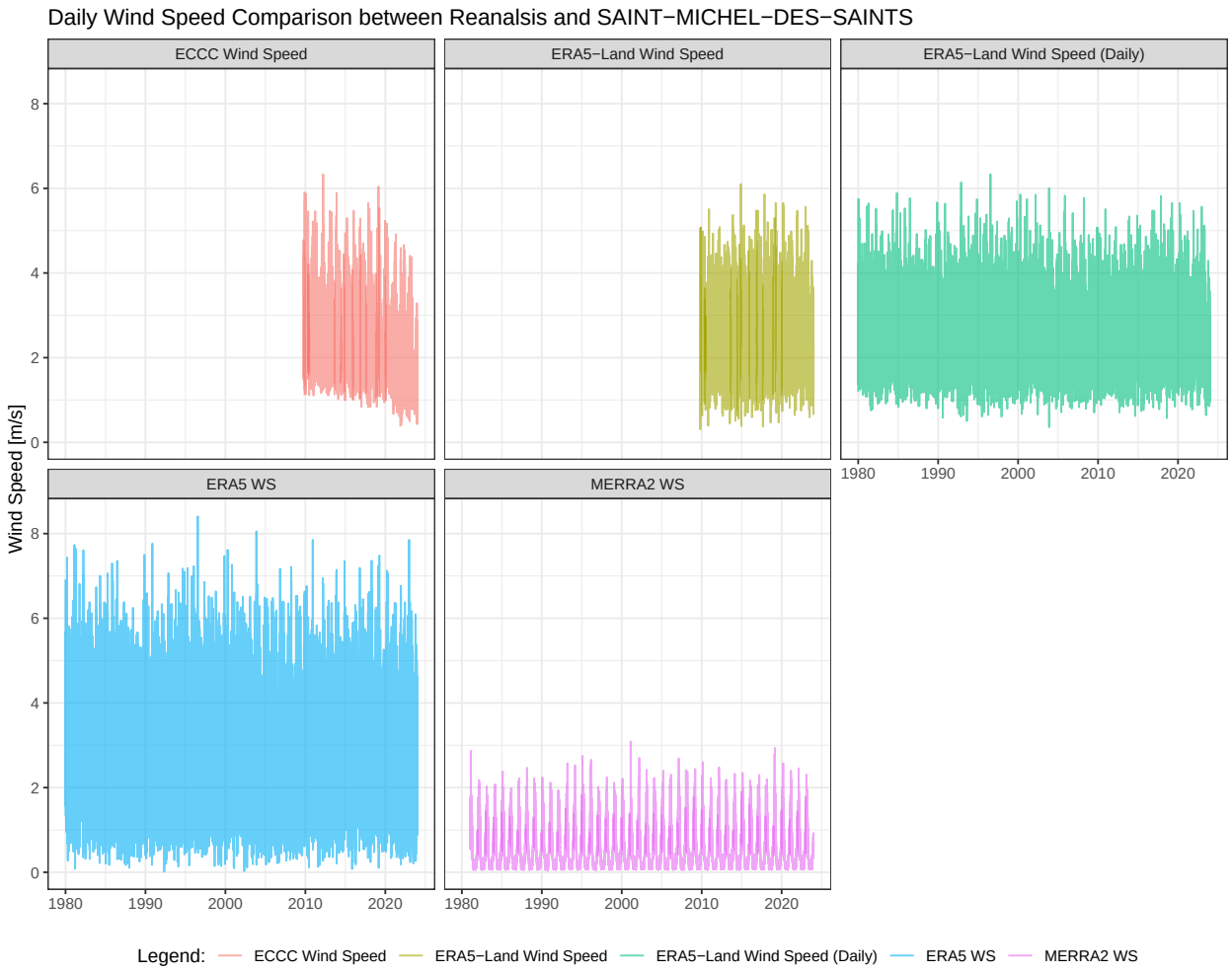
- Wind directions (wind roses) from ERA5-Land are generally different from overlapping records from all four stations. This is likely due to ERA5-Land grid size (~9km) still being too large to be an accurate representation of wind direction locally in mountainous regions. In spite of its short record, Site wind rose usage is still recommended as the wind direction reference.
- Aside from Saint Jovite, ERA5-Land daily average wind speeds are fairly correlated to station data (R^2 around 0.5).
- While correlated, wind speed value range between ERA5-Land and Station datasets differs. Further bias correction is recommended to generate a long term timeseries of wind speed for site.

6.2.1 SAINT-MICHEL-DES-SAINTS - ERA5-Land



ERA5−Land Wind Rose at SAINT−MICHEL−DES−SAINTS




Daily Wind Speed Comparison between Reanalsis and SAINT−MICHEL−DES−SAINTS
ECCC Wind Speed
ERA5−Land Wind Speed
ERA5−Land Wind Speed (Daily)
ERA5 WS
MERRA2 WS
Wind Speed [m/s]
0
2
4
6
8
1980
1990
2000
2010
2020
Legend:
ECCC Wind Speed
ERA5−Land Wind Speed
ERA5−Land Wind Speed (Daily)
ERA5 WS
MERRA2 WS

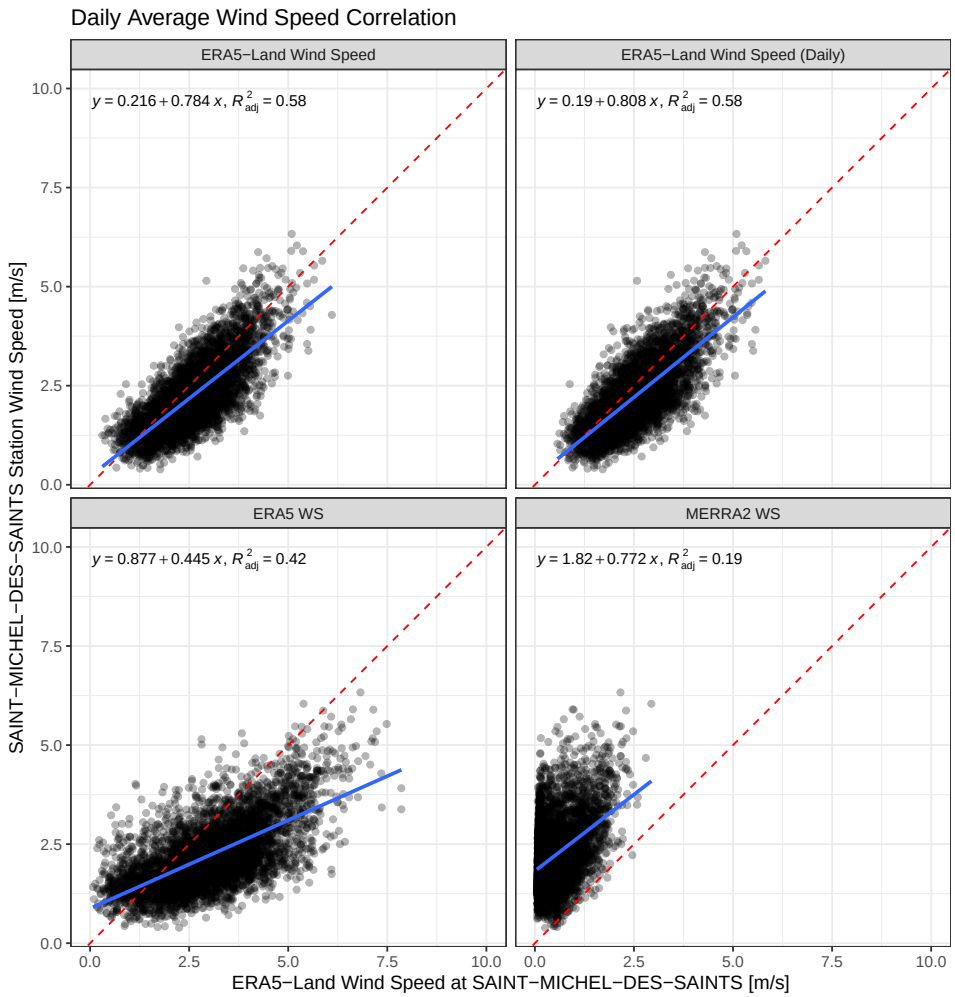
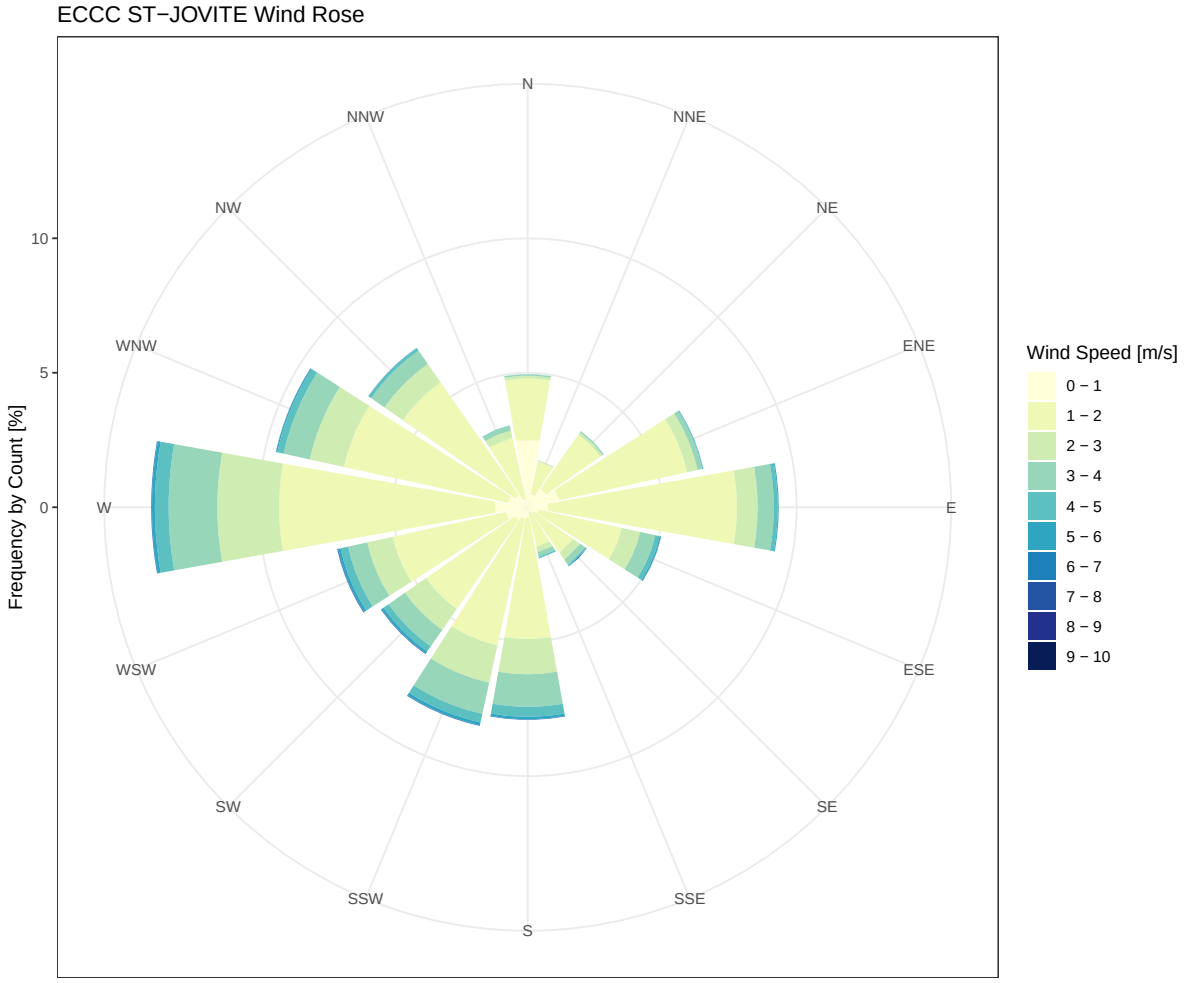
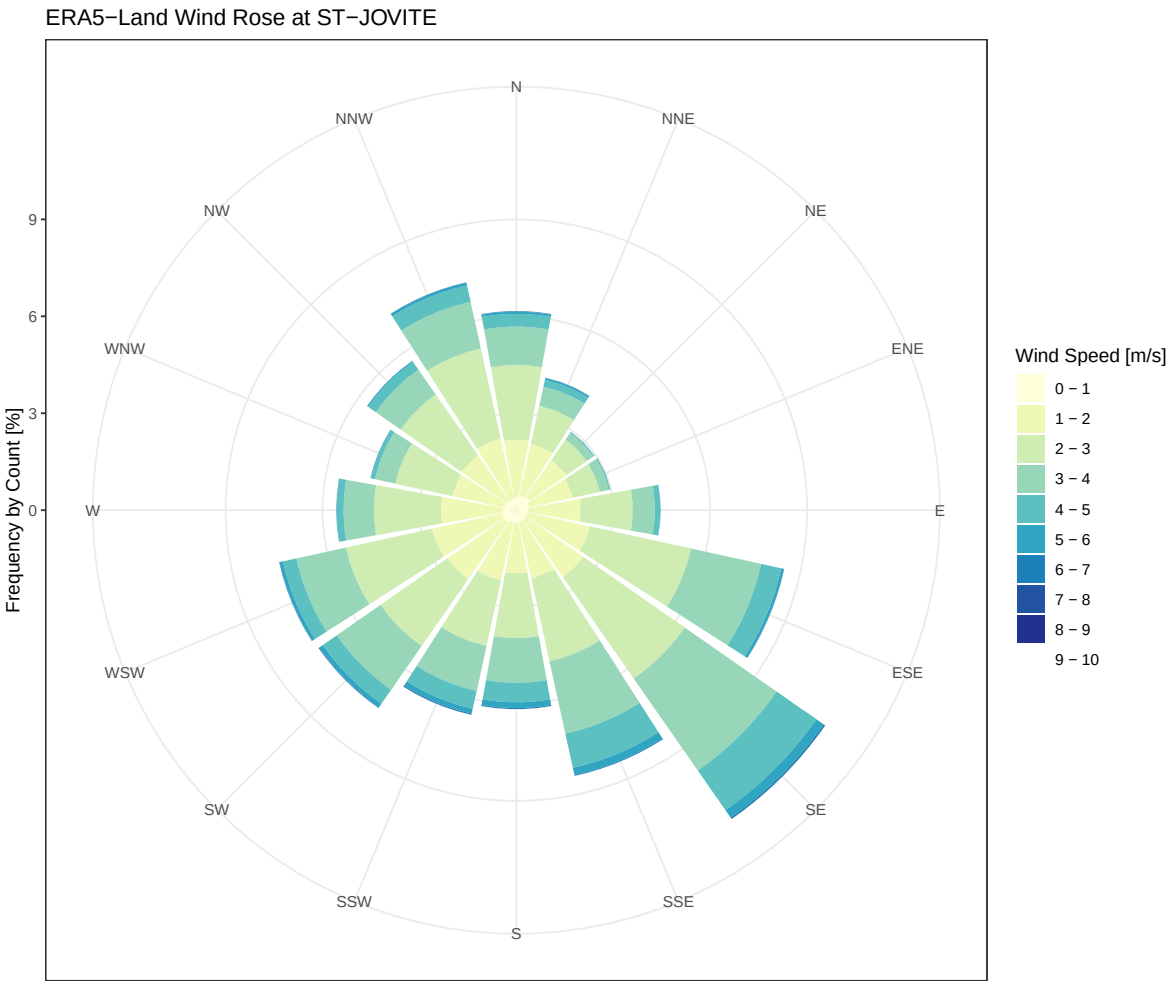


Table 6.1: Monthly Wind Speed [m/s] at SAINT-MICHEL-DES-SAINTS

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
ECCC Wind Speed	2.3	2.5	2.6	2.7	2.4	2.1	2	1.8	1.9	2.1	2.2	2.1	2.2
ERA5-Land Wind Speed	2.5	2.6	2.7	2.8	2.6	2.5	2.3	2.2	2.4	2.6	2.7	2.5	2.5
ERA5-Land Wind Speed (Daily)	2.5	2.5	2.6	2.7	2.5	2.4	2.3	2.2	2.5	2.6	2.6	2.5	2.5
ERA5 WS	3.1	3.1	3.2	3.2	2.9	2.8	2.7	2.6	2.9	3.2	3.2	3.1	3
MERRA2 WS	1	1.3	1.1	0.7	0.3	0.1	0.1	0.1	0.1	0.2	0.4	0.7	0.5

6.2.2 ST-JOVITE - ERA5-Land




ERA5−Land Wind Rose at ST−JOVITE
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
Frequency by Count [%]
0
3
6
9
Wind Speed [m/s]
0 – 1
1 – 2
2 – 3
3 – 4
4 – 5
5 – 6
6 – 7
7 – 8
8 – 9
9 – 10

Daily Wind Speed Comparison between Reanalsis and ST−JOVITE
ECCC Wind Speed
ERA5−Land Wind Speed
ERA5−Land Wind Speed (Daily)
ERA5 WS
MERRA2 WS
Wind Speed [m/s]
0
2
4
6
8
1980
1990
2000
2010
2020
Legend:
ECCC Wind Speed
ERA5−Land Wind Speed
ERA5−Land Wind Speed (Daily)
ERA5 WS
MERRA2 WS

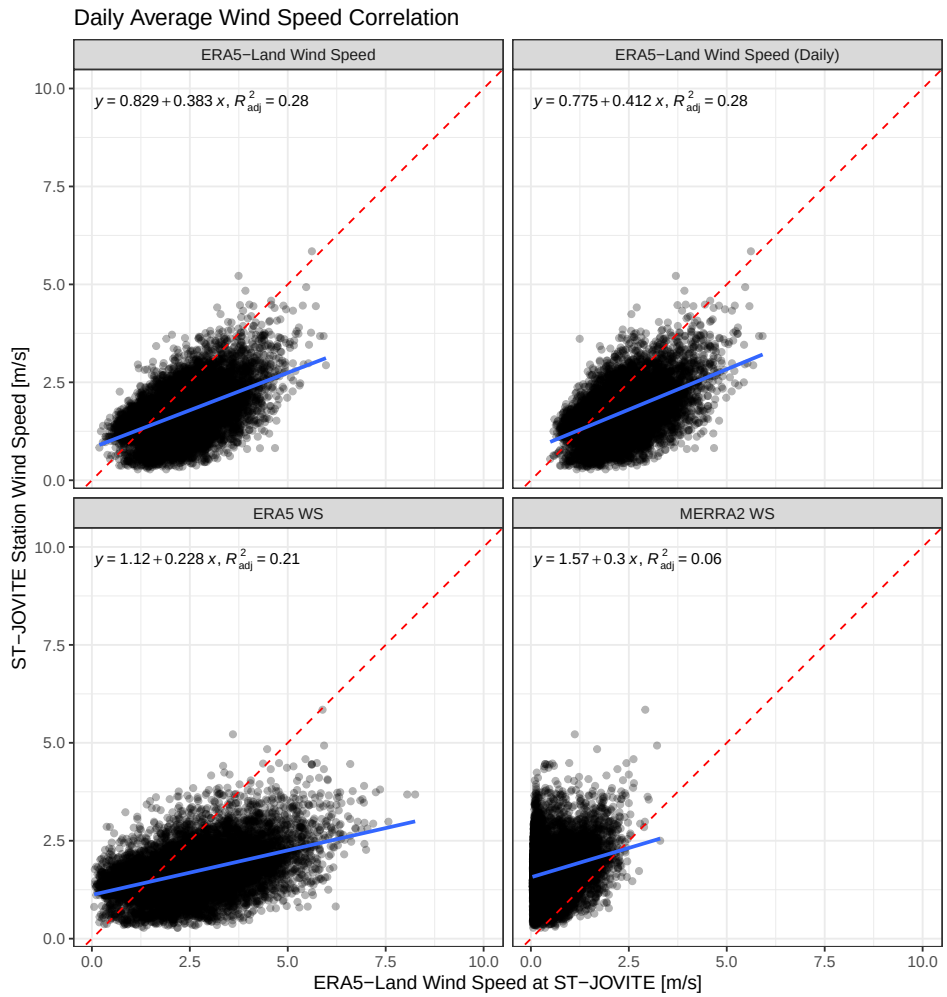
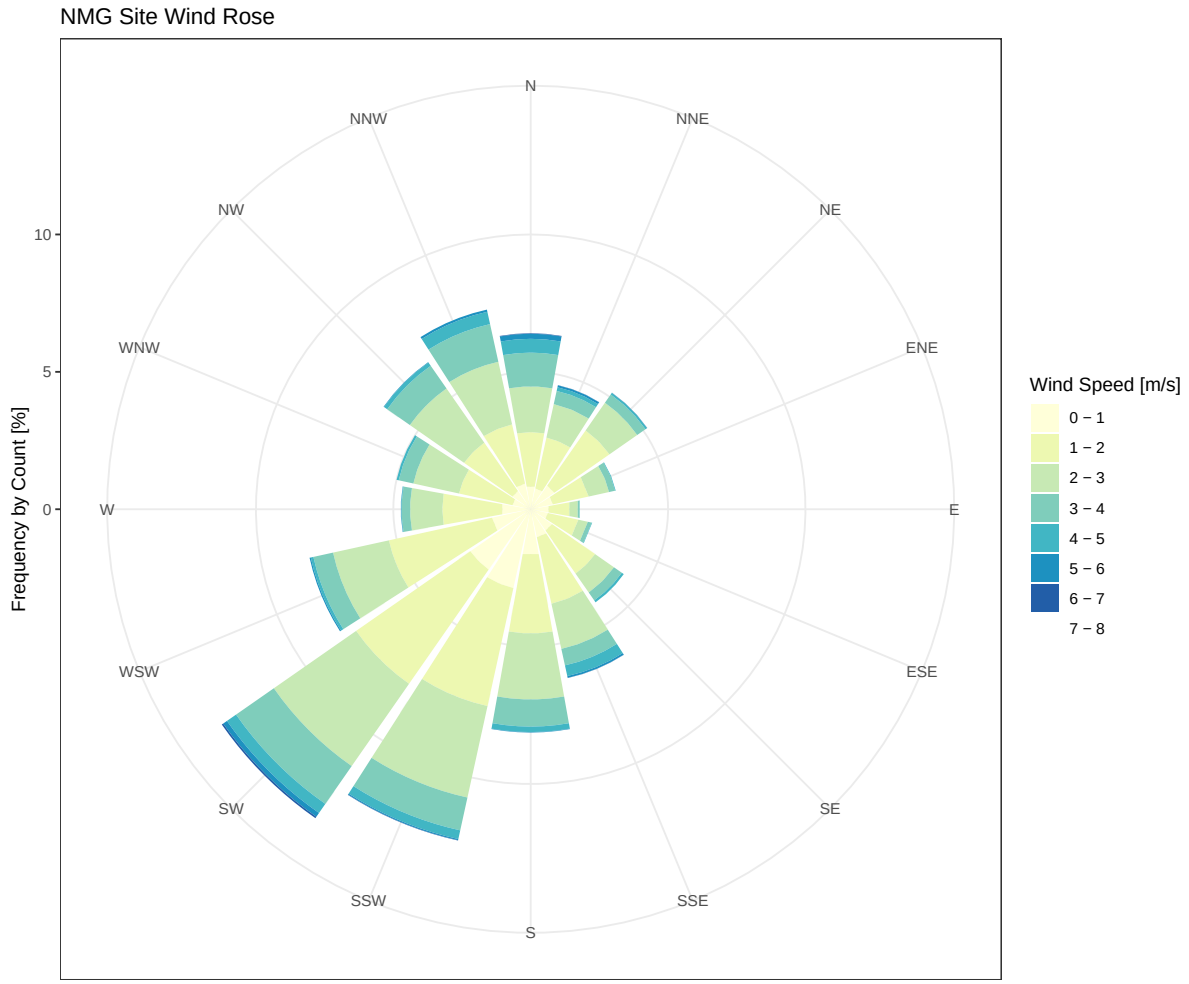
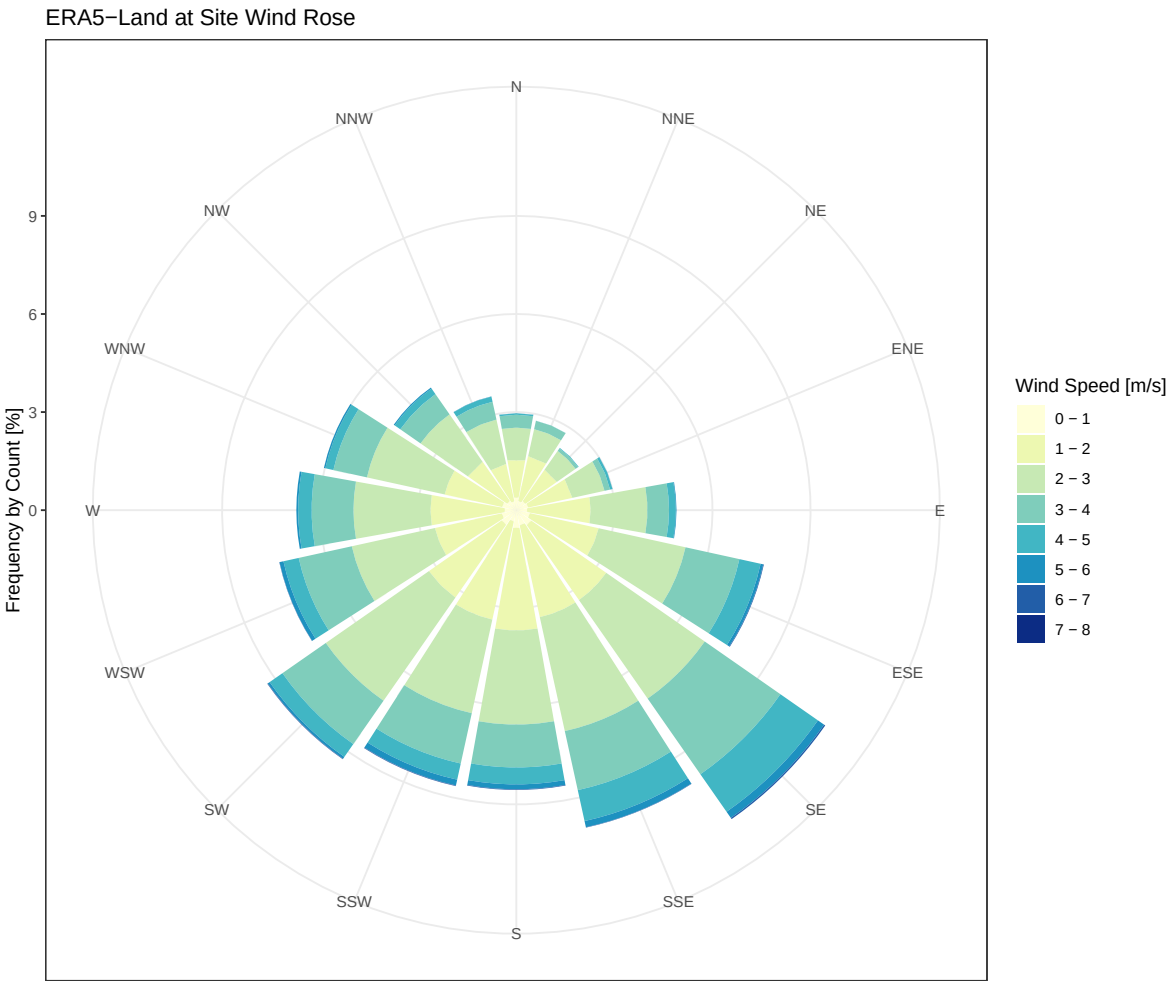


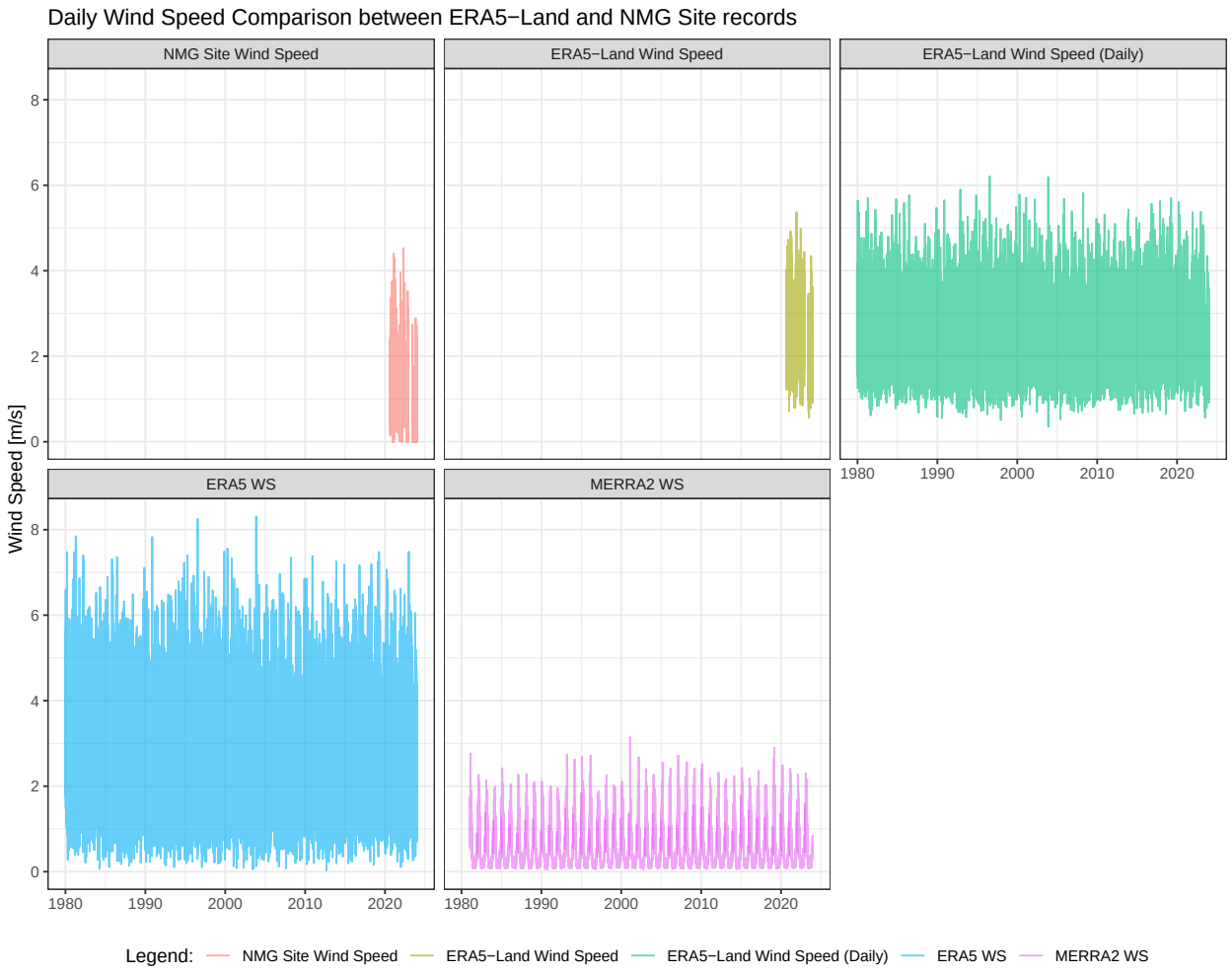
Table 6.2: Monthly Wind Speed [m/s] at ST-JOVITE

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
ECCC Wind Speed	1.7	1.8	1.9	1.9	1.8	1.7	1.6	1.6	1.6	1.7	1.7	1.6	1.7
ERA5-Land Wind Speed	2.3	2.4	2.5	2.6	2.4	2.2	2.1	2	2.2	2.4	2.4	2.3	2.3
ERA5-Land Wind Speed (Daily)	2.3	2.3	2.4	2.5	2.3	2.2	2	2	2.2	2.4	2.4	2.3	2.3
ERA5 WS	2.7	2.7	2.8	2.9	2.6	2.4	2.3	2.2	2.5	2.8	2.9	2.7	2.6
MERRA2 WS	1.1	1.3	1.1	0.6	0.2	0.1	0.1	0.1	0.1	0.1	0.3	0.7	0.5

6.2.3 NMG Site - ERA5-Land




ERA5−Land at Site Wind Rose
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
Frequency by Count [%]
0
3
6
9
Wind Speed [m/s]
0 – 1
1 – 2
2 – 3
3 – 4
4 – 5
5 – 6
6 – 7
7 – 8


Daily Wind Speed Comparison between ERA5−Land and NMG Site records
NMG Site Wind Speed
ERA5−Land Wind Speed
ERA5−Land Wind Speed (Daily)
ERA5 WS
MERRA2 WS
Wind Speed [m/s]
0
2
4
6
8
1980
1990
2000
2010
2020
Legend:
NMG Site Wind Speed
ERA5−Land Wind Speed
ERA5−Land Wind Speed (Daily)
ERA5 WS
MERRA2 WS

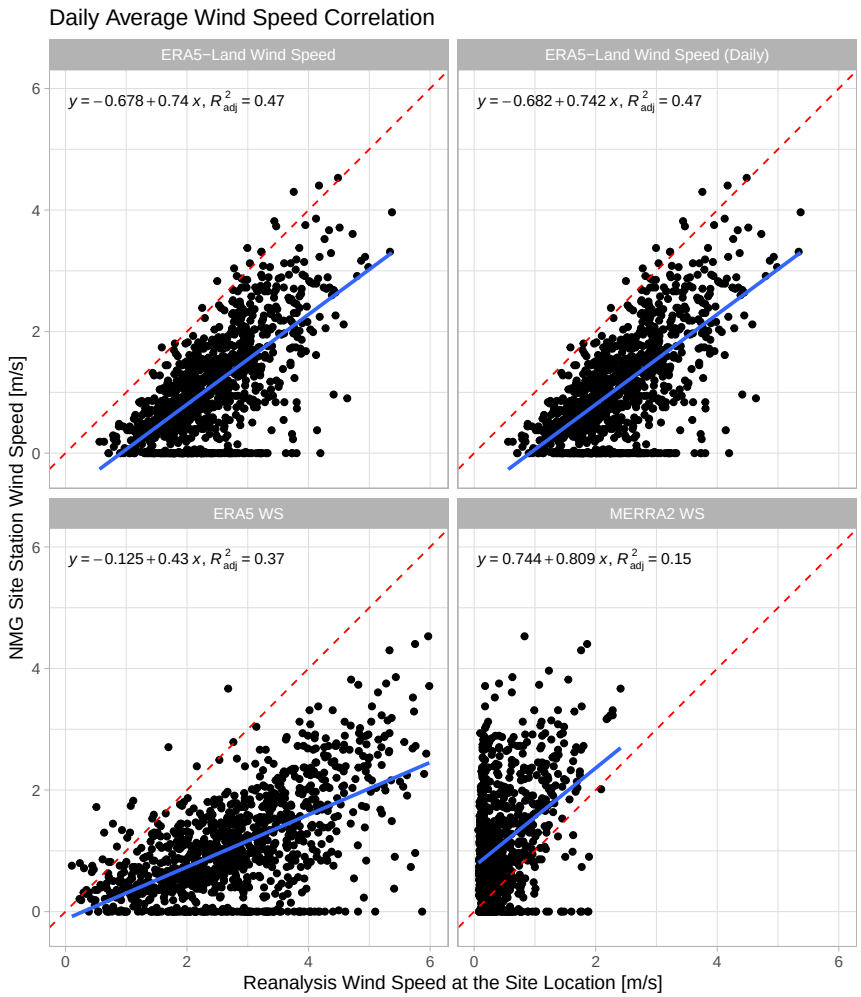


Table 6.3: Monthly Wind Speed [m/s] at NMG Site

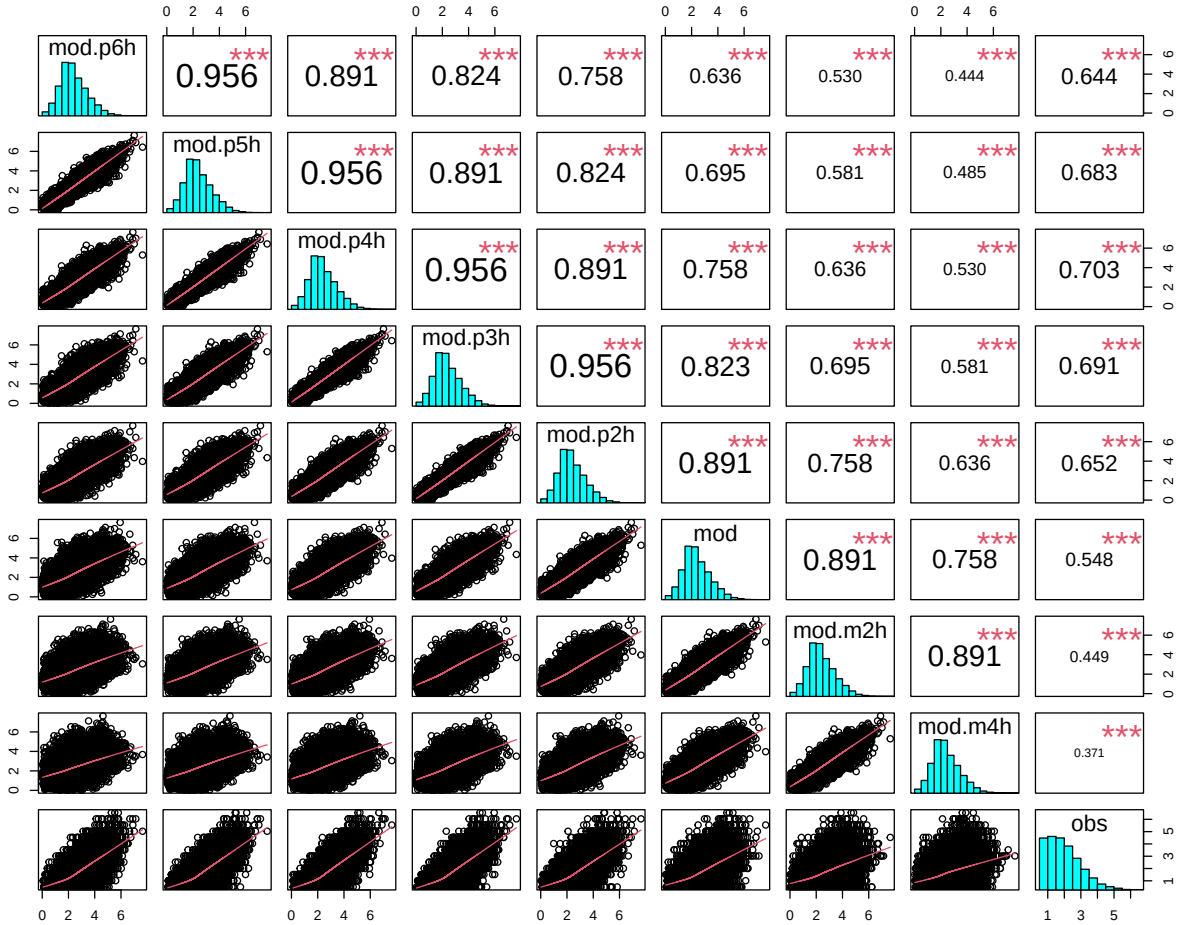
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
NMG Site Wind Speed	1.3	1.3	1.8	1.6	1.4	1	1	0.8	0.8	0.8	1.3	0.9	1.2
ERA5-Land Wind Speed	2.2	2.5	2.9	2.6	2.4	2.3	2.2	2.1	2.3	2.4	2.6	2.4	2.4
ERA5-Land Wind Speed (Daily)	2.5	2.5	2.6	2.7	2.5	2.4	2.3	2.2	2.4	2.6	2.6	2.5	2.5
ERA5 WS	3	3	3.1	3.1	2.9	2.8	2.7	2.6	2.8	3.1	3.1	3	2.9
MERRA2 WS	1	1.2	1.1	0.7	0.3	0.1	0.1	0.1	0.1	0.2	0.4	0.6	0.5

Chapter 7

Site Wind Speed Selection and Results

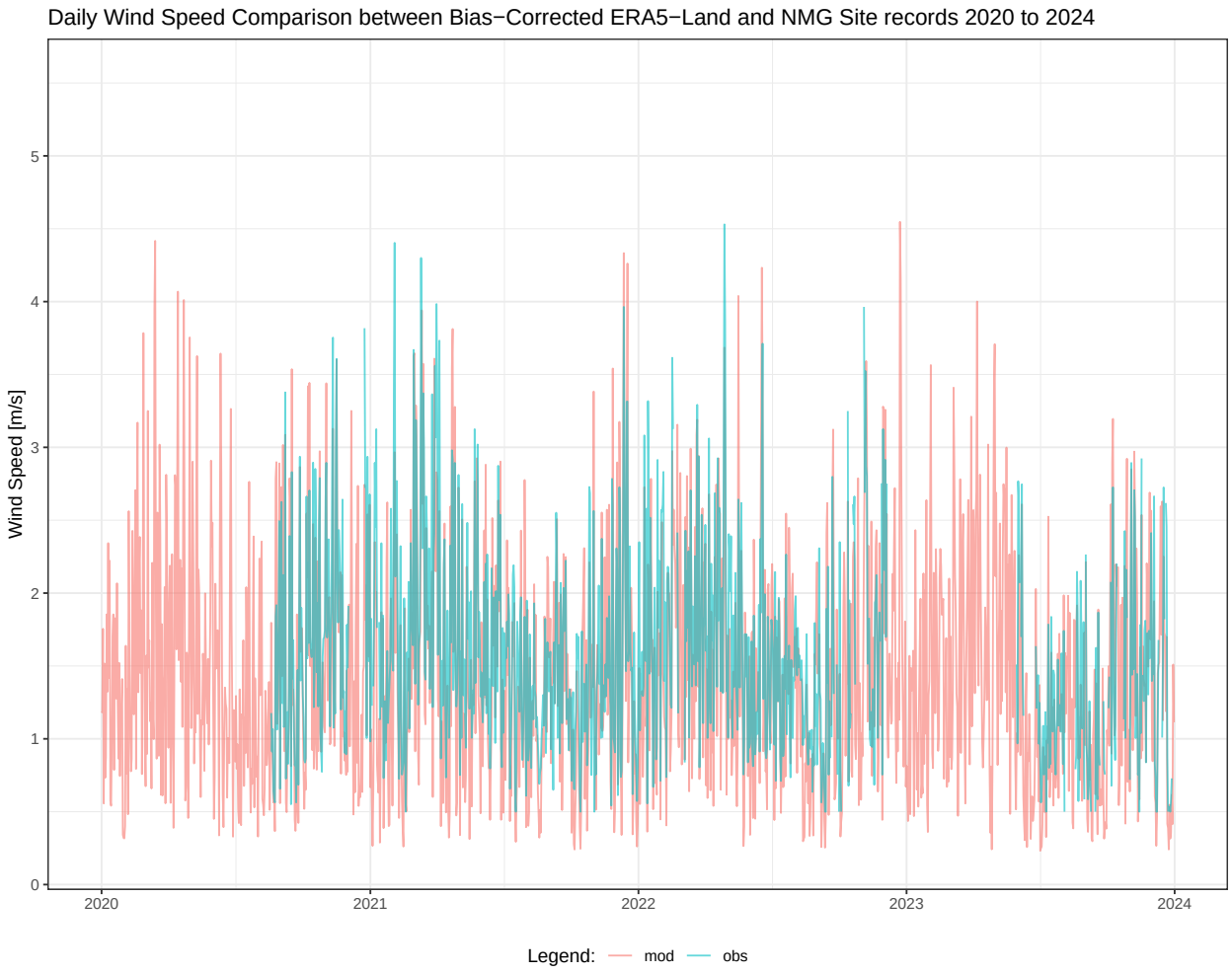
Wind speed for Site was then generated by bias correcting ERA5-Land records to Site timeseries by using the Quantile Delta Mapping (QDM) method. QDM bias correction is an algorithm commonly used to correct systematic distributional biases in outputs from climate models. The purpose is that the distributional properties would more closely match those of historical observations. Note that null values can skew bias correction procedures, so they were removed from the Site records.

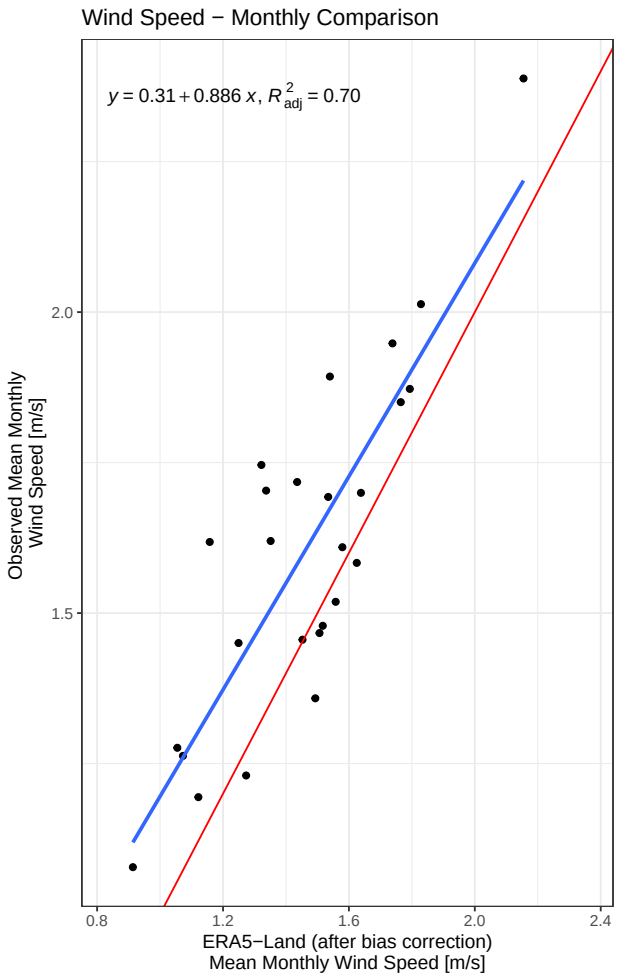
ERA5-Land record was delayed by 4 hours with respect to observed to improve performance, as described in the following correlation matrix.



The following plots showcase the resulting project wind speed timeseries as well as its daily and monthly correlation plots compared to observed data. The sustained wind speed normals for the 1994-2023 and 1985-2014 Periods are also presented in the following tables.

Daily Wind Speed Comparison between Bias−Corrected ERA5−Land and NMG Site records
Wind Speed [m/s]
0
1
2
3
4
5
1980
1990
2000
2010
2020
Legend:
mod
obs


Daily Wind Speed Comparison between Bias−Corrected ERA5−Land and NMG Site records 2020 to 2024
Wind Speed [m/s]
0
1
2
3
4
5
2020
2021
2022
2023
2024
Legend:
mod
obs



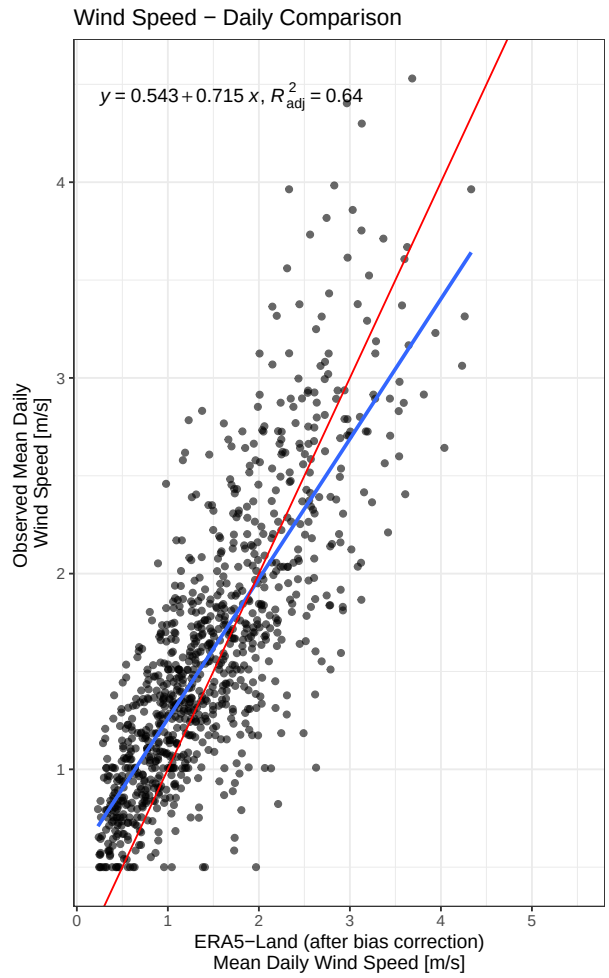


Table 7.1: Wind Speed Normals (1994-2023) for the Project [m/s]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1.5	1.6	1.7	1.7	1.6	1.4	1.3	1.2	1.4	1.6	1.6	1.5	1.5

Table 7.2: Wind Speed Normals (1985-2014) for the Project [m/s]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1.5	1.5	1.6	1.7	1.6	1.4	1.3	1.2	1.5	1.6	1.6	1.5	1.5

Chapter 8

Frequency Analysis

Frequency analysis is a process used to estimate the frequency of occurrence of a value based on a long-term time series. The desired frequency is typically in months or years and the periods are called return periods. The historical information is adjusted into a probabilistic distribution, and the most suitable distribution is selected.

The following distributions were included in the frequency analysis: Normal, Log-Normal, Generalized Extreme Value (GEV), Gumbel, Pearson III, and Log-Pearson III. The L-moments methodology was applied for selection of the distribution parameters.

The L-moments approach provides a more resistant estimation to outliers when compared with typical moment estimations. The selection of the best-fit distribution was prepared based on three criteria: Akaike Information Criterion, Anderson-Darling Criterion, and Bayesian Information Criterion, as described by (Laio, Di Baldassarre, and Montanari 2009).

The results of the frequency analysis for extended hourly records is recommended for design considerations. The Gumbel distribution was selected for hourly extended records. Results from the frequency analysis of daily records and site data are also presented for reference.

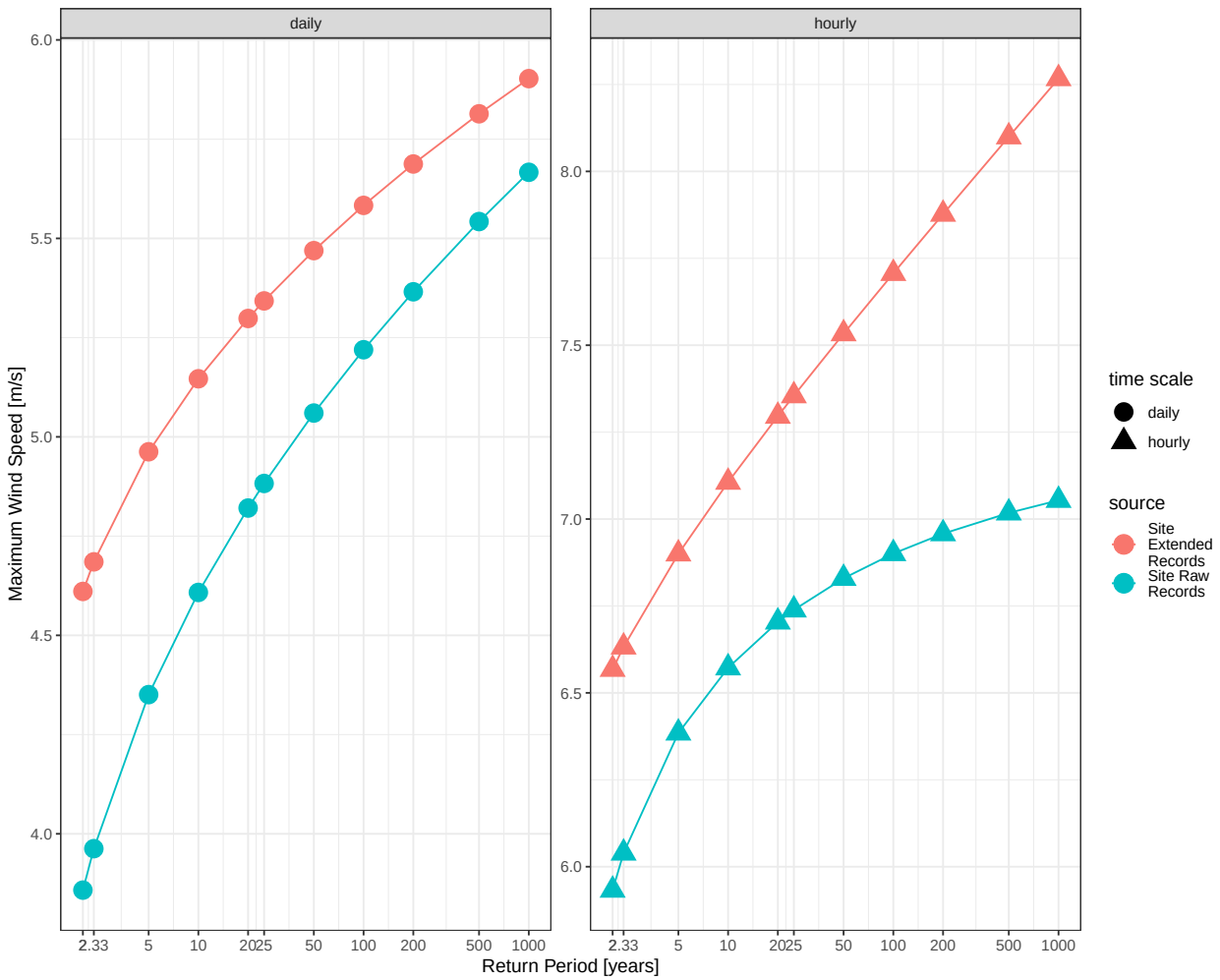


Table 8.1: Wind Speed Frequency Analysis of Site Records Extended with ERA5-Land [m/s]

Return Period	Prob	Site Extended Records - hourly	Site Extended Records - daily	Site Raw Records - hourly	Site Raw Records - daily
2	0.5	6.568	4.611	5.933	3.858
2.33	0.5708	6.632	4.685	6.039	3.963
5	0.8	6.9	4.962	6.385	4.351
10	0.9	7.106	5.146	6.572	4.608
20	0.95	7.296	5.298	6.704	4.821
25	0.96	7.355	5.342	6.739	4.883
50	0.98	7.533	5.469	6.829	5.06
100	0.99	7.707	5.583	6.901	5.219
200	0.995	7.877	5.687	6.958	5.365
500	0.998	8.099	5.814	7.018	5.542
1000	0.999	8.267	5.902	7.054	5.667

Chapter 9

Output

Output of this code has been backed up and saved as an rds file in the **/01_Data/rds** project folder.

References

Gelaro, Ronald, Will McCarty, Max J. Suárez, Ricardo Todling, Andrea Molod, Lawrence Takacs, Cynthia A. Randles, et al. 2017. "The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2)." *Journal of Climate* 30 (14): 5419–54. https://doi.org/10.1175/jcli-d-16-0758.1.

Hersbach, Hans, Bill Bell, Paul Berrisford, Shoji Hirahara, András Horányi, Joaquín Muñoz-Sabater, Julien Nicolas, et al. 2020. "The ERA5 Global Reanalysis." *Quarterly Journal of the Royal Meteorological Society* 146 (730): 1999–2049. https://doi.org/10.1002/qj.3803.

Laio, Francesco, Giuliano Di Baldassarre, and Alberto Montanari. 2009. "Model Selection Techniques for the Frequency Analysis of Hydrological Extremes." *Water Resources Research* 45 (7). https://doi.org/10.1029/2007wr006666.

Muñoz-Sabater, Joaquín, Emanuel Dutra, Anna Agustí-Panareda, Clément Albergel, Gabriele Arduini, Gianpaolo Balsamo, Souhail Boussetta, et al. 2021. "ERA5-Land: A State-of-the-Art Global Reanalysis Dataset for Land Applications." *Earth System Science Data* 13 (9): 4349–83. https://doi.org/10.5194/essd-13-4349-2021.

Thornton, M. M., R. Shrestha, Y. Wei, P. E. Thornton, and S-C. Kao. 2022. "Daymet: Daily Surface Weather Data on a 1-Km Grid for North America, Version 4 R1," November. https://doi.org/10.3334/ORNLDAAC/2129.

Appendix C Precipitation Detailed Analysis

3. NMG - Matawinie Precipitation Analysis

CAPR003306

Camilo Gallard

February 12, 2025

Abstract

This report compiles the precipitation anlaysis that was carried out by SRK Consulting (Canada) Inc. for the Nouveau Monde Graphite Matawinie Site in 2024 to support Engineering Design. The data compilation and subsequent analysis was conducted in the R Software environment.

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Chapter 1

Glossary

- **AMS**: Annual Maximum Series.
- **Daymet**: Reanalysis tool developed by the Oak Ridge National Laboratory and supported by NASA (Thornton et al. 2022).
- **ECCC**: Environment and Climate Change Canada.
- **ERA5**: Reanalysis tool developed by the European Centre for Medium-Range Weather Forecasts (Hersbach et al. 2020).
- **ERA5-Land**: Reanalysis tool based on ERA5 but for Land surfaces and a smaller grid, and developed by the European Centre for Medium-Range Weather Forecasts (Muñoz-Sabater et al. 2021).
- **ET**: Evapotranspiration
- **ET0**: Reference Evapotranspiration
- **IDF**: Intensity-Duration-Frequency (IDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
- **KST**: Kolmogorov–Smirnov Test.
- **MAAT**: Mean Annual Air Temperature.
- **MAP**: Mean Annual Precipitation.
- **MERRA2**: Modern-Era Retrospective analysis from Research and Applications, Version 2, is a global climate reanalysis model from the U.S. National Aeronautics and Space Administration (Gelaro et al. 2017).
- **NMG**: Nouveau Monde Graphite.
- **PCC**: Pearson Correlation Coefficient.
- **PDF**: Precipitation-Duration-Frequency (PDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
- **PMP**: Probable Maximum Precipitation.
- **RH**: Relative Humidity.

- **SRAD**: Shortwave (solar) radiation. Incident shortwave radiation flux density in watts per square meter.
- **SRK**: SRK Consulting (Canada) Inc.
- **SSR**: Surface net shortwave (solar) radiation. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth (both direct and diffuse) minus the amount reflected by the Earth's surface (which is governed by the albedo).
- **SSRD**: Surface short-wave (solar) radiation downwards. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth. This parameter comprises both direct and diffuse solar radiation.
- **Tavg**: Mean or Average Air Temperature over a given temporal unit (day, month, year…).
- **Tdew**: Mean or Average Dew Point Temperature over a given temporal unit (day, month, year…).
- **Tmax**: Maximum Air Temperature over a given temporal unit (day, month, year…).
- **Tmin**: Minimum Air Temperature over a given temporal unit (day, month, year…).

Chapter 2

General Parameters

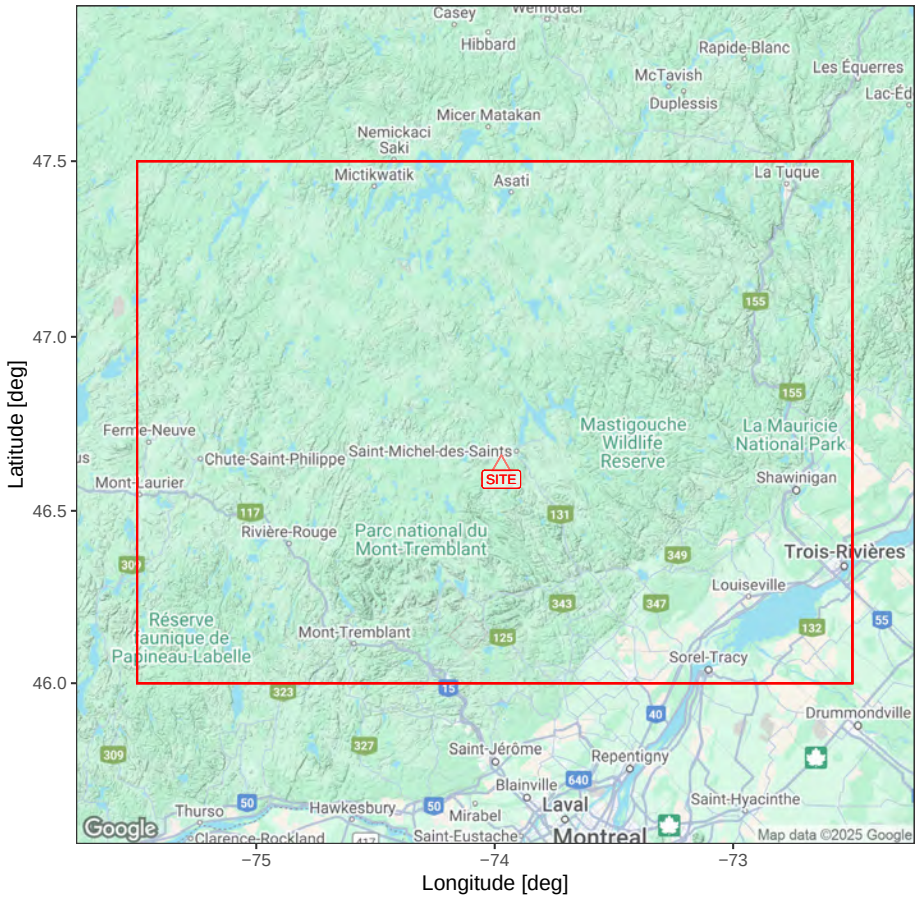
The NMG Matawinie site is located in southern Quebec, 125 km north of Montreal. Site latitude is 46.63 degrees, and longitude is -73.97 degrees, at an elevation of 562 masl. These coordinates were selected to match the location of the meteorological station on site.

For the purpose of this meteorological analysis, an area of interest was defined around site to capture regional data and climate trends, and was defined as the region between:

- 46° and 47.5° Latitude
- -75.5° and -72.5° Longitude

Site Location and Area of Interest for this Study

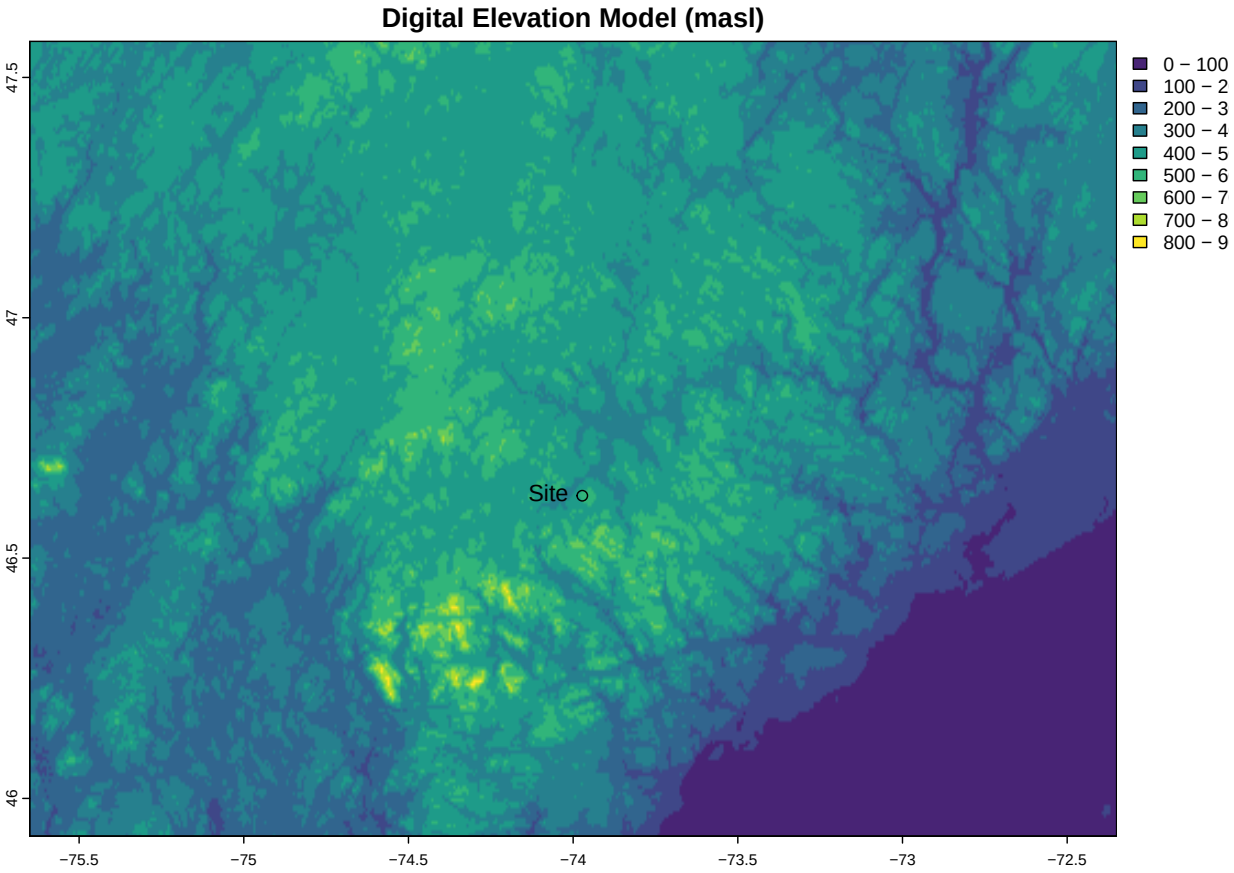
Area of interest covers a distance of up to 125km from Site



Chapter 3

Digital Elevation Model

Digital elevation model from the region was downloaded from the Shuttle Radar Topography Mission (SRTM) dataset. The SRTM database contains global elevation data with 3 arc-second (90 m) spatial resolution, which is deemed sufficient for climate analysis.



Chapter 4

NMG Precipitation Data

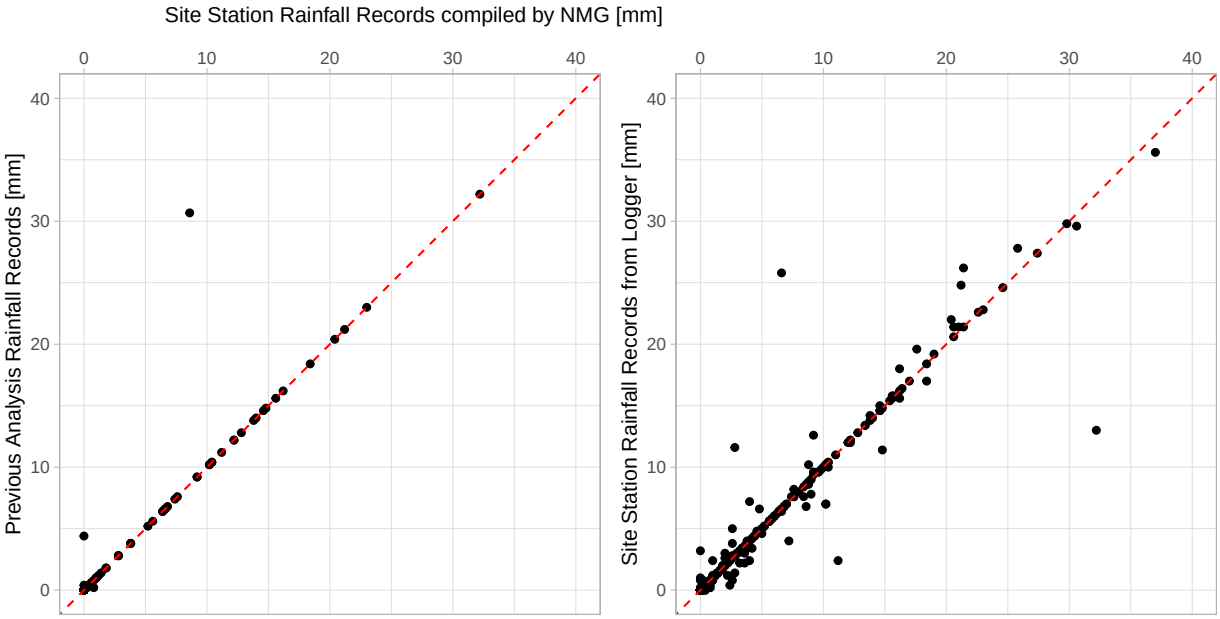
Site data is collected by NMG from two meteorological stations. The first station is located on Site, and the second station, called SoftdB, is located 1.5 km north at the following address: 200 Chemin des Hauteurs, Saint-Michel-des-Saints. Both records appear to only collect rainfall data.

Multiple data files were available for site. In the following section these were compiled and compared. Site records are consistent and the source file compiled by NMG has the longest records and is therefore selected for further analysis.

Note: SoftdB data is different from ECCC station 48188 data, so both records were kept.

NMG Stations Records and Missing Data
NMG Site Station
NMG SoftdB Station
Previous Analysis Site
Site Logger data
Daily Rainfall [mm]
0
50
100
2021
2022
2023
2024

Comparison between all the Site Station data files for Precipitation



Chapter 5

Regional Precipitation Analysis

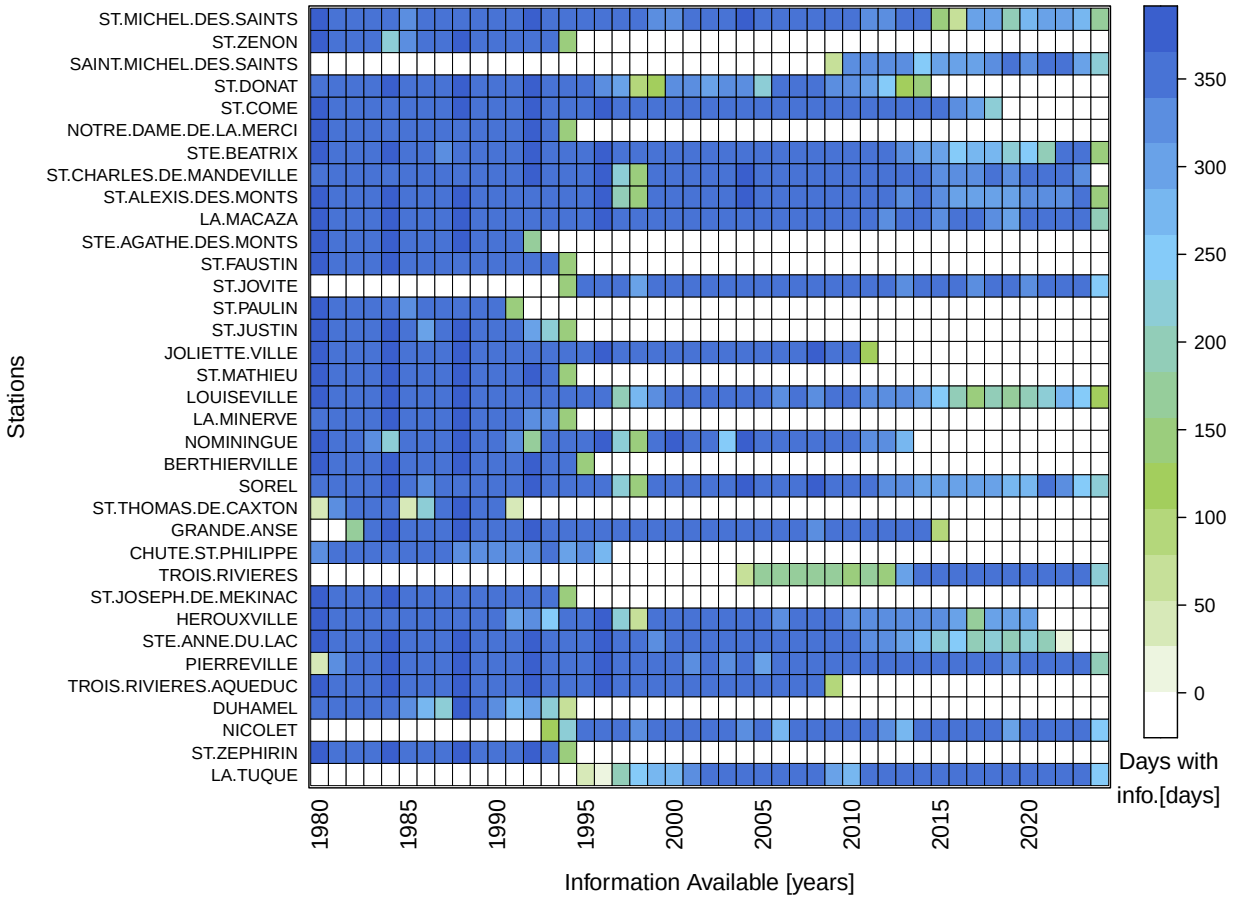
5.1 ECCC Precipitation Data

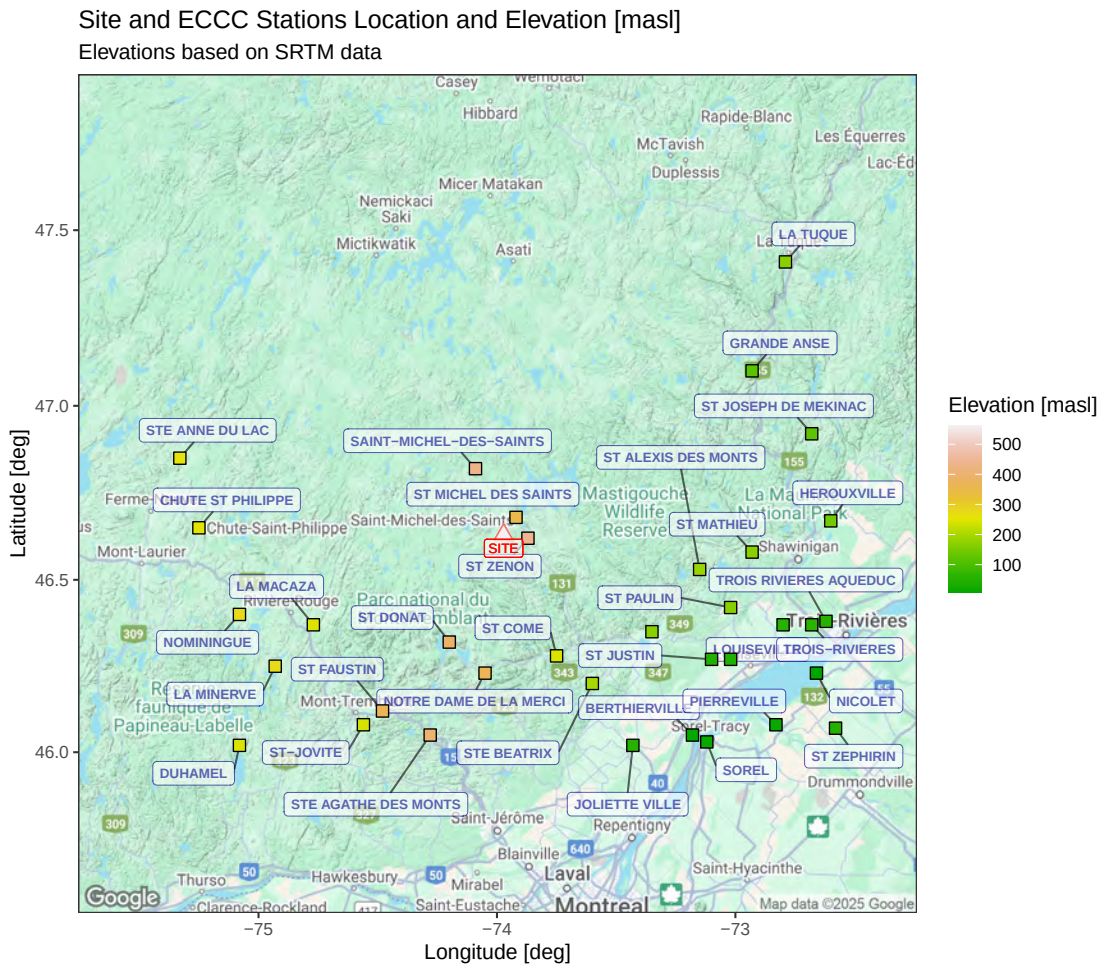
Environment and Climate Change Canada (ECCC) data was downloaded and prepared for analysis. The information is captured on a daily or hourly timestep when available. No complementary/redundant stations were detected so patching was not required for stations within the area of interest.

The following figures show:

1. Data availability over time at each station (only records from 1980 to 2023 were considered for this analysis).
2. Selected ECCC stations location and elevation.

Refer to the "eccc_read.r" for pre-processing details.


ST.MICHEL.DES.SAINTS
ST.ZENON
SAINT.MICHEL.DES.SAINTS
ST.DONAT
ST.COME
NOTRE.DAME.DE.LA.MERCI
STE.BEATRIX
ST.CHARLES.DE.MANDEVILLE
ST.ALEXIS.DES.MONTS
LA.MACAZA
STE.AGATHE.DES.MONTS
ST.FAUSTIN
ST.JOVITE
ST.PAULIN
ST.JUSTIN
JOLIETTE.VILLE
ST.MATHIEU
LOUISEVILLE
LA.MINERVE
NOMININGUE
BERTHIERVILLE
SOREL
ST.THOMAS.DE.CAXTON
GRANDE.ANSE
CHUTE.ST.PHILIPPE
TROIS.RIVIERES
ST.JOSEPH.DE.MEKINAC
HEROUXVILLE
STE.ANNE.DU.LAC
PIERREVILLE
TROIS.RIVIERES.AQUEDUC
DUHAMEL
NICOLET
ST.ZEPHIRIN
LA.TUQUE
Stations
1980
1985
1990
1995
2000
2005
2010
2015
2020
Information Available [years]
350
300
250
200
150
100
50
0
Days with
info.[days]



5.2 Reanalysis Regional Overview

Climate reanalysis combines gridded global models with observed historical data to produce historical climate and to incorporate adjustments based on developed relationships. Multiple reanalysis datasets are available in different spatio-temporal resolutions.

For this project four reanalysis datasets were evaluated. These are presented as gridded climate models and cover an area of interest defined between

5.2.1 Gridded Dataset Analysis Function

A general function is created to review each selected gridded dataset and compare it to station records. Four graphs are presented as outputs including:

- Graph 1: Mean annual precipitation (MAP) as a gridded map over the analysis extents, compared to station results. This aims to help visualize any regional trends in mean precipitation.
- Graph 2: Mean Annual Precipitation Elevation gradient over the analysis extents and regression, compared to station results.
- Graph 3: Mean Monthly Precipitation Elevation gradient over the analysis extents, compared to station results. Results and regressions split by month.

- Graph 4: Mean Annual Precipitation Elevation gradient and regression, compared to station results, split by location by latitude and longitude increments of 0.5 degrees. This graph offers a visualization of any local trends that might be more significant than regional trends.

5.2.2 Daymet

Daymet is a reanalysis tool developed by the Oak Ridge National Laboratory and supported by NASA, Daymet provides long-term, continuous, gridded estimates of daily weather and climatology in North America (Thornton et al. 2022) including variables such as daily maximum and minimum temperatures, precipitation, and shortwave radiation.

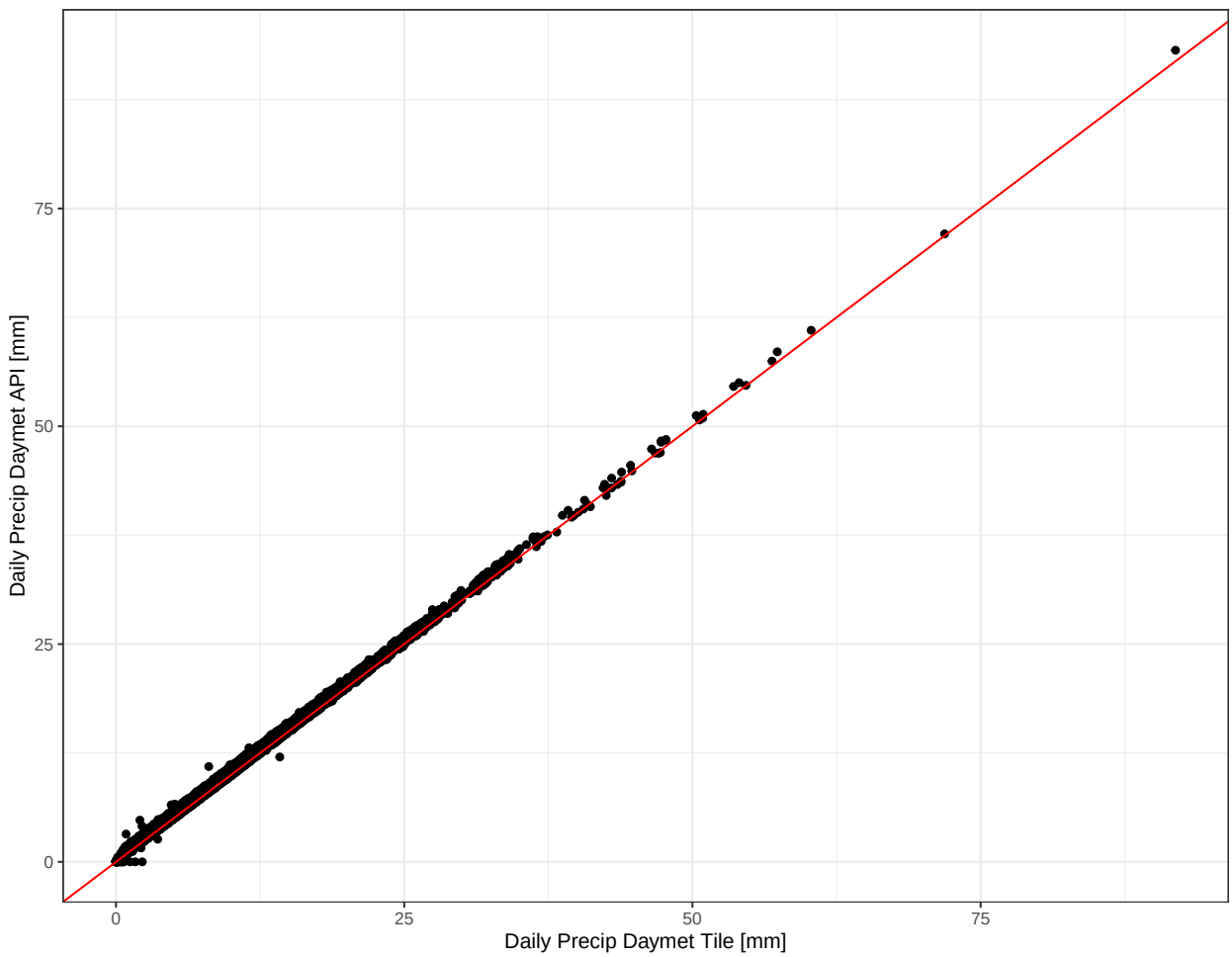
Daymet uses a set of spatial interpolation algorithms to estimate weather and climate patterns at a 1 km spatial resolution. Daymet is particularly useful for ecological and hydrological modeling. It offers high spatial resolution data covering an extended time period, making it suitable for analyzing long-term climate trends and their impacts on various environmental processes.

5.2.2.1 Daymet Source Selection

Two Daymet sources are compared:

1. API: data retrieved directly for a location from the Daymet site (interpolation function used)
2. Tiles: data extracted from the raster dataset

Both are mostly equivalent although slight differences are observed, likely due to interpolation/re-projection methods.

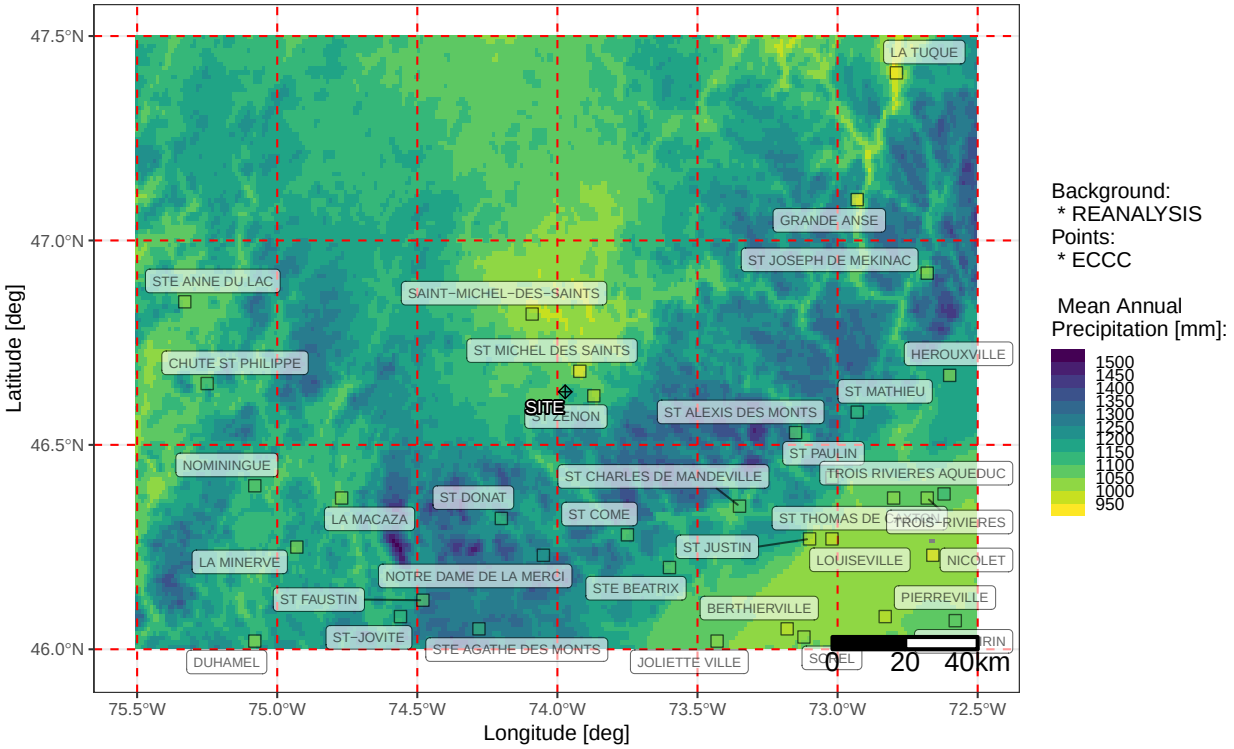


5.2.2.2 Daymet Regional Overview for Precipitation

The main findings of the Daymet regional overview are listed below (the corresponding figures follow):

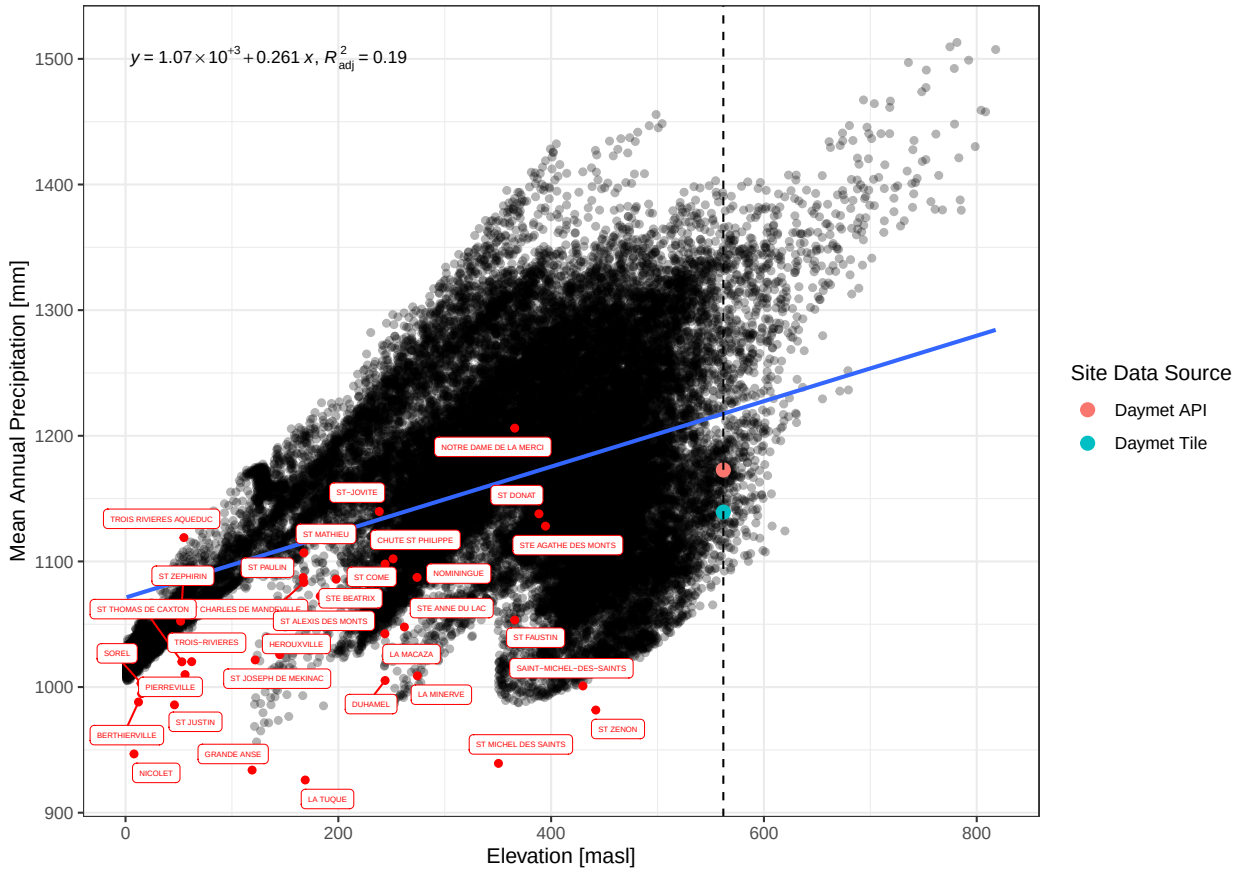
- On a regional scale, Daymet is consistent with ECCC in terms of spatial trends on MAP (Graph 1).
- The MAP versus Elevation gradient (Graph 2) shows a slight overprediction of MAP for Daymet on a regional scale. This observation is generally consistent with the monthly breakdown of this data (Graph 3).
- The localized breakdown of MAP vs Elevation (Graph 4) shows signifantly improved correlations between elevation and MAP, suggesting the existence of localized orthographic effects that don't follow a regional trend. Daymet overprediction of MAP appears to be consistent across the smaller areas.

Graph 1: Mean Annual Precipitation [mm]:
(1980 − 2023)



Graph 2: Regional Elevation Gradient

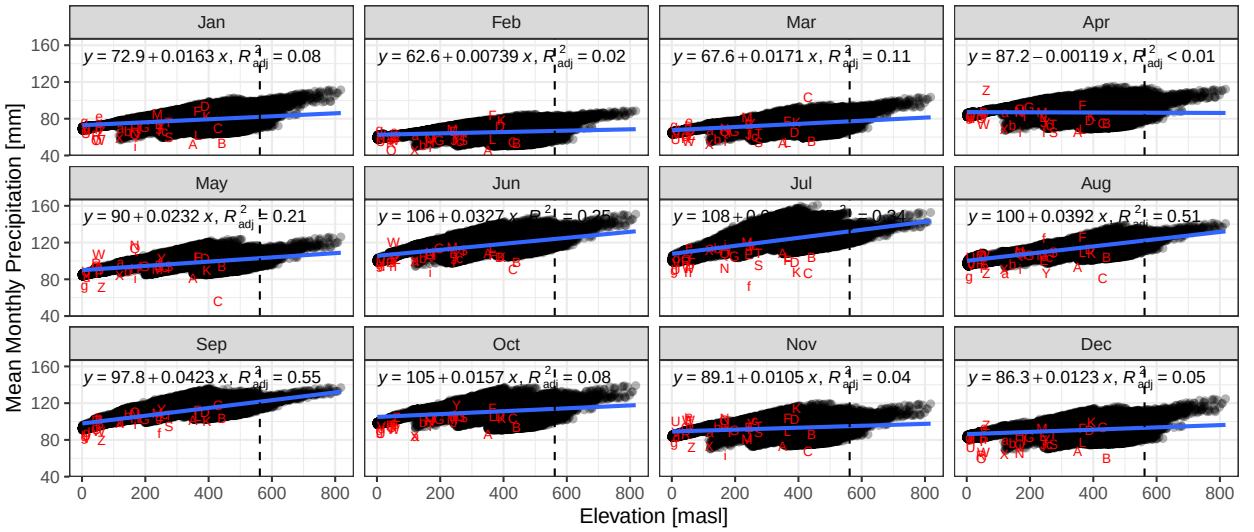
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

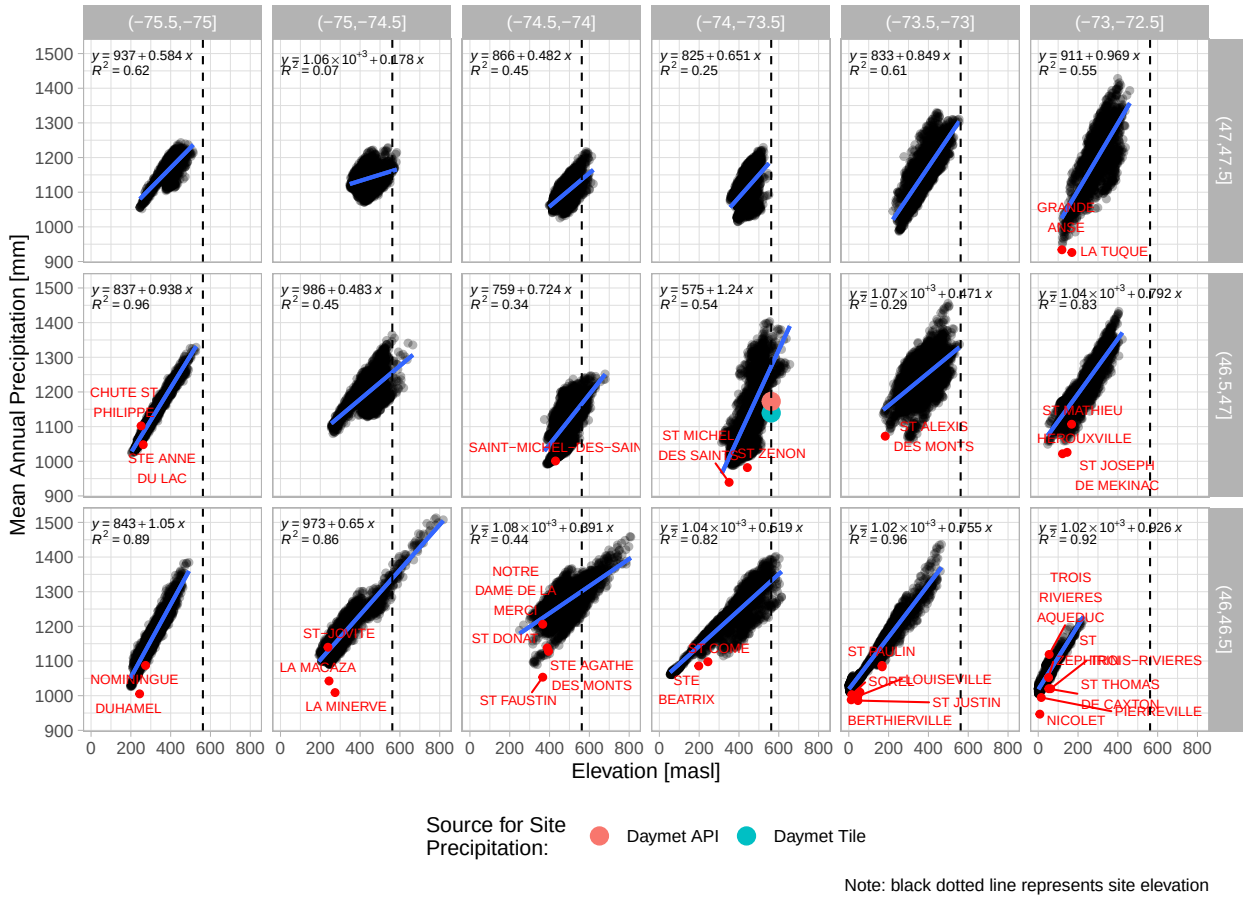
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



A	ST MICHEL DES SAINTS	H	ST CHARLES DE MANDEVILLE	O	ST JUSTIN	V	SOREL	c	STE ANNE DU
B	ST ZENON	I	ST ALEXIS DES MONTS	P	JOLIETTE VILLE	W	ST THOMAS DE CAXTON	d	PIERREVILLE
C	SAINT−MICHEL−DES−SAINTS	J	LA MACAZA	Q	ST MATHIEU	X	GRANDE ANSE	e	TROIS RIVIERE
D	ST DONAT	K	STE AGATHE DES MONTS	R	LOUISEVILLE	Y	CHUTE ST PHILIPPE	f	DUHAMEL
E	ST COME	L	ST FAUSTIN	S	LA MINERVE	Z	TROIS−RIVIERES	g	NICOLET
F	NOTRE DAME DE LA MERCI	M	ST−JOVITE	T	NOMININGUE	a	ST JOSEPH DE MEKINAC	h	ST ZEPHIRIN
G	STE BEATRIX	N	ST PAULIN	U	BERTHIERVILLE	b	HEROUXVILLE	i	LA TUQUE

Note: black dotted line represents site elevation

Graph 4: Mean Annual Precipitation [mm] versus Elevation [masl] (1980 − 2023)
Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



5.2.3 ERA5 Regional Overview for Precipitation

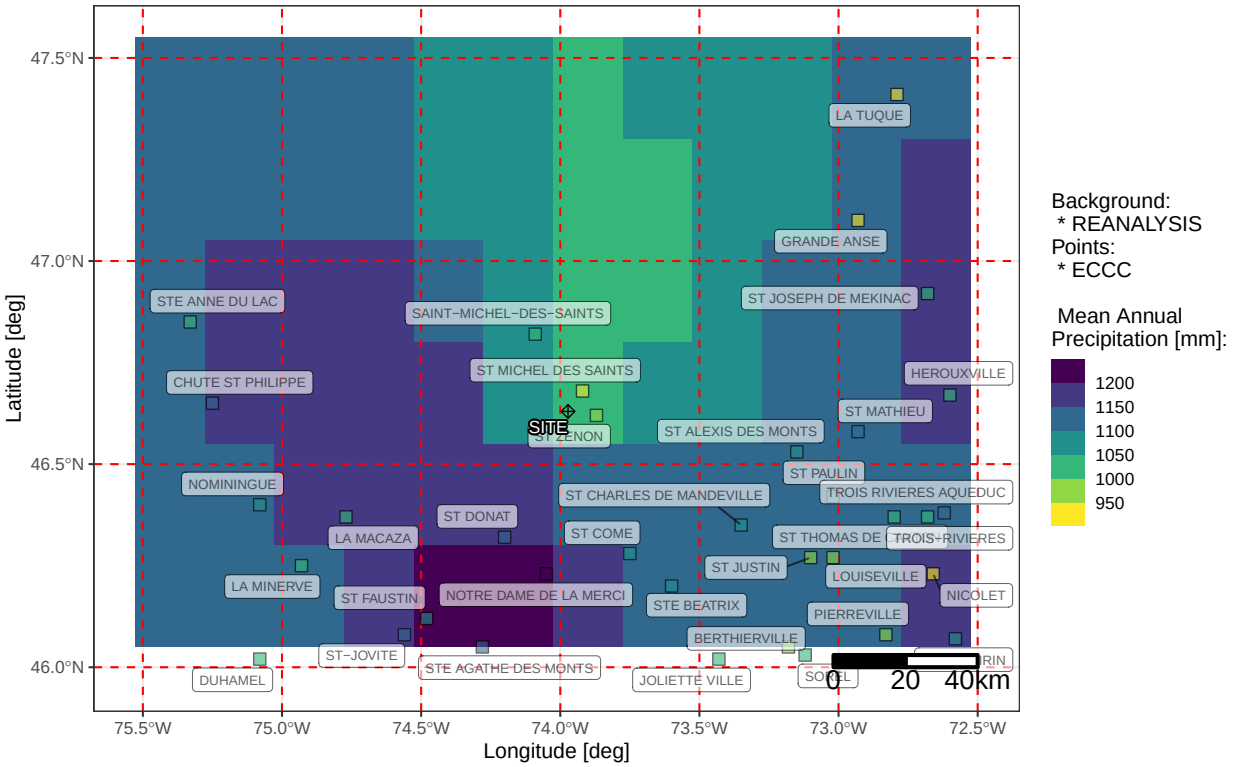
ERA5 is the fifth generation ECMWF atmospheric reanalysis of the global climate covering the period from January 1940 to present (Hersbach et al. 2020). ERA5 is produced by the Copernicus Climate Change Service (C3S) at the European Centre for Medium-Range Weather Forecasts (ECMWF). It offers information about multiple meteorological parameters.

ERA5 provides hourly estimates of a large number of atmospheric, land and oceanic climate variables. The data cover the Earth on a 31km grid and resolve the atmosphere using 137 levels from the surface up to a height of 80km. Surface level parameters were evaluated in this analysis.

The main findings of the ERA5 regional overview are listed below (the corresponding figures follow):

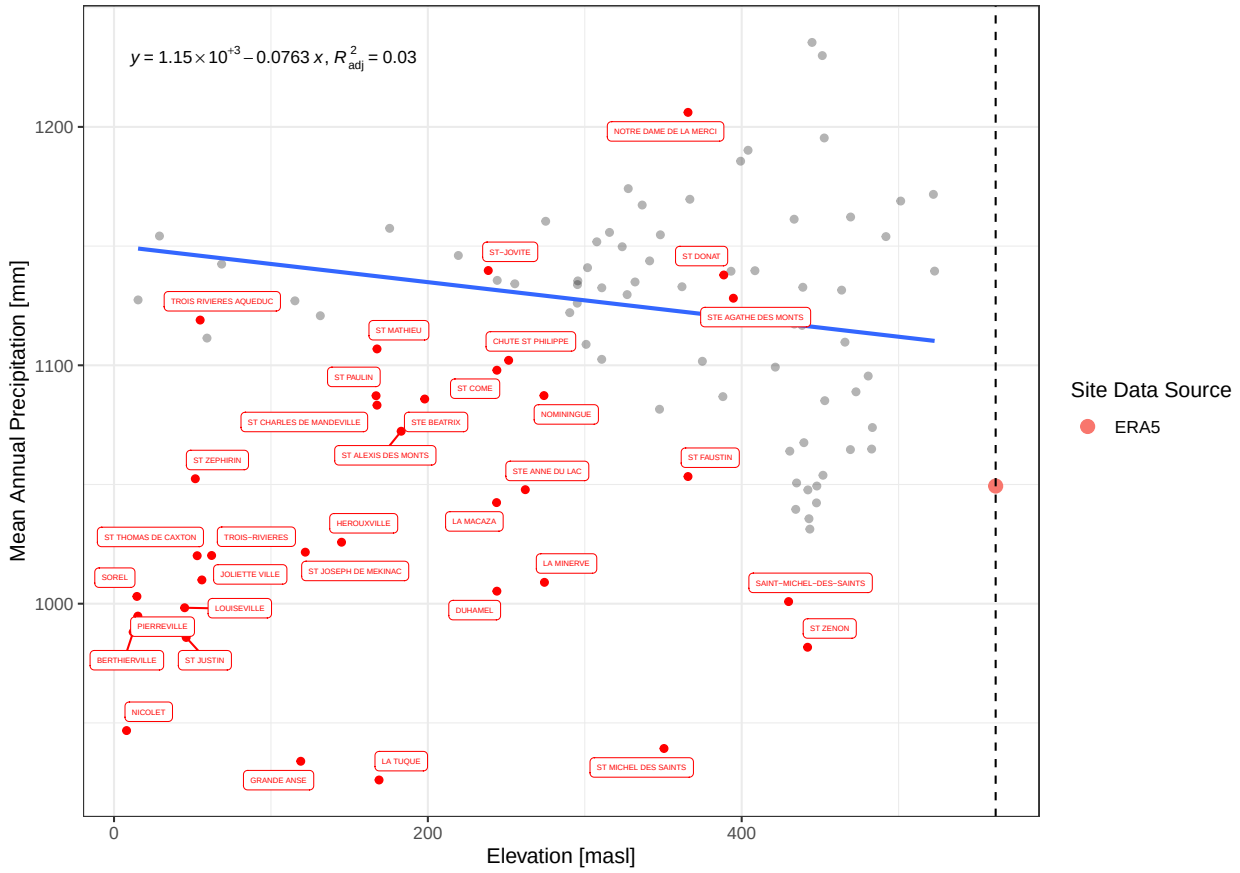
- On a regional scale, ERA5 is consistent with ECCC in terms of spatial trends on MAP (Graph 1).
- The MAP versus Elevation gradient (Graph 2) shows a slight overprediction of MAP for ERA5 on a regional scale. This observation is generally consistent with the monthly breakdown of this data (Graph 3). Mean grid elevation is generally higher than the stations elevation due to the mountainous nature of the region.
- The localized breakdown of MAP vs Elevation (Graph 4) is not relevant for precipitation analysis due to the lower resolution of the ERA5 dataset. Note that mean grid elevation is generally higher than the stations elevation due to the mountainous nature of the region.

Graph 1: Mean Annual Precipitation [mm]:
(1980 – 2023)



Graph 2: Regional Elevation Gradient

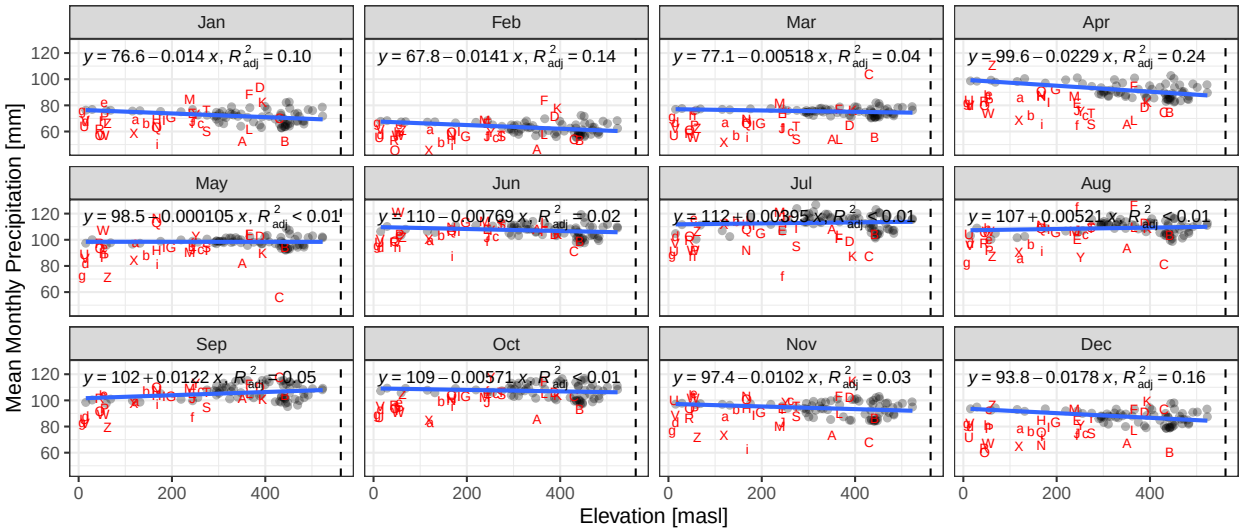
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

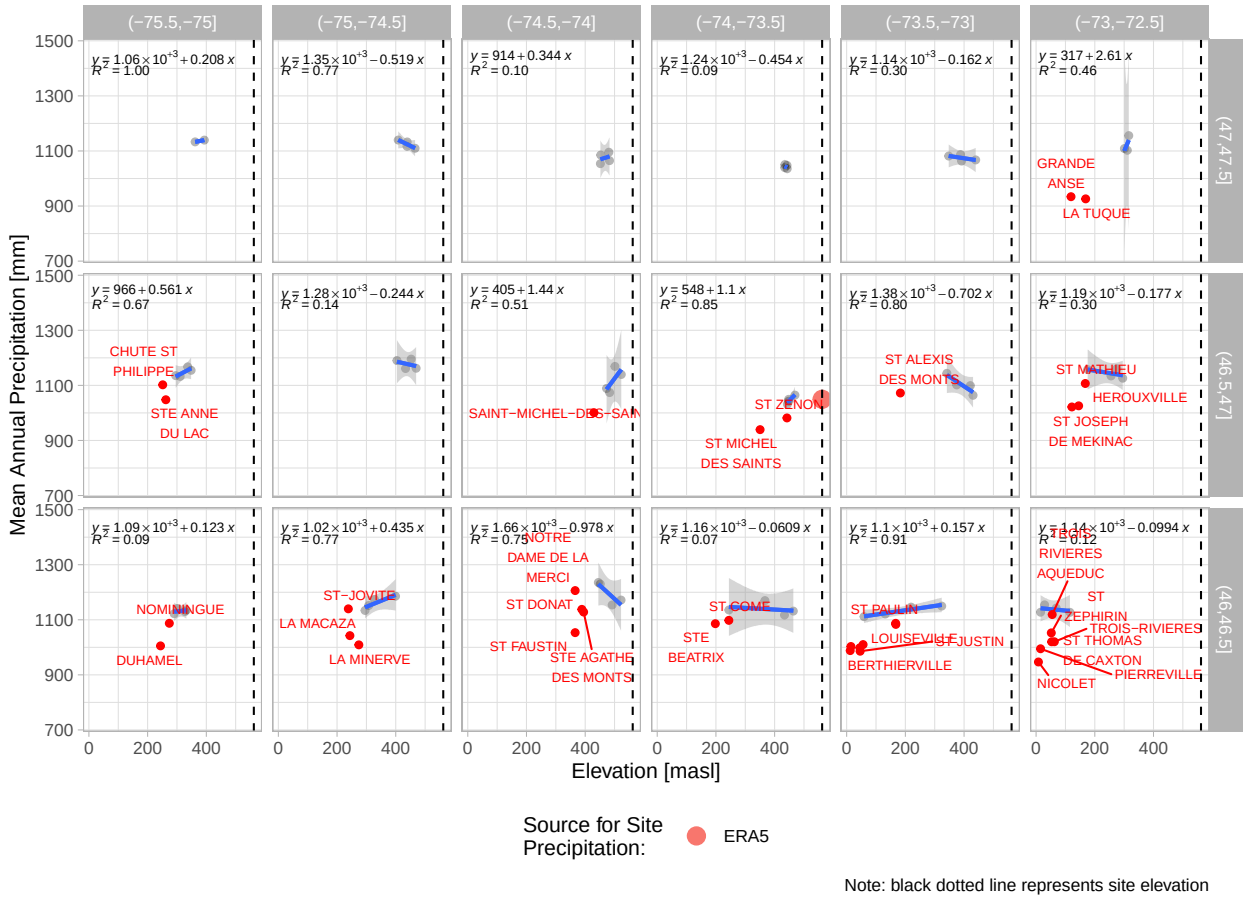
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



A	ST MICHEL DES SAINTS	H	ST CHARLES DE MANDEVILLE	O	ST JUSTIN	V	SOREL	c	STE ANNE DU
B	ST ZENON	I	ST ALEXIS DES MONTS	P	JOLIETTE VILLE	W	ST THOMAS DE CAXTON	d	PIERREVILLE
C	SAINT−MICHEL−DES−SAINTS	J	LA MACAZA	Q	ST MATHIEU	X	GRANDE ANSE	e	TROIS RIVIERE
D	ST DONAT	K	STE AGATHE DES MONTS	R	LOUISEVILLE	Y	CHUTE ST PHILIPPE	f	DUHAMEL
E	ST COME	L	ST FAUSTIN	S	LA MINERVE	Z	TROIS−RIVIERES	g	NICOLET
F	NOTRE DAME DE LA MERCI	M	ST−JOVITE	T	NOMININGUE	a	ST JOSEPH DE MEKINAC	h	ST ZEPHIRIN
G	STE BEATRIX	N	ST PAULIN	U	BERTHIERVILLE	b	HEROUXVILLE	i	LA TUQUE

Note: black dotted line represents site elevation

Graph 4: Mean Annual Precipitation [mm] versus Elevation [masl] (1980 − 2023)
Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



Note: black dotted line represents site elevation

5.2.4 ERA5-Land Regional Overview for Precipitation

ERA5-Land is a higher spatial and temporal resolution reanalysis dataset produced by the European Centre for Medium-Range Weather Forecasts (ECMWF) (Muñoz-Sabater et al. 2021). It offers detailed information about a large number of atmospheric, land and oceanic climate variables.

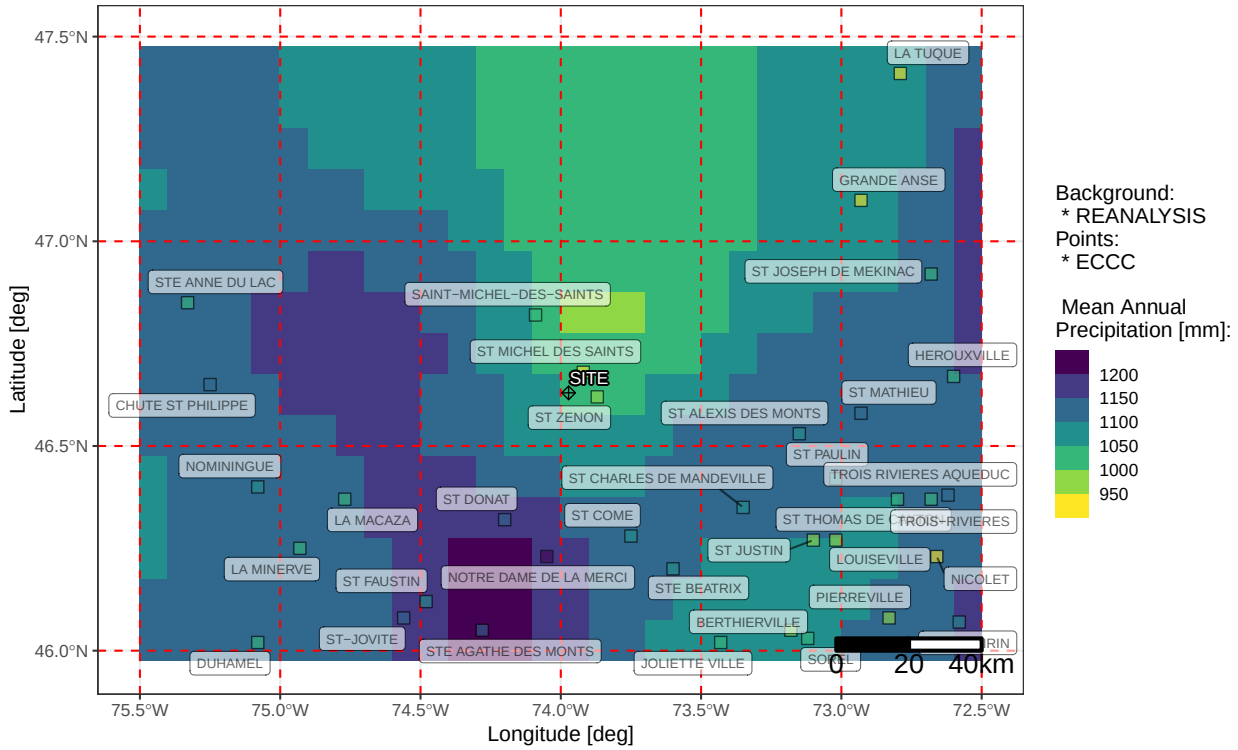
ERA5-Land operates at a spatial resolution of approximately 9 km and provides data at hourly intervals, making it particularly useful for hydrological and environmental studies. This dataset is widely used in research and operational applications due to its comprehensive coverage and high accuracy in representing land-surface conditions.

The main findings of the Era5-Land regional overview are listed below (the corresponding figures follow):

- On a regional scale, Era5-Land is consistent with ECCC in terms of spatial trends on MAP (Graph 1).
- Similarly to ERA5, the MAP versus Elevation gradient (Graph 2) shows a slight overprediction of MAP for Era5-Land on a regional scale. This observation is generally consistent with the monthly breakdown of this data (Graph 3).
- The localized breakdown of MAP vs Elevation (Graph 4) shows slightly improved correlations between elevation and MAP in some areas, suggesting the existence of some localized orthographic effects. Era5-Land overprediction of MAP appears to be consistent across the smaller

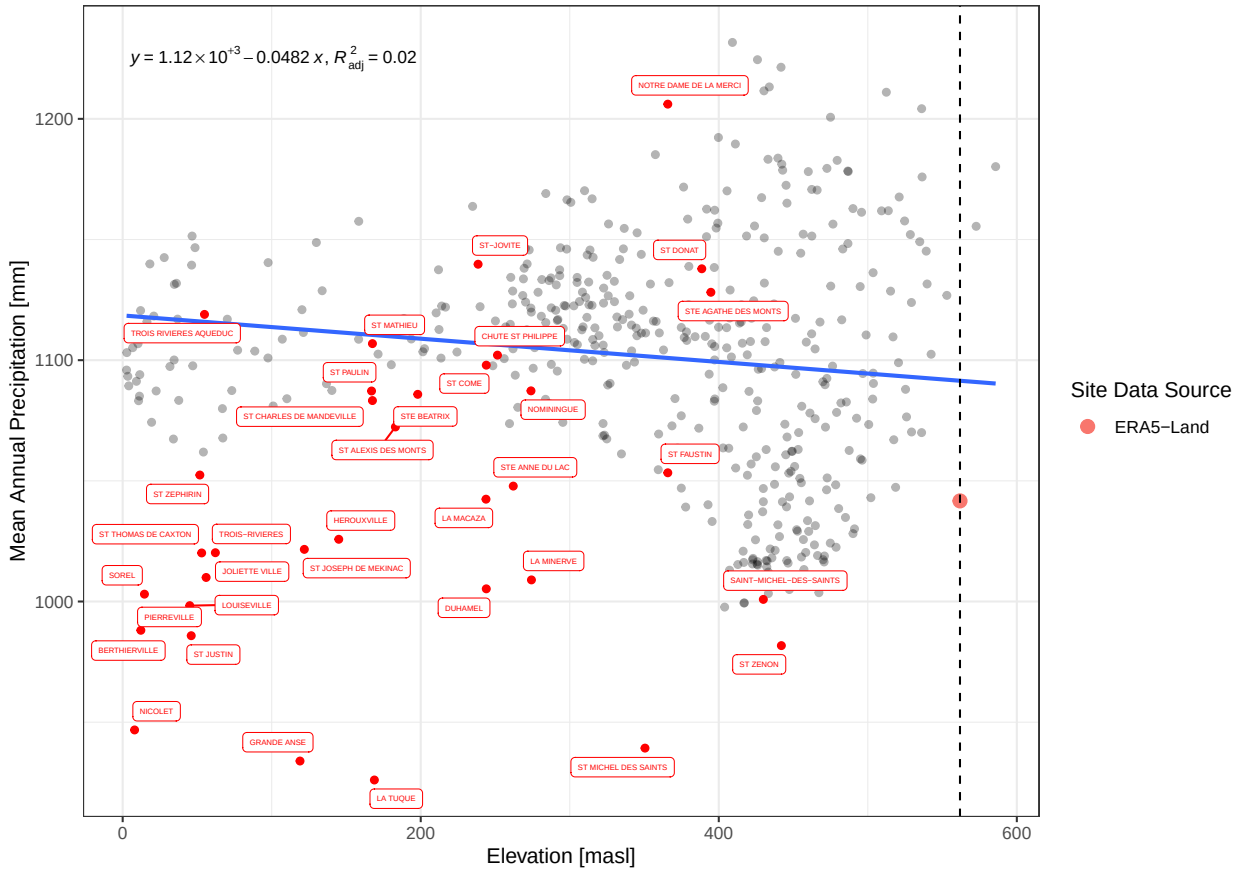
areas.

Graph 1: Mean Annual Precipitation [mm]:
(1980 − 2023)



Graph 2: Regional Elevation Gradient

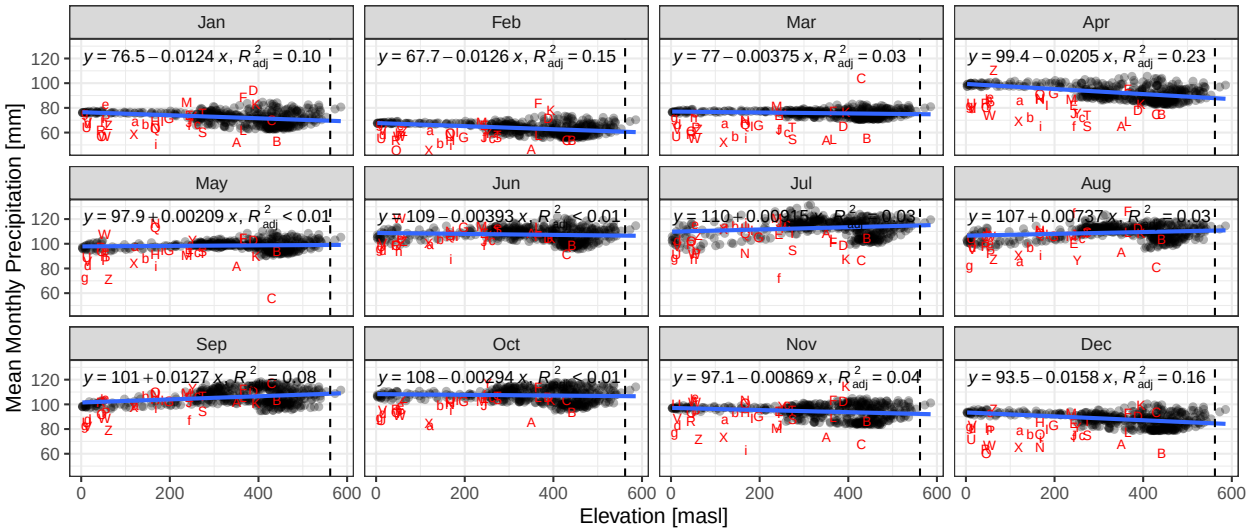
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

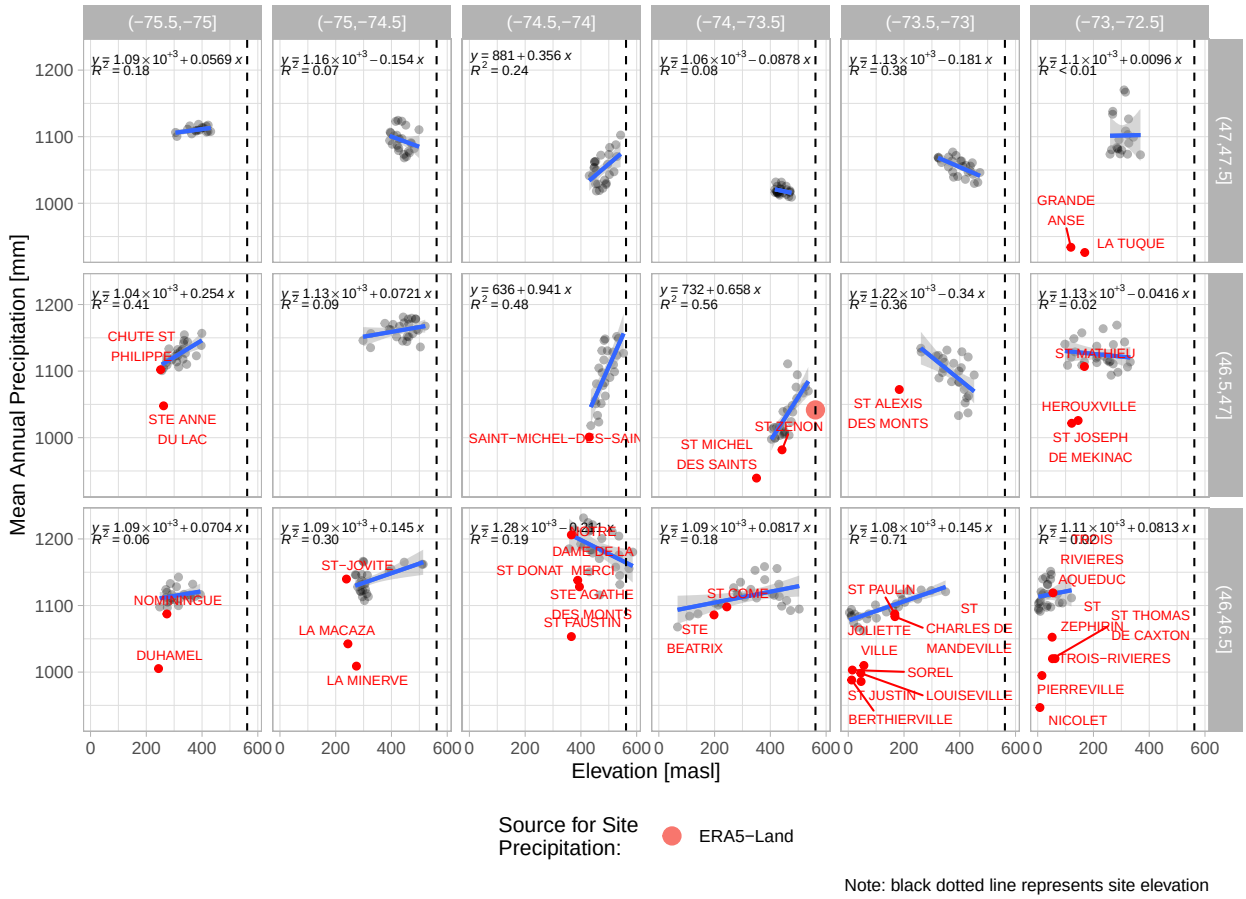
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



A ST MICHEL DES SAINTS	H ST CHARLES DE MANDEVILLE	O ST JUSTIN	V SOREL	c STE ANNE DU
B ST ZENON	I ST ALEXIS DES MONTS	P JOLIETTE VILLE	W ST THOMAS DE CAXTON	d PIERREVILLE
C SAINT−MICHEL−DES−SAINTS	J LA MACAZA	Q ST MATHIEU	X GRANDE ANSE	e TROIS RIVIERE
D ST DONAT	K STE AGATHE DES MONTS	R LOUISEVILLE	Y CHUTE ST PHILIPPE	f DUHAMEL
E ST COME	L ST FAUSTIN	S LA MINERVE	Z TROIS−RIVIERES	g NICOLET
F NOTRE DAME DE LA MERCI	M ST−JOVITE	T NOMININGUE	a ST JOSEPH DE MEKINAC	h ST ZEPHIRIN
G STE BEATRIX	N ST PAULIN	U BERTHIERVILLE	b HEROUXVILLE	i LA TUQUE

Note: black dotted line represents site elevation

Graph 4: Mean Annual Precipitation [mm] versus Elevation [masl] (1980 − 2023)
Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



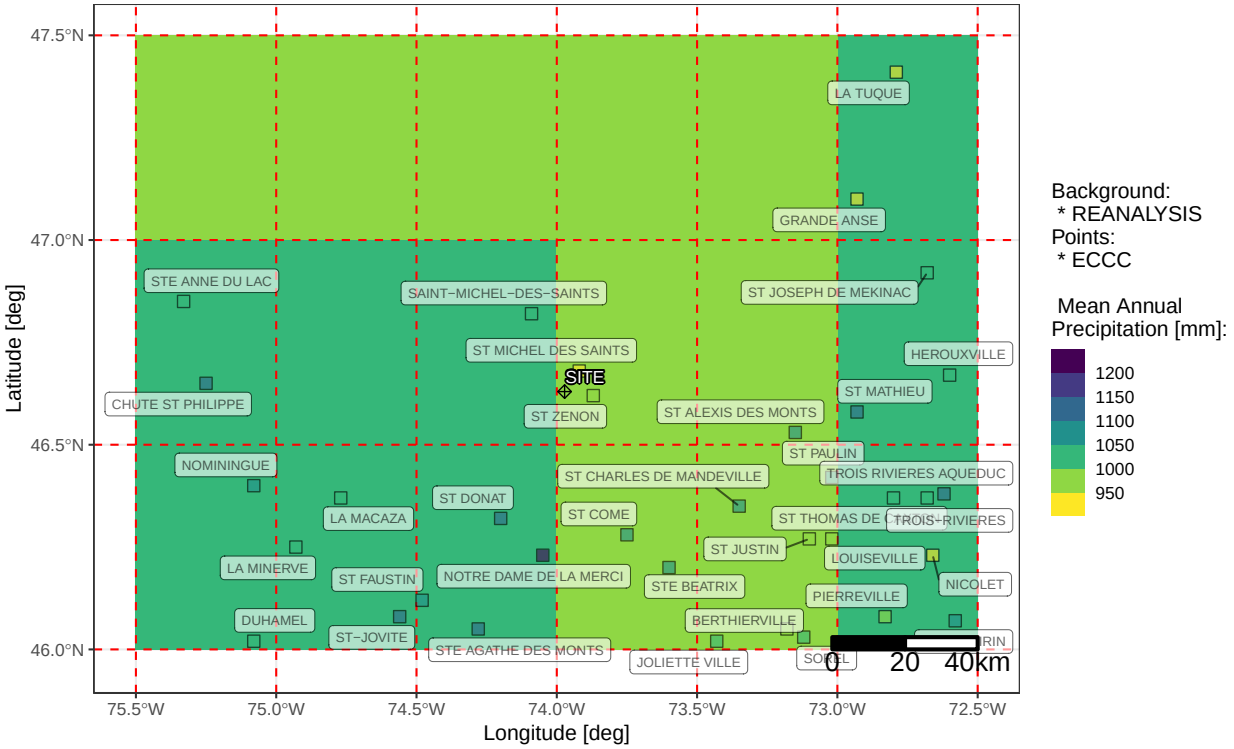
5.2.5 MERRA2 Regional Overview for Precipitation

MERRA2 (Modern-Era Retrospective analysis from Research and Applications, Version 2) is a global climate reanalysis model from the U.S. National Aeronautics and Space Administration (NASA) (Gelaro et al. 2017). MERRA2 offers daily data from 1981 to present (2024) on a grid of 0.5 degrees latitude by 0.5 degrees longitude covering the entire globe.

The main findings of the MERRA2 regional overview are listed below (the corresponding figures follow):

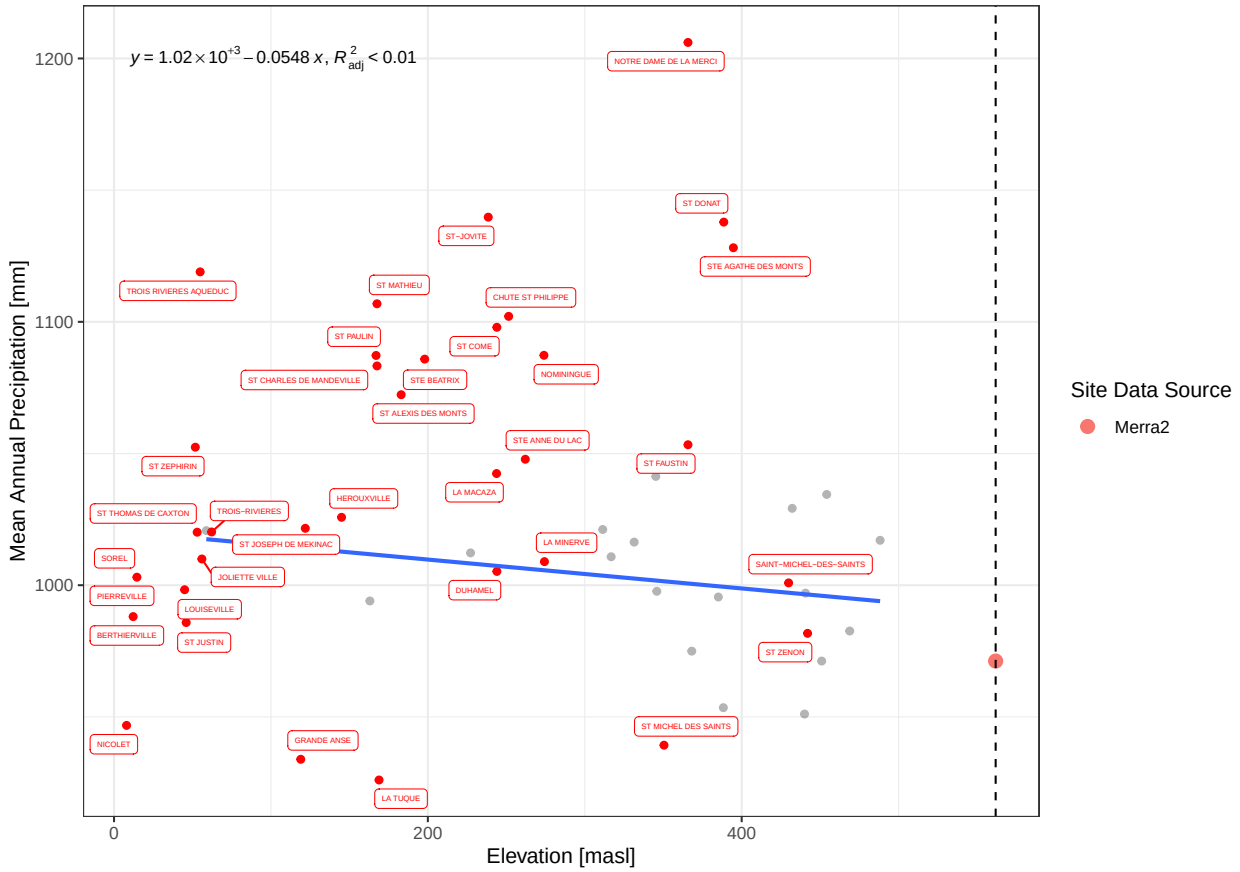
- On a regional scale, MERRA2 appears to be somewhat consistent with ECCC in terms of spatial trends on MAP (Graph 1).
- The MAP versus Elevation gradient (Graph 2) shows MAP predictions below the range of station data for MERRA2 on a regional scale, although mean grid elevation is generally higher than the stations elevation . This observation is generally consistent with the monthly breakdown of this data (Graph 3).
- The localized breakdown of MAP vs Elevation (Graph 4) is not relevant for precipitation analysis due to the lower resolution of the MERRA2 dataset. Note that mean grid elevation is generally higher than the stations elevation due to the mountainous nature of the region.

Graph 1: Mean Annual Precipitation [mm]:
(1980 – 2023)



Graph 2: Regional Elevation Gradient

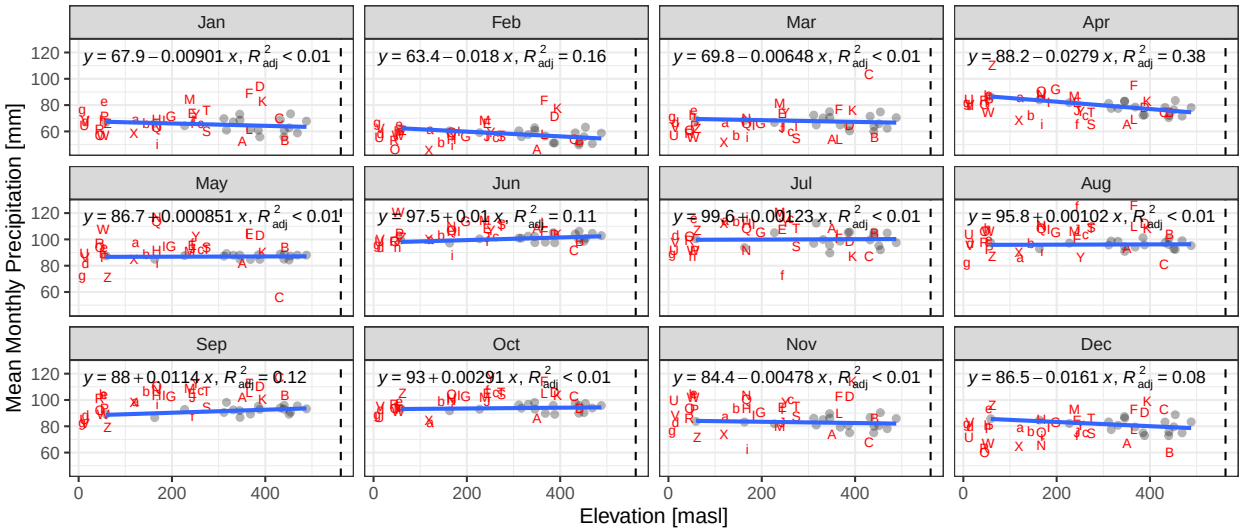
Reanalsis source as background: 1980 to 2023 (distance 125 km from site)



Note: black dotted line represents site elevation

Graph 3: Monthly Elevation Gradient

Reanalsis source as background: 1980 to 2023 (distance 125 km from site)

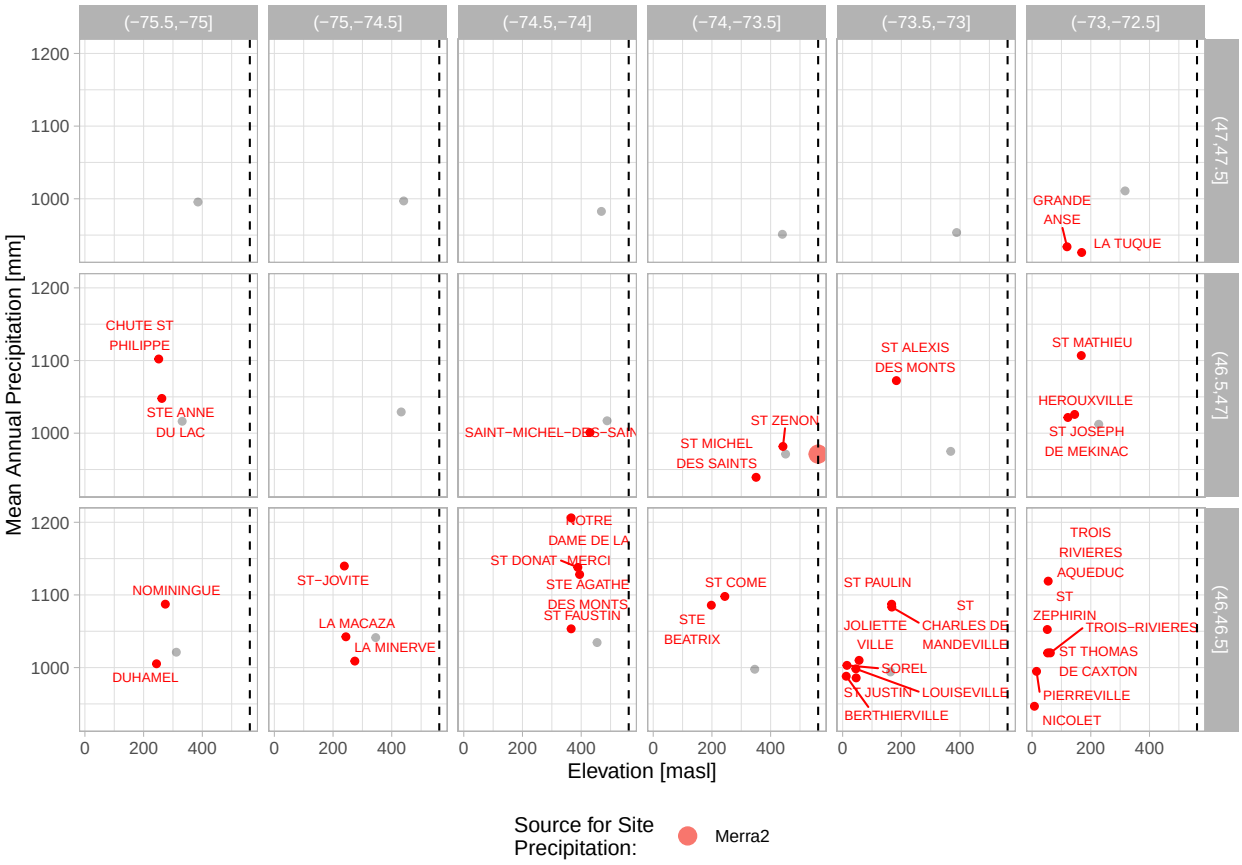


A ST MICHEL DES SAINTS	H ST CHARLES DE MANDEVILLE	O ST JUSTIN	V SOREL	c STE ANNE DU
B ST ZENON	I ST ALEXIS DES MONTS	P JOLIETTE VILLE	W ST THOMAS DE CAXTON	d PIERREVILLE
C SAINT−MICHEL−DES−SAINTS	J LA MACAZA	Q ST MATHIEU	X GRANDE ANSE	e TROIS RIVIERE
D ST DONAT	K STE AGATHE DES MONTS	R LOUISEVILLE	Y CHUTE ST PHILIPPE	f DUHAMEL
E ST COME	L ST FAUSTIN	S LA MINERVE	Z TROIS−RIVIERES	g NICOLET
F NOTRE DAME DE LA MERCI	M ST−JOVITE	T NOMININGUE	a ST JOSEPH DE MEKINAC	h ST ZEPHIRIN
G STE BEATRIX	N ST PAULIN	U BERTHIERVILLE	b HEROUXVILLE	i LA TUQUE

Note: black dotted line represents site elevation

Graph 4: Mean Annual Precipitation [mm] versus Elevation [masl] (1980 − 2023)

Based on grid 0.5 x 0.5 (deg) − grey points: Reanalysis / red points: ECCC



Note: black dotted line represents site elevation

Chapter 6

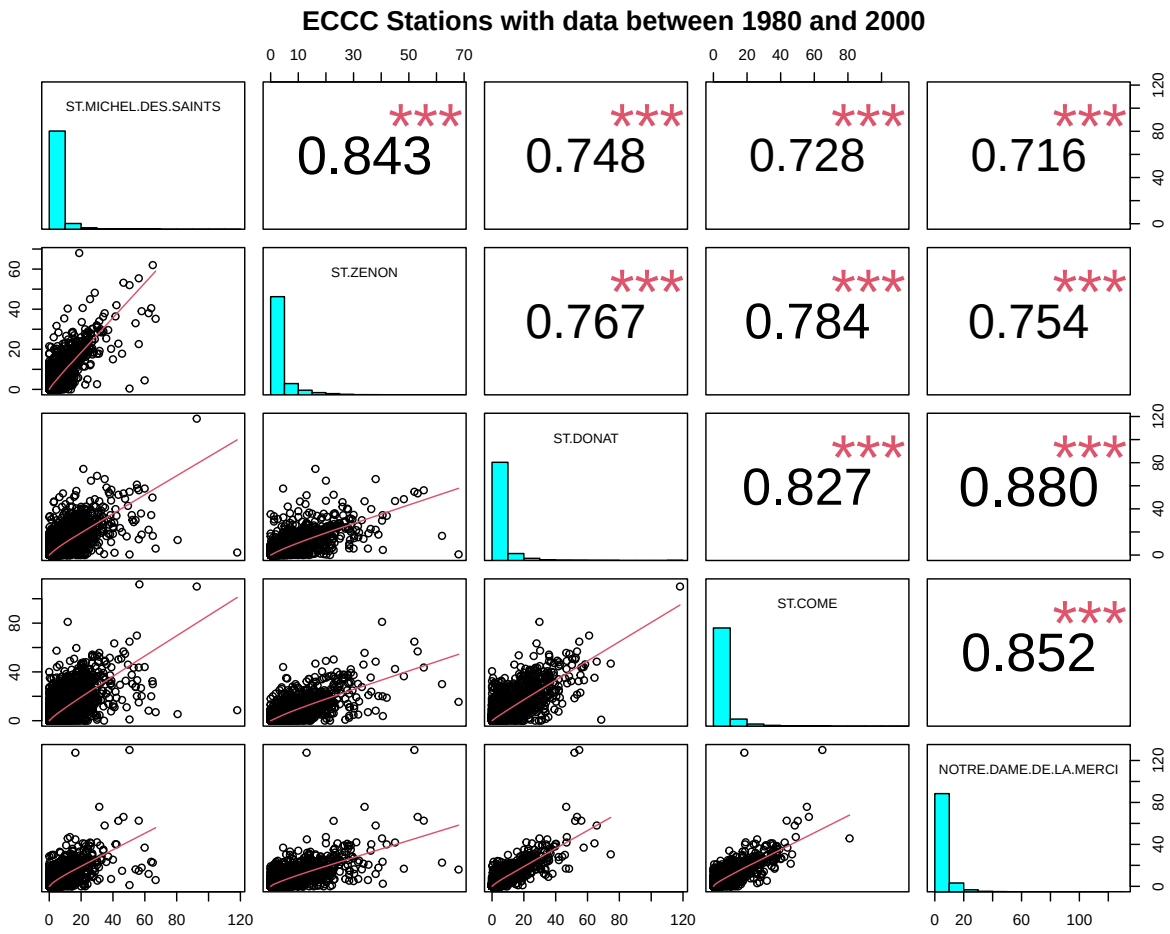
Local Analysis

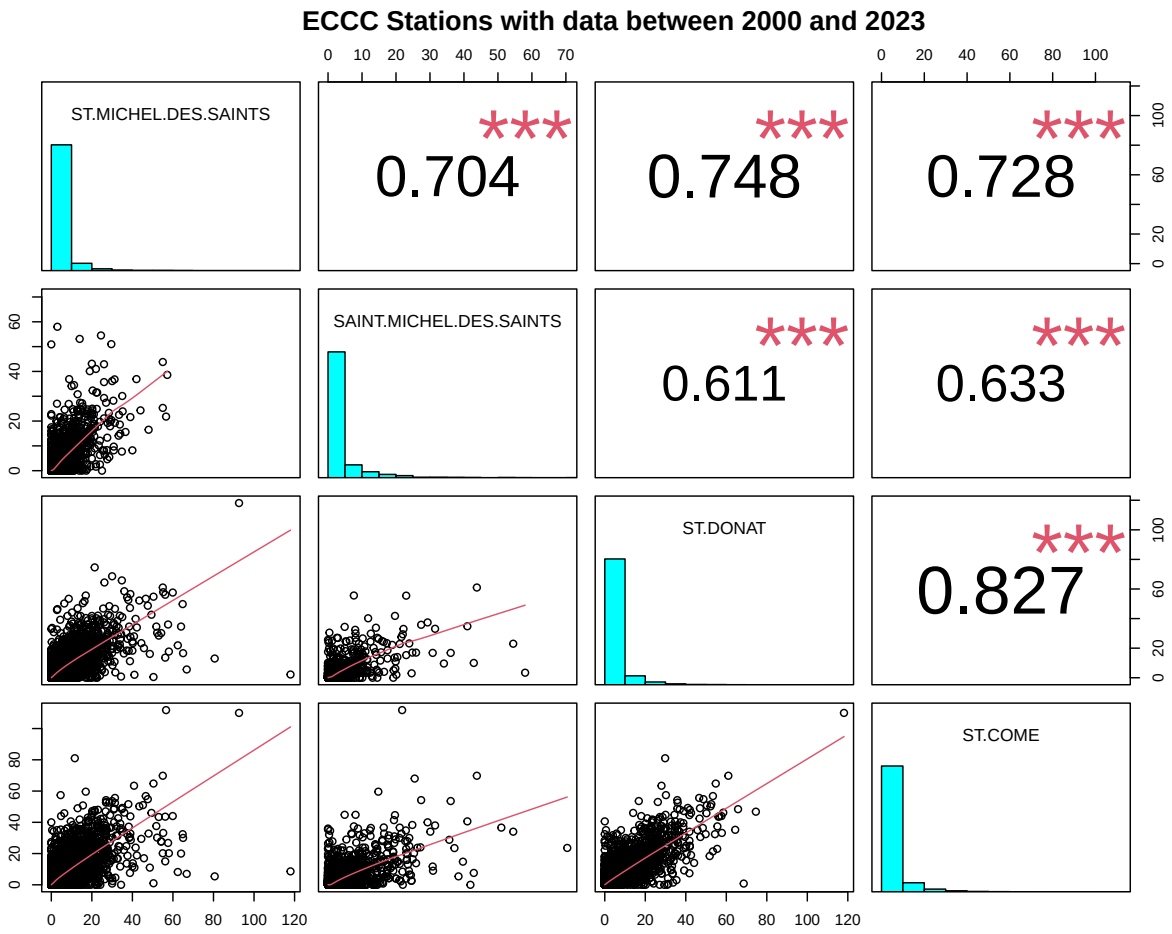
The regional analysis shows that local orographic effects are prominent and variable in the region, therefore a smaller area around Site should be more representative of its climate. The following analysis only considers data within 50km of the Matawinie Site.

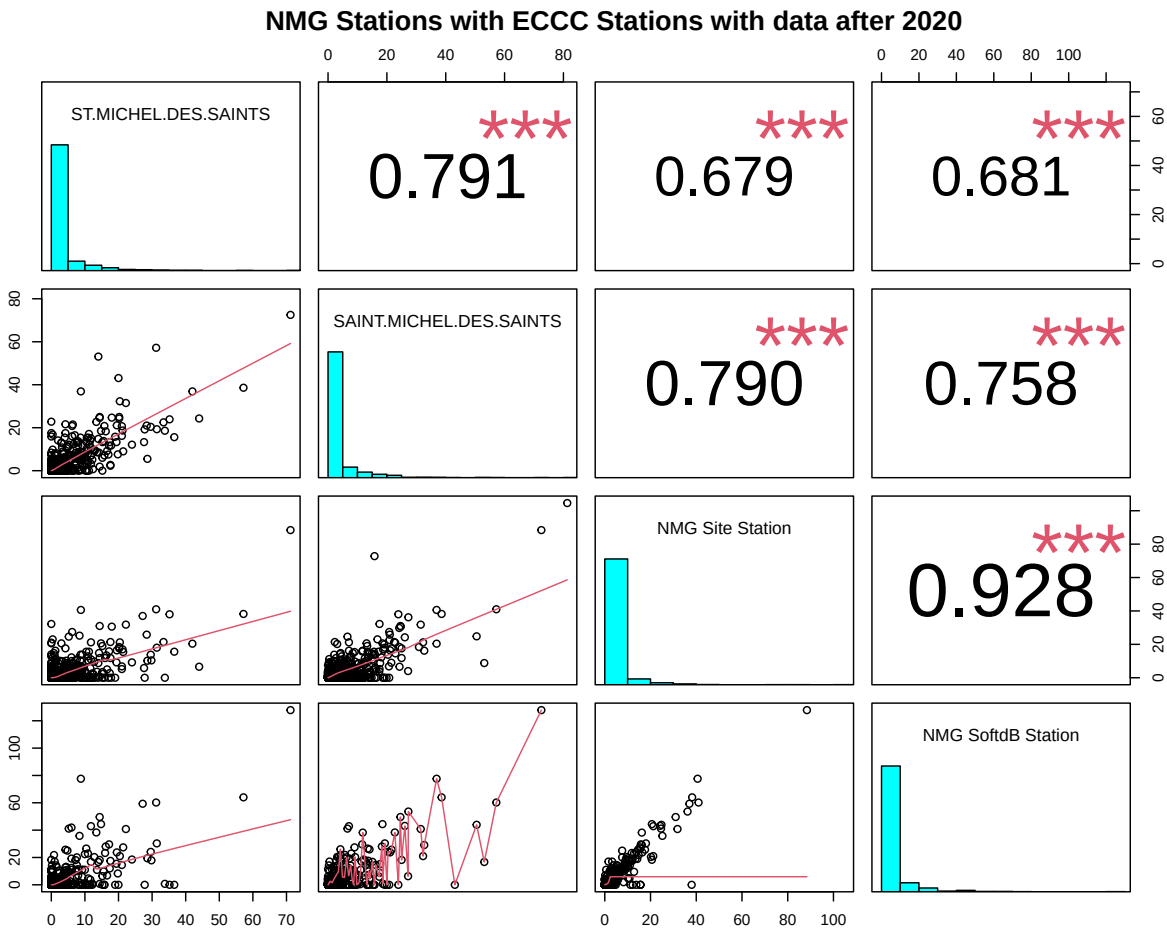
6.1 ECCC and NMG Stations data correlations

The following visualization is a correlation matrix between daily precipitation records from stations close to site. On the top right quadrant, the (absolute) value of the correlation is presented together with the result of the Pearson's product moment correlation coefficient as stars. On bottom-left quadrant the bivariate scatterplots, with a fitted line are presented. On the diagonal there is an histogram of each variable.

Precipitation from the ECCC stations close to site correlate well between each other. Similarly, NMG station records correlate well with both ECCC Saint Michel des Saints stations, but the best correlation is found between both NMG stations.


ECCC Stations with data between 1980 and 2000
ST.MICHEL.DES.SAINTS
ST.ZENON
ST.DONAT
ST.COME
NOTRE.DAME.DE.LA.MERCI
0.843 ***
0.748 ***
0.728 ***
0.716 ***
0.767 ***
0.784 ***
0.754 ***
0.827 ***
0.880 ***
0.852 ***


ECCC Stations with data between 2000 and 2023
ST.MICHEL.DES.SAINTS
0.704
0.748
0.728
SAINT.MICHEL.DES.SAINTS
0.611
0.633
ST.DONAT
0.827
ST.COME
***



6.2 Reanalysis Evaluation Against Station Records

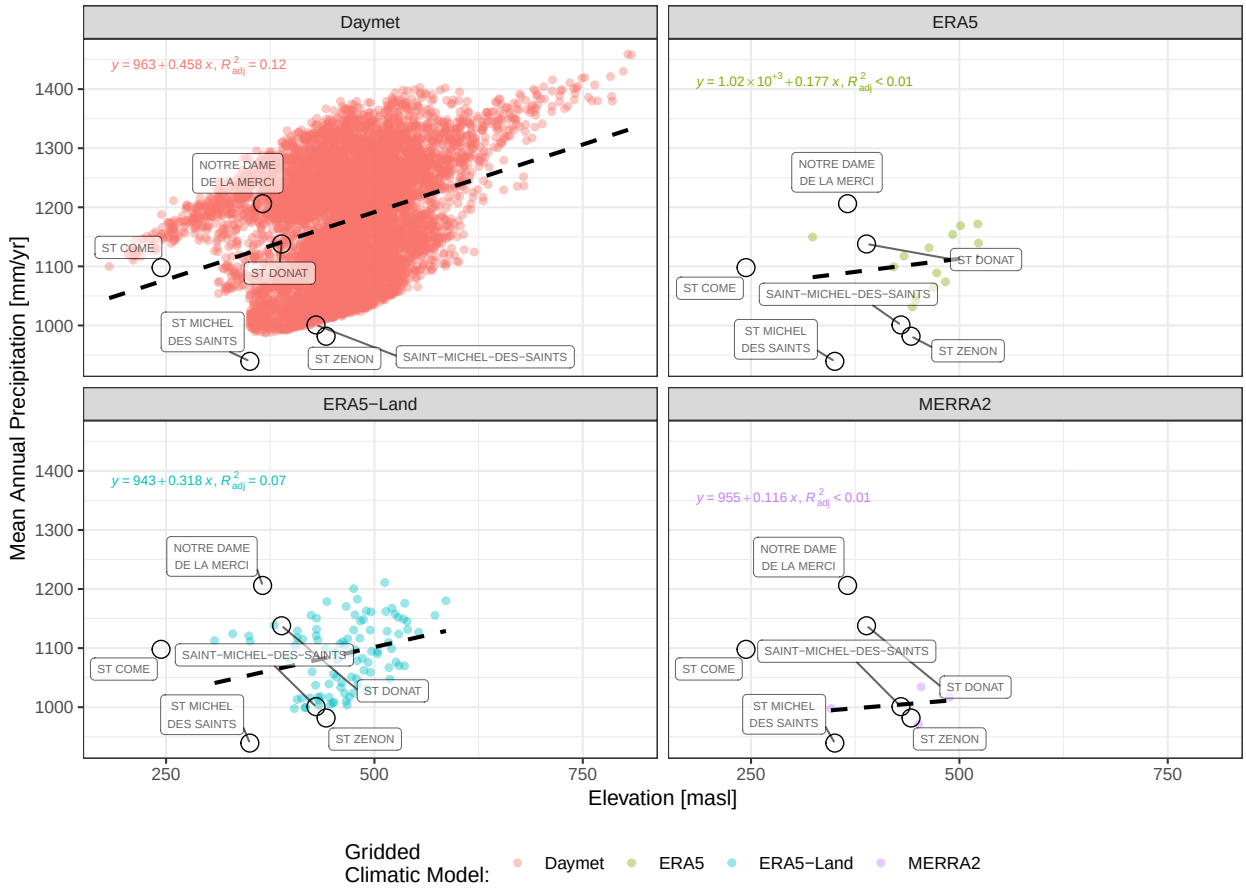
6.2.1 Local MAP Elevation Gradient Comparison

A local MAP to elevation regression is generated with data available within 50km, 30km and 10km from site. NMG stations were excluded for this graph due to only consisting of rainfall data. All the gridded climate models from the previous analysis were kept for reference.

- At an analysis distance of 50km, MAP correlations to elevation for all climate models are poor (R^2 0.2). Similarly no clear relation between MAP and Elevation is evident from the six ECCC stations records within this range.
- At an analysis distance of 30km, MAP correlations to elevation increase (0.4 R^2 0.6). This improvement is significant for Daymet. ERA5, and to a lesser extent ERA5-Land have their data population considerably reduced at this distance so the correlation improvement might not be significant. MERRA2 variability at this scale is not relevant due to it's larger grid size. Only three selected ECCC stations exist within this range.
- At an analysis distance of 10km, Daymet is the only climate model with a data population large enough (i.e. grid size small enough) to be relevant. Daymet shows a clear MAP to Elevation gradient at this scale. Only two selected ECCC stations exist within this range.

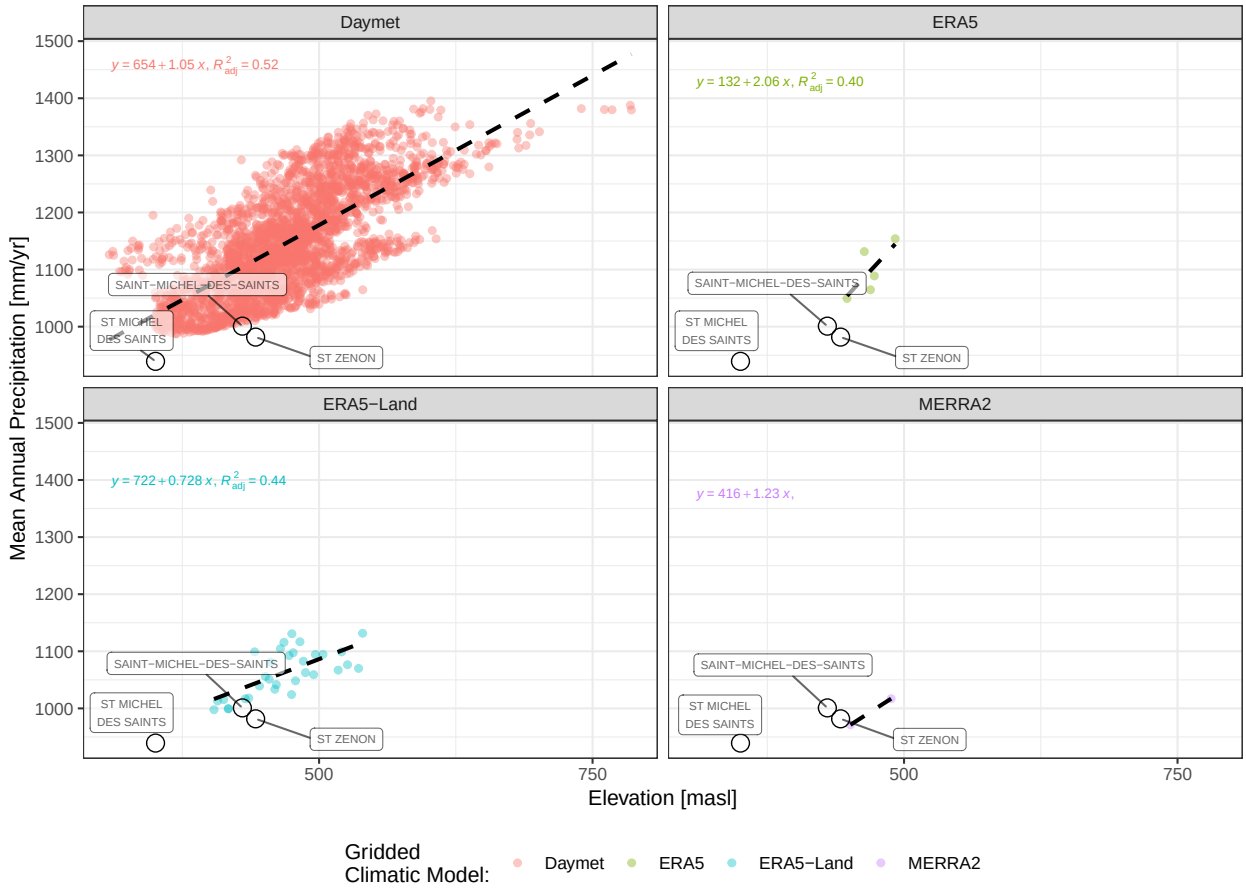
Graph 1: Elevation Gradient for MAP within 50km of Site (1980 to 2023)

Near site comparison of Gridded Climatic Models and ECCC Stations

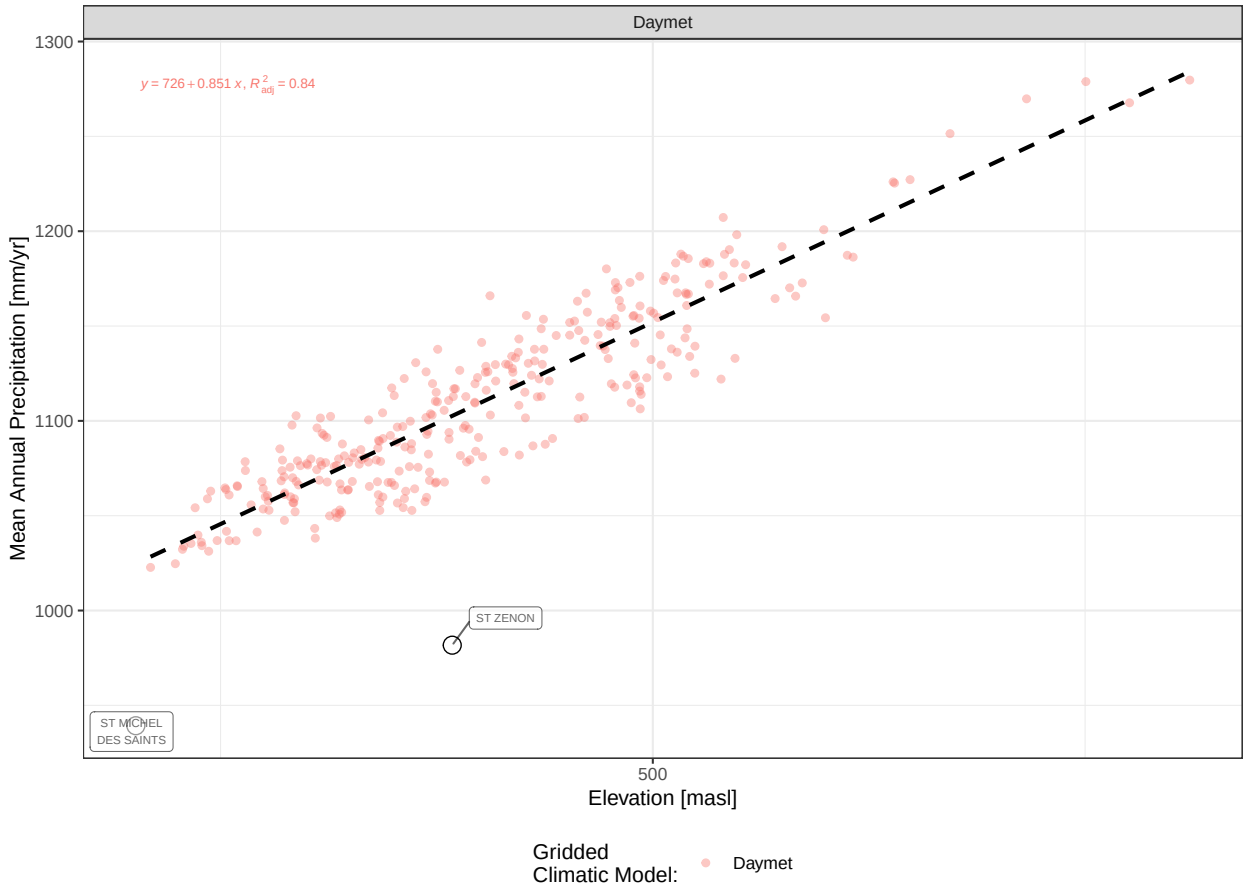


Graph 2: Elevation Gradient for MAP within 30km of Site (1980 to 2023)

Near site comparison of Gridded Climatic Models and ECCC Stations



Graph 3: Elevation Gradient for MAP within 10km of Site (1980 to 2023)
Near site comparison of Daymet and ECCC Stations



6.2.2 Station to Climate Model - Monthly Correlations

Monthly correlations between station and climate model data at each location help comparing model coherence with measured data and highlight seasonal bias. Monthly analysis allows inclusion of the NMG stations records that only collect rainfall. The ECCC stations within 50km of site were kept for this analysis.

The main findings of this section are summarized below:

- All the climate models present good correlation with ECCC station data. Daymet shows the strongest correlation with all ECCC stations for monthly precipitation.
- NMG station records are too short for the results of this test to be significant, although good correlation with all the climate models can be inferred. Site station records span four years only, but all climate models except MERRA2 appear to overestimate precipitation compared to NMG records (only considering May to Oct).

6.2.2.1 Functions Definition

A function is defined to compare monthly station records against data produced for the same location by all four climate models included in this study.

- Monthly precipitation results are summarized in a table comparing climate model results to station records for the same overlapping record period. Only May to October are presented

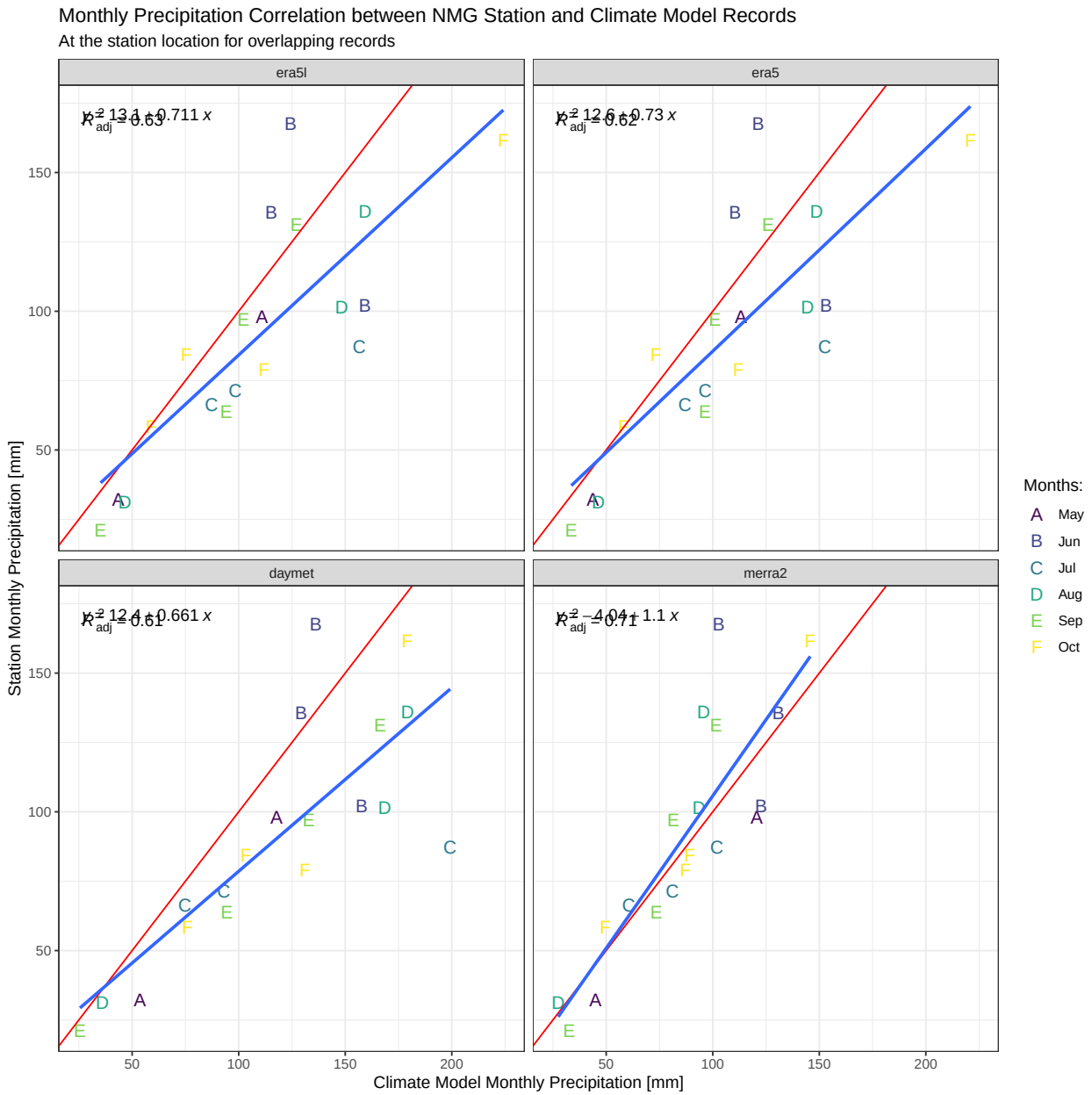
for NMG stations to remove bias related to unmeasured snowfall.

- The plot shows correlation between each station monthly data and all four climate models for the same overlapping record period.

6.2.2.2 Monthly Correlations for NMG Site

Table 6.1: Monthly Summary of Reanalysis Data matching Observed Data at NMG Site

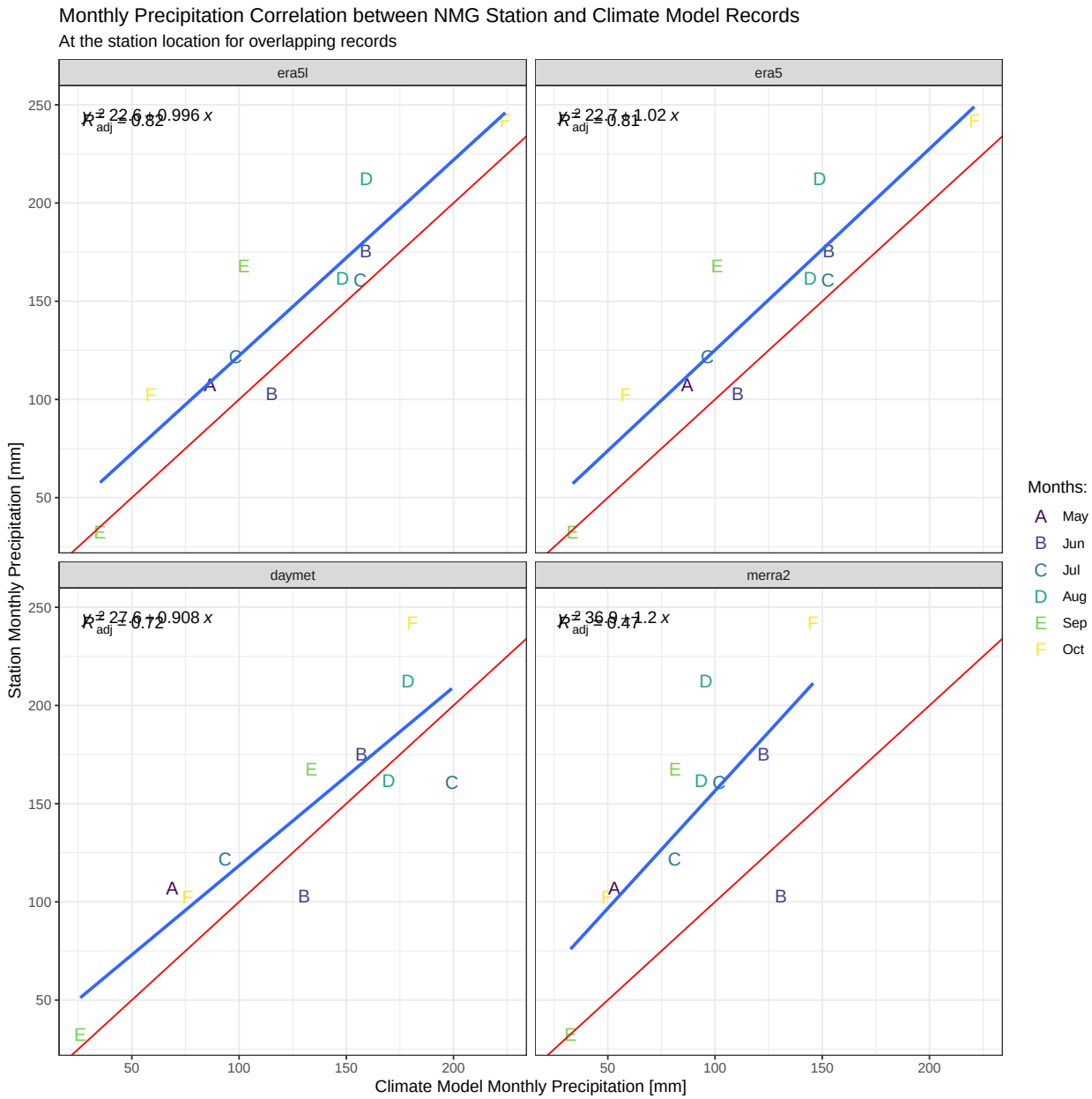
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	NA	NA	NA	NA	77.2	133	114.1	118.1	89.7	117.6	NA	NA	NA
era5	NA	NA	NA	NA	78.5	128.3	112	113.2	89.3	116.1	NA	NA	NA
daymet	NA	NA	NA	NA	85.7	141.1	122.4	128	104.8	122.4	NA	NA	NA
merra2	NA	NA	NA	NA	82.8	118.8	81.2	72.3	72.3	92.9	NA	NA	NA
station	NA	NA	NA	NA	71.7	144.6	76.2	89.6	78.4	96	NA	NA	NA



6.2.2.3 Monthly Correlations for NMG SoftdB

Table 6.2: Monthly Summary of Reanalysis Data matching Observed Data at NMG SoftdB

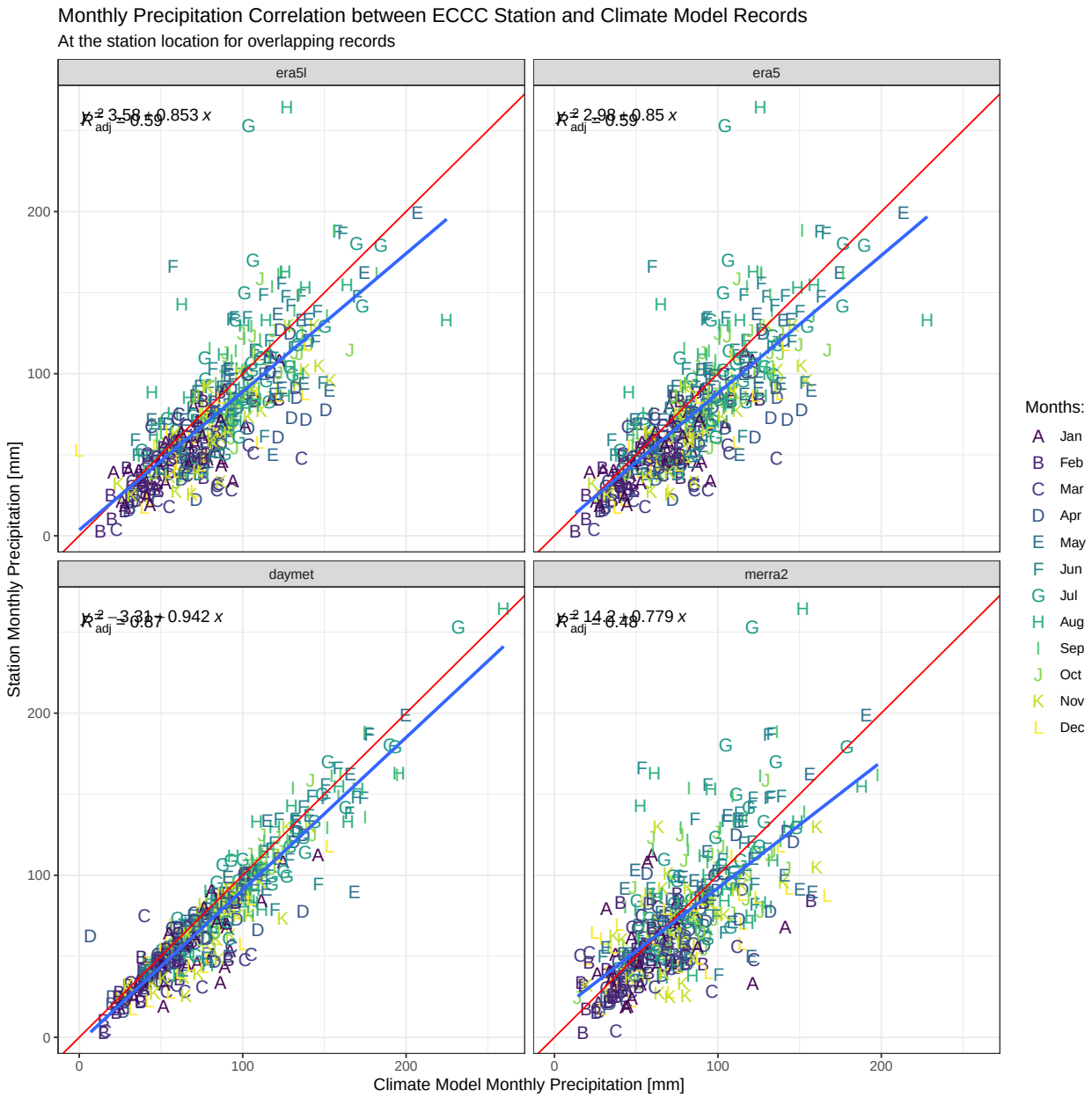
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	NA	NA	NA	NA	86.6	137.2	127.5	153.8	68.7	141.6	NA	NA	NA
era5	NA	NA	NA	NA	87	131.9	124.5	146.6	67.3	139.6	NA	NA	NA
daymet	NA	NA	NA	NA	68.8	143.8	146.3	174.3	79.9	128.4	NA	NA	NA
merra2	NA	NA	NA	NA	53.1	126.7	91.5	94.7	57	97.6	NA	NA	NA
station	NA	NA	NA	NA	108	174.6	141.4	187.2	100.2	172.4	NA	NA	NA



6.2.2.4 Monthly Correlations for ST MICHEL DES SAINTS

Table 6.3: Monthly Summary of Reanalysis Data matching Observed Data at ST MICHEL DES SAINTS

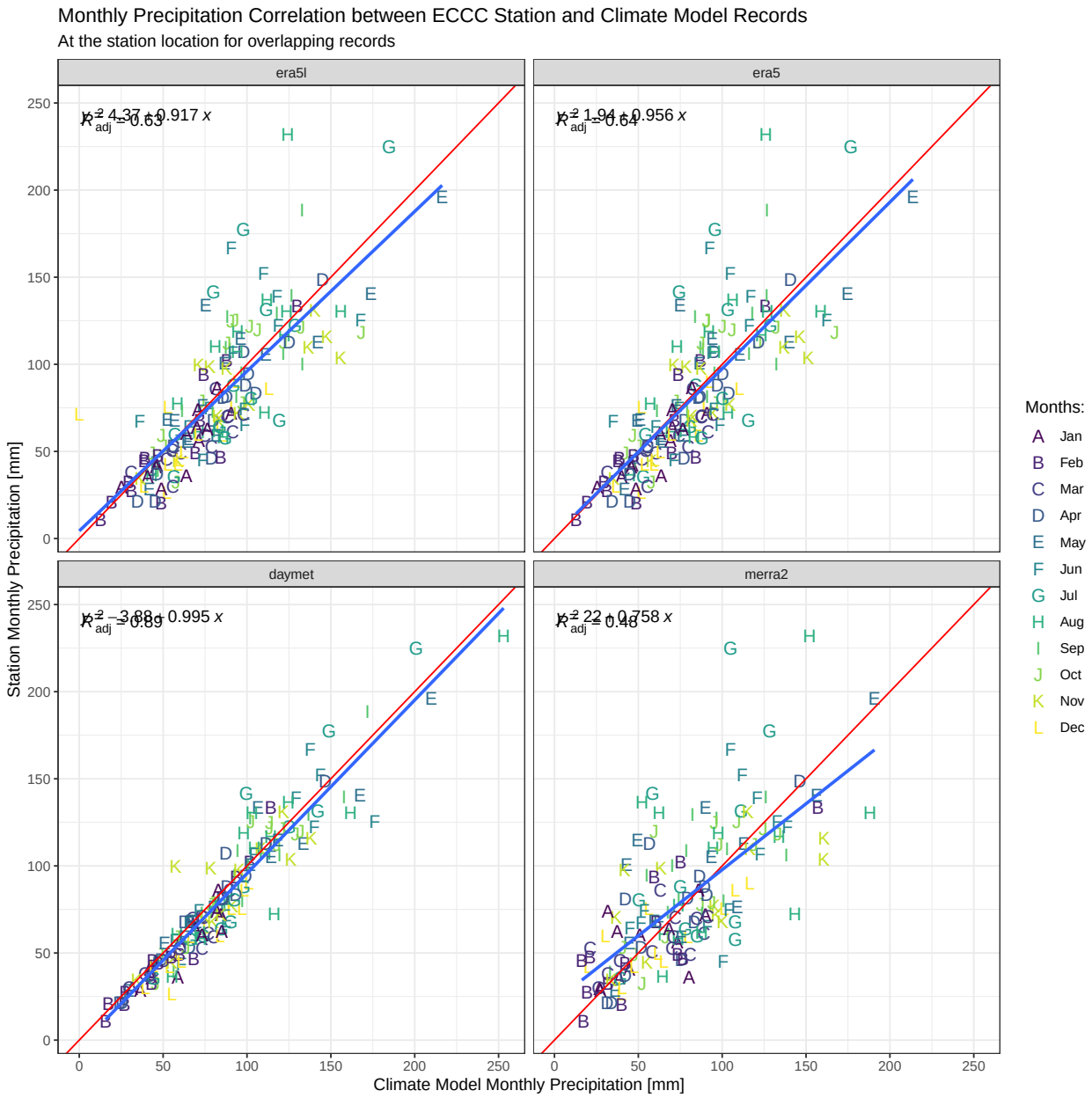
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	65.6	56.2	69.1	88.4	93.9	100.4	102.6	96	97.4	91.3	86.7	77.5	1025
era5	66.1	56.7	69.6	89.4	95.3	101.9	104.2	97	97.7	92.2	87.4	80.4	1038
daymet	66.1	51.3	61	74.4	90.3	112.8	109.7	102.5	105.4	90.1	79.9	76.3	1020
merra2	59.6	53.2	62.8	76.2	86	99.5	94.8	94.3	90.4	87	80.1	77.4	961.3
station	55.9	46.8	55.2	65.7	82.4	103.7	99.9	95.6	99.9	83.1	69.9	68.6	926.5



6.2.2.5 Monthly Correlations for ST ZENON

Table 6.4: Monthly Summary of Reanalysis Data matching Observed Data at ST ZENON

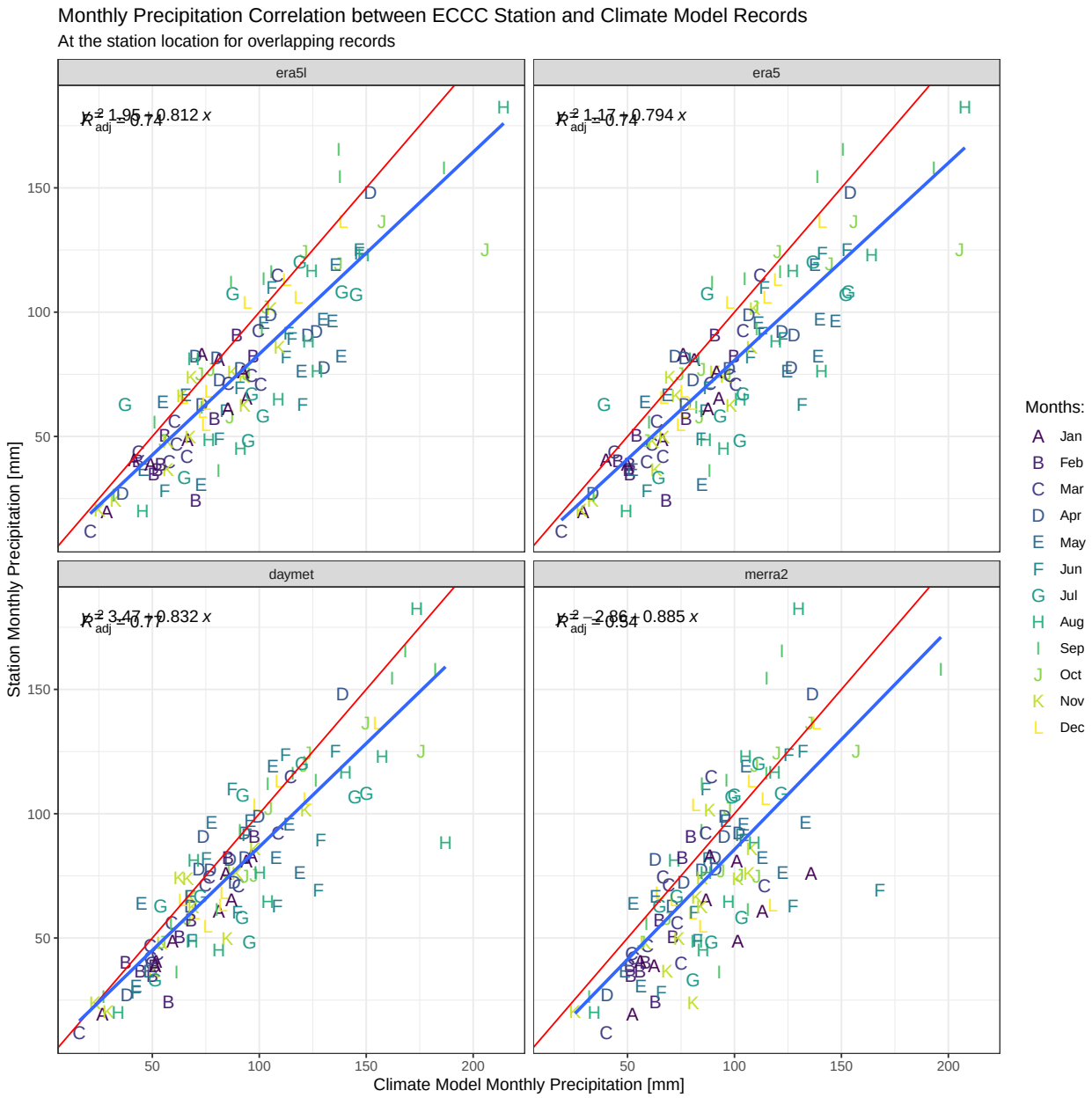
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	61.3	56	68.2	84.9	95.6	91.7	100.1	97.2	98.6	90.8	98.1	65.5	1008
era5	61	55.6	67.7	83.3	93.8	89.8	96.3	95.6	96.8	89.9	97.3	70.1	997.1
daymet	60.9	55.7	62.1	76.2	97.8	101.6	105.6	109.2	105.5	93.9	88.2	71.3	1028
merra2	54.6	53.1	61.4	70	86.4	98.2	86.1	99.2	85.7	86.6	89.7	63.9	935
station	65.6	52.6	62.1	75.2	89	100.5	92.3	105.6	104.7	94.4	88.1	71.6	1002



6.2.2.6 Monthly Correlations for SAINT-MICHEL-DES-SAINTS

Table 6.5: Monthly Summary of Reanalysis Data matching Observed Data at SAINT-MICHEL-DES-SAINTS

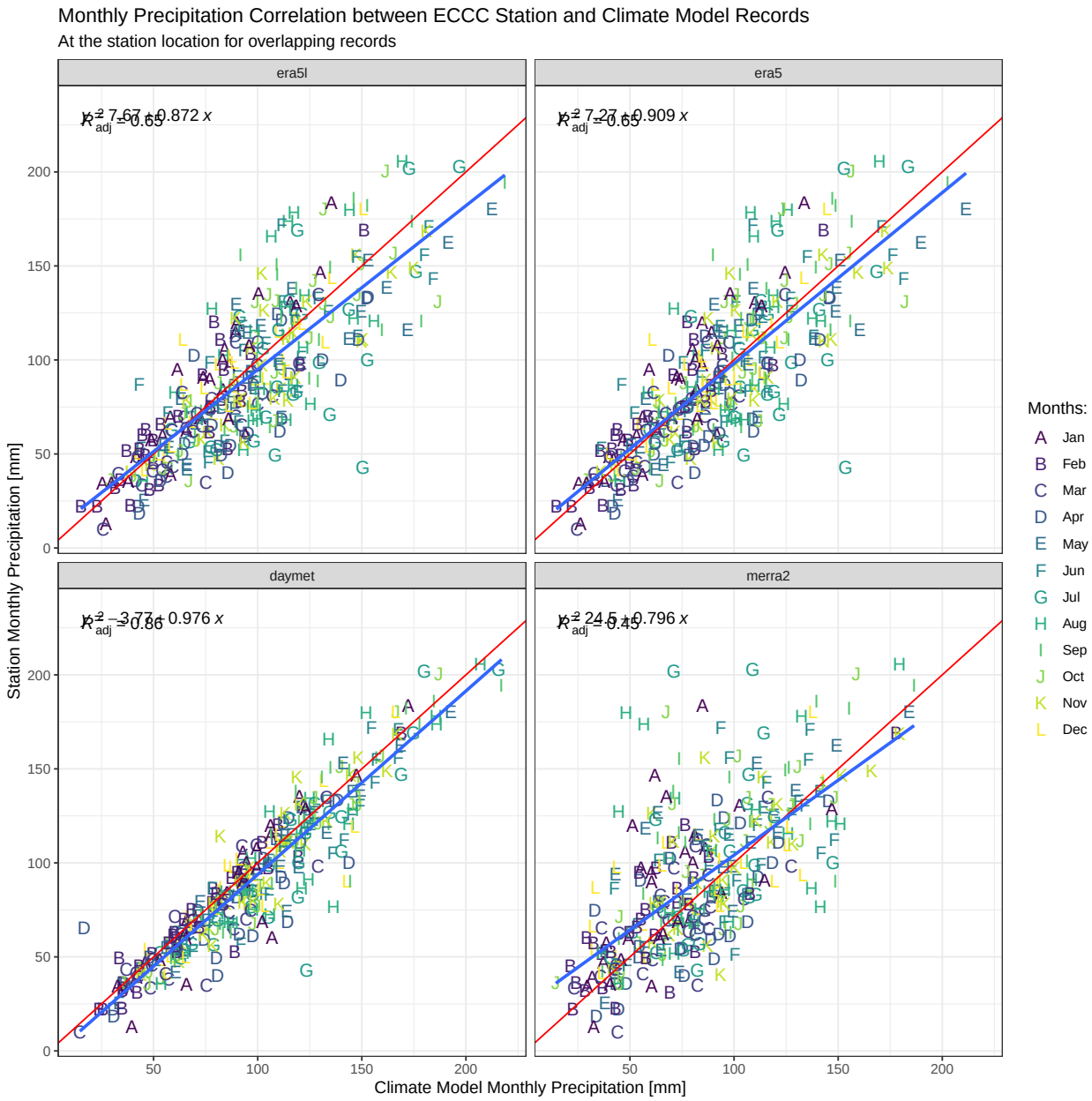
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	68	65.8	72.8	97.2	99.9	106.7	98.5	112.9	99.5	110.9	71.9	92.2	1096
era5	68.3	65.4	74.2	97.8	106.4	109.1	103.7	117.4	106.7	113.4	75.1	94.4	1132
daymet	70.3	61.6	67.3	84.4	82.4	97.3	96.9	111.6	107	107	68.3	95.9	1050
merra2	88.6	63.5	70.8	86.1	89.5	105.8	93.7	92.2	100.4	105	80.4	96	1072
station	57.1	48.6	58.6	82	78.3	87	82.2	84.8	99.5	94.2	60	85.7	918.1



6.2.2.7 Monthly Correlations for ST DONAT

Table 6.6: Monthly Summary of Reanalysis Data matching Observed Data at ST DONAT

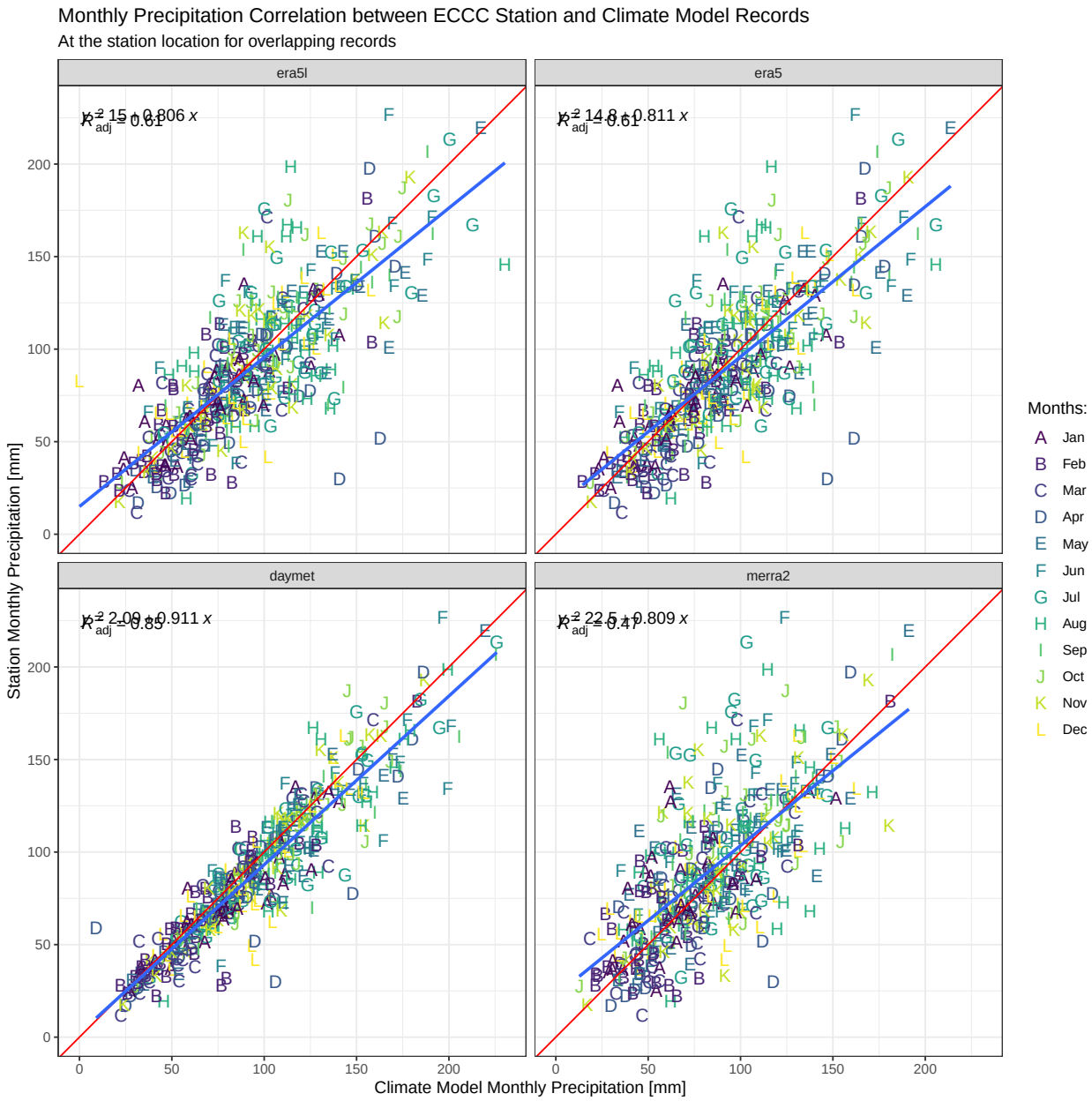
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	74.8	65.2	73.9	94.3	108.7	106.8	117.6	104.6	111.9	105.2	107	88.7	1159
era5	72.5	63.4	71.4	91.4	105.2	102.2	112.9	101.1	106.6	101.4	103.3	85.7	1117
daymet	86.3	68.5	73.2	85	106.1	112.3	114.2	115.1	112.2	107.6	101.7	93.7	1176
merra2	66.8	60.1	70.4	80.8	92.5	98.1	89.4	93.4	92.1	92.9	95.6	81.8	1014
station	84.6	66.4	69.5	72.3	95.7	105.9	102.9	102.9	105.2	101.2	95	96	1098



6.2.2.8 Monthly Correlations for ST COME

Table 6.7: Monthly Summary of Reanalysis Data matching Observed Data at ST COME

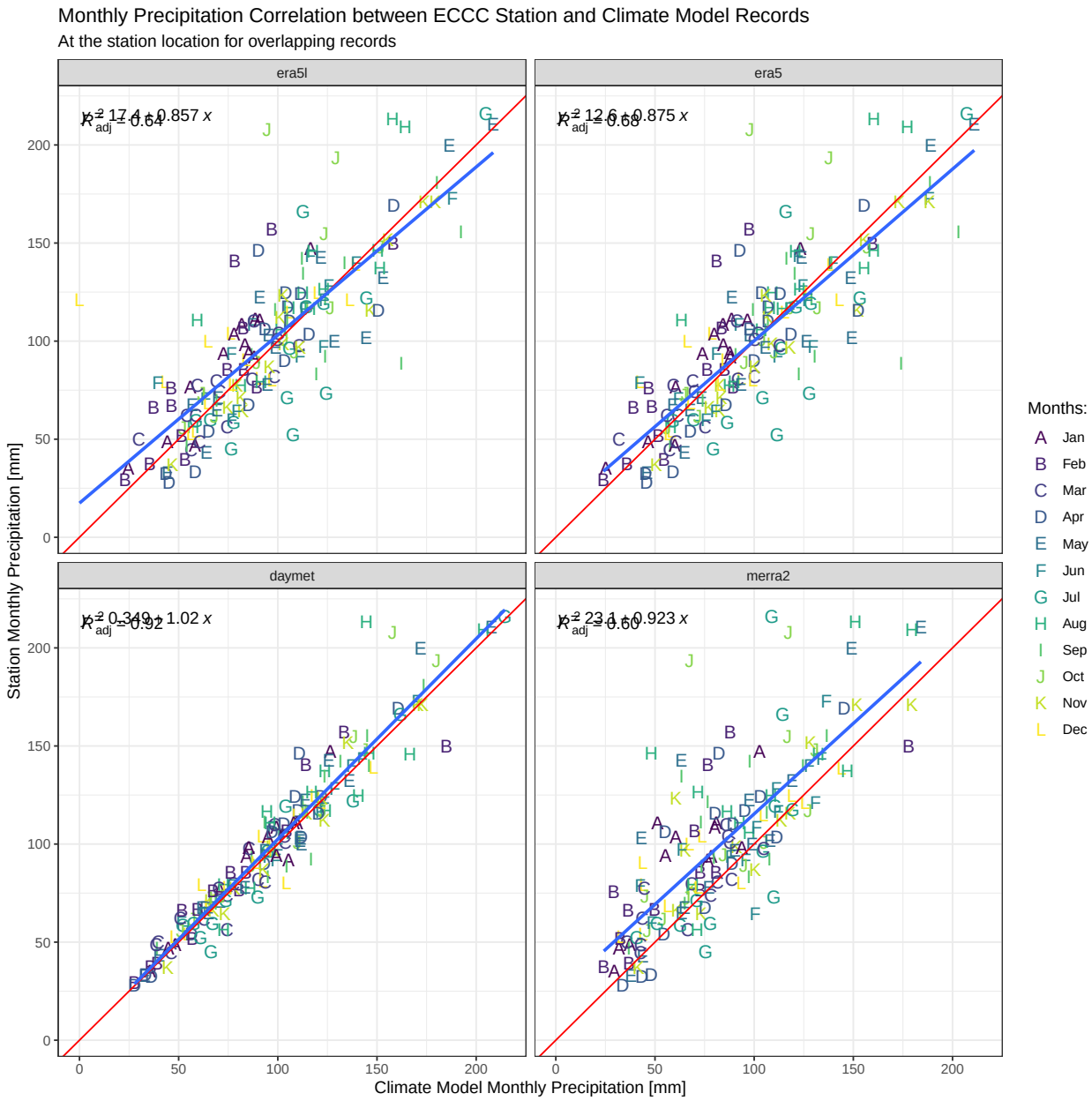
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	73.9	64.6	75.1	95.1	103.4	108	111.3	104.8	105	103	95	85.6	1125
era5	75.6	65.8	75.5	97.6	101.5	105.1	104.2	100.9	104	103.7	96.8	89.9	1120
daymet	80.8	66.5	75.4	90.5	100.1	116.6	114	112.2	111.3	109	97.4	92	1166
merra2	68.2	60.9	72	82.2	87.9	99.4	91	93.8	89.6	93.1	88	86.9	1013
station	74	64.9	71.3	72.9	87.7	102.7	100.1	98.9	103.7	95.1	91.6	89.1	1052



6.2.2.9 Monthly Correlations for NOTRE DAME DE LA MERCI

Table 6.8: Monthly Summary of Reanalysis Data matching Observed Data at NOTRE DAME DE LA MERCI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	74.5	68.3	74.5	95.8	108.5	104.6	109.4	113.7	119.6	98.7	109.6	81	1158
era5	76.9	69.5	75.9	96.8	109.7	106.8	113.7	116.4	125.2	102.9	113.4	89.8	1197
daymet	85.6	79.7	73.9	90.4	102.5	105.3	100.2	120.8	110.8	106.7	104	91.1	1171
merra2	64.9	65.2	68.4	79	88.7	99.5	87.2	101.8	87.6	87.8	96.4	78.6	1005
station	93.7	76	80.7	89.7	103.4	110.3	97.6	114.8	109	110.4	99.3	103	1188

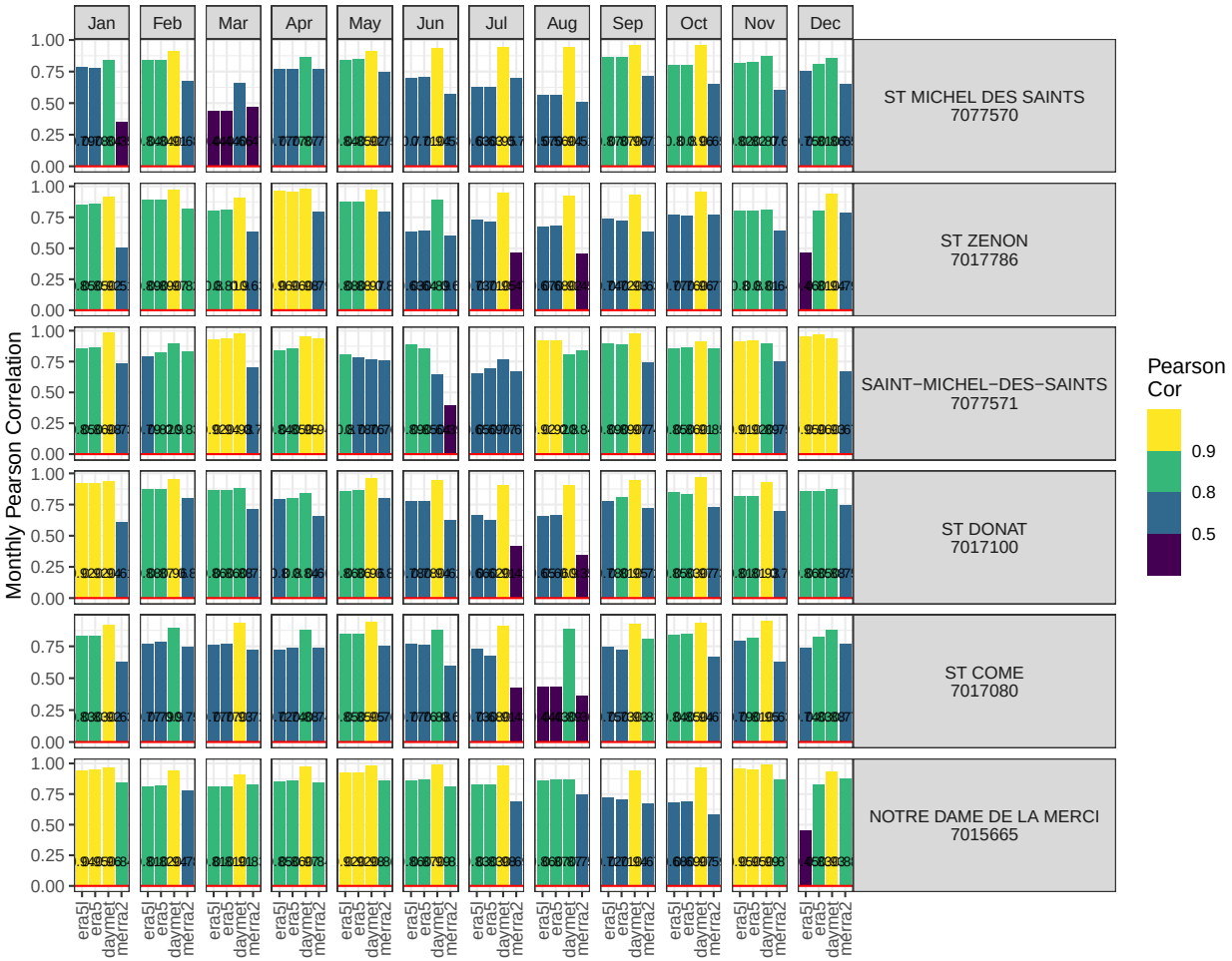


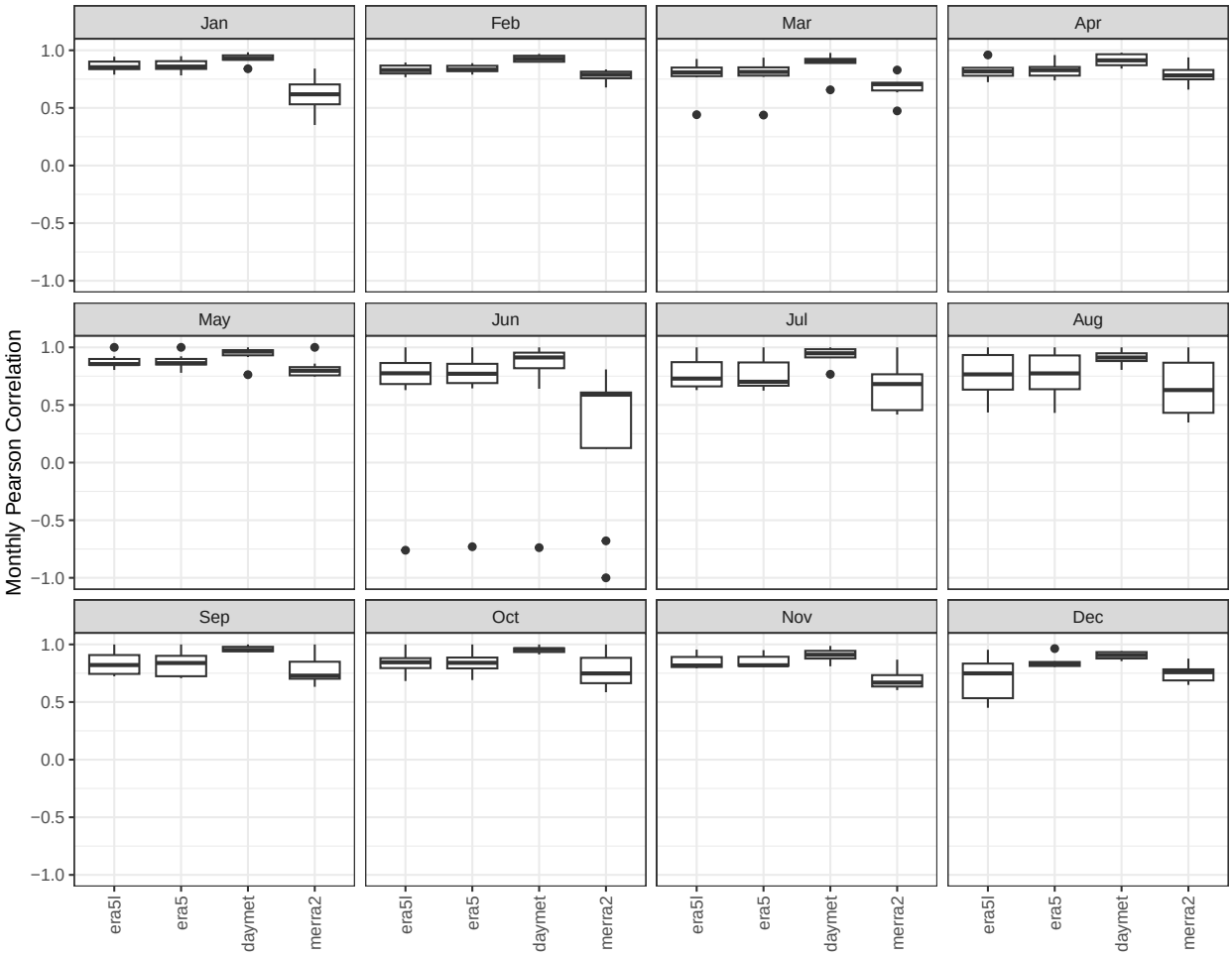
6.2.3 Monthly Pearson Correlation Coefficient

The Pearson correlation coefficient (PCC) is a correlation coefficient that measures linear correlation (and linear only) between two sets of data. It represents a normalized measurement of the covariance, such that the result always has a value between −1 and 1. A value of 0 represents no linear correlation between both datasets. A value of 1 represents perfect positive linear correlation, and a value of -1 perfect negative linear correlation.

Monthly data reviewed in the previous section is summarized in the following figures that represent PCC monthly for ECCC stations versus climate models comparisons.

Daymet generally presents the better linear correlations with station data year round.


Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
ST MICHEL DES SAINTS
7077570
ST ZENON
7017786
SAINT−MICHEL−DES−SAINTS
7077571
ST DONAT
7017100
ST COME
7017080
NOTRE DAME DE LA MERCI
7015665
Monthly Pearson Correlation
1.00
0.75
0.50
0.25
0.00
era5l
era5
daymet
merra2
Pearson
Cor
0.9
0.8
0.5


Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Monthly Pearson Correlation
1.0
0.5
0.0
−0.5
−1.0
era5l
era5
daymet
merra2

Chapter 7

Rainfall and Snowfall Analysis

Total precipitation relationships across stations and areas can be better interpreted by dividing precipitation records into components of rainfall and snowfall.

Given regional trends, the analysis was completed at a local scale (50 km) using all available ECCC records and four reanalysis products: Daymet, ERA5, ERA5-Land, and MERRA2.

The division of rainfall and snowfall for reanalysis products was directly based on zero degrees. Different methods for partitioning total precipitation for local stations and outcomes are evaluated and summarized in a subsequent review.

- Rainfall = total precipitation when Tavg>0
- Snowfall = total precipitation when Tavg 0

Main findings of this section are:

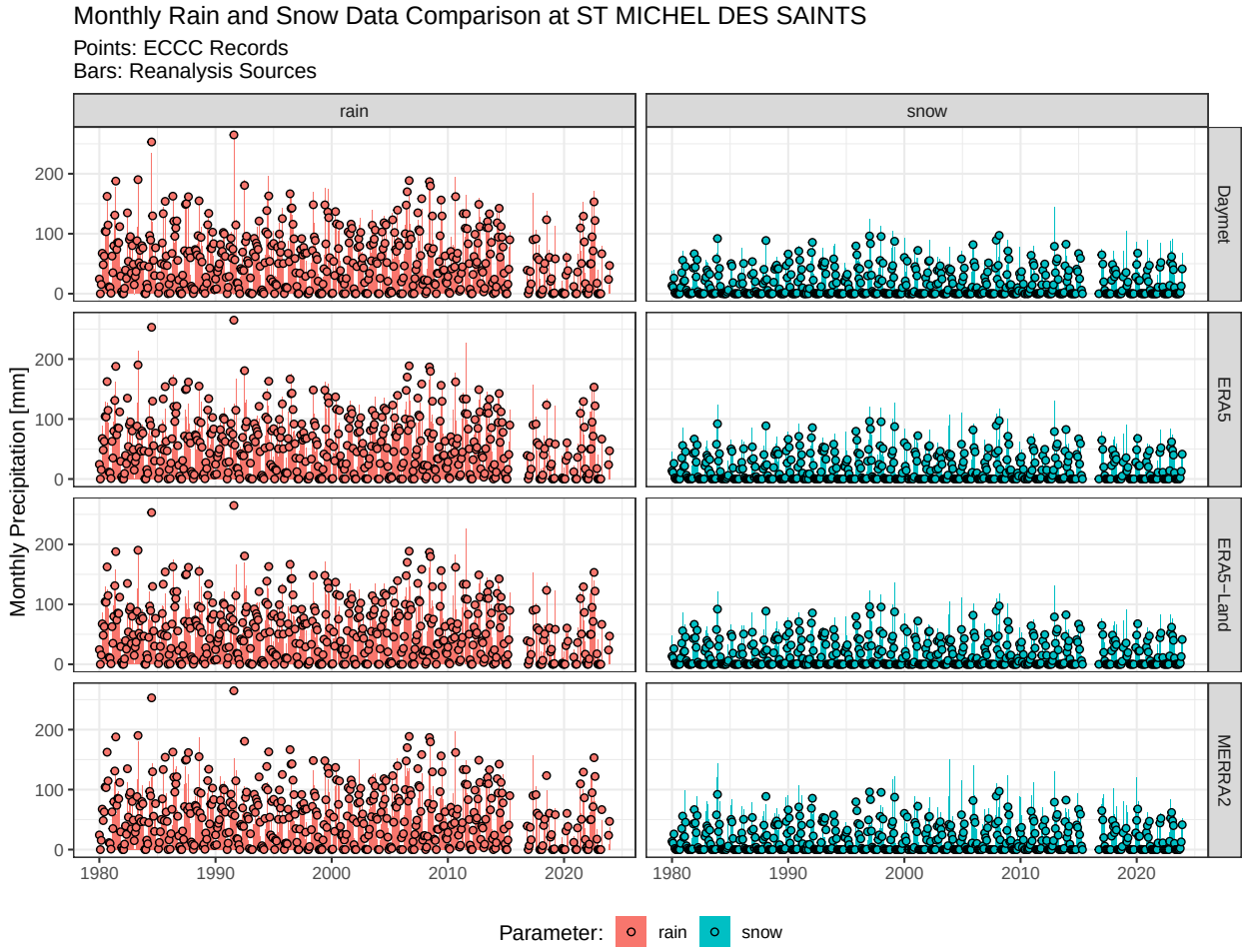
- Daymet is the reanalysis tool that best correlates with ECCC rain and snow data in the project region.
- Reanalysis tools (including Daymet) present bias compared to ECCC measured data. Generally, precipitation, rain and/or snow values presented by the reanalysis tools are greater than measured values reported by ECCC.
- Reanalysis snow records generally present more bias than reanalysis rainfall records when compared to ECCC measured data.

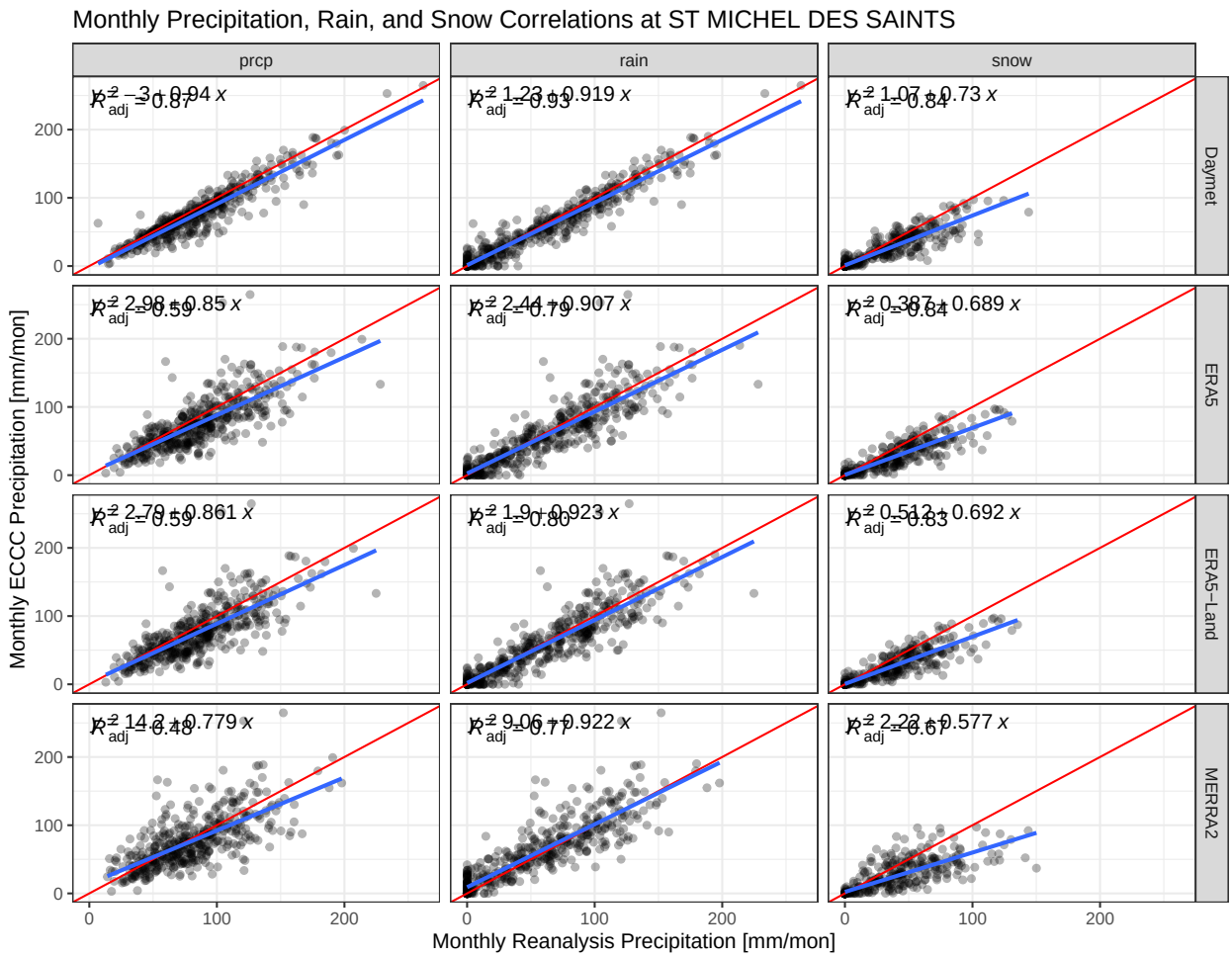
7.1 Rain/Snow ST MICHEL DES SAINTS

Table 7.1: Mean Rain and Snow Monthly Values at ST MICHEL DES SAINTS

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
prcp	ECCC	52	45	52	66	83	106	103	95	101	84	68	64	921
prcp	Daymet	66	51	61	74	90	113	110	102	105	90	80	76	1018
prcp	ERA5	66	57	70	89	95	102	104	97	98	92	87	80	1038
prcp	ERA5-Land	66	56	69	88	94	100	103	96	97	91	87	80	1027
prcp	MERRA2	60	53	63	76	86	100	95	94	90	87	80	77	961
rain	ECCC	10	6	19	52	83	106	103	95	101	81	42	12	709
rain	Daymet	7	6	19	61	90	113	110	102	105	86	44	12	756

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
rain	ERA5	7	7	22	70	95	102	104	97	98	86	45	13	746
rain	ERA5-Land	7	7	22	69	94	100	103	96	97	87	45	13	740
rain	MERRA2	2	2	8	49	86	100	95	94	90	80	37	6	649
snow	ECCC	43	39	35	13	0	0	0	0	0	3	25	50	208
snow	Daymet	60	48	42	12	0	0	0	0	0	4	36	66	268
snow	ERA5	60	52	48	19	0	0	0	0	0	6	42	68	295
snow	ERA5-Land	59	52	48	20	0	0	0	0	0	4	41	67	291
snow	MERRA2	60	52	55	27	0	0	0	0	0	7	43	70	315



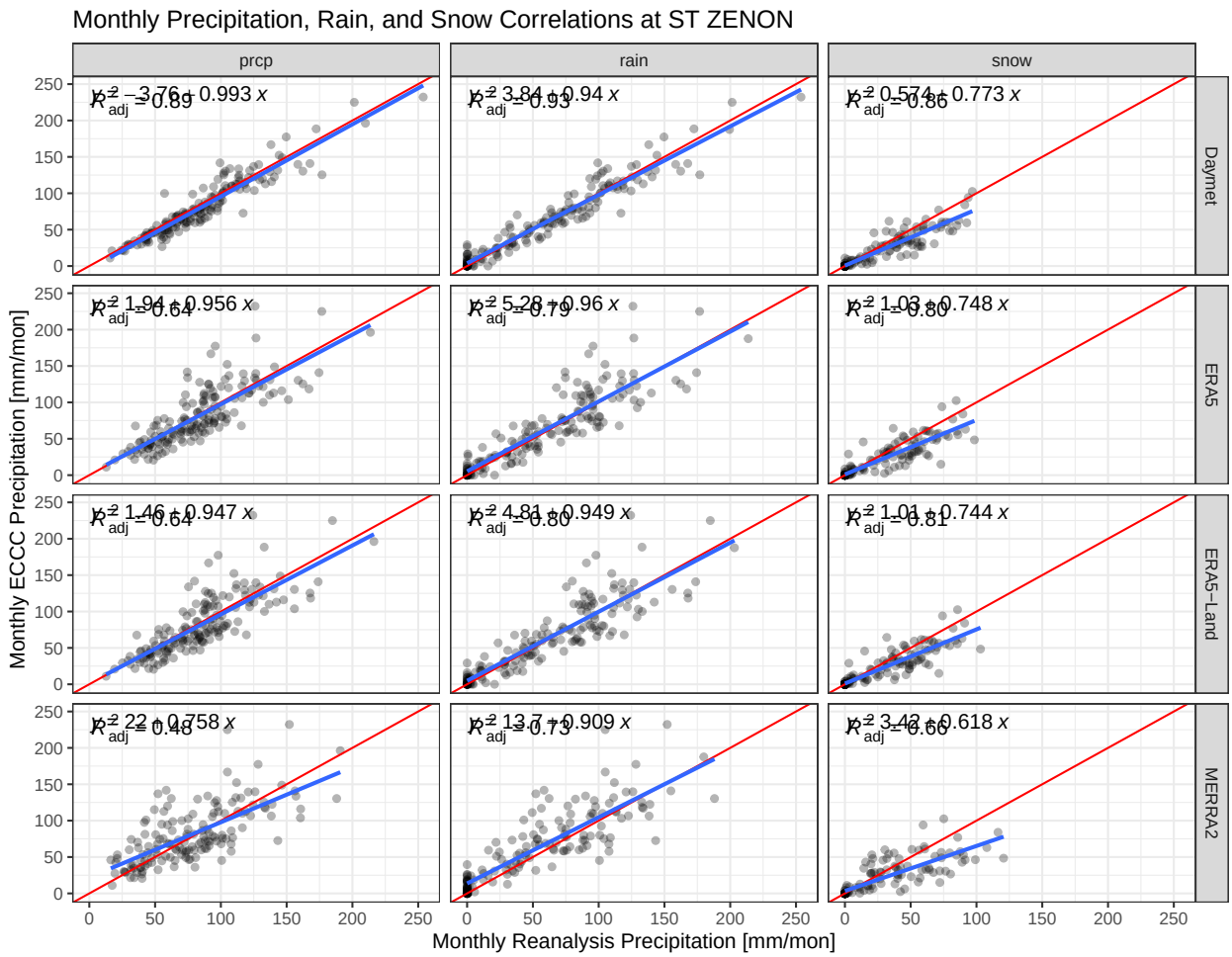


7.2 Rain/Snow ST ZENON

Table 7.2: Mean Rain and Snow Monthly Values at ST ZENON

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
prcp	ECCC	53	53	56	75	94	96	104	104	104	93	86	58	976
prcp	Daymet	61	56	62	76	98	102	106	109	106	94	88	72	1030
prcp	ERA5	61	56	68	83	94	90	96	96	97	90	97	70	997
prcp	ERA5-Land	61	56	68	85	96	92	100	97	99	91	98	71	1013
prcp	MERRA2	55	53	61	70	86	98	86	99	86	87	90	64	935
rain	ECCC	9	9	22	59	93	96	104	104	104	90	56	10	755
rain	Daymet	3	7	22	60	97	102	106	109	106	88	46	6	753
rain	ERA5	3	10	26	67	94	90	96	96	97	86	48	6	719
rain	ERA5-Land	3	8	26	67	95	92	100	97	99	89	52	6	733
rain	MERRA2	0	5	10	50	85	98	86	99	86	81	38	3	642
snow	ECCC	44	45	34	16	1	0	0	0	0	4	31	47	220
snow	Daymet	59	48	40	16	1	0	0	0	0	6	43	65	277
snow	ERA5	59	46	41	16	0	0	0	0	0	4	49	64	279
snow	ERA5-Land	60	48	42	18	1	0	0	0	0	2	46	64	281
snow	MERRA2	54	49	51	20	1	0	0	0	0	5	52	61	292

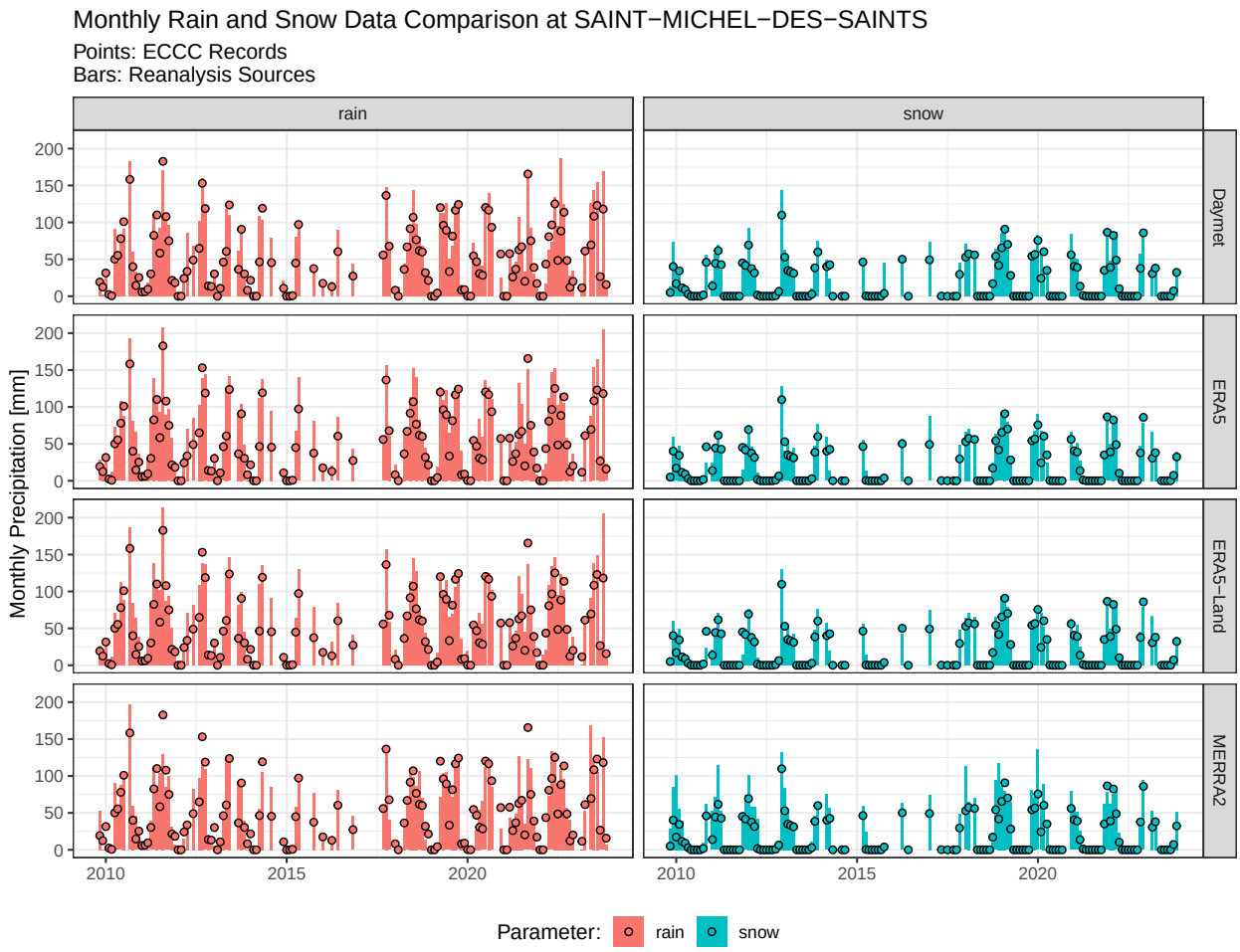
Monthly Rain and Snow Data Comparison at ST ZENON
Points: ECCC Records
Bars: Reanalysis Sources
rain
snow
Daymet
ERA5
ERA5−Land
MERRA2
Monthly Precipitation [mm]
0
50
100
150
200
250
1980
1985
1990
1995
Parameter:
rain
snow

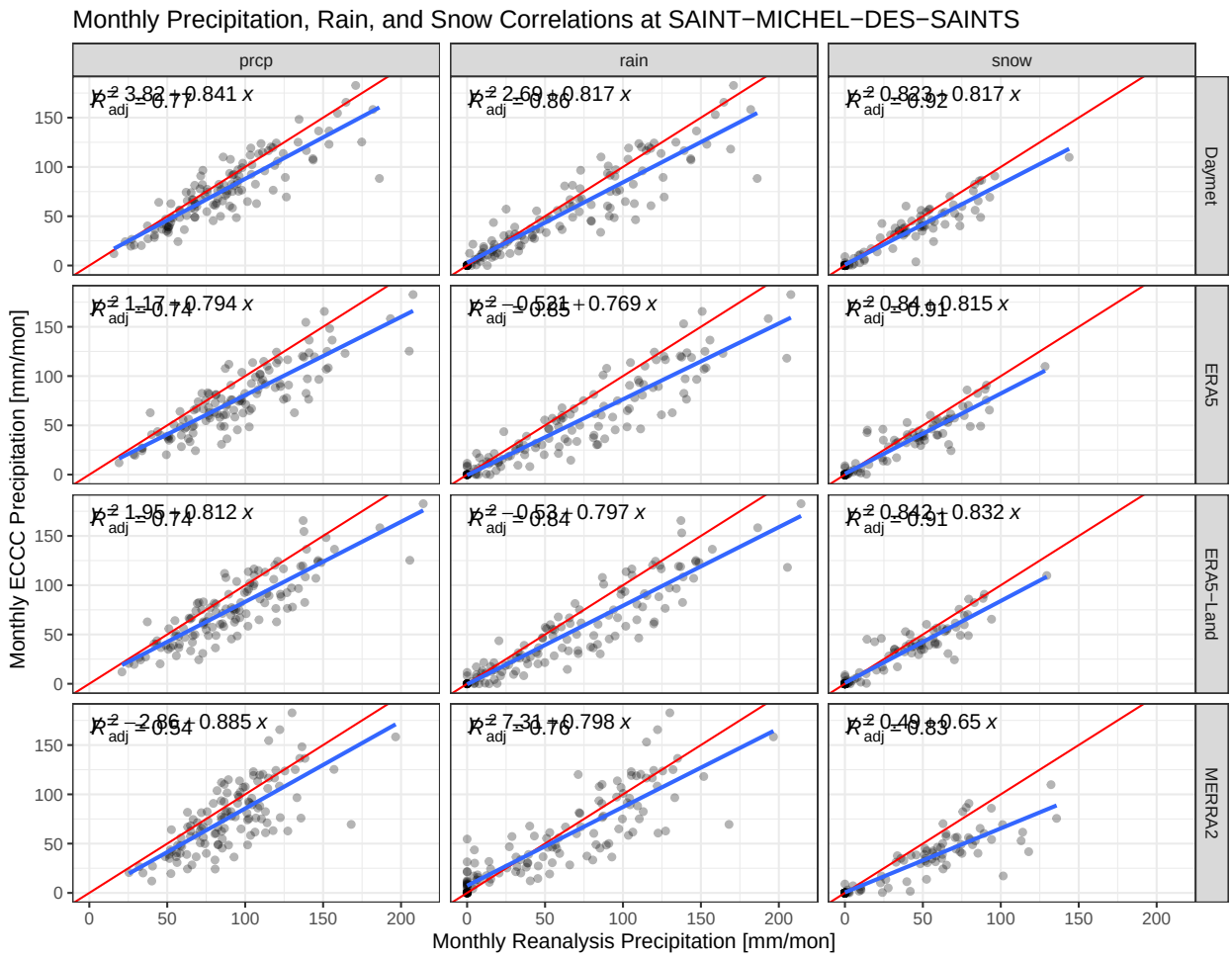


7.3 Rain/Snow SAINT-MICHEL-DES-SAINTS

Table 7.3: Mean Rain and Snow Monthly Values at SAINT-MICHEL-DES-SAINTS

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
prcp	ECCC	57	51	60	83	77	81	79	85	100	94	60	86	913
prcp	Daymet	69	61	66	83	81	96	95	110	106	105	67	95	1033
prcp	ERA5	68	65	74	98	106	109	104	117	107	113	75	94	1132
prcp	ERA5-Land	68	66	73	97	100	107	98	113	99	111	72	92	1096
prcp	MERRA2	89	63	71	86	90	106	94	92	100	105	80	96	1072
rain	ECCC	10	1	20	49	74	81	80	89	99	84	25	19	631
rain	Daymet	8	2	21	64	81	96	100	114	106	96	29	16	734
rain	ERA5	10	3	23	71	105	109	112	121	107	107	41	20	830
rain	ERA5-Land	12	3	22	71	99	107	106	117	99	105	38	20	800
rain	MERRA2	1	0	7	48	89	106	97	93	100	98	31	8	681
snow	ECCC	48	49	41	27	0	0	0	0	0	3	35	64	267
snow	Daymet	62	58	45	23	0	0	0	0	0	8	41	80	316
snow	ERA5	60	62	51	27	1	0	0	0	0	3	36	75	316
snow	ERA5-Land	57	62	51	27	0	0	0	0	0	3	35	74	309
snow	MERRA2	87	63	63	39	0	0	0	0	0	6	52	89	399

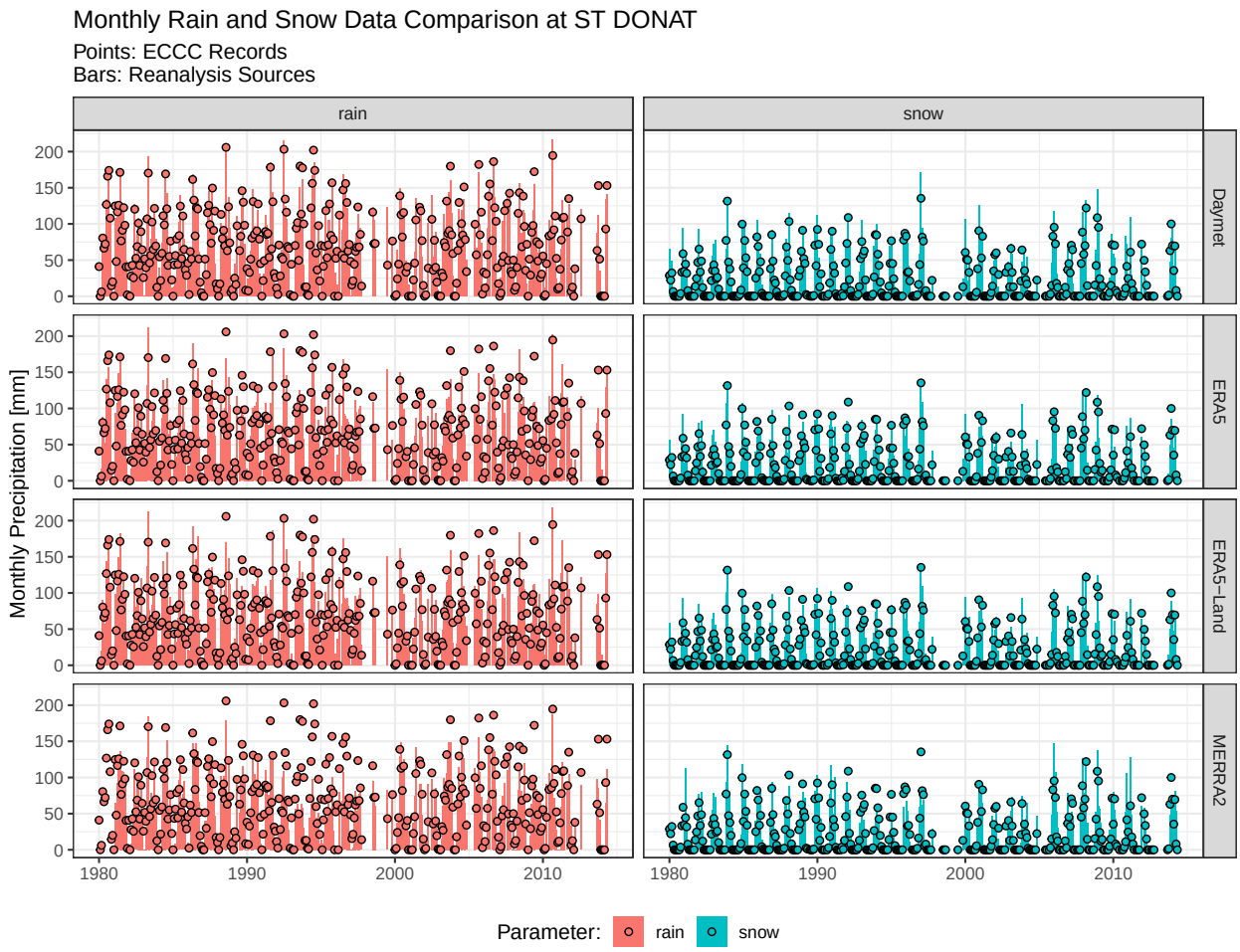

Monthly Rain and Snow Data Comparison at SAINT−MICHEL−DES−SAINTS
Points: ECCC Records
Bars: Reanalysis Sources
rain
snow
Daymet
ERA5
ERA5−Land
MERRA2
Monthly Precipitation [mm]
0
50
100
150
200
2010
2015
2020
Parameter:
rain
snow

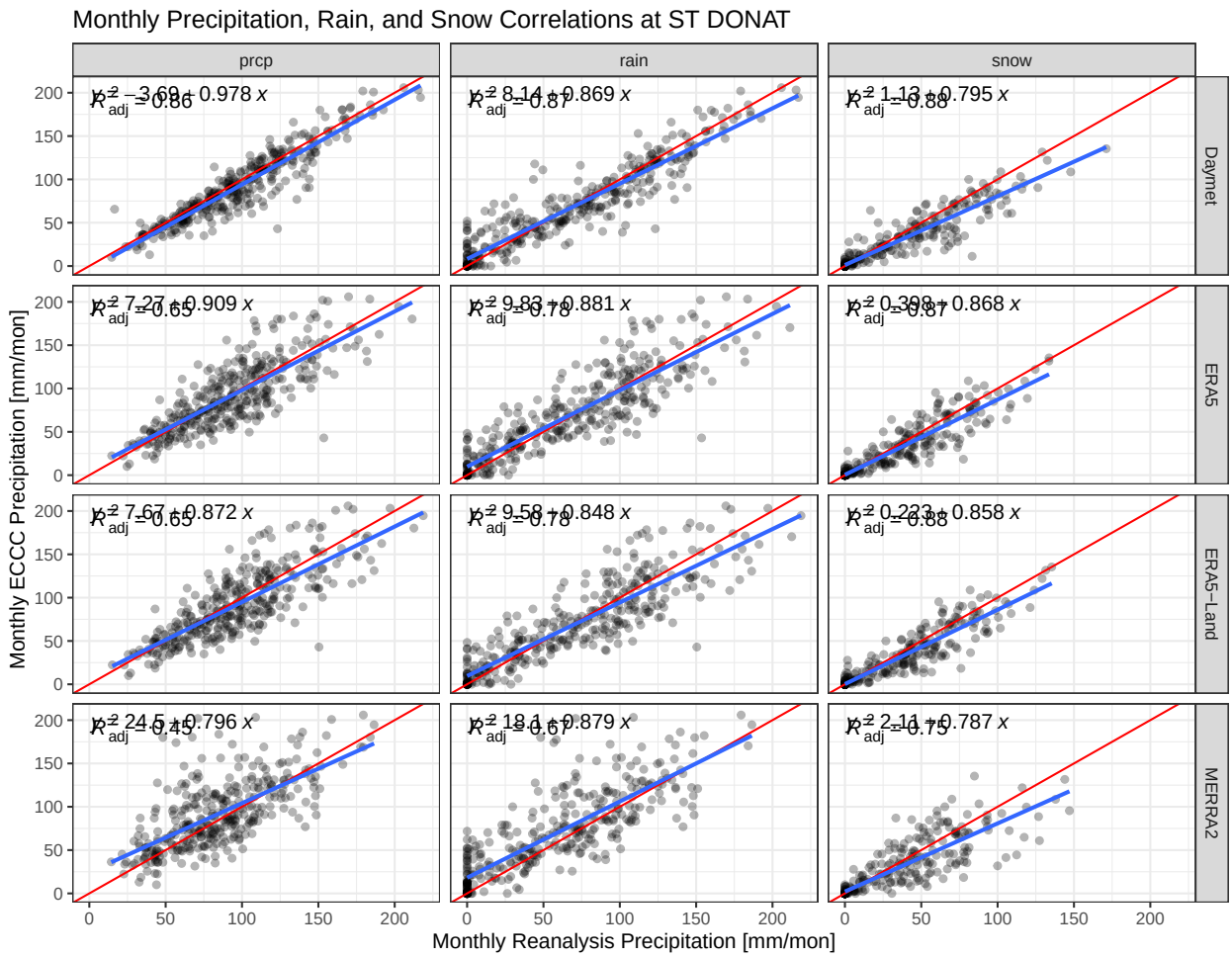


7.4 Rain/Snow ST DONAT

Table 7.4: Mean Rain and Snow Monthly Values at ST DONAT

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
prcp	ECCC	84	68	67	76	100	103	100	105	108	104	98	90	1101
prcp	Daymet	86	68	73	85	106	112	114	115	112	107	101	93	1173
prcp	ERA5	72	63	71	91	105	102	113	101	107	101	103	86	1117
prcp	ERA5-Land	75	65	74	94	109	107	118	105	112	105	107	89	1159
prcp	MERRA2	67	60	70	81	92	98	89	93	92	93	96	82	1014
rain	ECCC	21	15	27	63	99	103	100	105	108	99	65	23	828
rain	Daymet	9	9	22	71	106	112	114	115	112	102	58	12	841
rain	ERA5	8	10	23	76	105	102	113	101	107	95	55	12	807
rain	ERA5-Land	8	10	25	77	108	107	118	105	112	100	59	13	842
rain	MERRA2	4	3	14	60	92	98	89	93	92	87	50	9	691
snow	ECCC	63	52	41	15	1	0	0	0	0	6	31	68	276
snow	Daymet	77	59	51	14	0	0	0	0	0	6	42	82	331
snow	ERA5	65	53	48	18	0	0	0	0	0	7	48	74	313
snow	ERA5-Land	67	56	49	20	1	0	0	0	0	5	46	76	319
snow	MERRA2	63	57	57	21	0	0	0	0	0	6	44	73	322

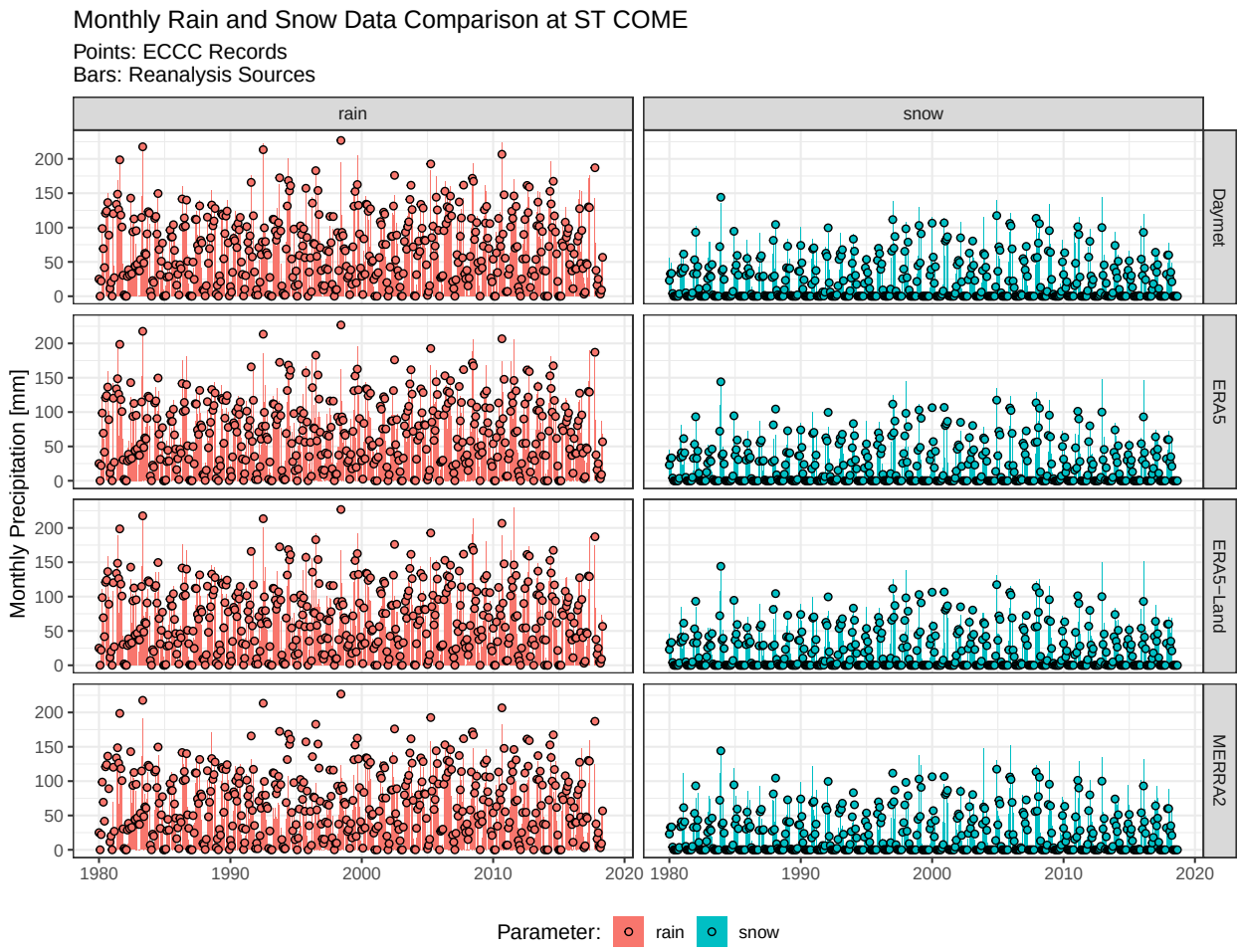

Monthly Rain and Snow Data Comparison at ST DONAT
Points: ECCC Records
Bars: Reanalysis Sources
rain
snow
Daymet
ERA5
ERA5−Land
MERRA2
Monthly Precipitation [mm]
0
50
100
150
200
1980
1990
2000
2010
Parameter:
rain
snow

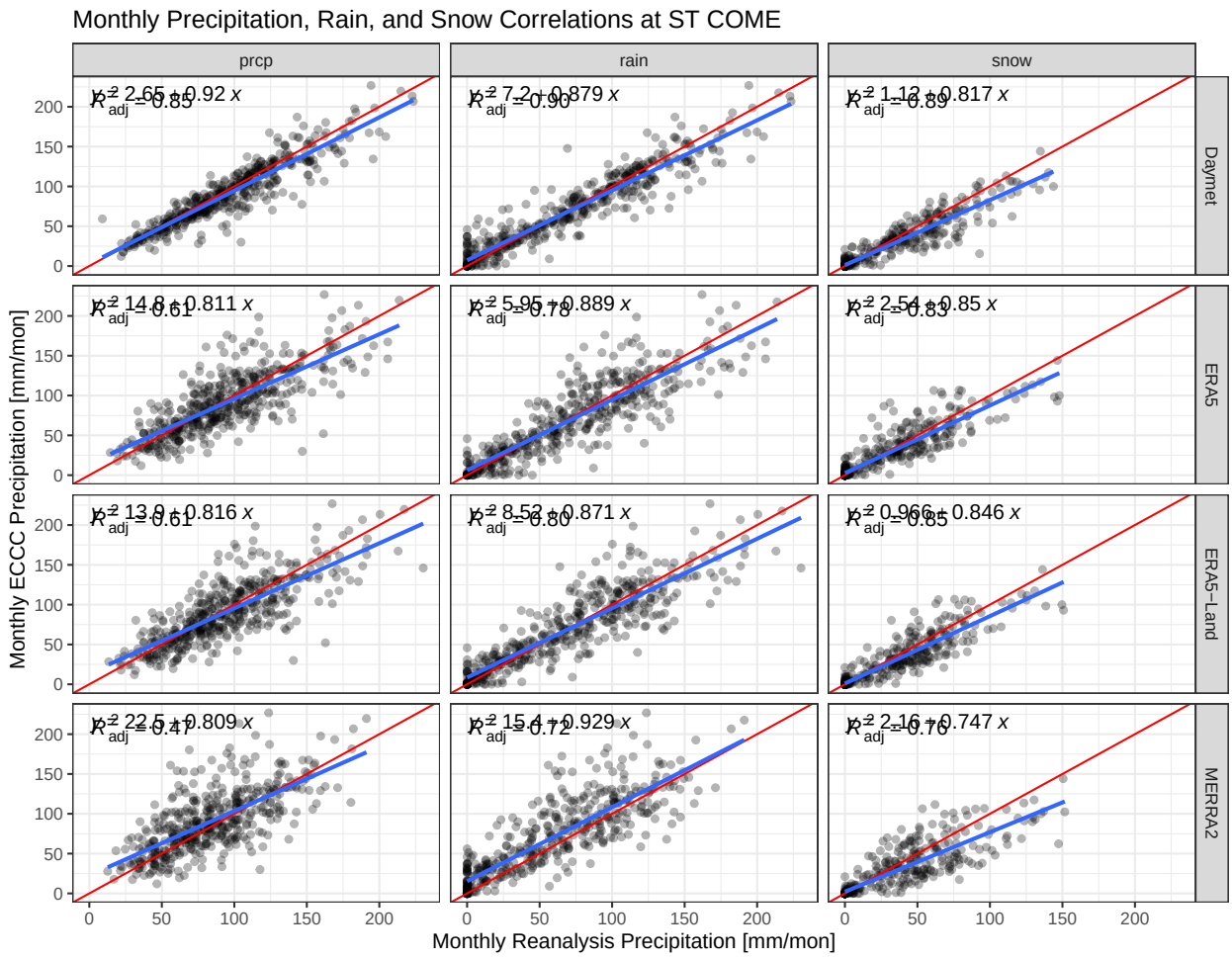


7.5 Rain/Snow ST COME

Table 7.5: Mean Rain and Snow Monthly Values at ST COME

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
prcp	ECCC	74	63	73	81	93	108	107	102	103	105	94	84	1087
prcp	Daymet	79	65	74	89	99	115	112	110	110	107	96	90	1147
prcp	ERA5	76	66	75	98	101	105	104	101	104	104	97	90	1121
prcp	ERA5-Land	74	65	75	95	103	108	111	105	105	103	95	88	1127
prcp	MERRA2	68	61	72	82	88	99	91	94	90	93	88	87	1013
rain	ECCC	16	13	30	68	93	108	107	102	103	102	68	20	829
rain	Daymet	9	9	24	79	99	115	112	110	110	104	61	12	845
rain	ERA5	12	15	33	87	101	105	104	101	104	102	67	19	850
rain	ERA5-Land	10	11	27	79	103	108	111	105	105	100	58	15	833
rain	MERRA2	4	3	15	63	88	99	91	94	90	90	49	10	695
snow	ECCC	59	51	43	14	0	0	0	0	0	3	26	64	261
snow	Daymet	70	56	50	11	0	0	0	0	0	3	35	78	303
snow	ERA5	64	51	42	12	0	0	0	0	0	2	30	71	271
snow	ERA5-Land	64	54	48	17	0	0	0	0	0	3	37	73	295
snow	MERRA2	64	58	57	20	0	0	0	0	0	4	39	76	317

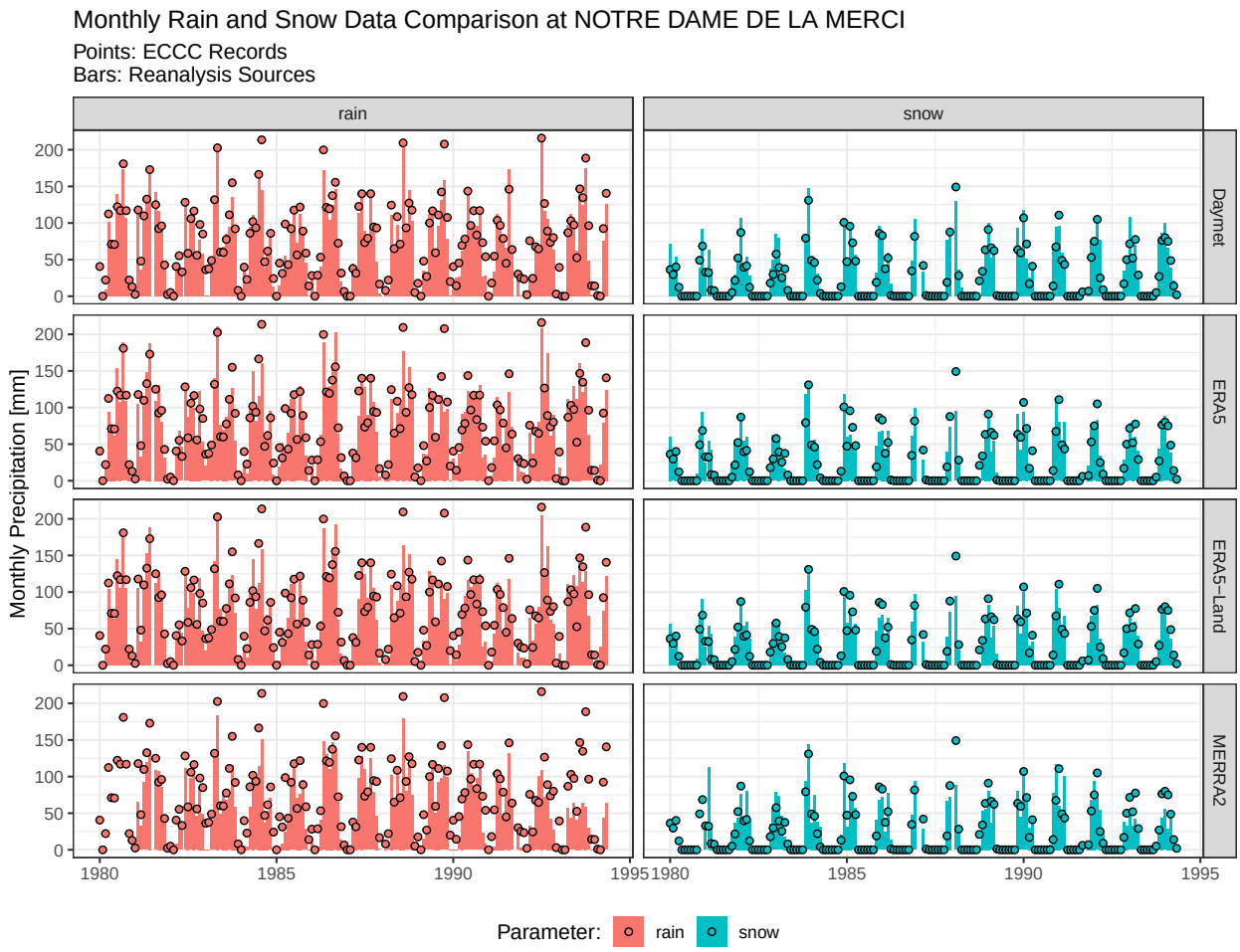

Monthly Rain and Snow Data Comparison at ST COME
Points: ECCC Records
Bars: Reanalysis Sources
rain
snow
Daymet
ERA5
ERA5−Land
MERRA2
Monthly Precipitation [mm]
0
50
100
150
200
1980
1990
2000
2010
2020
Parameter:
rain
snow

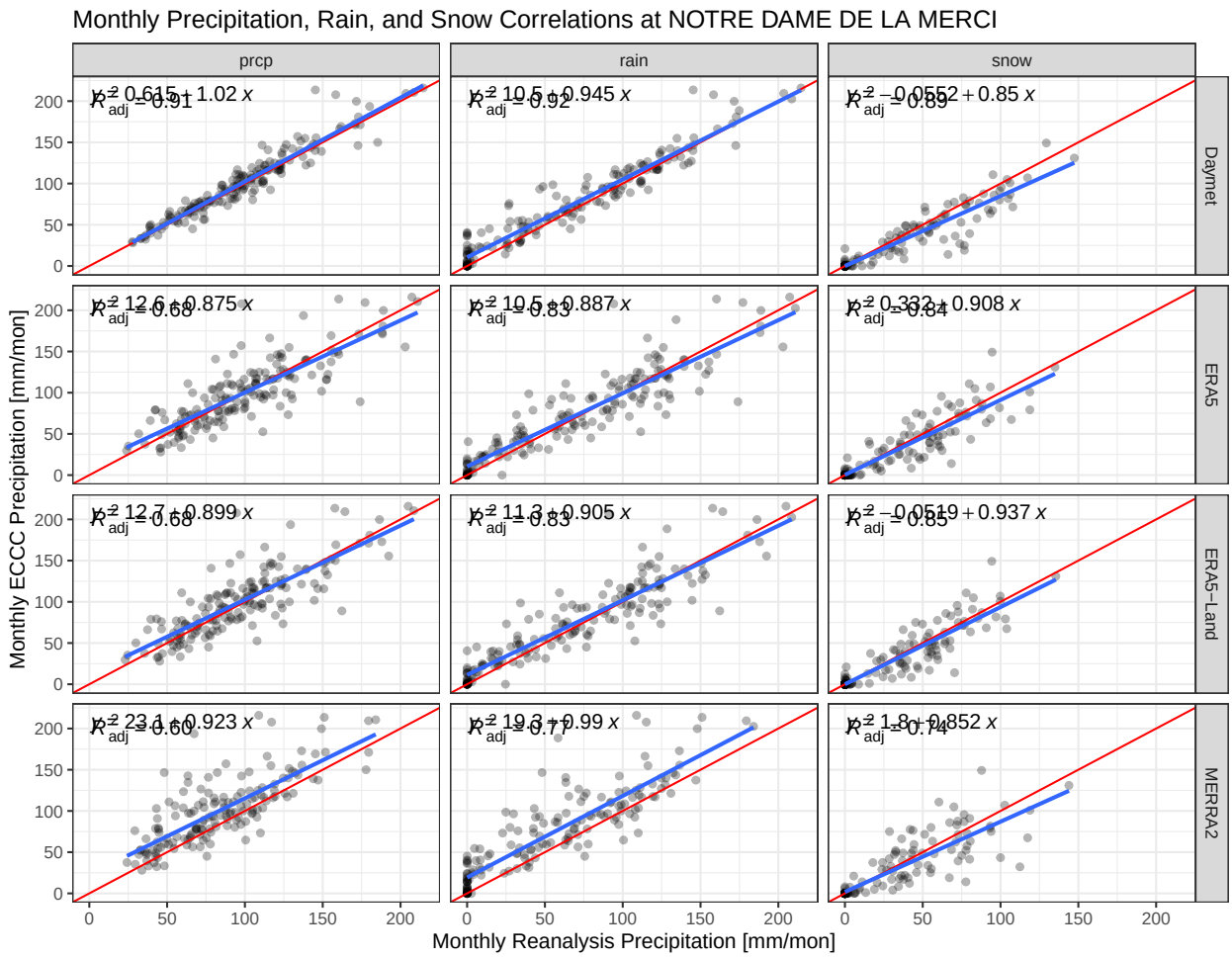


7.6 Rain/Snow NOTRE DAME DE LA MERCI

Table 7.6: Mean Rain and Snow Monthly Values at NOTRE DAME DE LA MERCI

par	variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
prcp	ECCC	90	84	75	95	105	106	97	126	113	114	103	92	1200
prcp	Daymet	86	80	74	91	102	105	100	121	111	107	104	91	1172
prcp	ERA5	77	70	76	97	110	107	114	116	125	103	113	90	1197
prcp	ERA5-Land	75	68	74	96	109	105	109	114	120	99	110	87	1164
prcp	MERRA2	65	65	68	79	89	99	87	102	88	88	96	79	1005
rain	ECCC	18	19	35	80	104	106	97	126	112	112	74	21	904
rain	Daymet	4	14	25	74	102	105	100	121	111	104	56	8	823
rain	ERA5	7	13	31	82	110	107	114	116	125	99	62	9	876
rain	ERA5-Land	6	12	30	79	109	105	109	114	120	97	60	9	848
rain	MERRA2	1	5	15	59	89	99	87	102	88	84	48	5	681
snow	ECCC	71	63	40	14	1	0	0	0	0	2	30	72	295
snow	Daymet	82	65	49	17	0	0	0	0	0	3	48	83	348
snow	ERA5	69	55	45	15	0	0	0	0	0	4	51	80	320
snow	ERA5-Land	68	55	45	17	0	0	0	0	0	2	50	78	315
snow	MERRA2	64	60	54	20	0	0	0	0	0	4	48	74	324


Monthly Rain and Snow Data Comparison at NOTRE DAME DE LA MERCI
Points: ECCC Records
Bars: Reanalysis Sources
rain
snow
Daymet
ERA5
ERA5−Land
MERRA2
Monthly Precipitation [mm]
0
50
100
150
200
1980
1985
1990
1995
Parameter:
rain
snow


Monthly Precipitation, Rain, and Snow Correlations at NOTRE DAME DE LA MERCI
prcp
rain
snow
Daymet
ERA5
ERA5−Land
MERRA2
$R^2_{adj} = 0.91$ $0.615 + 1.02\,x$
$R^2_{adj} = 0.92$ $10.5 + 0.945\,x$
$R^2_{adj} = 0.89$ $-0.0552 + 0.85\,x$
$R^2_{adj} = 0.68$ $12.6 + 0.875\,x$
$R^2_{adj} = 0.83$ $10.5 + 0.887\,x$
$R^2_{adj} = 0.84$ $0.332 + 0.908\,x$
$R^2_{adj} = 0.68$ $12.7 + 0.899\,x$
$R^2_{adj} = 0.83$ $11.3 + 0.905\,x$
$R^2_{adj} = 0.85$ $-0.0519 + 0.937\,x$
$R^2_{adj} = 0.60$ $23.1 + 0.923\,x$
$R^2_{adj} = 0.77$ $19.3 + 0.99\,x$
$R^2_{adj} = 0.74$ $1.8 + 0.852\,x$
Monthly ECCC Precipitation [mm/mon]
Monthly Reanalysis Precipitation [mm/mon]
0
50
100
150
200

Chapter 8

Snowmelt Validation

To further assess reanalysis model results, a separate regional snowpack and snowmelt validation review was undertaken. Please refer to Report **03a Snowpack Check** for further details.

The main takeaways from this analysis are listed below:

- Overprediction bias in Snowpack model was consistent with review of reanalysis products. Further correction to Daymet to better represent site precipitation is required.
- Precipitation undercatch correction is not required due to general overprediction bias both in the reanalysis products for precipitation and the snowpack model results.

Chapter 9

Site Precipitation Selection and Results

9.1 Daymet Correction Factors for Site

Based on regional analysis, Daymet is the most reliable reanalysis source for precipitation near the project location. However, overprediction bias was generally observed when compared to observed data (See **Section 6.2**). This was consistent with snowpack modelling completed as verification (See report **03a Snowpack Check**). The analysis completed in **Section 7** indicates Daymet precipitation overprediction bias appears to be more significant for snowfall than rainfall.

For these reasons, monthly correction factors are developed to adjust the Daymet dataset, and provide a more likely representation of precipitation at Site.

The following graph shows contours of the best fit coefficients for Daymet to Measured precipitation transformations on a monthly basis, based on values calculated at stations locations by using the loess regression. Loess regression is a nonparametric technique that uses local weighted regression to fit a smooth curve through points in a scatter plot. Loess curves can reveal trends and cycles in data that might be difficult to model with a parametric curve.

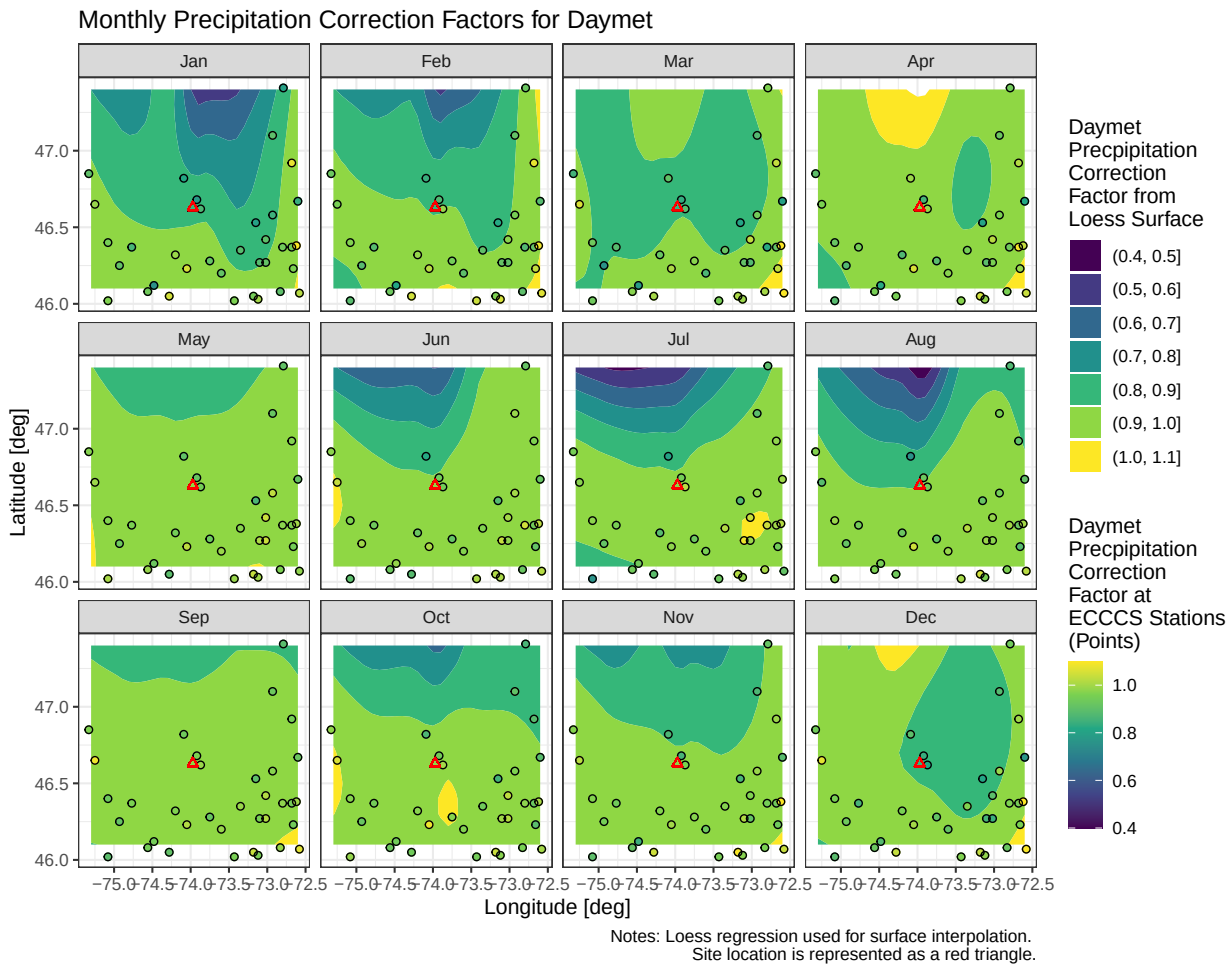
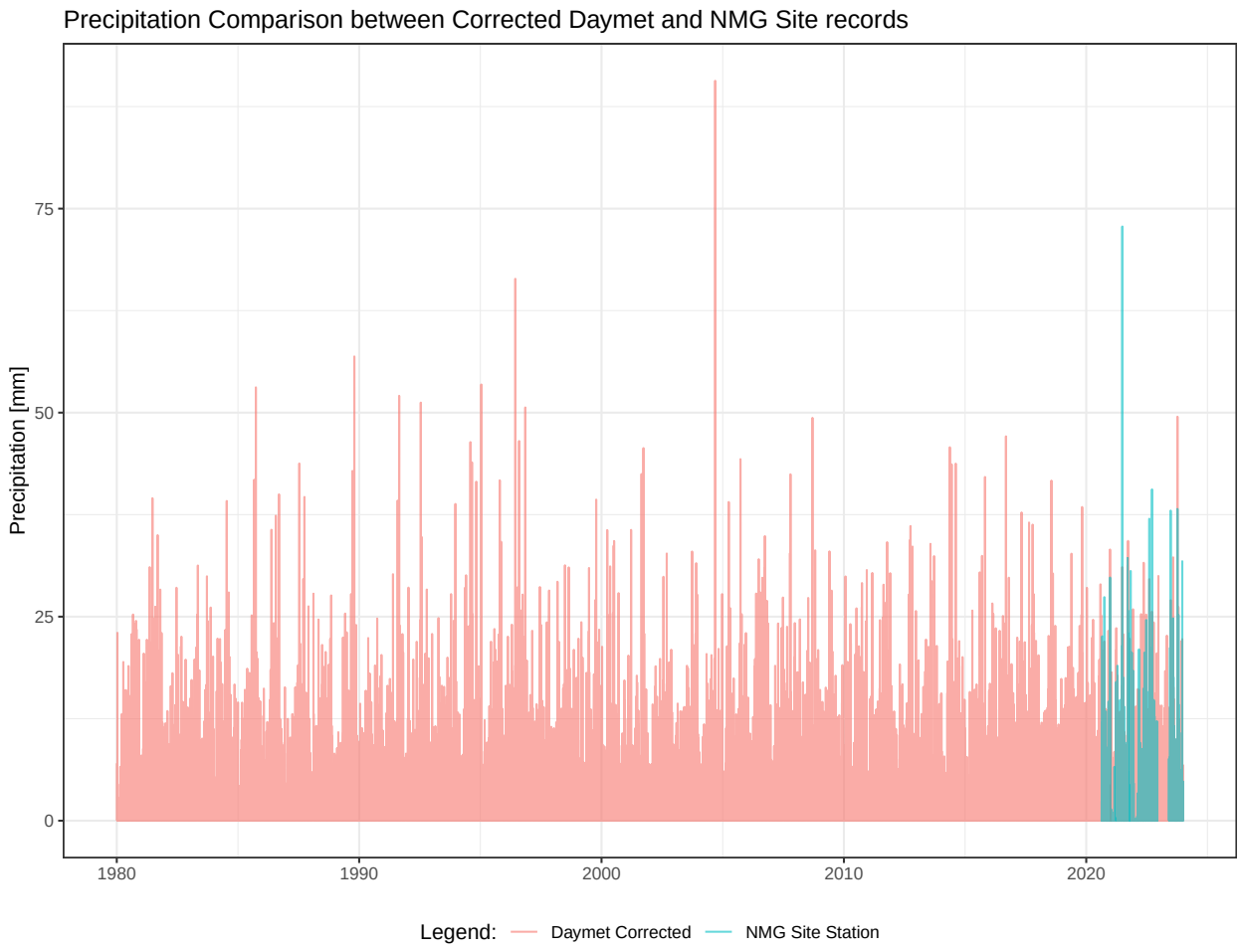


Table 9.1: Daymet Montly Correction Factors for Site

Month	Coef
Jan	0.88
Feb	0.9
Mar	0.9
Apr	0.94
May	0.95
Jun	0.92
Jul	0.93
Aug	0.91
Sep	0.97
Oct	0.97
Nov	0.93
Dec	0.89

9.2 Project Precipitation Timeseries

Coefficients from the previous analysis are applied to the raw Daymet timeseries at the site location to obtain the Project Precipitation Timeseries.



9.3 Climatogram

A climatogram, is a time-based graph that presents a location's average temperature and precipitation on a monthly basis. The following figure was produced for the Project location based on this analysis.

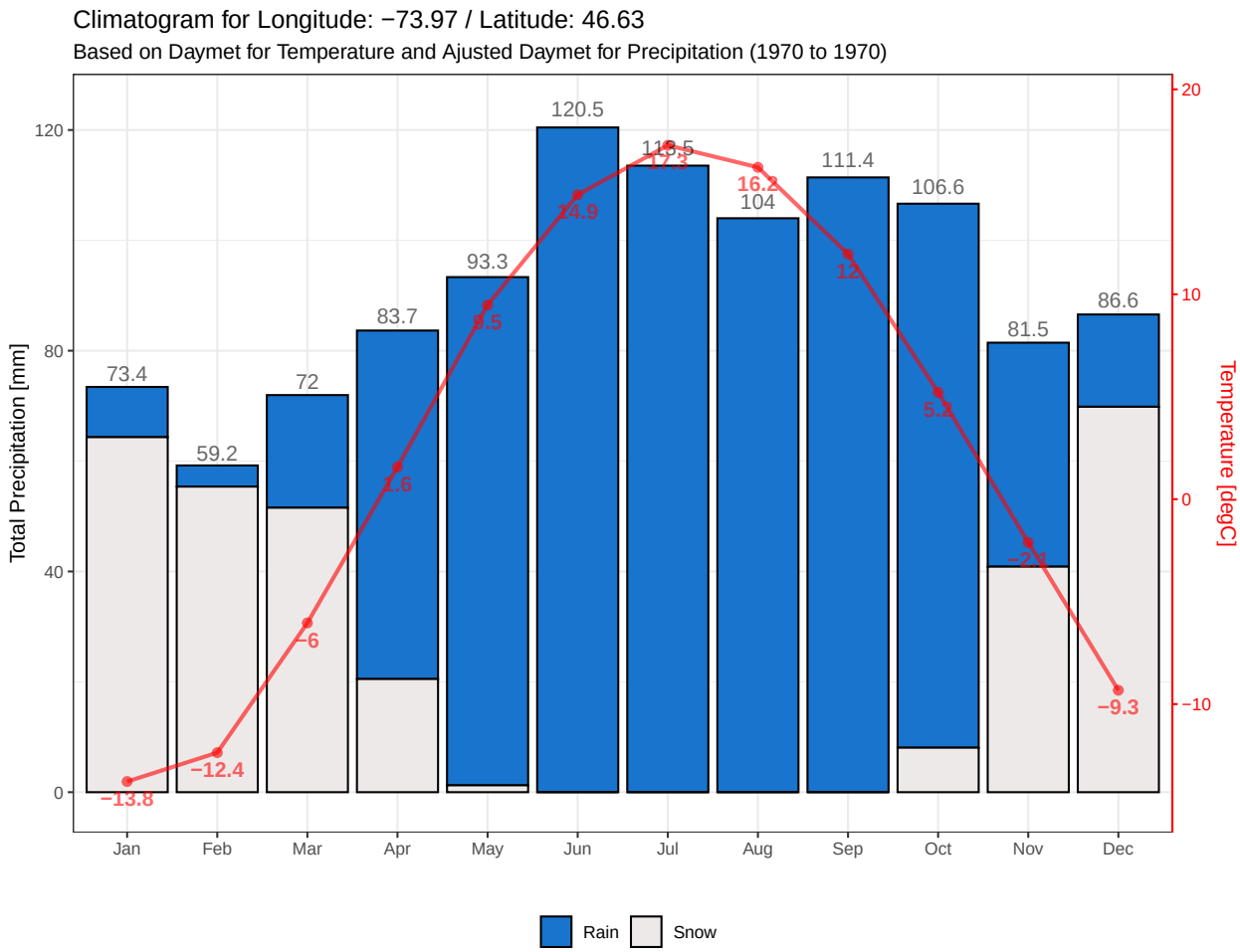


Table 9.2: Mean monthly parameters based on Daymet for Temperature and Ajusted Daymet for Precipitation

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Prcp	73.4	59.2	72	83.7	93.3	120.5	113.5	104	111.4	106.6	81.5	86.6	1106
Rain	9.1	3.8	20.4	63.1	92.1	120.5	113.5	104	111.4	98.6	40.6	16.7	793.9
Snow	64.3	55.4	51.5	20.5	1.2	0	0	0	0	8.1	40.9	69.8	311.8

Table 9.3: Precipitation Normals (1985-2014) for the Project [mm]

Par	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Prcp	73.3	53	66.2	74.6	93.8	116.2	112.7	103	114.1	101	83.5	78	1069
Snow	64.2	50	47.8	18.1	1.2	0	0	0	0.1	7.1	41.8	67.4	297.6
Rain	9.1	3	18.4	56.5	92.7	116.2	112.7	103	113.9	93.9	41.7	10.7	771.9

9.4 Annual Precipitation Frequency Analysis and Monthly Distribution

This section describes the statistical analysis that was completed on yearly precipitation for the Matawinie Site, based on the Project Precipitation Timeseries as defined in Section 9.2. Frequency

analysis were completed on a yearly and monthly basis to estimate precipitation values for typical probabilities of occurrence, or return periods.

Note that the storm event anlysis is included in a separate document. For further information about storm events analysis, please refer to Report **03b Storm Analysis**.

9.4.1 Annual Frequency Analysis

A frequency analysis was completed on yearly precipitation from the Project Precipitation Timeseries. The following results table presents return periods and corresponding monthly and annual precipitation values for the Project.

Tested distributions: [1] NORM LN GEV GUMBEL ———————— Chosen distributions: AIC AICc BIC ADC
LN LN LN LN
whose Maximum-Likelihood parameters are: NORM parameters of log(x): 6.985555 0.09873324

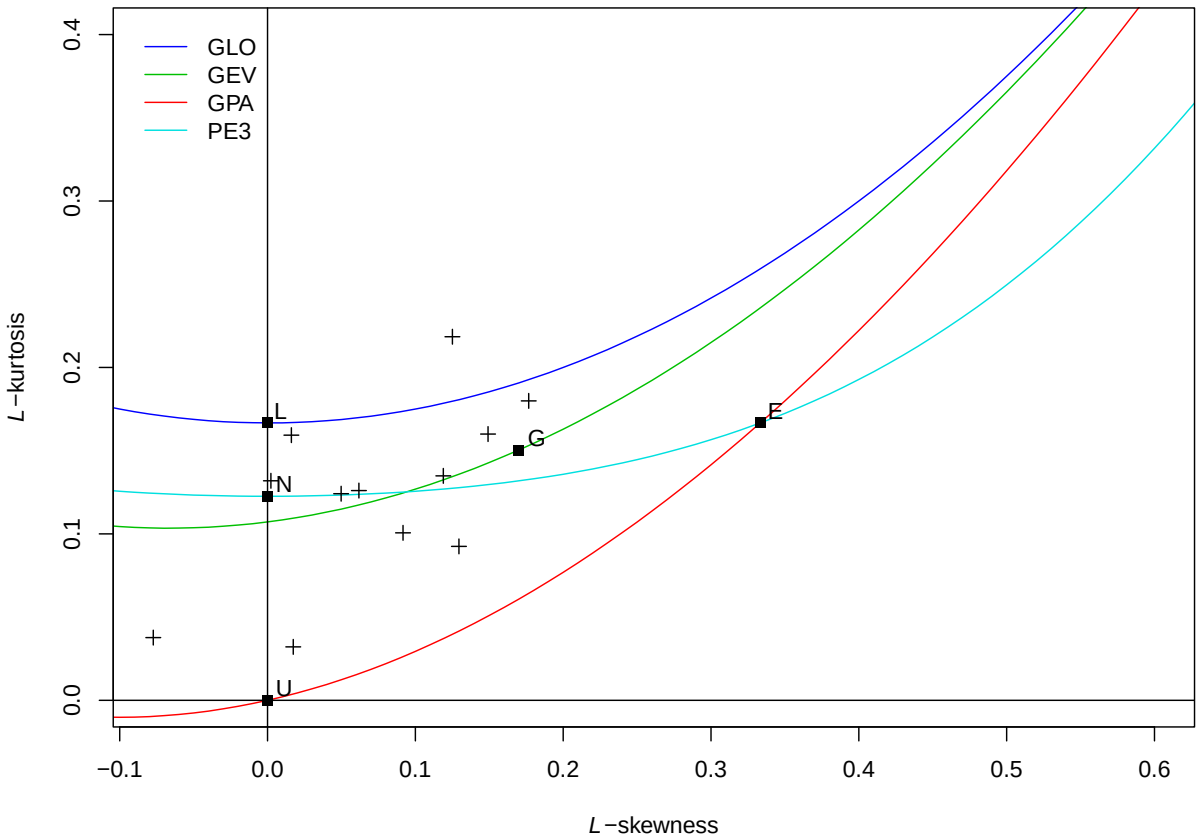
Table 9.4: Annual Precipitation Return Periods [mm]

	Return Period [years]	Annual
1	Wet 10000	1537
2	Wet 2000	1480
3	Wet 1000	1454
4	Wet 500	1426
5	Wet 200	1388
6	Wet 100	1357
7	Wet 50	1323
8	Wet 25	1286
9	Wet 20	1273
10	Wet 10	1230
11	Wet 5	1178
13	Regular 2	1083
15	Dry 5	992
16	Dry 10	946
17	Dry 20	909
18	Dry 25	898
19	Dry 50	868
20	Dry 100	841
21	Dry 200	816
22	Dry 500	787
23	Dry 1000	767
24	Dry 2000	748
25	Dry 10000	709

9.4.2 Monthly Distribution

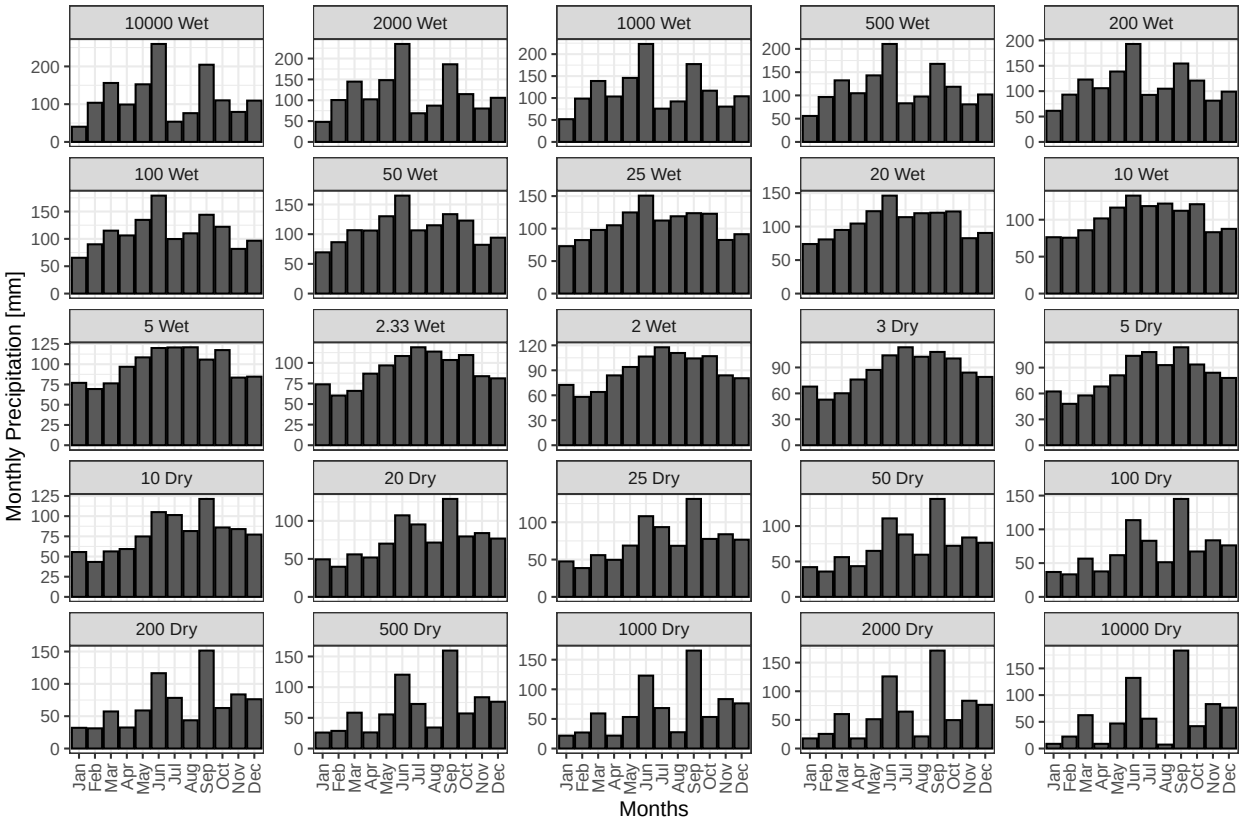
The monthly distribution of precipitation for different return periods might not follow the average distribution of the project precipitation timeseries. An incremental frequency analysis approach was developed and is described below. Note that the monthly distribution of annual precipitation is not equivalent to a monthly precipitation frequency analysis.

First, an L-moments ratio diagram was built to select representative probability distributions to assess data on a monthly basis. The L-moments ratio diagram is the plot of the sample moments on the moment-ratio diagram. The Project Precipitation was summarized monthly and grouped per calendar month. Skewness and kurtosis (L-moments) were computed and plotted in a moment-ratio diagram for each month (black crosses). On the same plot, multiple two parameter (black squares), and three-parameter (colored curves) candidate distributions to model the data are represented. The cluster of L-moments representing the samples are be closer to the distributions that better represent the data.



The generalized extreme value (GEV) distribution, the Pearson Type III (PE3), and the Log-Pearson Type III distributions were selected from this analysis.

The monthly distribution of precipitation was adjusted for each return period by completing an incremental frequency analysis month to month, resulting in the following graphs and table.


10000 Wet
2000 Wet
1000 Wet
500 Wet
200 Wet
100 Wet
50 Wet
25 Wet
20 Wet
10 Wet
5 Wet
2.33 Wet
2 Wet
3 Dry
5 Dry
10 Dry
20 Dry
25 Dry
50 Dry
100 Dry
200 Dry
500 Dry
1000 Dry
2000 Dry
10000 Dry
Monthly Precipitation [mm]
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Months

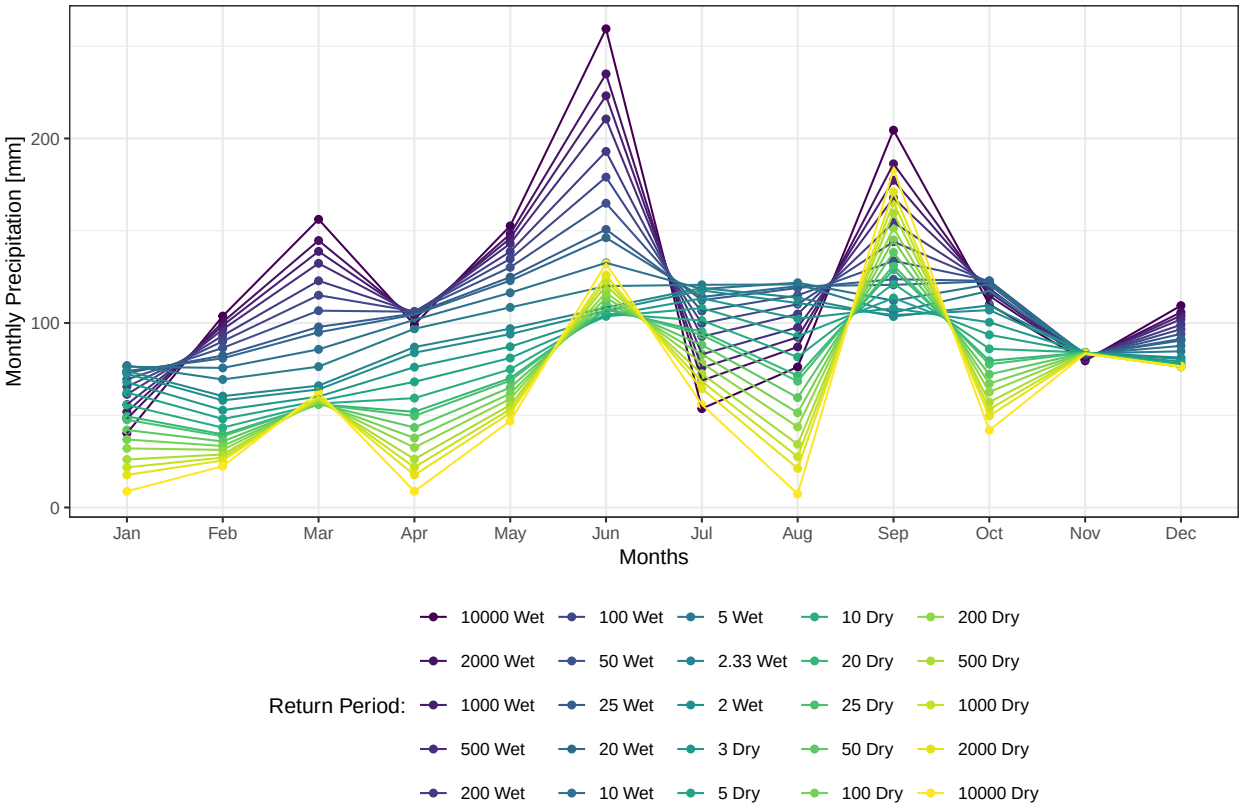

Monthly Precipitation [mm]
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Months
Return Period:
10000 Wet
2000 Wet
1000 Wet
500 Wet
200 Wet
100 Wet
50 Wet
25 Wet
20 Wet
10 Wet
5 Wet
2.33 Wet
2 Wet
3 Dry
5 Dry
10 Dry
20 Dry
25 Dry
50 Dry
100 Dry
200 Dry
500 Dry
1000 Dry
2000 Dry
10000 Dry

Table 9.5: Monthly Distribution of Annual Precipitation [mm]

RP	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
10000 Wet	40	104	156	99	153	259	54	76	205	110	79	109	1444
2000 Wet	48	100	145	102	148	235	69	87	186	115	80	106	1421
1000 Wet	52	99	139	103	146	223	76	92	177	117	80	104	1408
500 Wet	56	97	132	105	143	211	83	98	168	119	81	102	1393
200 Wet	61	93	123	106	139	193	93	105	154	121	81	99	1368
100 Wet	65	90	115	106	135	179	100	110	144	122	82	97	1345
50 Wet	69	87	107	106	130	165	106	115	134	123	82	94	1318
25 Wet	73	82	98	105	125	151	112	119	124	123	83	91	1286
20 Wet	74	81	95	105	123	146	114	120	121	123	83	90	1274
10 Wet	76	76	86	102	116	133	118	122	112	121	83	88	1232
5 Wet	77	69	76	97	108	120	121	121	106	117	83	85	1181
2.33 Wet	74	60	66	87	97	108	119	114	104	110	84	81	1103
2 Wet	72	58	64	84	94	107	118	111	104	107	84	80	1083
3 Dry	68	53	60	76	87	104	113	102	108	100	84	79	1035
5 Dry	62	48	58	68	81	104	108	93	114	94	84	78	991
10 Dry	56	43	56	59	75	105	101	82	121	86	84	77	946
20 Dry	49	40	56	52	70	107	95	71	129	80	84	77	910
25 Dry	48	39	56	50	69	108	93	68	131	78	84	77	900
50 Dry	42	36	56	43	65	111	88	60	138	72	84	76	871
100 Dry	37	33	57	38	62	114	83	51	145	67	84	76	846
200 Dry	32	31	57	32	59	116	78	44	151	63	84	76	824
500 Dry	26	29	58	26	56	120	72	34	160	57	84	76	798
1000 Dry	22	27	59	22	53	123	68	28	165	53	83	76	780
2000 Dry	18	26	60	18	51	126	64	21	171	50	83	76	764
10000 Dry	9	22	62	9	47	132	56	7	183	42	83	76	729

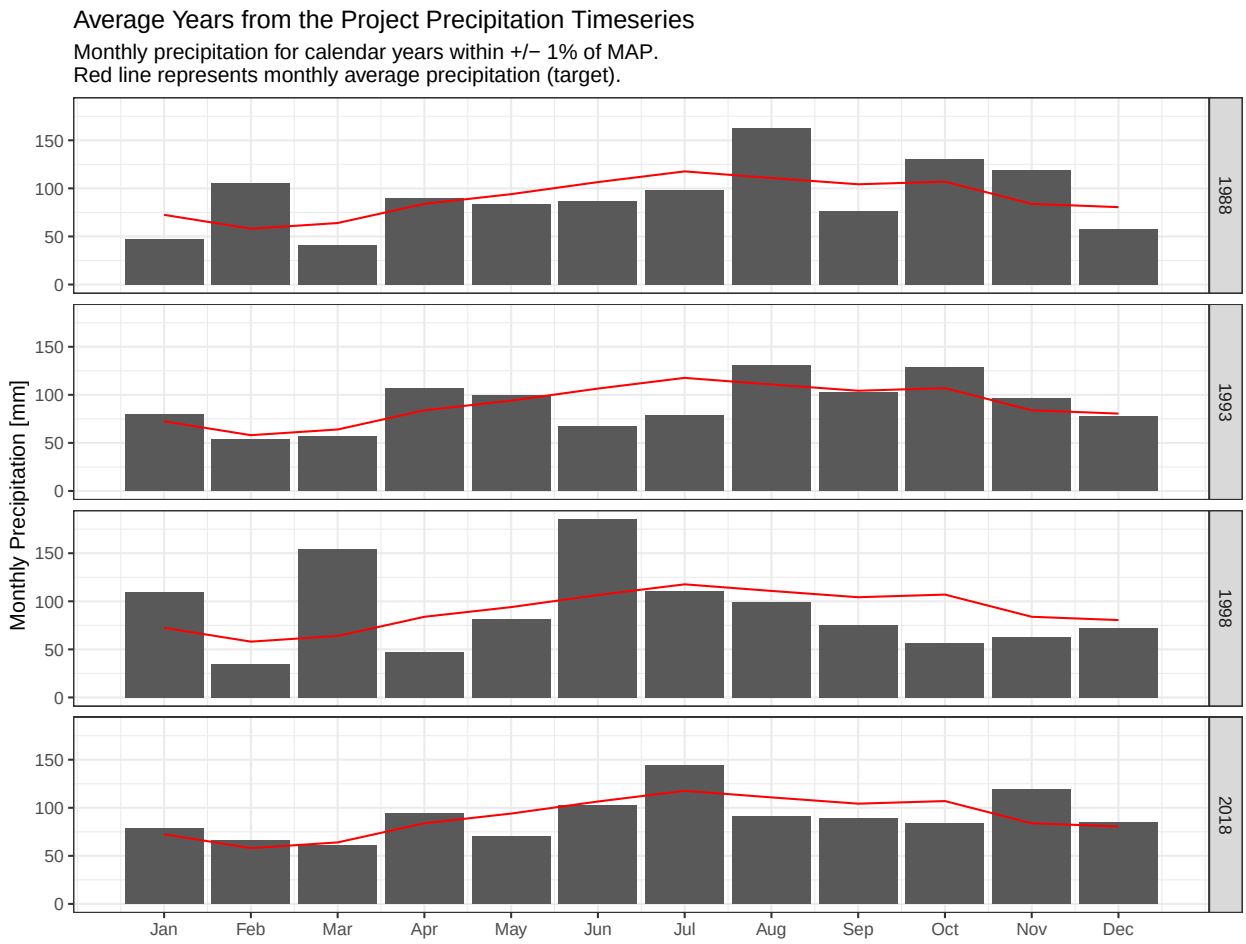
9.5 Representative Years for Water Balance

The site water balance looks to assess different hydrological scenarios. The following scenarios were requested:

- Average year
- 1 in 100 wet year
- 1 in 100 dry year

9.5.1 Average Year

The average year was selected from the project precipitation timeseries as the best matching year to the previous section results.



Based on this analysis, the calendar year 2018 from the project precipitation timeseries is the most representative of an average precipitation year for the Project for historical conditions. 2018 has a total annual precipitation of 1085 mm (target MAP of 1083 mm) and total monthly precipitations that are similar to monthly average precipitation targets.

9.5.2 Extreme Yearly Precipitation Scenarios

The wet and dry scenarios do not have a good 'as is' match within the project precipitation timeseries due to the high return period. Representative months from the project precipitation timeseries corresponding to the selected scenarios are identified in the following table.

Table 9.6: Monthly Selection for Extreme Event Scenarios

Month	Wet Scenario (1 in 100 years)	Dry Scenario (1 in 100 years)
Jan	1989	1987
Feb	2022	1995
Mar	2020	2000
Apr	2002	1987
May	1981	1980
Jun	1998	1990
Jul	2013	2011
Aug	2016	1985

Month	Wet Scenario (1 in 100 years)	Dry Scenario (1 in 100 years)
Sep	1985	1985
Oct	2006	1986
Nov	2001	2001
Dec	2013	2016

Chapter 10

Output

Output of this code has been backed up and saved as an rds file in the **/01_Data/rds** project folder.

References

Gelaro, Ronald, Will McCarty, Max J. Suárez, Ricardo Todling, Andrea Molod, Lawrence Takacs, Cynthia A. Randles, et al. 2017. "The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2)." *Journal of Climate* 30 (14): 5419–54. https://doi.org/10.1175/jcli-d-16-0758.1.

Hersbach, Hans, Bill Bell, Paul Berrisford, Shoji Hirahara, András Horányi, Joaquín Muñoz-Sabater, Julien Nicolas, et al. 2020. "The ERA5 Global Reanalysis." *Quarterly Journal of the Royal Meteorological Society* 146 (730): 1999–2049. https://doi.org/10.1002/qj.3803.

Muñoz-Sabater, Joaquín, Emanuel Dutra, Anna Agustí-Panareda, Clément Albergel, Gabriele Arduini, Gianpaolo Balsamo, Souhail Boussetta, et al. 2021. "ERA5-Land: A State-of-the-Art Global Reanalysis Dataset for Land Applications." *Earth System Science Data* 13 (9): 4349–83. https://doi.org/10.5194/essd-13-4349-2021.

Thornton, M. M., R. Shrestha, Y. Wei, P. E. Thornton, and S-C. Kao. 2022. "Daymet: Daily Surface Weather Data on a 1-Km Grid for North America, Version 4 R1," November. https://doi.org/10.3334/ORNLDAAC/2129.

Appendix D Snow Cover Review

3a. NMG - Matawinie Snowpack Check

CAPR003306

Camilo Gallard

February 14, 2025

Abstract

This report compiles the snowpack review that was completed to validate the precipitation analysis. It was carried out by SRK Consulting (Canada) Inc. for the Nouveau Monde Graphite Matawinie Site in 2024 to support Engineering Design. The data compilation and subsequent analysis was conducted in the R Software environment.

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Chapter 1

Glossary

- **AMS**: Annual Maximum Series.
- **Daymet**: Reanalysis tool developed by the Oak Ridge National Laboratory and supported by NASA (Thornton et al. 2022).
- **ECCC**: Environment and Climate Change Canada.
- **ERA5**: Reanalysis tool developed by the European Centre for Medium-Range Weather Forecasts (Hersbach et al. 2020).
- **ERA5-Land**: Reanalysis tool based on ERA5 but for Land surfaces and a smaller grid, and developed by the European Centre for Medium-Range Weather Forecasts (Muñoz-Sabater et al. 2021).
- **ET**: Evapotranspiration
- **ET0**: Reference Evapotranspiration
- **IDF**: Intensity-Duration-Frequency (IDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
- **KST**: Kolmogorov–Smirnov Test.
- **MAAT**: Mean Annual Air Temperature.
- **MAP**: Mean Annual Precipitation.
- **MERRA2**: Modern-Era Retrospective analysis from Research and Applications, Version 2, is a global climate reanalysis model from the U.S. National Aeronautics and Space Administration (Gelaro et al. 2017).
- **NMG**: Nouveau Monde Graphite.
- **PCC**: Pearson Correlation Coefficient.
- **PDF**: Precipitation-Duration-Frequency (PDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
- **PMP**: Probable Maximum Precipitation.
- **RH**: Relative Humidity.

- **SRAD**: Shortwave (solar) radiation. Incident shortwave radiation flux density in watts per square meter.
- **SRK**: SRK Consulting (Canada) Inc.
- **SSR**: Surface net shortwave (solar) radiation. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth (both direct and diffuse) minus the amount reflected by the Earth's surface (which is governed by the albedo).
- **SSRD**: Surface short-wave (solar) radiation downwards. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth. This parameter comprises both direct and diffuse solar radiation.
- **Tavg**: Mean or Average Air Temperature over a given temporal unit (day, month, year…).
- **Tdew**: Mean or Average Dew Point Temperature over a given temporal unit (day, month, year…).
- **Tmax**: Maximum Air Temperature over a given temporal unit (day, month, year…).
- **Tmin**: Minimum Air Temperature over a given temporal unit (day, month, year…).

Chapter 2

General Parameters

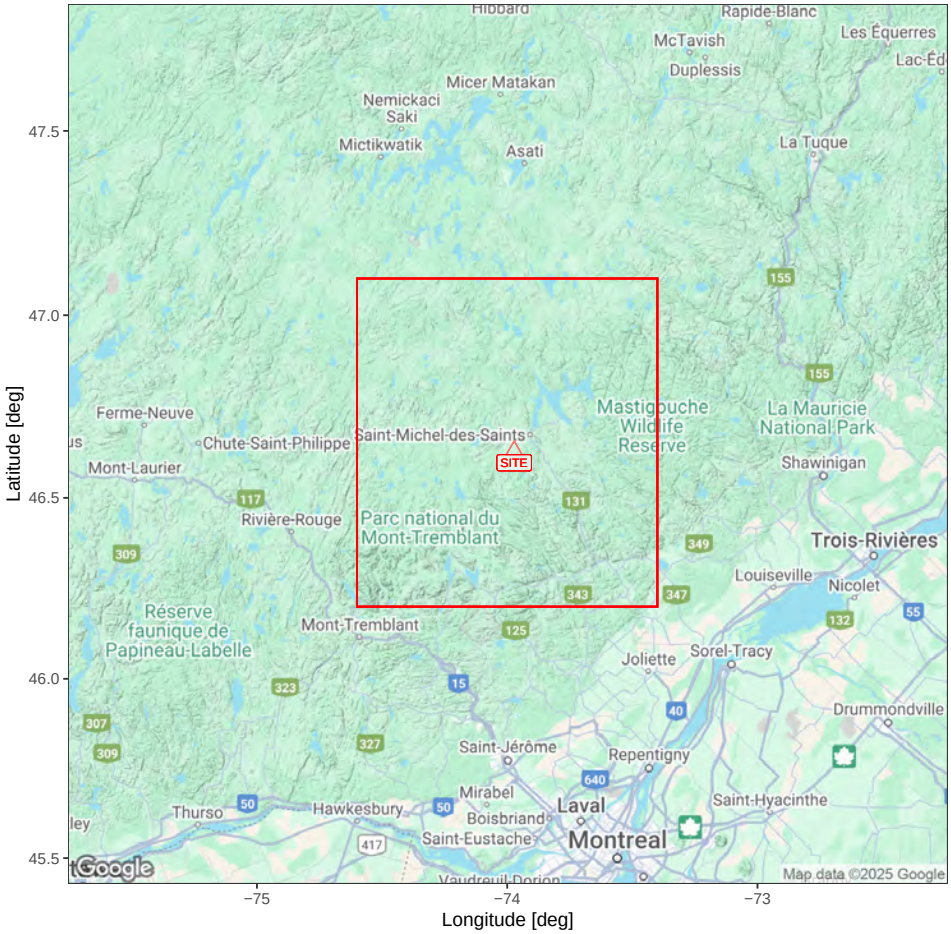
The NMG Matawinie site is located in southern Quebec, 125 km north of Montreal. Site latitude is 46.63 degrees, and longitude is -73.97 degrees, at an elevation of 562 masl. These coordinates were selected to match the location of the meteorological station on site.

For the purpose of this analysis, an area of interest was defined around site to capture local snowpack data, and was defined as the region between:

- 46.2° and 47.1° Latitude
- -74.6° and -73.4° Longitude

Site Location and Area of Interest for this Study

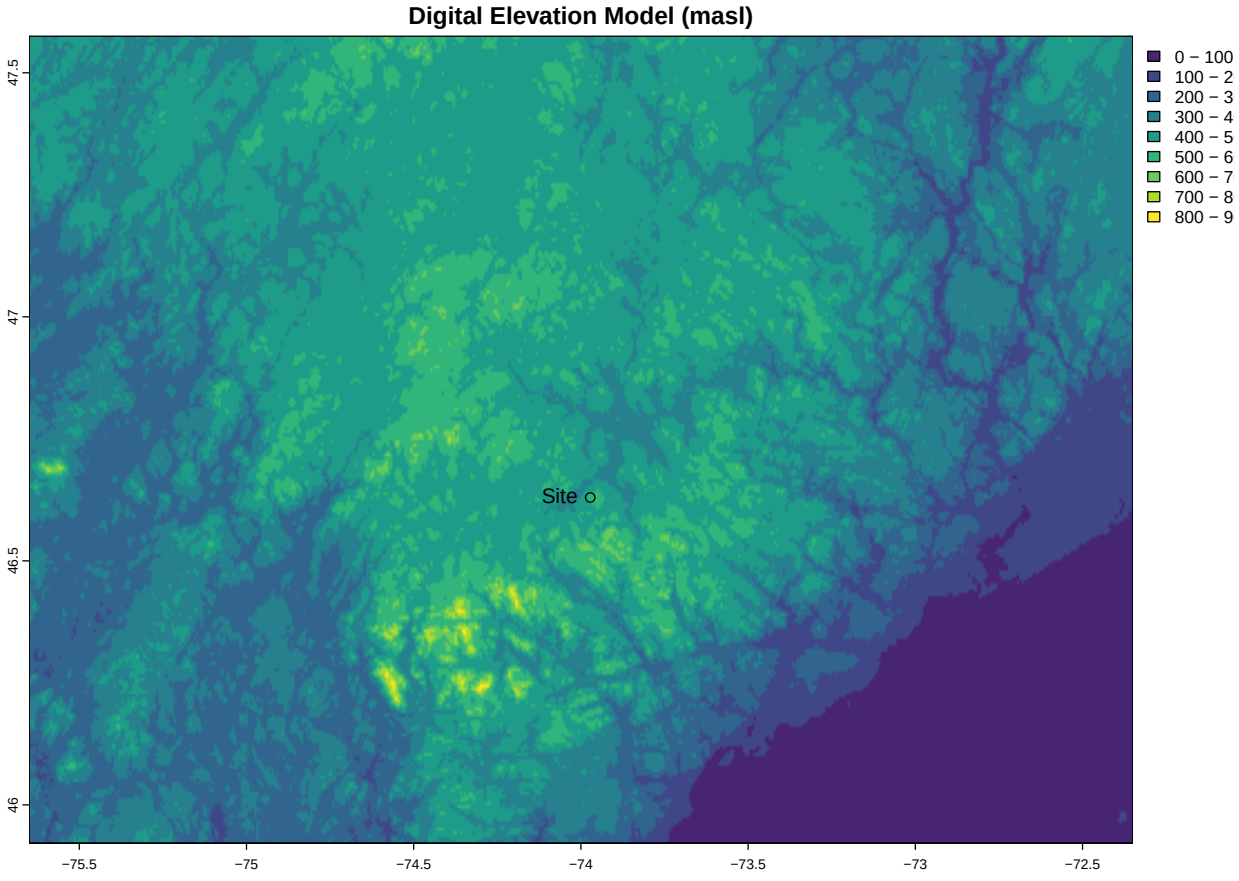
Area of interest covers a radius of 50km around Site



Chapter 3

Digital Elevation Model

Digital elevation model from the region was downloaded from the Shuttle Radar Topography Mission (SRTM) dataset. The SRTM database contains global elevation data with 3 arc-second (90 m) spatial resolution, which is deemed sufficient for climate analysis.

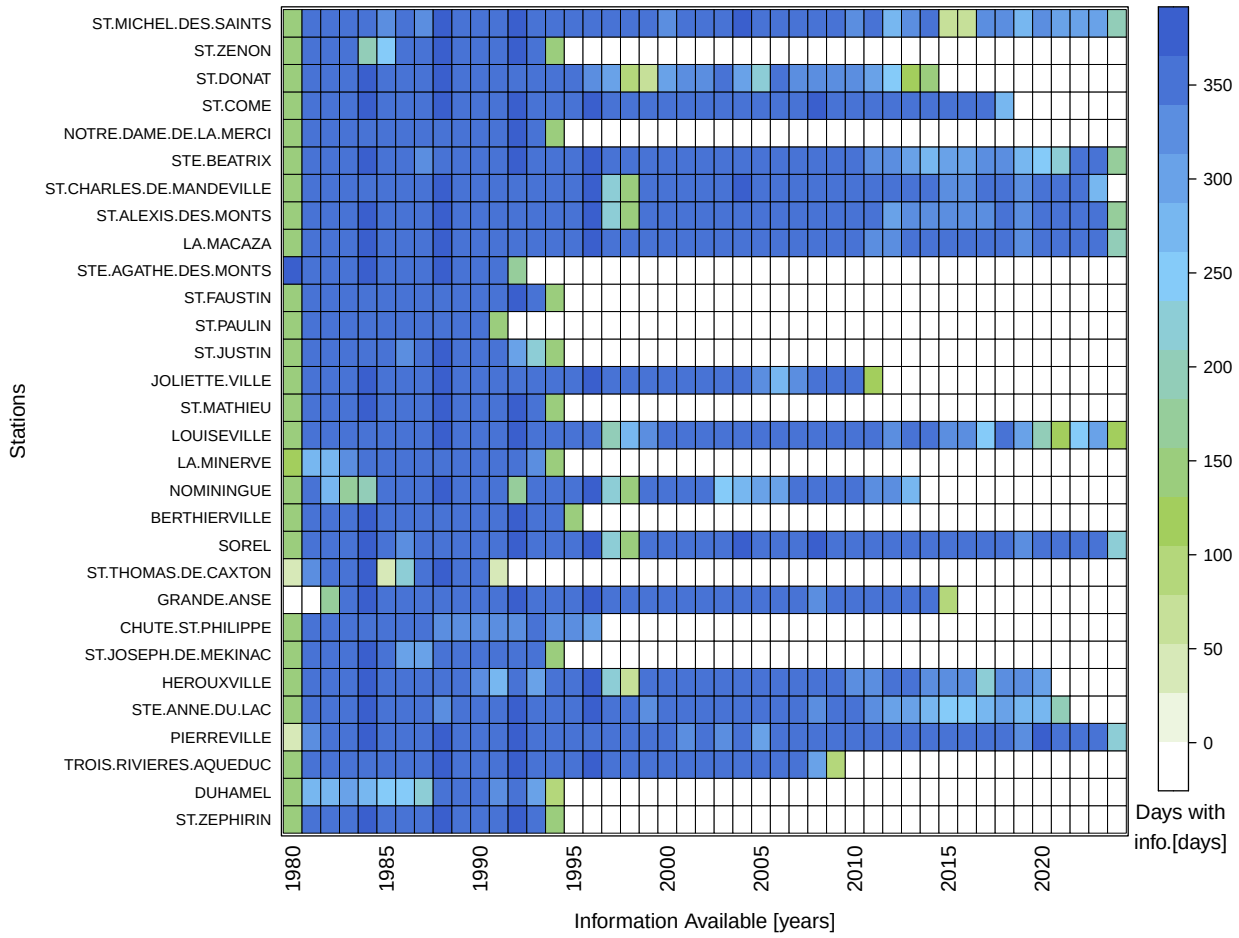


Chapter 4

Snowpack data

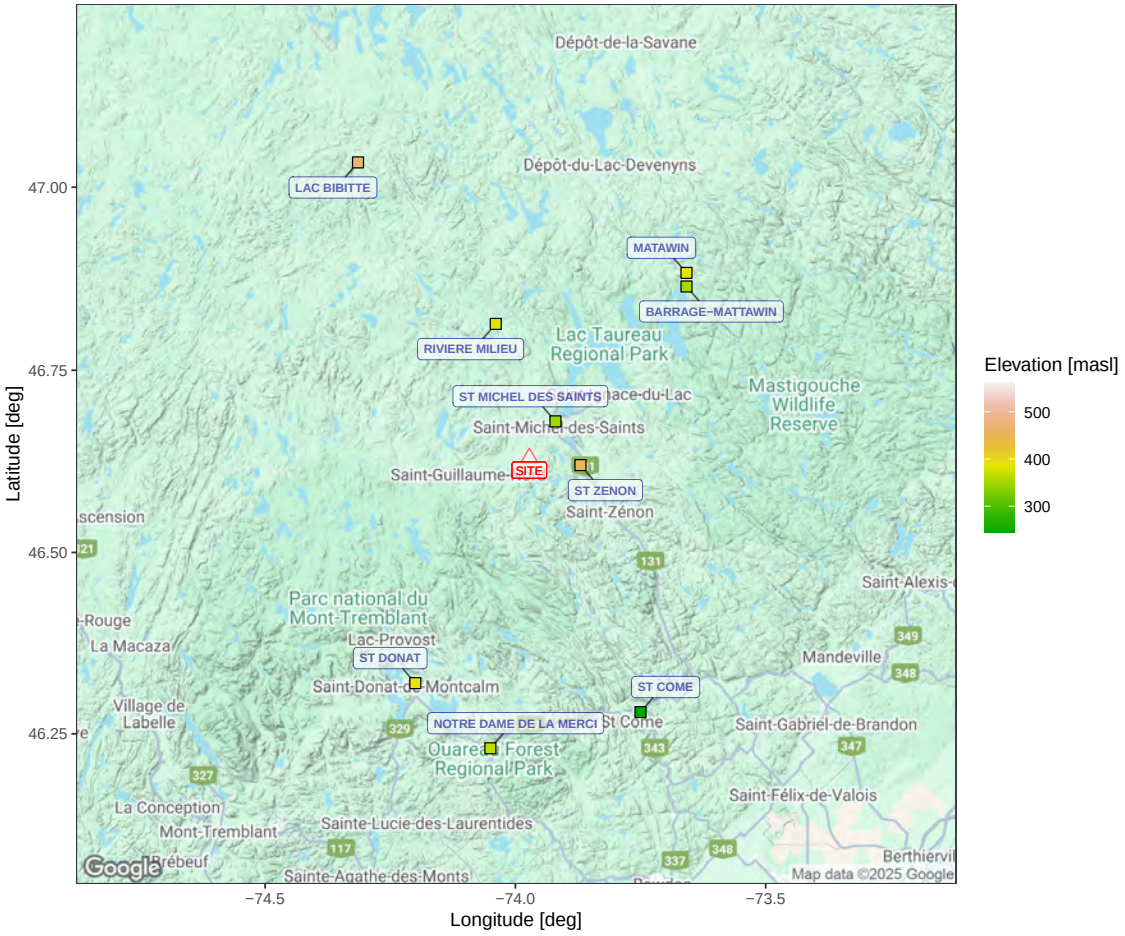
Regional Snowpack records were retrieved from the Canadian historical water equivalent of snow cover dataset version 6 (CanSWE6) (Vionnet et al. 2024) and ECCC weather station records for each station within the area of interest of the Project.

Due to regional geography and previous analysis findings, only stations within ~50 km from site were selected for further review.



Site and Snow Depth Stations Location and Elevation [masl]

Elevations based on SRTM data



Chapter 5

Snowpack Modelling

Snowpack data is compared to modeled results using reanalysis sources as input datasets, similar to what was selected for site. For the purpose of this analysis, the process based snow accumulation and snowmelt model described in (Todd Walter et al. 2005) was used. This model requires relatively straightforward inputs and generally produces better accuracy than temperature-index models.

In the following sections, the results of the snow accumulation and snowmelt model are compared to station records. The following results are presented for each station:

- Graph comparing snow depth records to model outputs on a daily basis. The graph also present relevant Goodness of Fit (GOF) statistics The selected GOF statistics for this analysis are:
  - Nash-Sutcliffe model efficiency coefficient (NSE) (Nash and Sutcliffe 1970), typically used to assess the predictive skill of hydrological models. In the situation of a perfect model with an estimation error variance equal to zero, the resulting Nash–Sutcliffe Efficiency equals 1 (NSE = 1). Conversely, a model that produces an estimation error variance equal to the variance of the observed time series results in a Nash–Sutcliffe efficiency of 0.0 (NSE = 0). In reality, NSE = 0 indicates that the model has the same predictive skill as the mean of the time-series in terms of the sum of the squared error. In the case of a modeled time series with an estimation error variance that is significantly larger than the variance of the observations, the NSE becomes negative. An efficiency less than zero (NSE < 0) occurs when the observed mean is a better predictor than the model. Values of the NSE nearer to 1, suggest a model with more predictive skill.
  - Kling–Gupta efficiency (KGE) (Gupta and Kling 2011), is a goodness-of-fit indicator widely used in the hydrologic sciences for comparing simulations to observations. It was proposed to overcome the limitations of other measures such as Nash-Sutcliffe Efficiency and R-squared that focus only on reproducing the mean and variance of observed data. The KGE combines three statistical metrics: correlation coefficient, variability ratio and bias ratio, into a single measure of model performance. The KGE ranges between -infinity and 1, where a value of 1 indicates perfect agreement between the model predictions and the observed data. The KGE measures not only the accuracy of the model predictions but also its ability to reproduce the variability and timing of the observed data. It has been widely used in hydrology and water resources engineering to evaluate the performance of hydrological models in simulating streamflow, groundwater recharge, and water quality parameters.

  - Percent bias (PBIAS) measures the average tendency of the simulated values to be larger or smaller than their observed ones. The optimal value of PBIAS is 0.0, with low-magnitude values indicating accurate model simulation. Positive values indicate overestimation bias, whereas negative values indicate model underestimation bias.

- Summary table with station characteristics, the main GOF results associated to each station at daily and monthly scales, and mean annual values for meteorological parameters.

The main findings of this section are:

- NSE and KGE results for daily time series for all the stations are between 0.55 and 0.85, suggesting a good performance of the snowmelt model in the proximity of the project location.
- There is a consistent overestimation bias in the model results that is consistent with previous precipitation analysis.

5.1 ST MICHEL DES SAINTS - 5969 - 7km

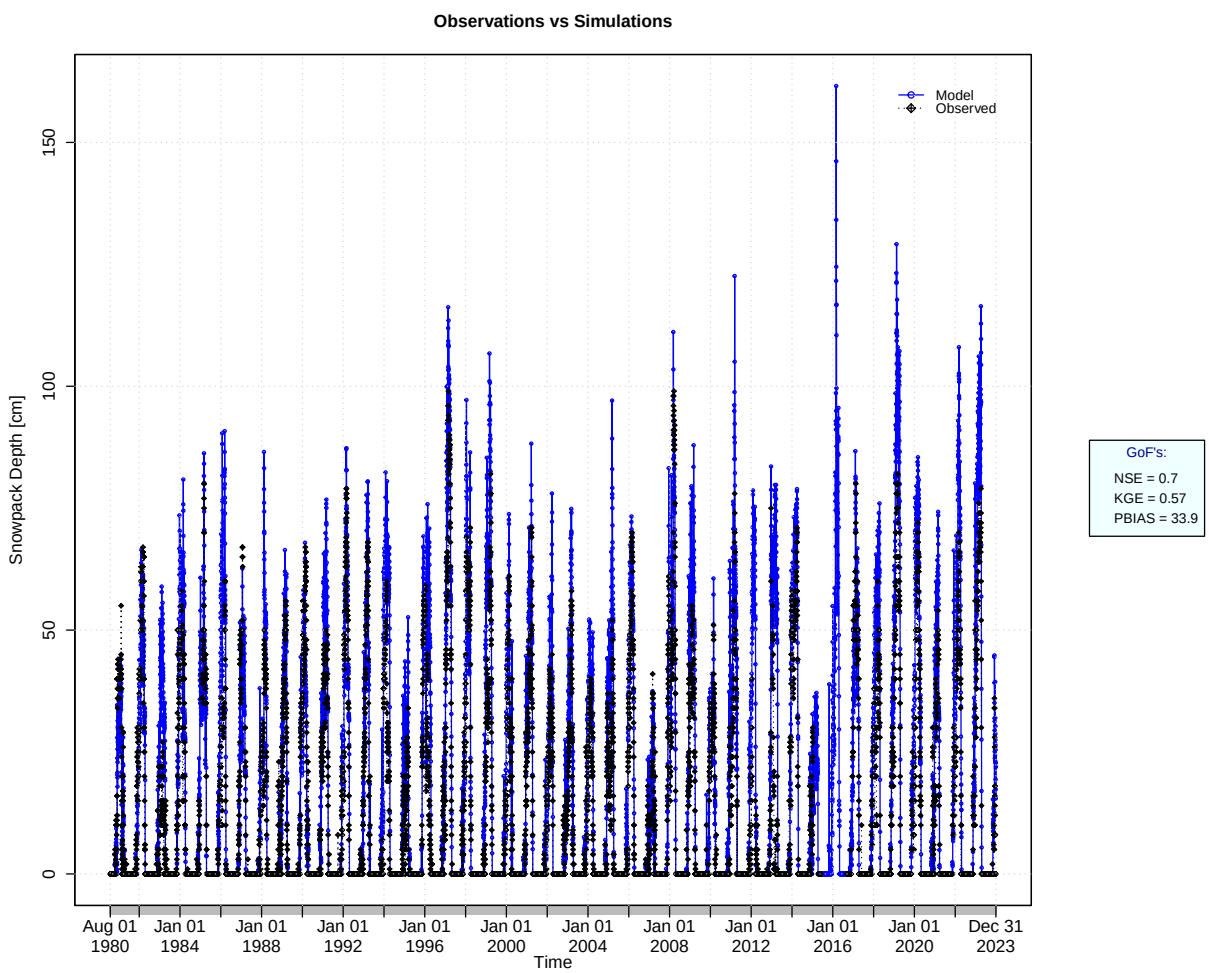


Table 5.1: Summary of Station and Climatic Data at ST MICHEL DES SAINTS

station_id	station_name	lat	lon	elev	MA_prcp	MA_rain	MA_snow	MA_tavg	MA_ws
5969	ST MICHEL DES SAINTS	46.68	-73.92	350.5	1033	758.5	274.9	3.14	2.48

Table 5.2: Summary of Snowpack Modelling GOF at ST MICHEL DES SAINTS

station_id	station_name	nse_dly	kge_dly	pbias_dly	nse_mon	kge_mon	pbias_mon
5969	ST MICHEL DES SAINTS	0.7	0.57	33.9	0.68	0.53	35.8

5.2 ST ZENON - 5289 - 8km

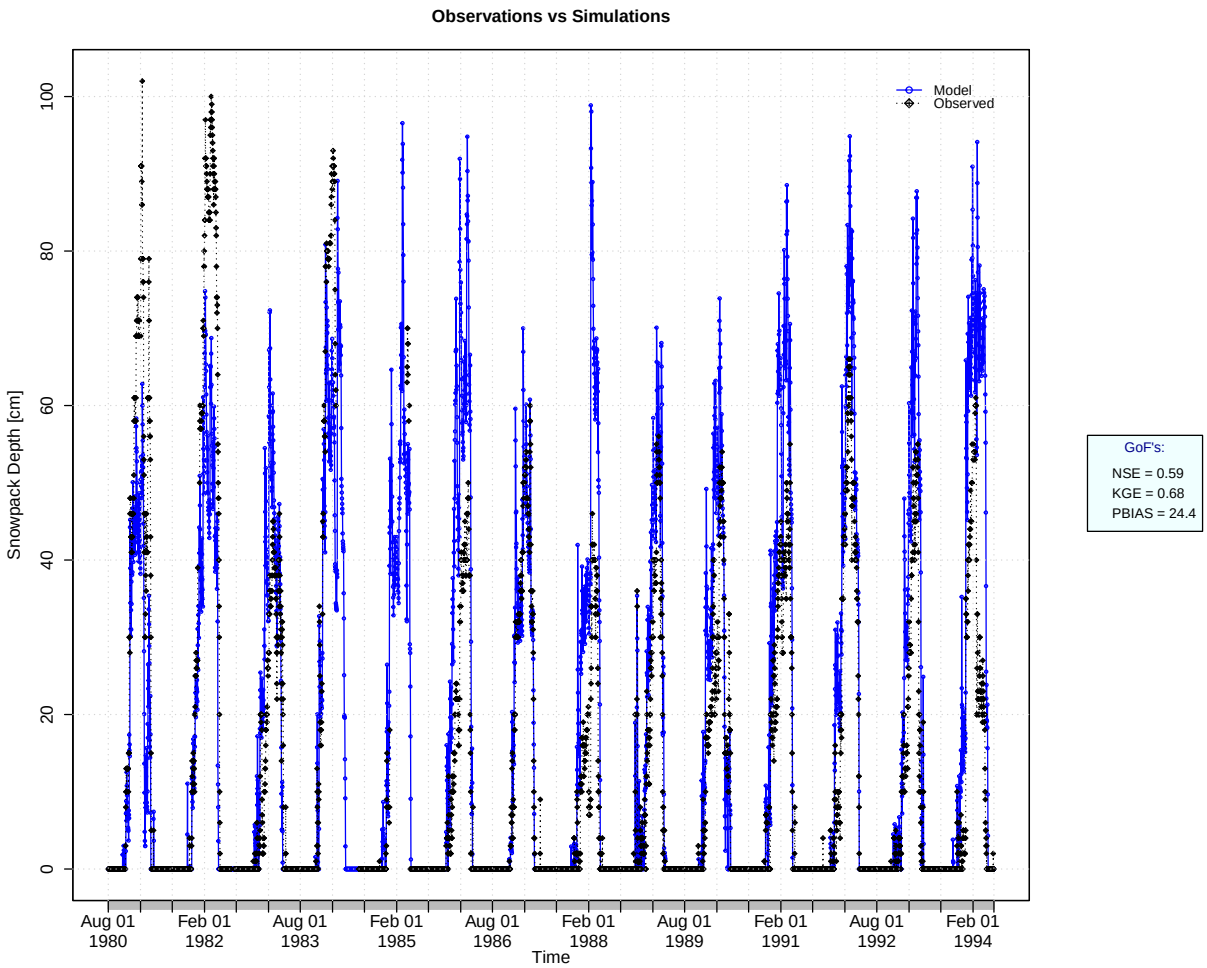


Table 5.3: Summary of Station and Climatic Data at ST ZENON

station_id	station_name	lat	lon	elev	MA_prcp	MA_rain	MA_snow	MA_tavg	MA_ws
5289	ST ZENON	46.62	-73.87	442	1094	791.3	302.8	2.96	2.47

Table 5.4: Summary of Snowpack Modelling GOF at ST ZENON

station_id	station_name	nse_dly	kge_dly	pbias_dly	nse_mon	kge_mon	pbias_mon
5289	ST ZENON	0.59	0.68	24.4	0.49	0.54	35.9

5.3 RIVIERE MILIEU - HQ-CM5N - 21km

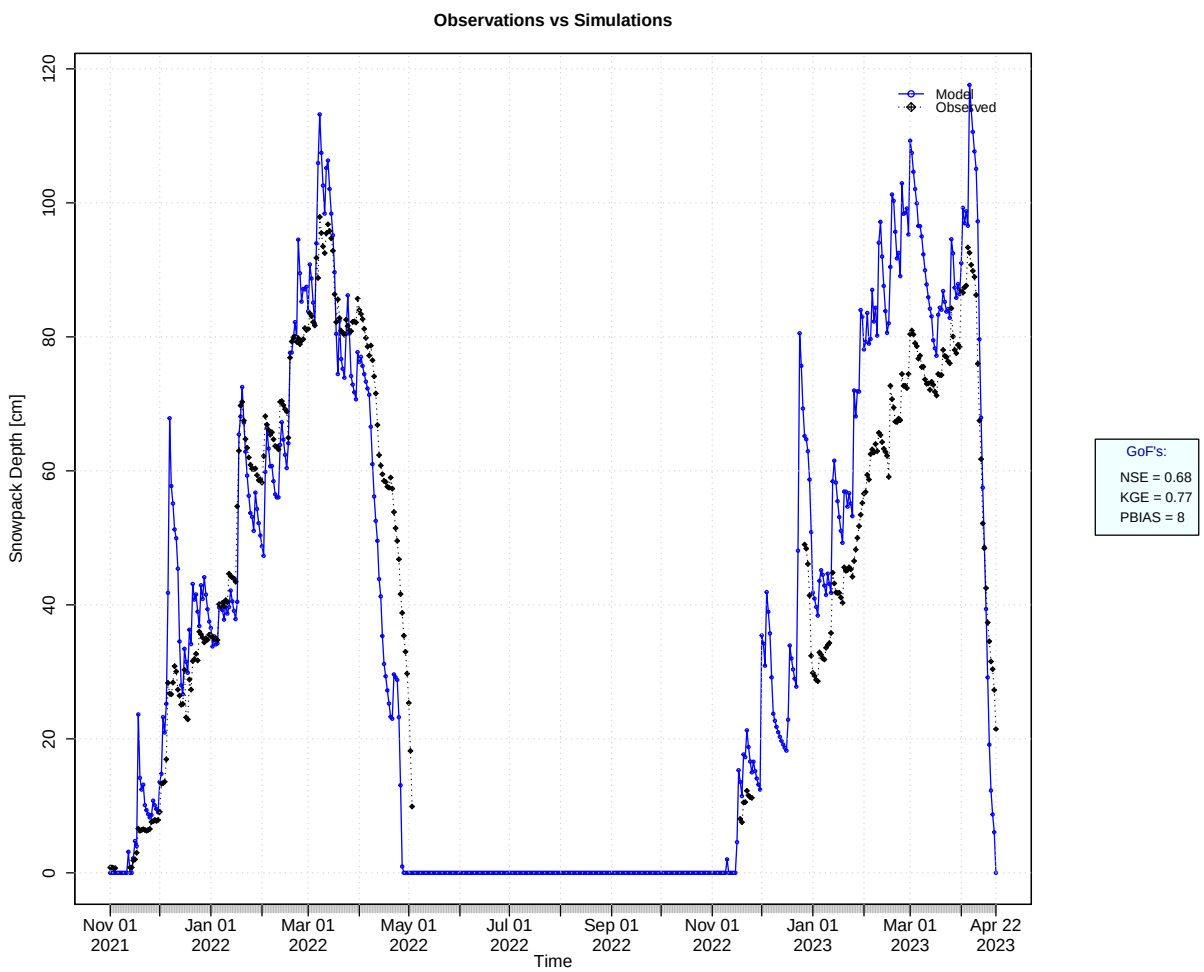


Table 5.5: Summary of Station and Climatic Data at RIVIERE MILIEU

station_id	station_name	lat	lon	elev	MA_prcp	MA_rain	MA_snow	MA_tavg	MA_ws
HQ-CM5N	RIVIERE MILIEU	46.81	-74.04	380	1002	735.7	266.2	2.83	2.5

Table 5.6: Summary of Snowpack Modelling GOF at RIVIERE MILIEU

station_id	station_name	nse_dly	kge_dly	pbias_dly	nse_mon	kge_mon	pbias_mon
HQ-CM5N	RIVIERE MILIEU	0.68	0.77	8	-0.42	0.61	23.6

5.4 BARRAGE-MATTAWIN - HQ-0501025 - 35km

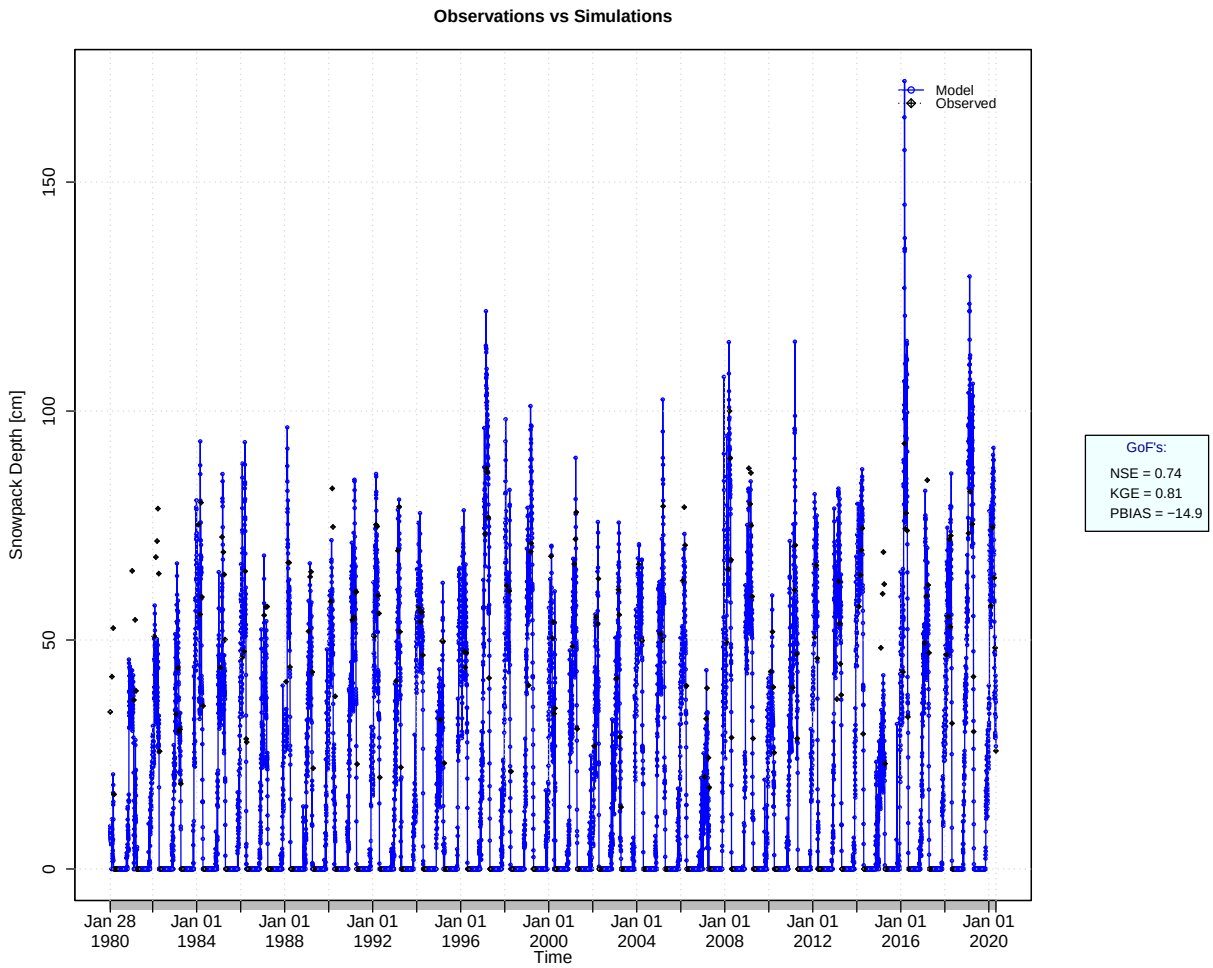


Table 5.7: Summary of Station and Climatic Data at BARRAGE-MATTAWIN

station_id	station_name	lat	lon	elev	MA_prcp	MA_rain	MA_snow	MA_tavg	MA_ws
HQ-0501025	BARRAGE-MATTAWIN	46.86	-73.66	354.5	1051	770.9	280.4	2.96	2.52

Table 5.8: Summary of Snowpack Modelling GOF at BARRAGE-MATTAWIN

station_id	station_name	nse_dly	kge_dly	pbias_dly	nse_mon	kge_mon	pbias_mon
HQ-0501025	BARRAGE-MATTAWIN	0.74	0.81	-14.9	NA	NA	NA

5.5 MATAWIN - HQ-CM3S - 37km

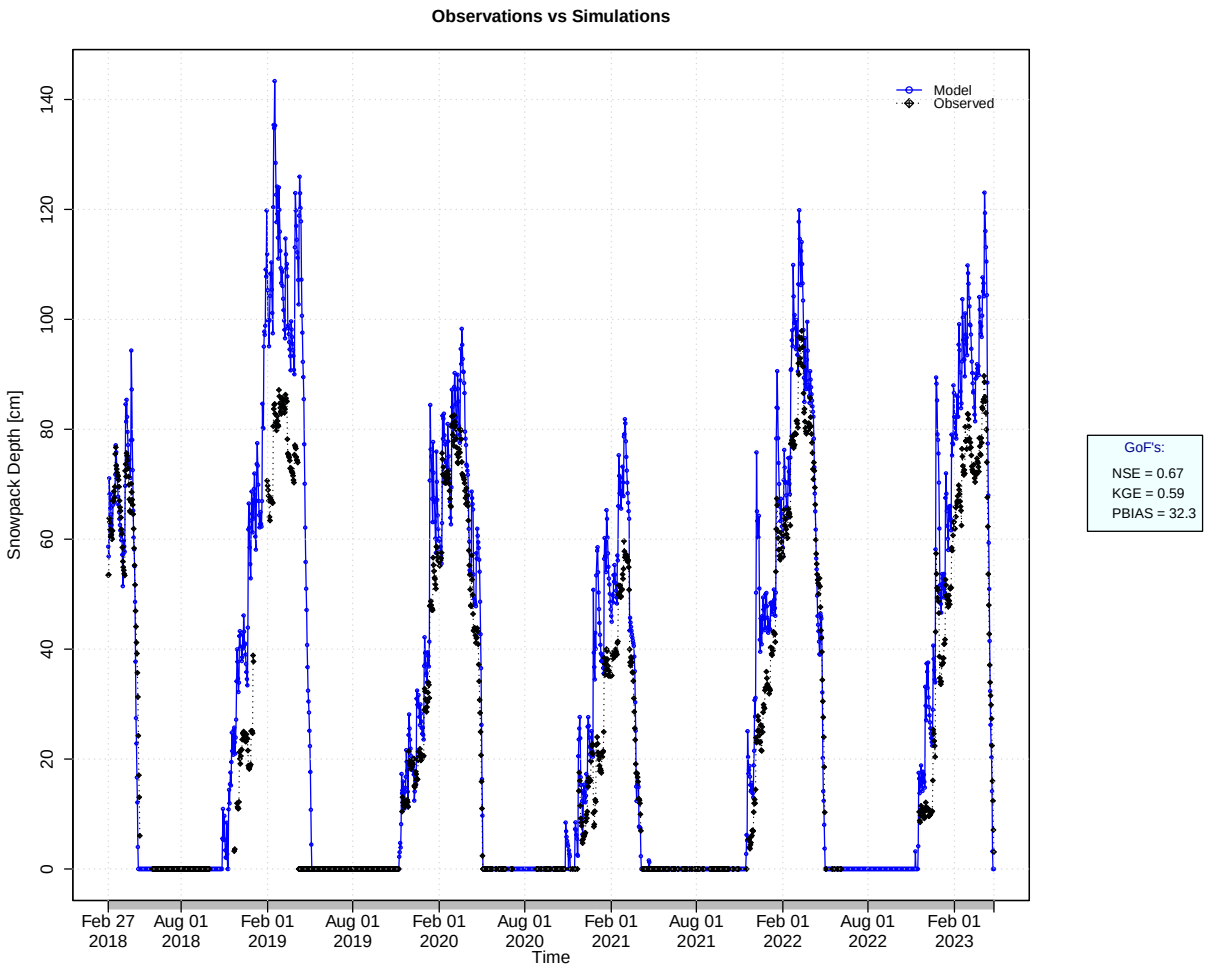


Table 5.9: Summary of Station and Climatic Data at MATAWIN

station_id	station_name	lat	lon	elev	MA_prcp	MA_rain	MA_snow	MA_tavg	MA_ws
HQ-CM3S	MATAWIN	46.88	-73.66	386.9	1115	808.8	306.5	2.52	2.51

Table 5.10: Summary of Snowpack Modelling GOF at MATAWIN

station_id	station_name	nse_dly	kge_dly	pbias_dly	nse_mon	kge_mon	pbias_mon
HQ-CM3S	MATAWIN	0.67	0.59	32.3	0.56	0.51	38.7

5.6 ST DONAT - 5269 - 39km

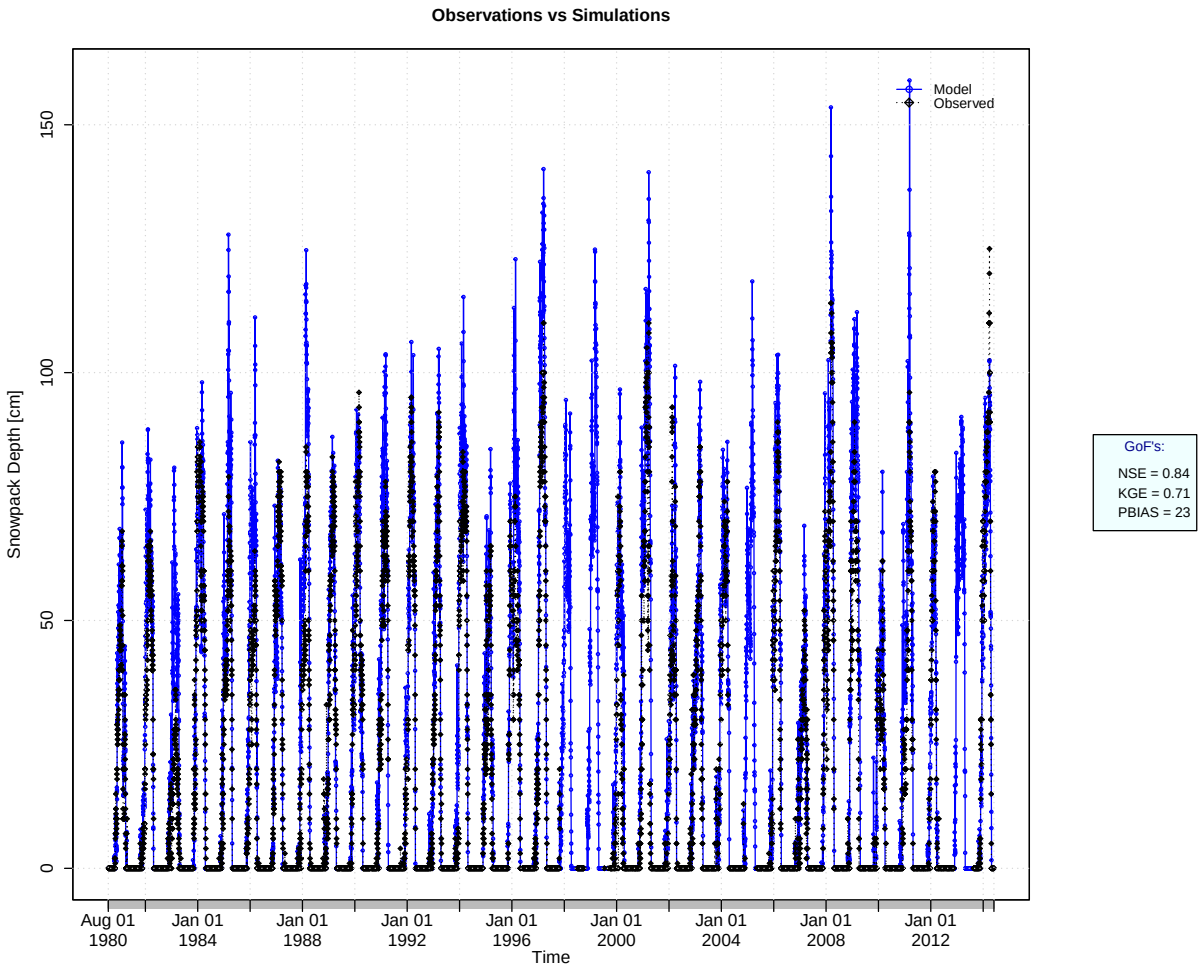


Table 5.11: Summary of Station and Climatic Data at ST DONAT

station_id	station_name	lat	lon	elev	MA_prcp	MA_rain	MA_snow	MA_tavg	MA_ws
5269	ST DONAT	46.32	-74.2	388.6	1197	860.8	336.1	3.44	2.35

Table 5.12: Summary of Snowpack Modelling GOF at ST DONAT

station_id	station_name	nse_dly	kge_dly	pbias_dly	nse_mon	kge_mon	pbias_mon
5269	ST DONAT	0.84	0.71	23	0.8	0.64	26.5

5.7 ST COME - 5268 - 42km

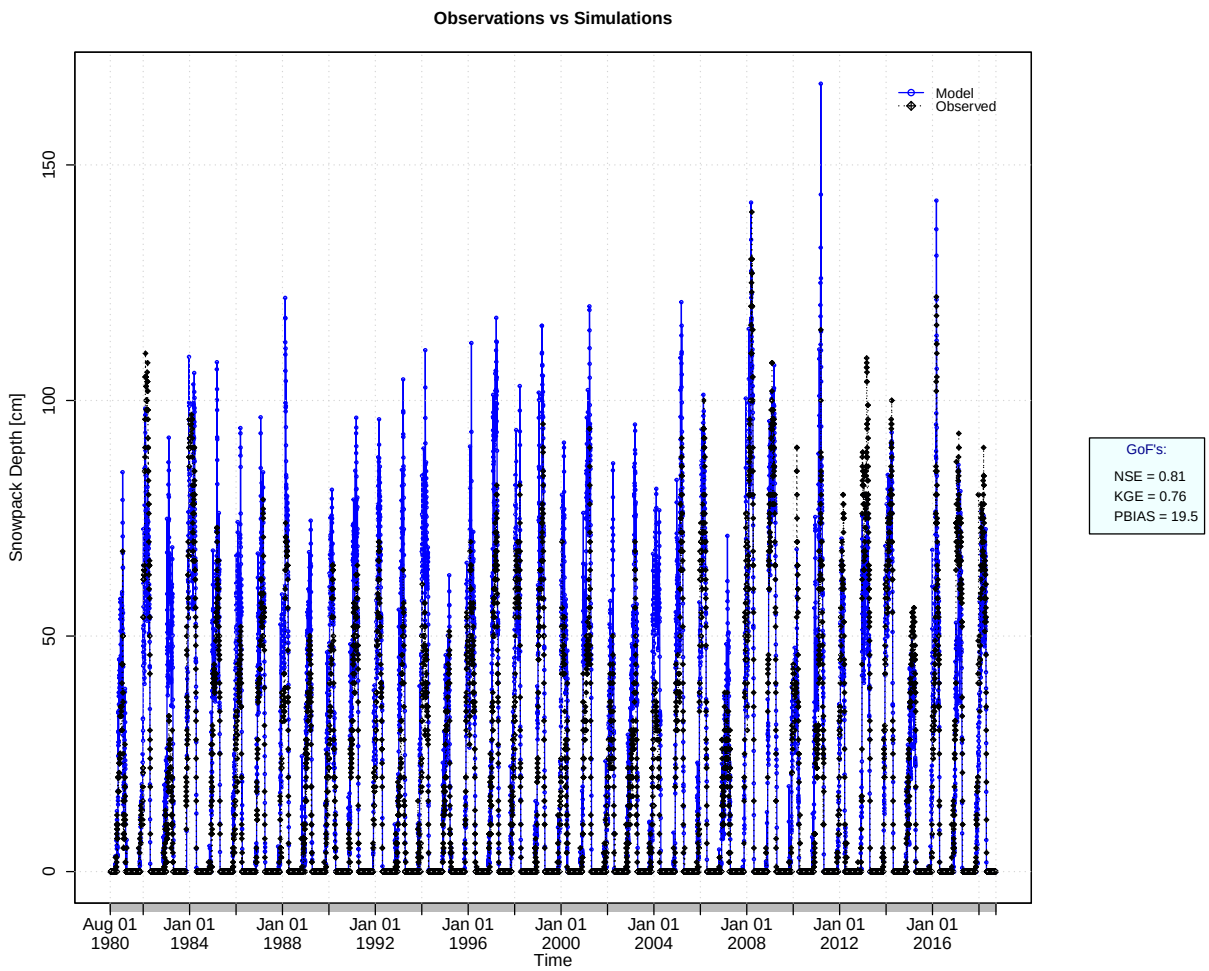


Table 5.13: Summary of Station and Climatic Data at ST COME

station_id	station_name	lat	lon	elev	MA_prcp	MA_rain	MA_snow	MA_tavg	MA_ws
5268	ST COME	46.28	-73.75	244	1149	843.3	306.2	4.11	2.34

Table 5.14: Summary of Snowpack Modelling GOF at ST COME

station_id	station_name	nse_dly	kge_dly	pbias_dly	nse_mon	kge_mon	pbias_mon
5268	ST COME	0.81	0.76	19.5	0.77	0.67	26.5

5.8 NOTRE DAME DE LA MERCI - 5247 - 45km

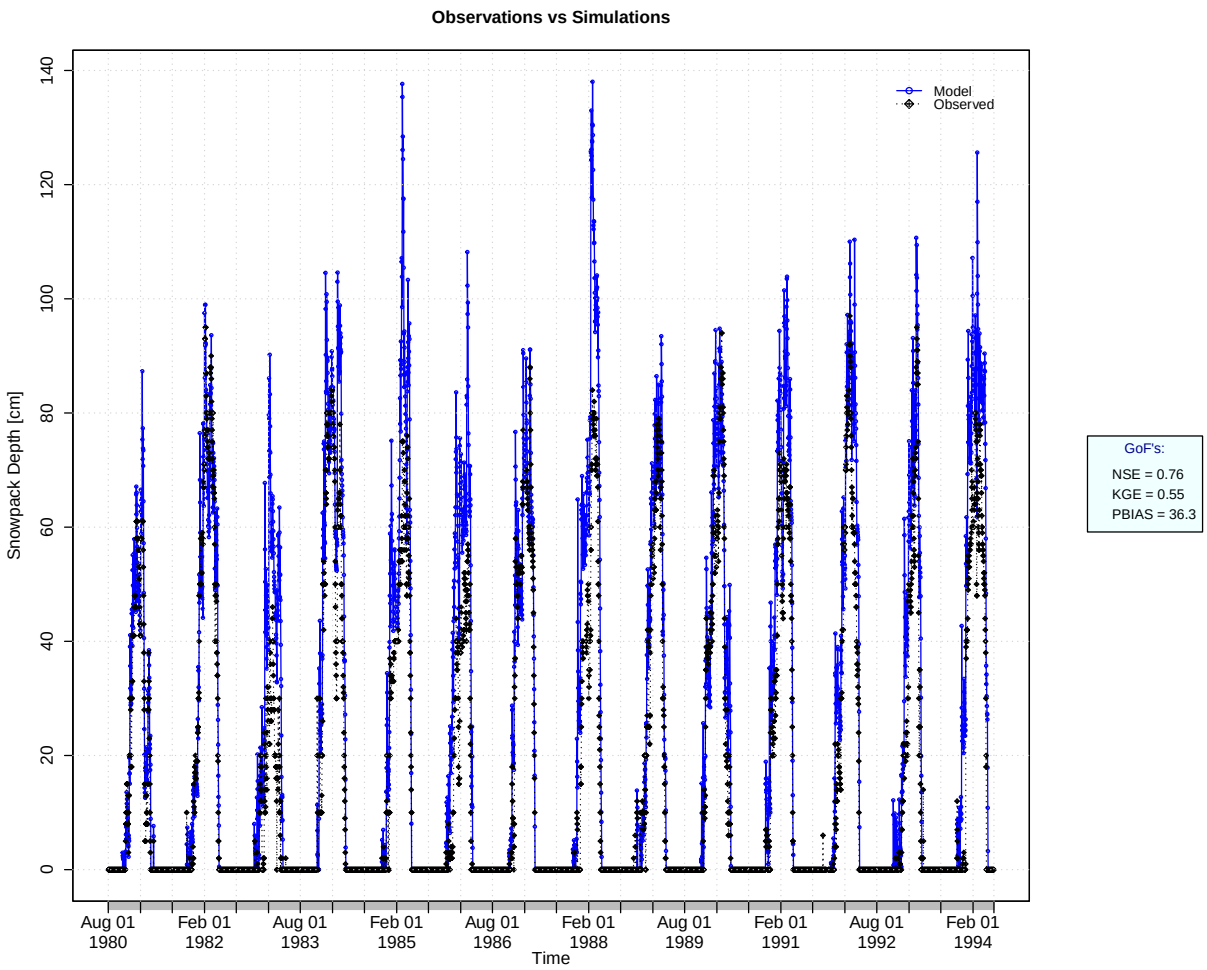


Table 5.15: Summary of Station and Climatic Data at NOTRE DAME DE LA MERCI

station_id	station_name	lat	lon	elev	MA_prcp	MA_rain	MA_snow	MA_tavg	MA_ws
5247	NOTRE DAME DE LA MERCI	46.23	-74.05	365.8	1217	868.8	348	3.66	2.35

Table 5.16: Summary of Snowpack Modelling GOF at NOTRE DAME DE LA MERCI

station_id	station_name	nse_dly	kge_dly	pbias_dly	nse_mon	kge_mon	pbias_mon
5247	NOTRE DAME DE LA MERCI	0.76	0.55	36.3	0.69	0.48	40.8

5.9 LAC BIBITTE - HQ-CM3Y - 52km

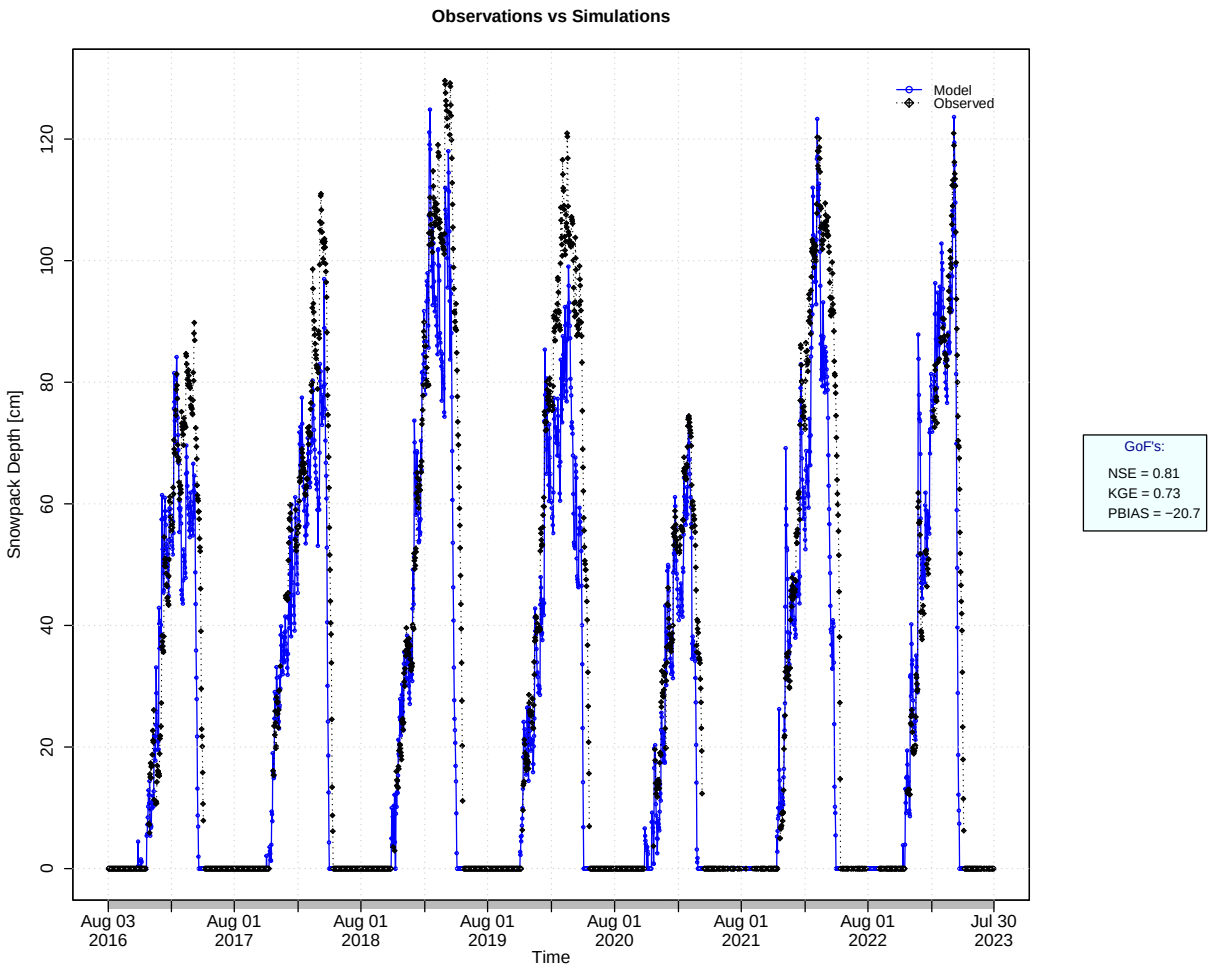


Table 5.17: Summary of Station and Climatic Data at LAC BIBITTE

station_id	station_name	lat	lon	elev	MA_prcp	MA_rain	MA_snow	MA_tavg	MA_ws
HQ-CM3Y	LAC BIBITTE	47.03	-74.31	472.5	1090	781.5	308.4	2.21	2.53

Table 5.18: Summary of Snowpack Modelling GOF at LAC BIBITTE

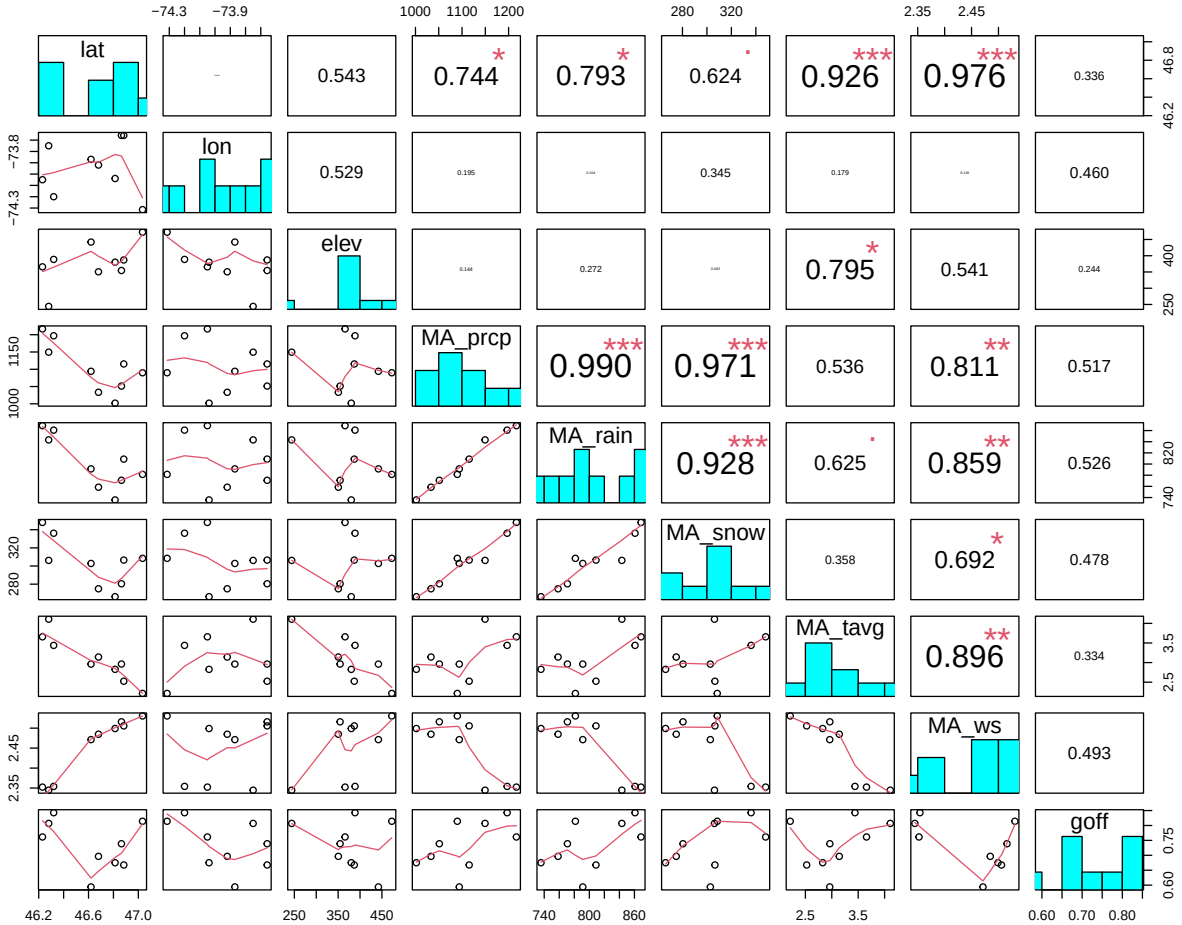
station_id	station_name	nse_dly	kge_dly	pbias_dly	nse_mon	kge_mon	pbias_mon
HQ-CM3Y	LAC BIBITTE	0.81	0.73	-20.7	0.85	0.85	-10.8

Chapter 6

Regional Correlations between Geographical and Climatic Parameters

The following visualization is a correlation matrix between main parameters from stations close to site. On the top right quadrant, the (absolute) value of the correlation is presented together with the result of the Pearson's product moment correlation coefficient as stars. On bottom-left quadrant the bivariate scatterplots, with a fitted line are presented. On the diagonal there is an histogram of each variable.

Correlations represented in this graph aim to identify links between various geographical and climatic variables. The correlations identified in this matrix match expectations and are consistent with previous analysis. No unexpected relationship can be inferred that could help improve snowpack modelling in the analysis area.


lat
lon
elev
MA_prcp
MA_rain
MA_snow
MA_tavg
MA_ws
goff
0.543
0.744 *
0.793 *
0.624 .
0.926 ***
0.976 ***
0.336
0.529
0.195
0.345
0.179
0.460
0.795 *
0.541
0.244
0.990 ***
0.971 ***
0.536
0.811 **
0.517
0.928 ***
0.625 .
0.859 **
0.526
0.692 *
0.478
0.896 **
0.334
0.493

Chapter 7

Snowpack Modelling Findings

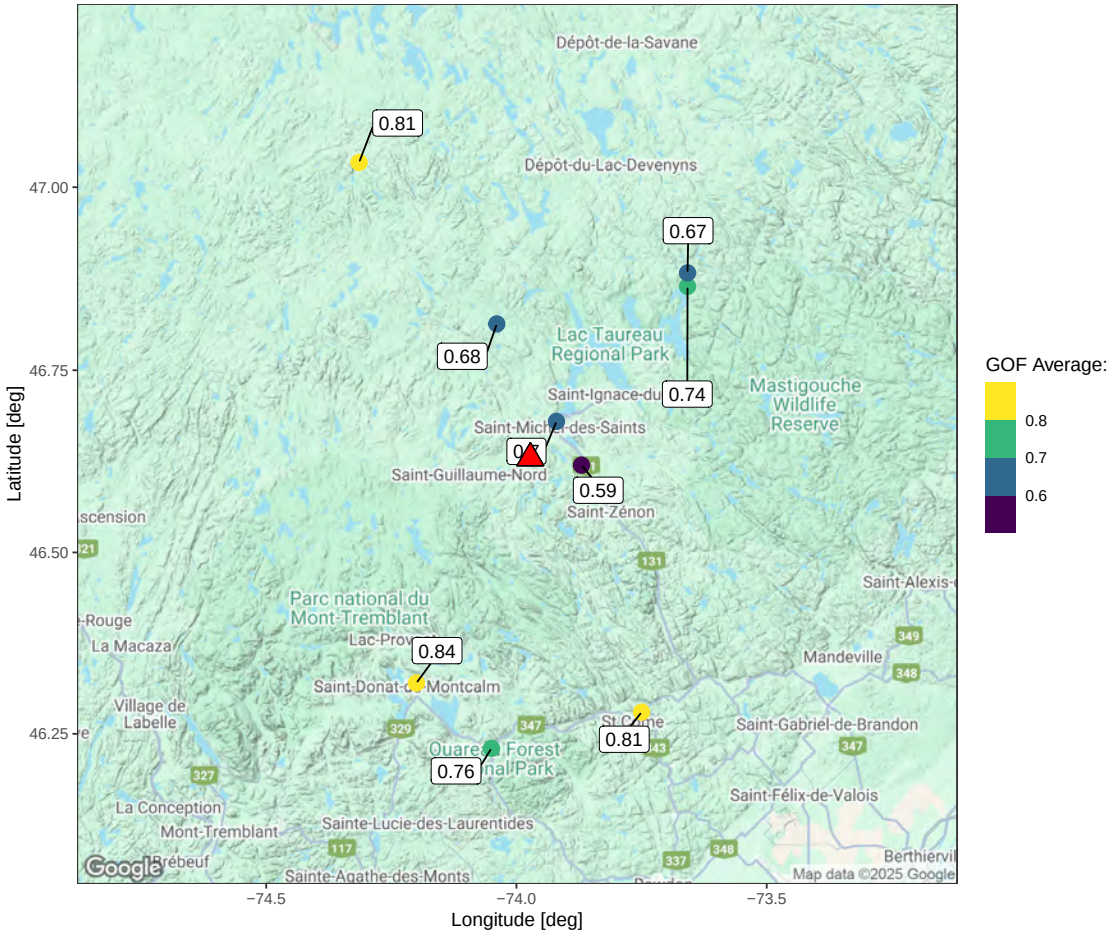
The following maps represent the results of the GOF parameters at each station. The NSE and KGE map doesn't reveal marked spatial trends. Overall, NSE and KGE results for daily time series for all the stations are between 0.55 and 0.85, suggesting a good performance of the snowmelt model in the proximity of the project location.

The Pbias map suggests consistent overprediction bias near the project location, meaning snowpack depth is usually overestimated by the model. The main takeaways from this are:

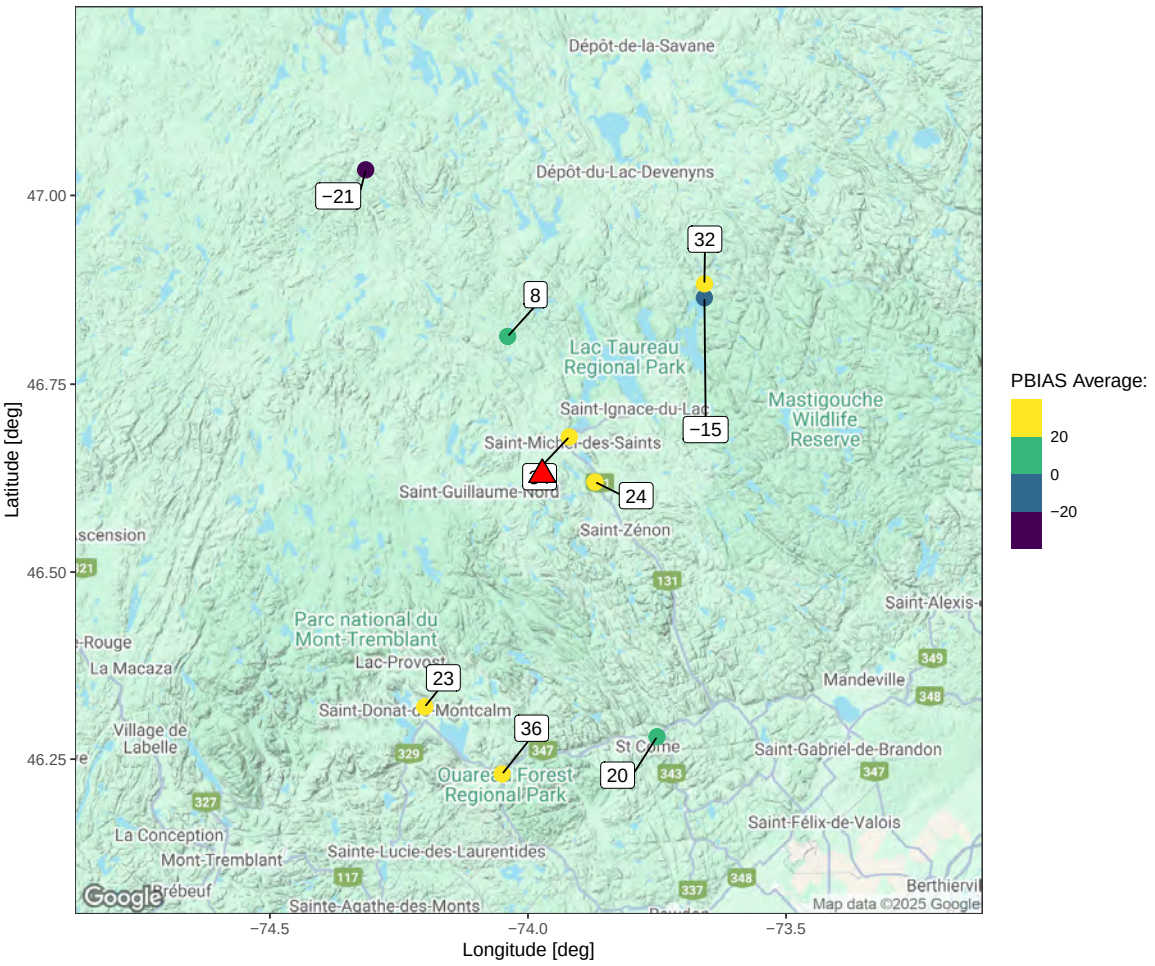
- Overprediction bias in the snowpack model is consistent with review of reanalysis products as described in the **03 Precipitation Analysis** report.
- Snow undercatch correction is not required due to general overprediction bias in the snowpack model results.

Site Location and Snowpack Modelling GOF values at Station Locations

Area of interest covers a distance of up to 125km from Site



Site Location and Snowpack Modelling PBIAS values at Station Locations



Chapter 8

Output

Output of this code has been backed up and saved as an rds file in the **/01_Data/rds** project folder.

References

Gelaro, Ronald, Will McCarty, Max J. Suárez, Ricardo Todling, Andrea Molod, Lawrence Takacs, Cynthia A. Randles, et al. 2017. "The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2)." *Journal of Climate* 30 (14): 5419–54. https://doi.org/10.1175/jcli-d-16-0758.1.

Gupta, Hoshin Vijai, and Harald Kling. 2011. "On Typical Range, Sensitivity, and Normalization of Mean Squared Error and Nash-Sutcliffe Efficiency Type Metrics." *Water Resources Research* 47 (10). https://doi.org/10.1029/2011wr010962.

Hersbach, Hans, Bill Bell, Paul Berrisford, Shoji Hirahara, András Horányi, Joaquín Muñoz-Sabater, Julien Nicolas, et al. 2020. "The ERA5 Global Reanalysis." *Quarterly Journal of the Royal Meteorological Society* 146 (730): 1999–2049. https://doi.org/10.1002/qj.3803.

Muñoz-Sabater, Joaquín, Emanuel Dutra, Anna Agustí-Panareda, Clément Albergel, Gabriele Arduini, Gianpaolo Balsamo, Souhail Boussetta, et al. 2021. "ERA5-Land: A State-of-the-Art Global Reanalysis Dataset for Land Applications." *Earth System Science Data* 13 (9): 4349–83. https://doi.org/10.5194/essd-13-4349-2021.

Nash, J. E., and J. V. Sutcliffe. 1970. "River Flow Forecasting Through Conceptual Models Part I — A Discussion of Principles." *Journal of Hydrology* 10 (3): 282–90. https://doi.org/10.1016/0022-1694(70)90255-6.

Thornton, M. M., R. Shrestha, Y. Wei, P. E. Thornton, and S-C. Kao. 2022. "Daymet: Daily Surface Weather Data on a 1-Km Grid for North America, Version 4 R1," November. https://doi.org/10.3334/ORNLDAAC/2129.

Todd Walter, M., Erin S. Brooks, Donald K. McCool, Larry G. King, Myron Molnau, and Jan Boll. 2005. "Process-Based Snowmelt Modeling: Does It Require More Input Data Than Temperature-Index Modeling?" *Journal of Hydrology* 300 (1-4): 65–75. https://doi.org/10.1016/j.jhydrol.2004.05.002.

Vionnet, Vincent, Colleen Mortimer, Mike Brady, Louise Arnal, and Ross Brown. 2024. "Canadian Historical Snow Water Equivalent Dataset (CanSWE, 1928-2023)." Zenodo. https://doi.org/10.5281/ZENODO.10835278.

Appendix E Storm Events Detailed Analysis

3b. NMG - Matawinie Storm Analysis

CAPR003306

Camilo Gallard

February 10, 2025

Abstract

This report compiles the Intensity Duration Frequency (IDF) and Probable Maximum Precipitation (PMP) analysis for precipitation at Nouveau Monde Graphite Matawinie Site. It was completed by SRK Consulting (Canada) Inc. in 2024 to support Engineering Design. The data compilation and subsequent analysis was conducted in the R Software environment.

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Chapter 1

Glossary

- **AMS**: Annual Maximum Series.
- **Daymet**: Reanalysis tool developed by the Oak Ridge National Laboratory and supported by NASA (Thornton et al. 2022).
- **ECCC**: Environment and Climate Change Canada.
- **ERA5**: Reanalysis tool developed by the European Centre for Medium-Range Weather Forecasts (Hersbach et al. 2020).
- **ERA5-Land**: Reanalysis tool based on ERA5 but for Land surfaces and a smaller grid, and developed by the European Centre for Medium-Range Weather Forecasts (Muñoz-Sabater et al. 2021).
- **ET**: Evapotranspiration
- **ET0**: Reference Evapotranspiration
- **IDF**: Intensity-Duration-Frequency (IDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
- **KST**: Kolmogorov–Smirnov Test.
- **MAAT**: Mean Annual Air Temperature.
- **MAP**: Mean Annual Precipitation.
- **MERRA2**: Modern-Era Retrospective analysis from Research and Applications, Version 2, is a global climate reanalysis model from the U.S. National Aeronautics and Space Administration (Gelaro et al. 2017).
- **NMG**: Nouveau Monde Graphite.
- **PCC**: Pearson Correlation Coefficient.
- **PDF**: Precipitation-Duration-Frequency (PDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
- **PMP**: Probable Maximum Precipitation.
- **RH**: Relative Humidity.

- **SRAD**: Shortwave (solar) radiation. Incident shortwave radiation flux density in watts per square meter.
- **SRK**: SRK Consulting (Canada) Inc.
- **SSR**: Surface net shortwave (solar) radiation. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth (both direct and diffuse) minus the amount reflected by the Earth's surface (which is governed by the albedo).
- **SSRD**: Surface short-wave (solar) radiation downwards. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth. This parameter comprises both direct and diffuse solar radiation.
- **Tavg**: Mean or Average Air Temperature over a given temporal unit (day, month, year…).
- **Tdew**: Mean or Average Dew Point Temperature over a given temporal unit (day, month, year…).
- **Tmax**: Maximum Air Temperature over a given temporal unit (day, month, year…).
- **Tmin**: Minimum Air Temperature over a given temporal unit (day, month, year…).

Chapter 2

General Parameters

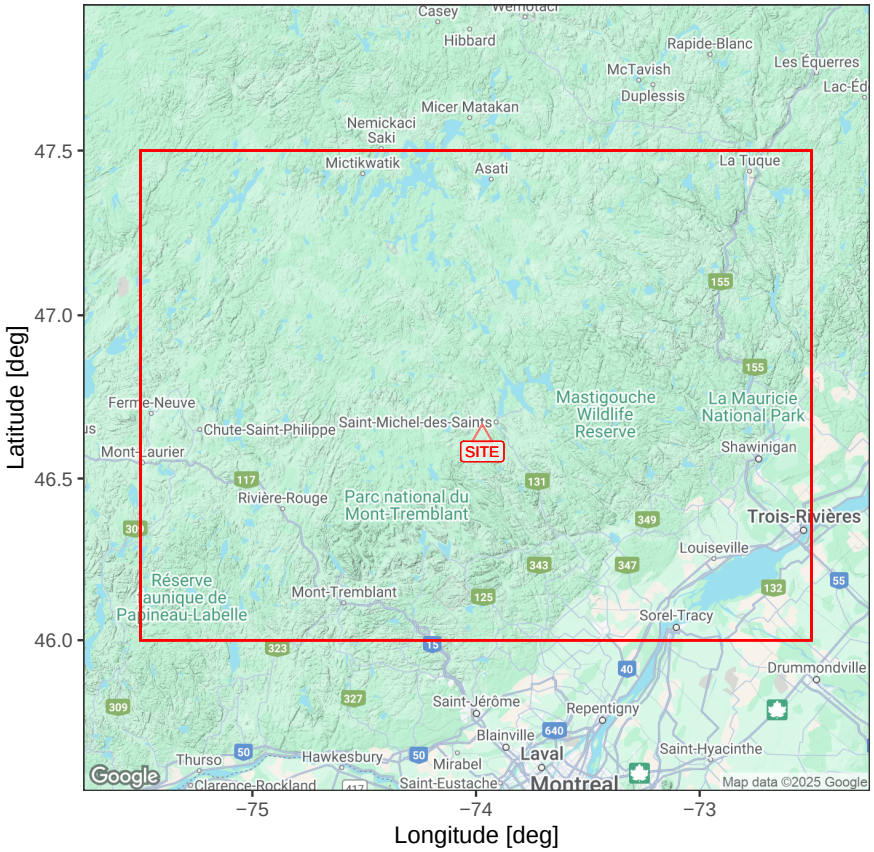
The NMG Matawinie site is located in southern Quebec, 125 km north of Montreal. Site latitude is 46.63 degrees, and longitude is -73.97 degrees, at an elevation of 562 masl. These coordinates were selected to match the location of the meteorological station on site.

For the purpose of this meteorological analysis, an area of interest was defined around site to capture regional data and climate trends, and was defined as the region between:

- 46° and 47.5° Latitude
- -75.5° and -72.5° Longitude

Site Location and Area of Interest for this Study

Area of interest covers a distance of up to 125km from Site



Chapter 3

NMG Precipitation Data

Site data is collected by NMG from two meteorological stations. The first station is located on Site, and the second station, called SoftdB, is located 1.5 km north at the following address: 200 Chemin des Hauteurs, Saint-Michel-des-Saints. Both records appear to only collect rainfall data.

For further details on NMG precipitation data processing and selection, refer to report **03 Precipitation Analysis**.

Chapter 4

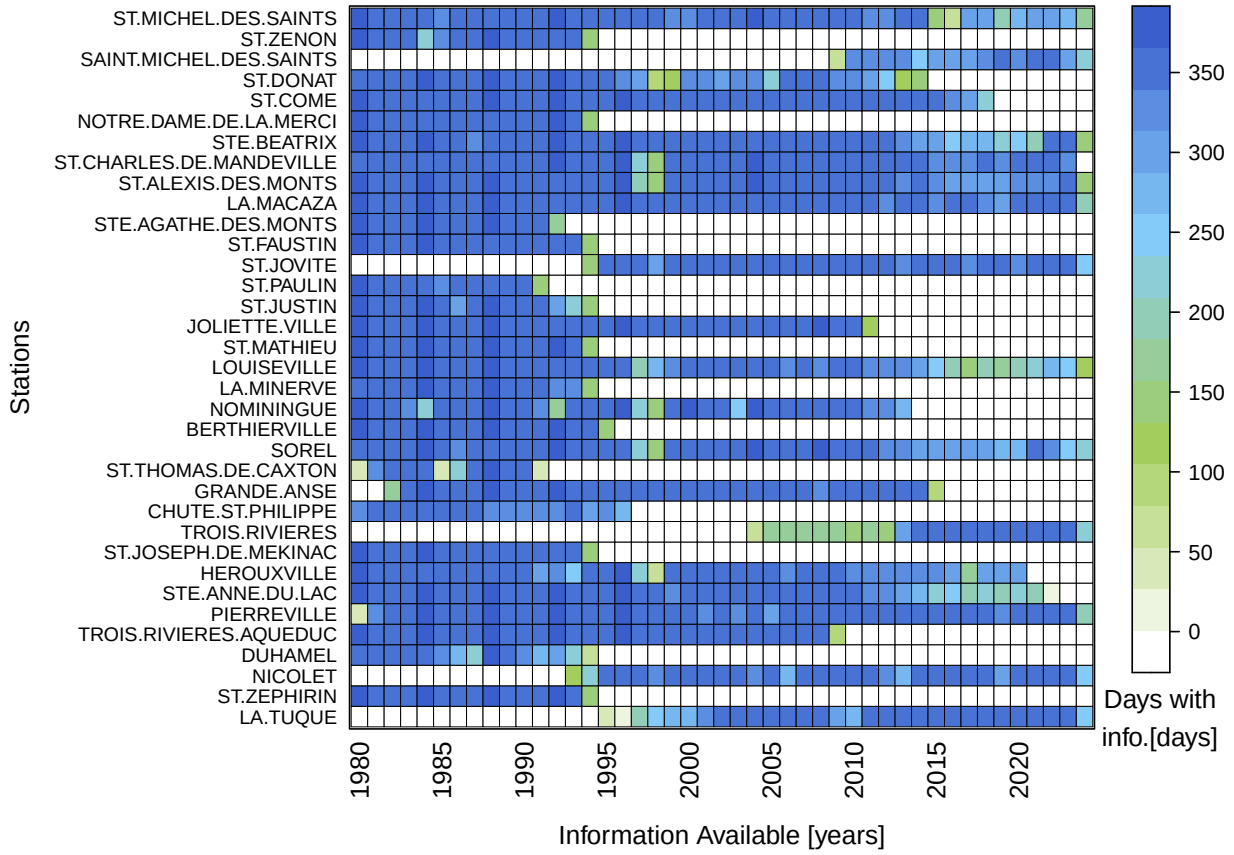
ECCC Precipitation Data

Environment and Climate Change Canada (ECCC) data was downloaded and prepared for analysis. The information is captured on a daily or hourly timestep when available. No complementary/redundant stations were detected so patching was not required for stations within the area of interest.

The following figures show:

1. Data availability over time at each station (only records from 1980 to 2023 were considered for this analysis).
2. Selected ECCC stations location and elevation.

Refer to the "eccc_read.r" for pre-processing details.


ST.MICHEL.DES.SAINTS
ST.ZENON
SAINT.MICHEL.DES.SAINTS
ST.DONAT
ST.COME
NOTRE.DAME.DE.LA.MERCI
STE.BEATRIX
ST.CHARLES.DE.MANDEVILLE
ST.ALEXIS.DES.MONTS
LA.MACAZA
STE.AGATHE.DES.MONTS
ST.FAUSTIN
ST.JOVITE
ST.PAULIN
ST.JUSTIN
JOLIETTE.VILLE
ST.MATHIEU
LOUISEVILLE
LA.MINERVE
NOMININGUE
BERTHIERVILLE
SOREL
ST.THOMAS.DE.CAXTON
GRANDE.ANSE
CHUTE.ST.PHILIPPE
TROIS.RIVIERES
ST.JOSEPH.DE.MEKINAC
HEROUXVILLE
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TROIS.RIVIERES.AQUEDUC
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Stations
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1990
1995
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2015
2020
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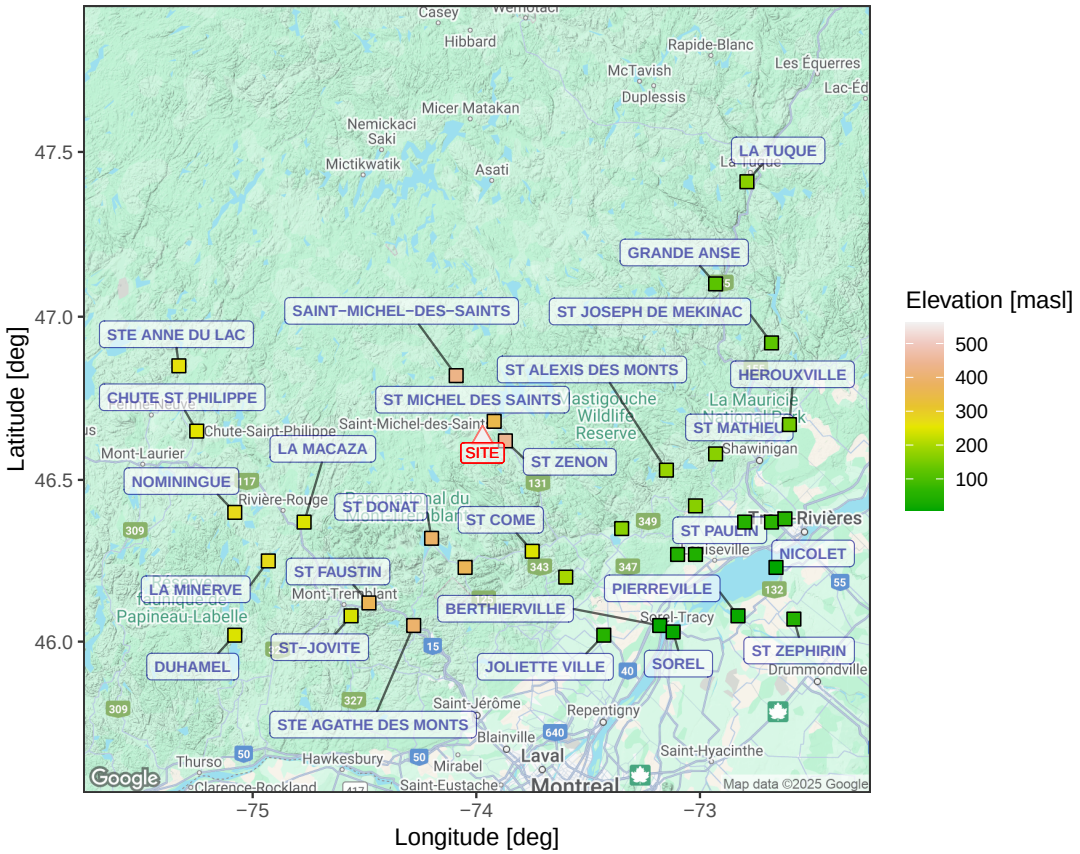
Site and ECCC Stations Location and Elevation [masl]

Elevations based on SRTM data



Chapter 5

Regional Data review

The precipitation timeseries generated for site in the previous analysis is meant to represent usual weather conditions for site over time, and might not be an accurate source for extreme events. In the following section, the best source for storm event data for the Project is assessed.

5.1 ECCC Extreme Event Consistency Review

The density of stations around site helps checking the validity of the largest rainfall events (> 90 mm) registered near the Project location (within 50 km of site) on a regional scale. The following table summarizes the regional rainfall records on the days of these events.

The 1996 Saint Michel des Saints event is the only one that was not registered in any other station. The other events are likely reliable as they all affected multiple stations within the area of interest.

Table 5.1: Major Rainfall Events near Site [mm/day]

station_name	distance	1984-08-14	1989-10-20	1996-06-11	2004-09-09	2014-08-13	2024-08-09
ST MICHEL DES SAINTS	6.9	16.4	50.4	118	92.6	56.6	-
ST ZENON	7.9	13	52	-	-	-	-
SAINT-MICHEL-DES-SAINTS	23	-	-	-	-	21.8	81.3
ST DONAT	38.6	51.8	54.8	-	118.1	-	-
ST COME	42.5	18.4	64.8	-	110	111.8	-
NOTRE DAME DE LA MERCI	44.9	127.4	130	-	-	-	-
STE BEATRIX	55.7	15	71.2	-	112	111	-
ST CHARLES DE MANDEVILLE	56.9	12.2	62.4	-	94.6	77.3	-
ST ALEXIS DES MONTS	63.8	-	34.3	-	90	46	-
LA MACAZA	67.6	39.4	48	-	75	53.6	-
STE AGATHE DES MONTS	68.7	75.4	69.2	-	-	-	-
ST FAUSTIN	68.8	16.6	30.6	-	-	-	-

station_name	distance	1984-08-14	1989-10-20	1996-06-11	2004-09-09	2014-08-13	2024-08-09
ST-JOVITE	76	-	-	-	105	40.3	103.8
ST PAULIN	76.5	-	77.2	-	-	-	-
ST JUSTIN	77.9	-	44.5	-	-	-	-
JOLIETTE VILLE	79.6	21.6	43	-	76	-	-
ST MATHIEU	79.8	-	68.4	-	-	-	-
LOUISEVILLE	83.2	-	62	-	91.4	43.8	-
LA MINERVE	84.7	50.2	38.8	-	-	-	-
NOMININGUE	88.5	58.5	46.6	-	72	-	-
BERTHIERVILLE	88.6	13.3	52.2	-	-	-	-
SOREL	93.4	-	54.8	-	87	41.2	-
ST THOMAS DE CAXTON	94.3	15.4	46.2	-	-	-	-
GRANDE ANSE	94.9	-	44.4	-	99.6	28	-
CHUTE ST PHILIPPE	97.6	26	40	-	-	-	-
TROIS-RIVIERES	103	-	-	-	-	48.1	113.8
ST JOSEPH DE MEKINAC	103.6	21.4	34	-	-	-	-
HEROUXVILLE	104.8	15.8	49.6	-	120.2	64.5	-
STE ANNE DU LAC	106.3	24	43.6	-	34.4	-	-
PIERREVILLE	106.9	11.8	44.8	-	92	27.4	-
TROIS RIVIERES AQUEDUC	107.1	15.2	51.4	-	94.4	-	-
DUHAMEL	108.8	21.6	44.5	-	-	-	-
NICOLET	110	-	-	-	78	34.3	118.1
ST ZEPHIRIN	123.7	15.8	36	-	-	-	-
LA TUQUE	124.7	-	-	-	67.1	27.4	39.7

5.2 Reanalysis Extreme Rainfall Events Review

Reanalysis precipitation datasets that were selected for this analysis (Daymet, ERA5, ERA5-Land, MERRA2) are descibed in the **03 Precipitation** report. In the following figures, reanalysis products were compared to ECCC station data specifically to review major storm events depth, which is the basis for storm frequency analysis (rainfall).

A graph is presented for each ECCC station within the area of interest of the project representing the population pyramid of daily maximum precipitation each year for matching records from Reanalysis and ECCC.

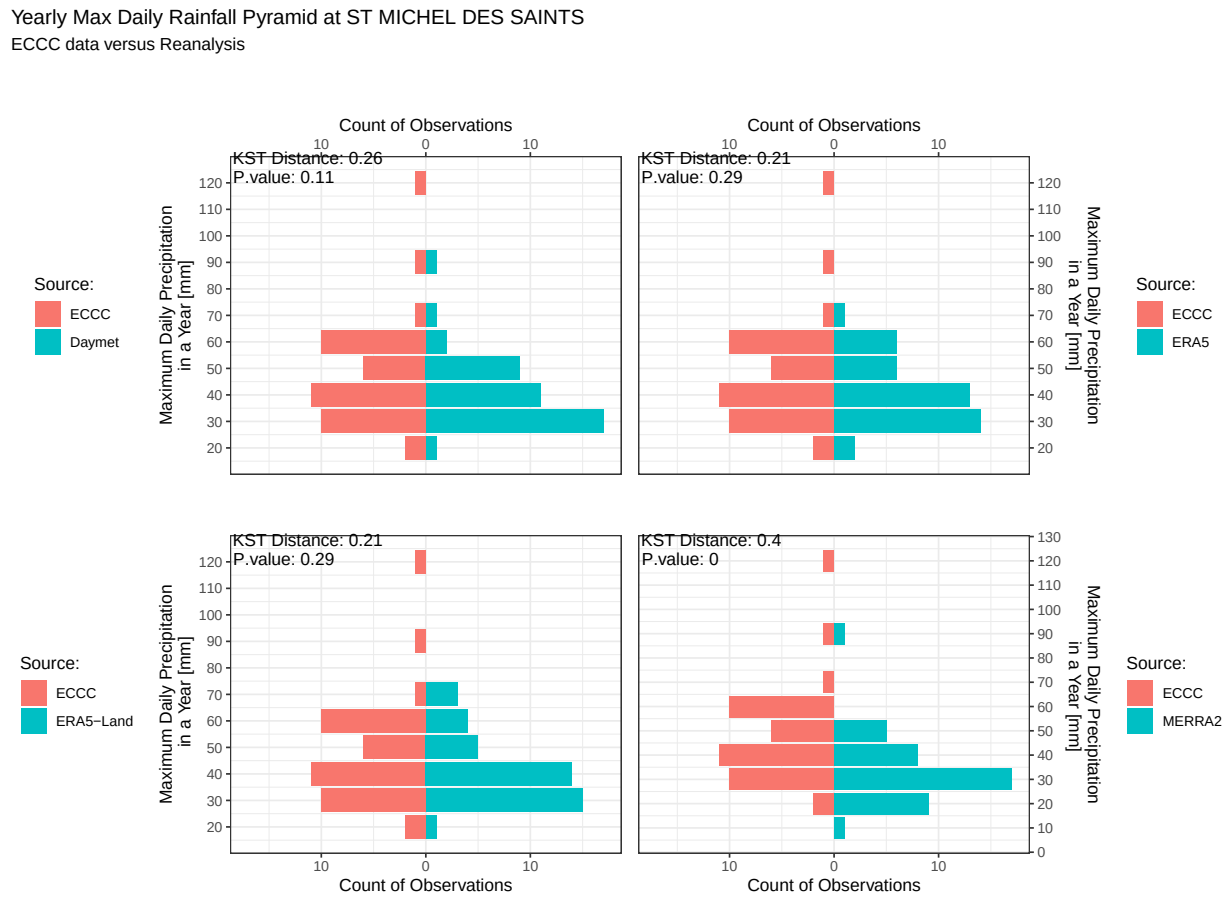
These samples are also compared by performing a Kolmogorov–Smirnov test. The Kolmogorov–Smirnov test (KST) is a nonparametric test that can be used to test whether two samples came from the same distribution (two-sample K–S test). The resulting Kolmogorov–Smirnov distance is small when the distributions are the same and close to 1 when they're very different. The P-value

computed from the test helps us with the interpretation of the result. If the P-value is small, we conclude that the two groups were sampled from populations with different distributions. The populations may differ in median, variability or the shape of the distribution. Note that this test becomes less reliable the shorter the station record.

The main takeaways of this analysis are:

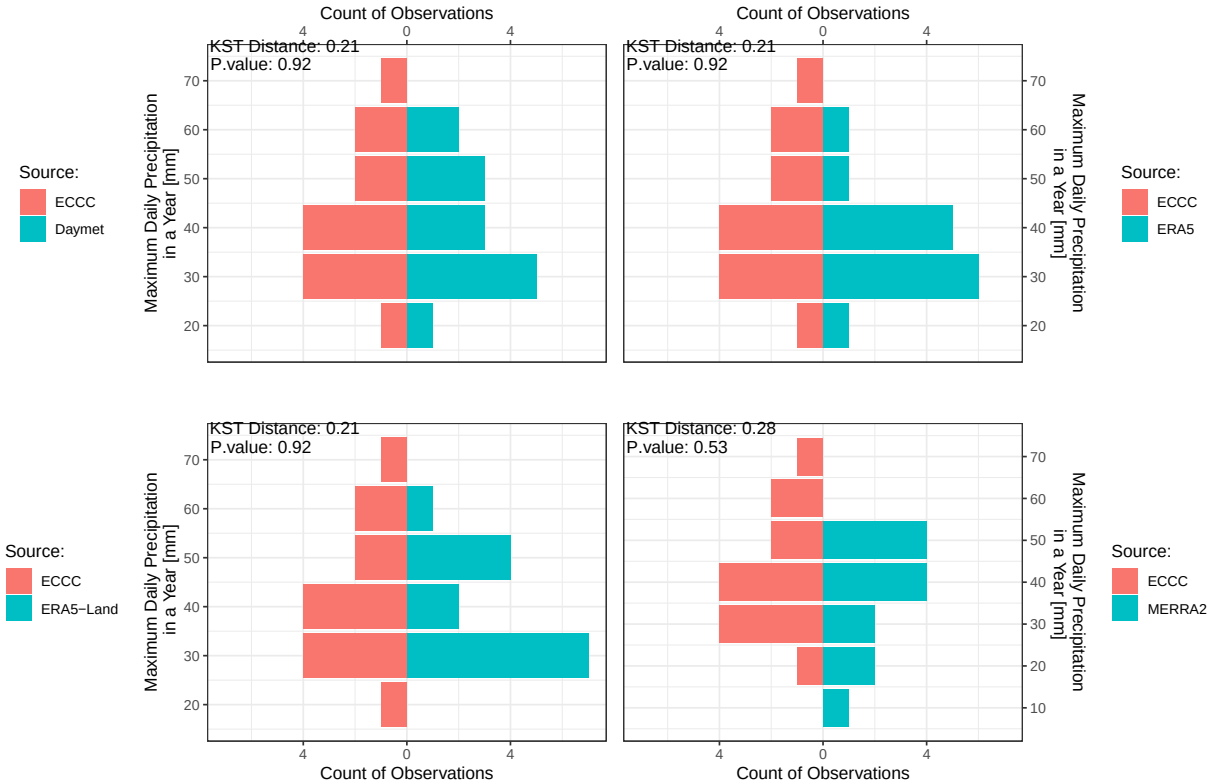
- Reanalysis products tend to miss/undepredict the larger precipitation events on record.
- Kolmogorov–Smirnov test results generally present low probabilities that ECCC and Reanalysis extreme event populations come from the same distribution, although this could be due to low population sizes.

5.2.1 Storm Events at ST MICHEL DES SAINTS

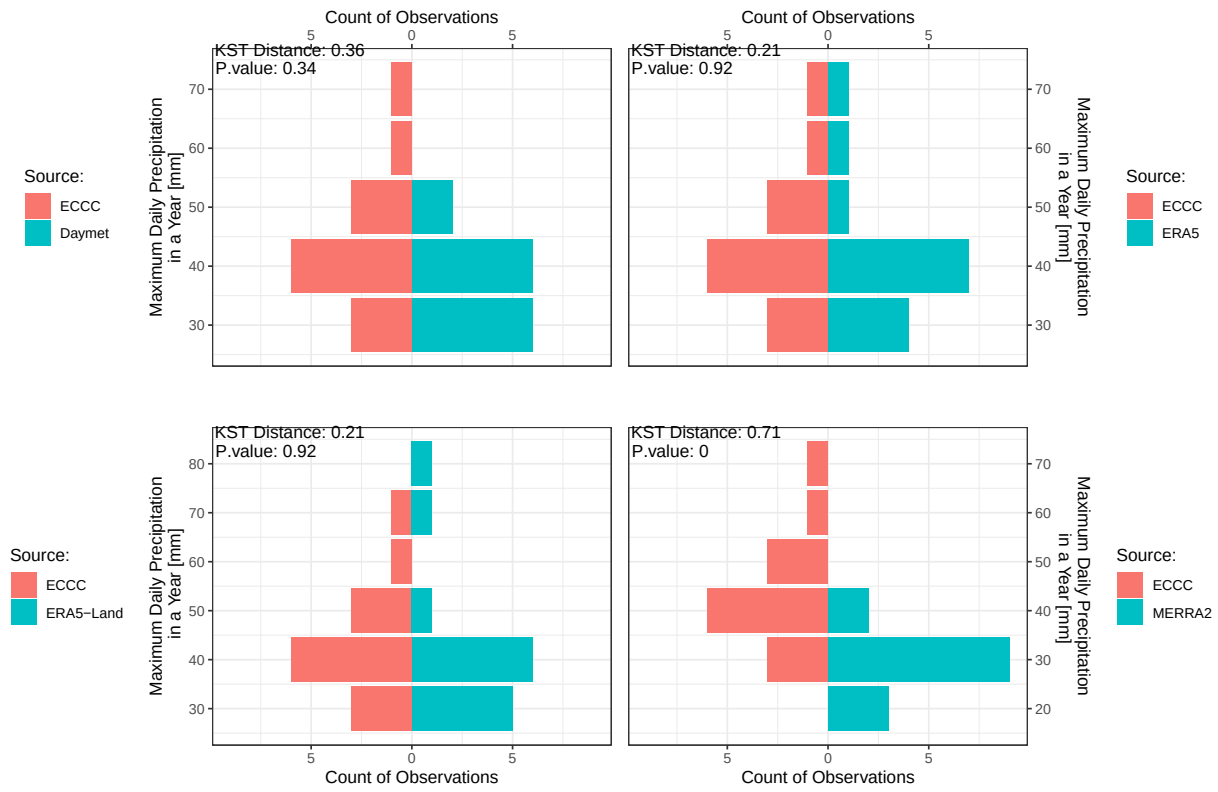


5.2.2 Storm Events at ST ZENON

Yearly Max Daily Rainfall Pyramid at ST ZENON
ECCC data versus Reanalysis

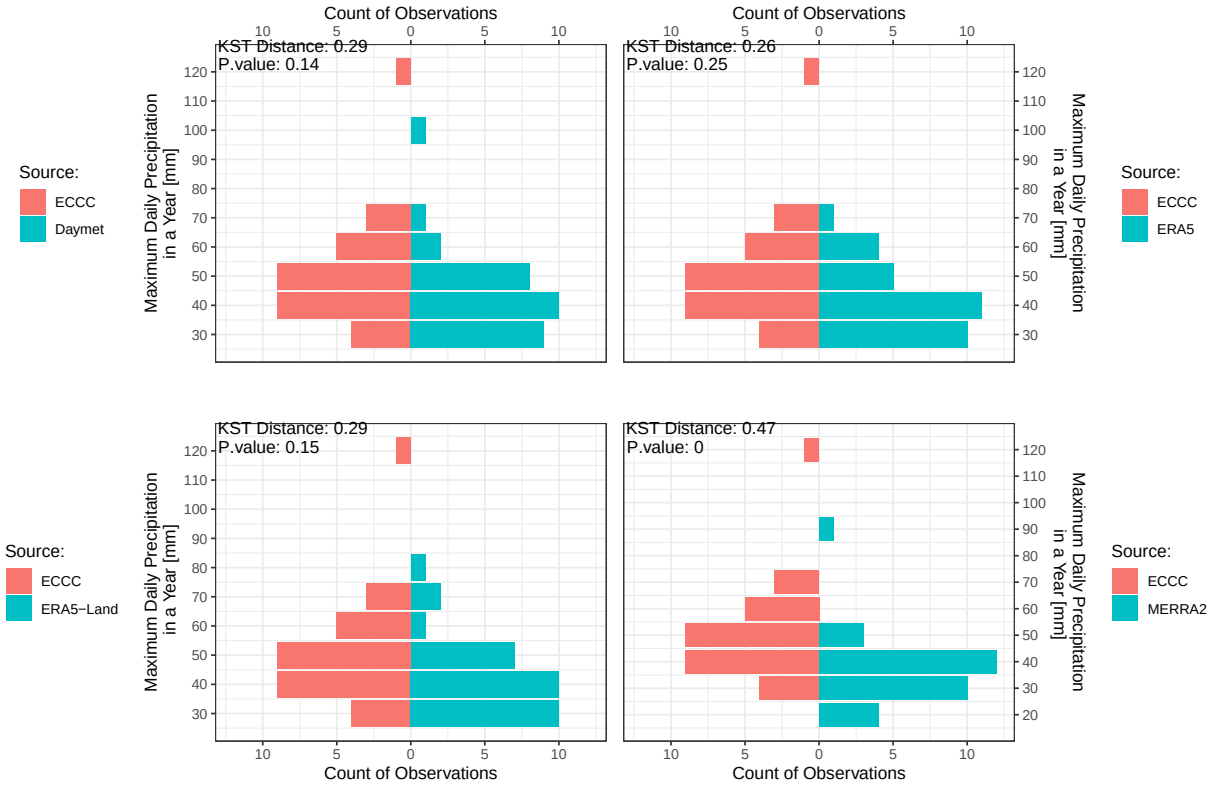


5.2.3 Storm Events at SAINT-MICHEL-DES-SAINTS



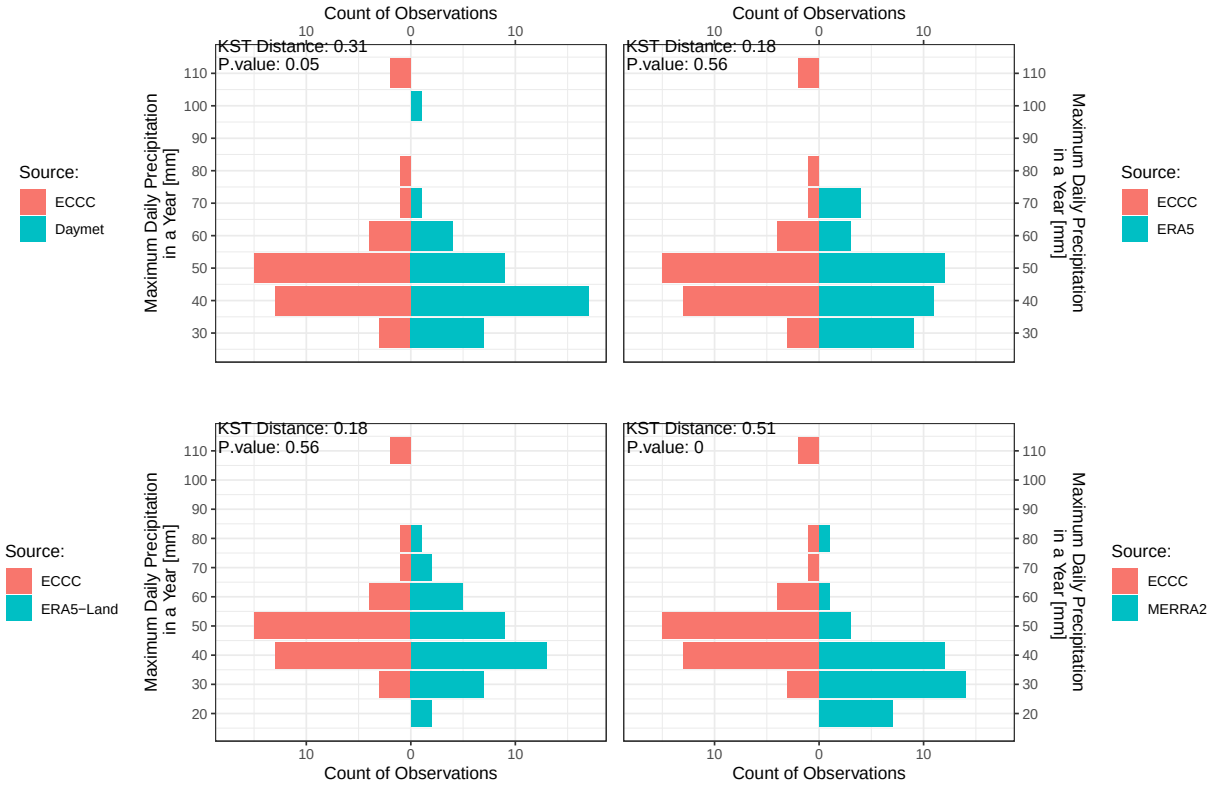
5.2.4 Storm Events at ST DONAT

Yearly Max Daily Rainfall Pyramid at ST DONAT
ECCC data versus Reanalysis



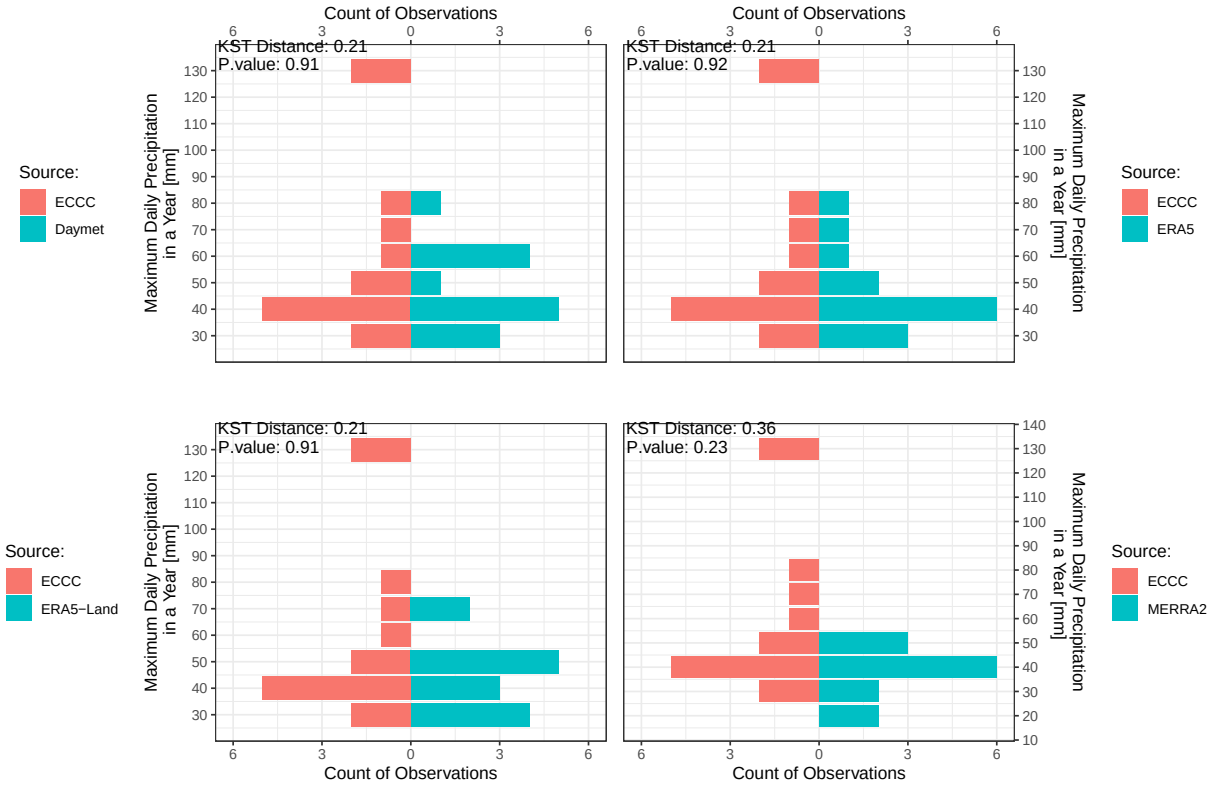
5.2.5 Storm Events at ST COME

Yearly Max Daily Rainfall Pyramid at ST COME
ECCC data versus Reanalysis



5.2.6 Storm Events at NOTRE DAME DE LA MERCI

Yearly Max Daily Rainfall Pyramid at NOTRE DAME DE LA MERCI
ECCC data versus Reanalysis



Chapter 6

Regional Frequency Analysis for 24-hour Storms

Previous analysis indicates neither reanalysis tool would be appropriate to use as storm frequency analysis source for site. ECCC stations are expected to provide more reliable storm event data. Due to the short precipitation record on site and to take advantage of all available data in the region, this analysis followed the framework of regional frequency analysis with L-moments proposed by Hosking & Wallis (Hosking and Wallis 1997) instead of selecting a single analogue station for site.

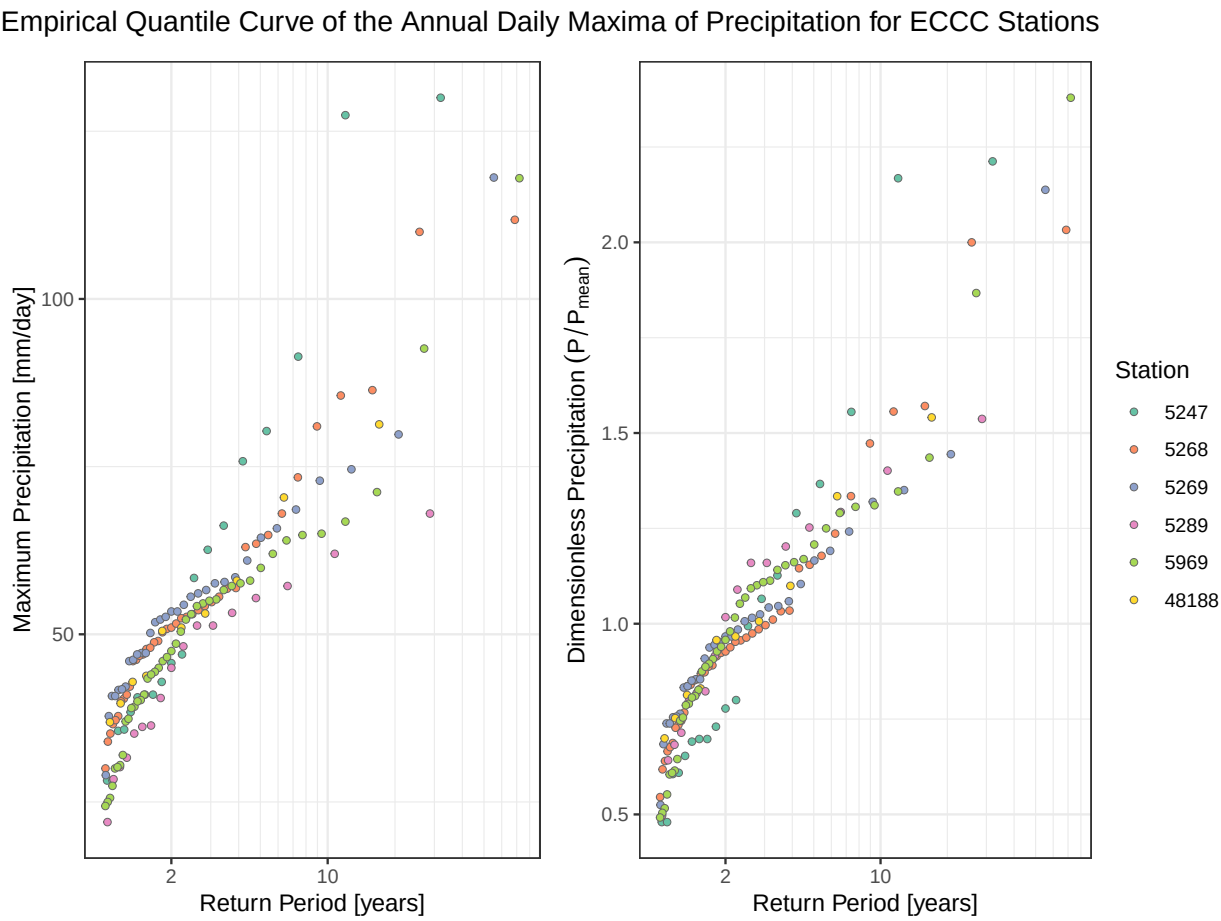
The general outline of the followed method is as follows:

1. For selected stations, years with too much missing information were removed from the records by following the Papalexiou & Koutsoyiannis method (Papalexiou and Koutsoyiannis 2013).
2. Annual Maximum Series (AMS) is compiled for each station, and tested with non parametric tests to assess if they are suited to be included in the regional frequency analysis. A storm dataset is selected for site.
3. A regional curve is fit to the dimensionless AMS (values divided by average) of the neighbor stations (L-moments).
4. The dimensionless quantile curve is scaled back to any site by multiplying its quantiles by the mean AMS. Since the mean AMS is unavailable at site, the correlation between physical covariates and this quantity at neighbor stations was used to predict values at the site.

6.1 AMS Preparation for Daily Storms

6.1.1 AMS Compilation and Outlier Removal

Selected stations are the ECCC stations located within 50 km of the Project.



6.1.2 AMS Testing

Non parametric tests assessed to investigate fundamental hypothesis of frequency analysis, assuming significance level of 5%:

- NERC (1975) test for testing randomness. Null hypotheses (H0) - data is random.
- Wald-Wolfwitz test for testing independence. Null hypotheses (H0) - data is independent.
- Mann-Whitney test for testing homogeneity. Null hypotheses (H0) - data is homogeneous.
- Spearman test for testing stationarity. Null hypotheses (H0) - data is stationary.

Table 6.1: Percentage of Annual Maximum Series in which the Non-parametric Test Rejected their Null Hypothesis

Randomness H0	Independence H0	Homogeneity H0	Stationarity H0
16.7%	0.0%	16.7%	16.7%

Table 6.2: Stations Within a 50 km Radius that Test Rejected their Null Hypothesis

station_id	station_name	distance	nt_rand	nt_inde	nt_homo	nt_stat
5289	ST ZENON	7.9	0	0.2	0.8	1

station_id	station_name	distance	nt_rand	nt_inde	nt_homo	nt_stat
5269	ST DONAT	38.6	0.5	0.6	0	0

6.1.3 Data Used in the Regional Frequency Analysis

The stations used in the regional frequency analysis are listed in the table below. The selection parameters are the following:

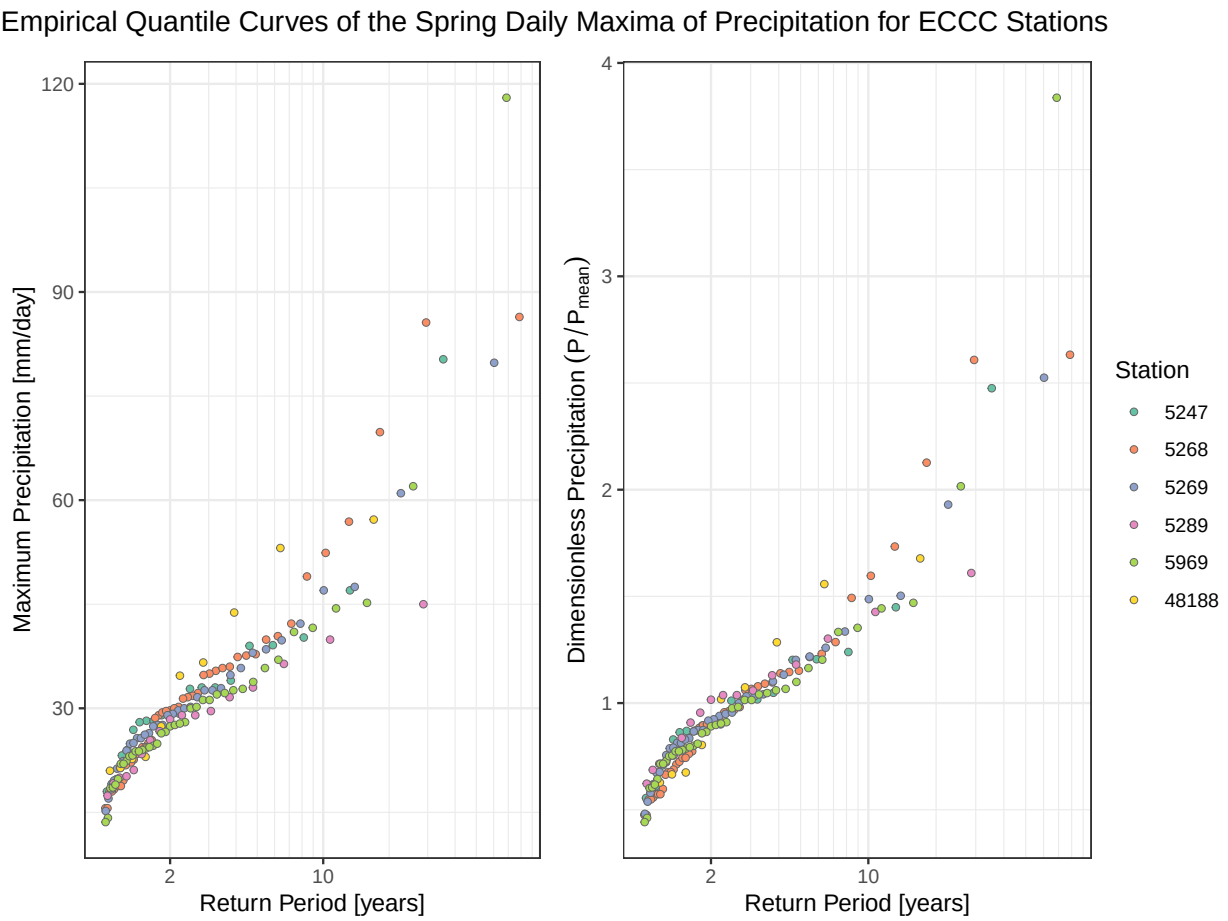
- Distance to the site < 50 km (six stations selected)
- Records in the AMS >= 10 (true for all six previously seleceted stations)
- p-value of at least three non-parametric tests >= 0.05 (Saint Donat station was exculded based on Homogeneity and Stationarity)

Table 6.3: Selected Stations for the Regional Daily Strom Frequency Analysis

station_id	station_name	lon	lat	distance	elev	Mean_AMS	n_max
5969	ST MICHEL DES SAINTS	-73.9	46.7	6.9	350.5	49.6	43
5289	ST ZENON	-73.9	46.6	7.9	442	44.2	17
48188	SAINT-MICHEL-DES-SAINTS	-74.1	46.8	23	429.9	52.8	10
5268	ST COME	-73.8	46.3	42.5	244	55	41
5247	NOTRE DAME DE LA MERCI	-74	46.2	44.9	365.8	58.8	19

6.2 AMS Preparation for Spring Storms

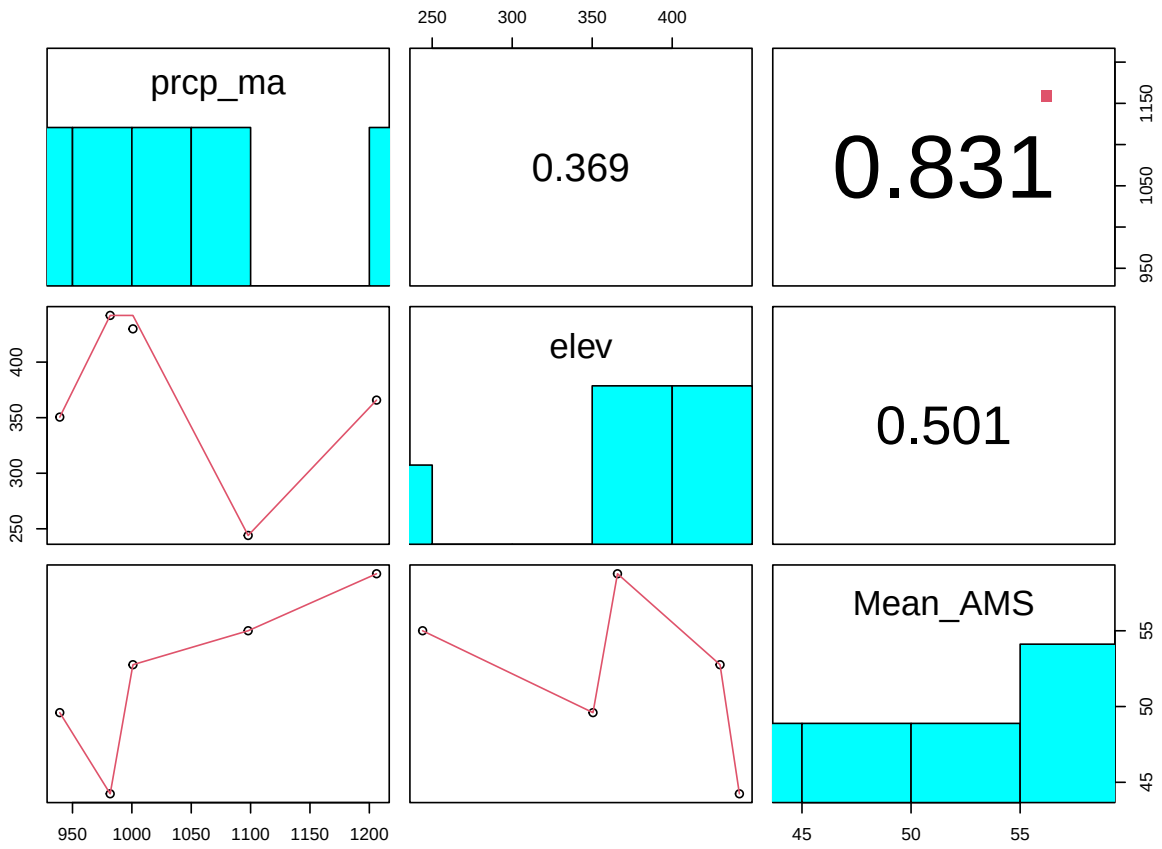
Spring storm events were selected as occurring between April 1st and June 21th. For methodology consistency, the same station selection was kept from the previous analysis, and AMS testing is not required.

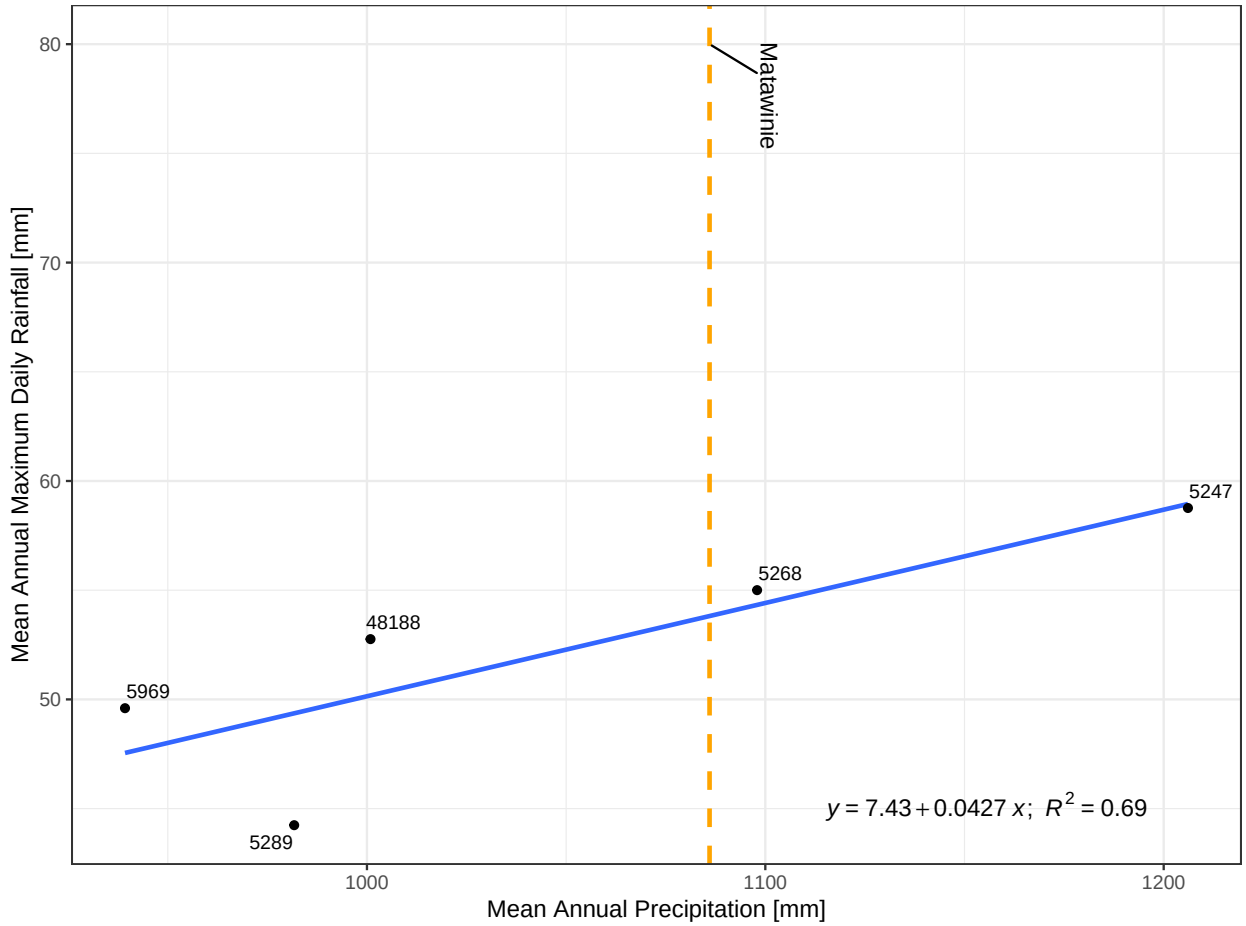


6.3 Covariates

Usually there is a strong correlation between annual precipitation and mean annual maximum daily rainfall that could be used to pull information from nearby stations while still making use of the site information (in this case, its mean annual precipitation since the daily values are unreliable for extreme events as they are based on Daymet). The relationship between the annual rainfall and the first momentum of the AMS is confirmed below.

In this figure, only stations with at least 10 records in the AMS and within 50 km from the site are selected.


prcp_ma
0.369
0.831
elev
0.501
Mean_AMS
250
300
350
400
950
1050
1150
45
50
55
1000
1100
1200



6.4 L-moments Application

6.4.1 Daily Storms

The L-moments outcomes resulting from following the regional frequency analysis framework (Hosking and Wallis 1997) are presented below:

Discordancy measures (critical value 1.33) 1.33 0.61 1.18 0.86 1.02

Heterogeneity measures (based on 10000 simulations) 0.82 0.56 0.06

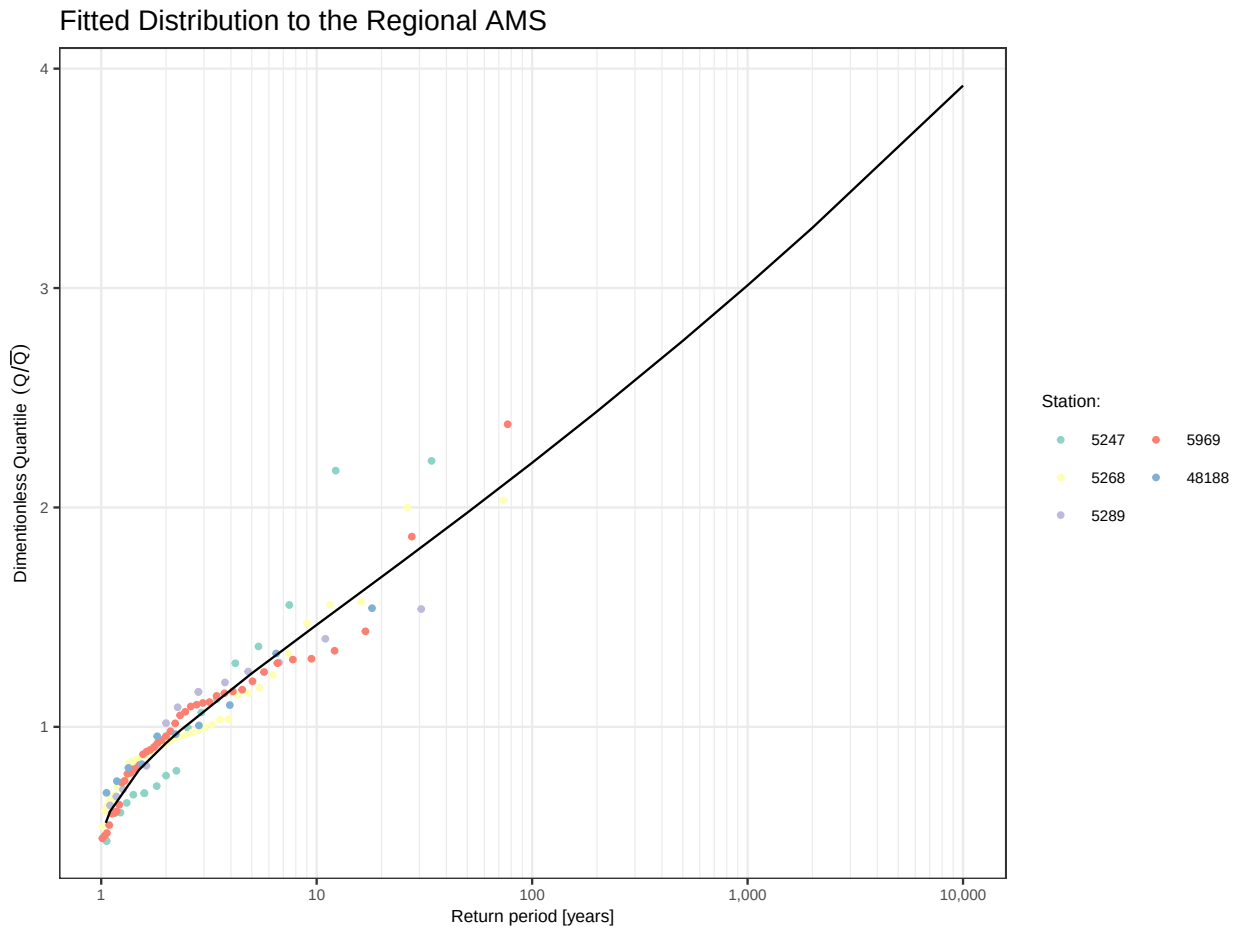
Goodness-of-fit measures (based on 10000 simulations) glo gev gno pe3 gpa 0.16 -0.65 -0.90 -1.40 -2.58

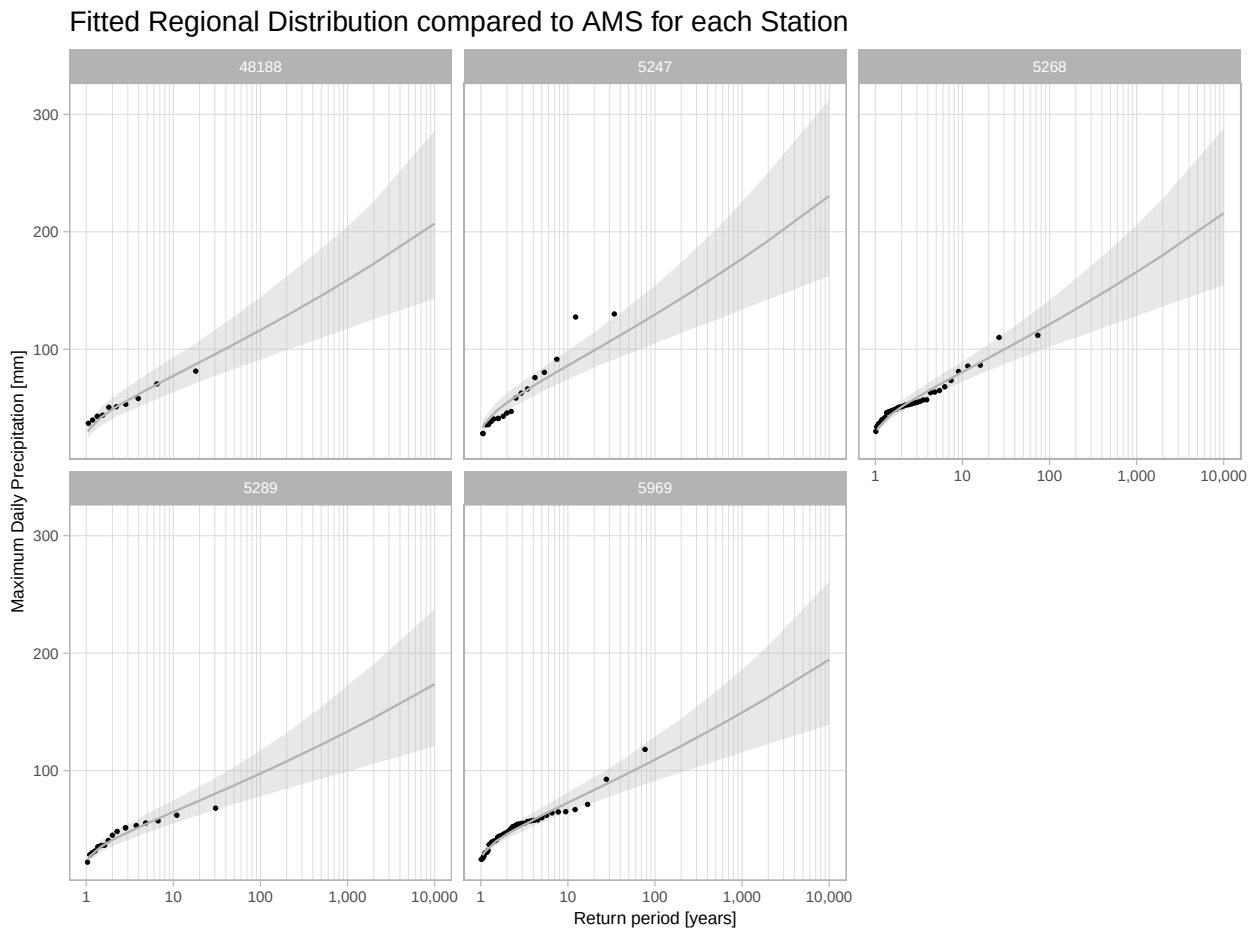
1. Discordancy measure check: - Condition: D < Dcrit - In this case, max(D) was 1.33 <= 1.33
2. Homogeneous region check: - Conditions:
   - H < 1 - homogeneous region
   - 1 < H < 2 - possibly heterogeneous region
   - H > 2 - definitely heterogeneous region

   In this case, H was 0.82 (first measures of regional heterogeneity) which confirms the selected region is homogeneous
3. Goodness-of-fit measure - Condition: |Z| < 1.645 - Smallest Z was |Z| = 0.16 for the generalized

logistic distribution. However, all distributions apart from generalized Pareto are below the Z value condition, meaning they can be considered acceptable at the 10 per cent significance level. After further graphical review, the Generalized Normal distribution was selected for the region as it fitted better for larger storms.

The graphs below show the selected distribution fitness to the regional AMS, and relative to each Station.





6.4.2 Spring Daily Storms

The L-moments outcomes resulting from following the regional frequency analysis framework (Hosking and Wallis 1997) are presented below:

Discordancy measures (critical value 1.33) 0.47 1.32 1.19 0.70 1.31

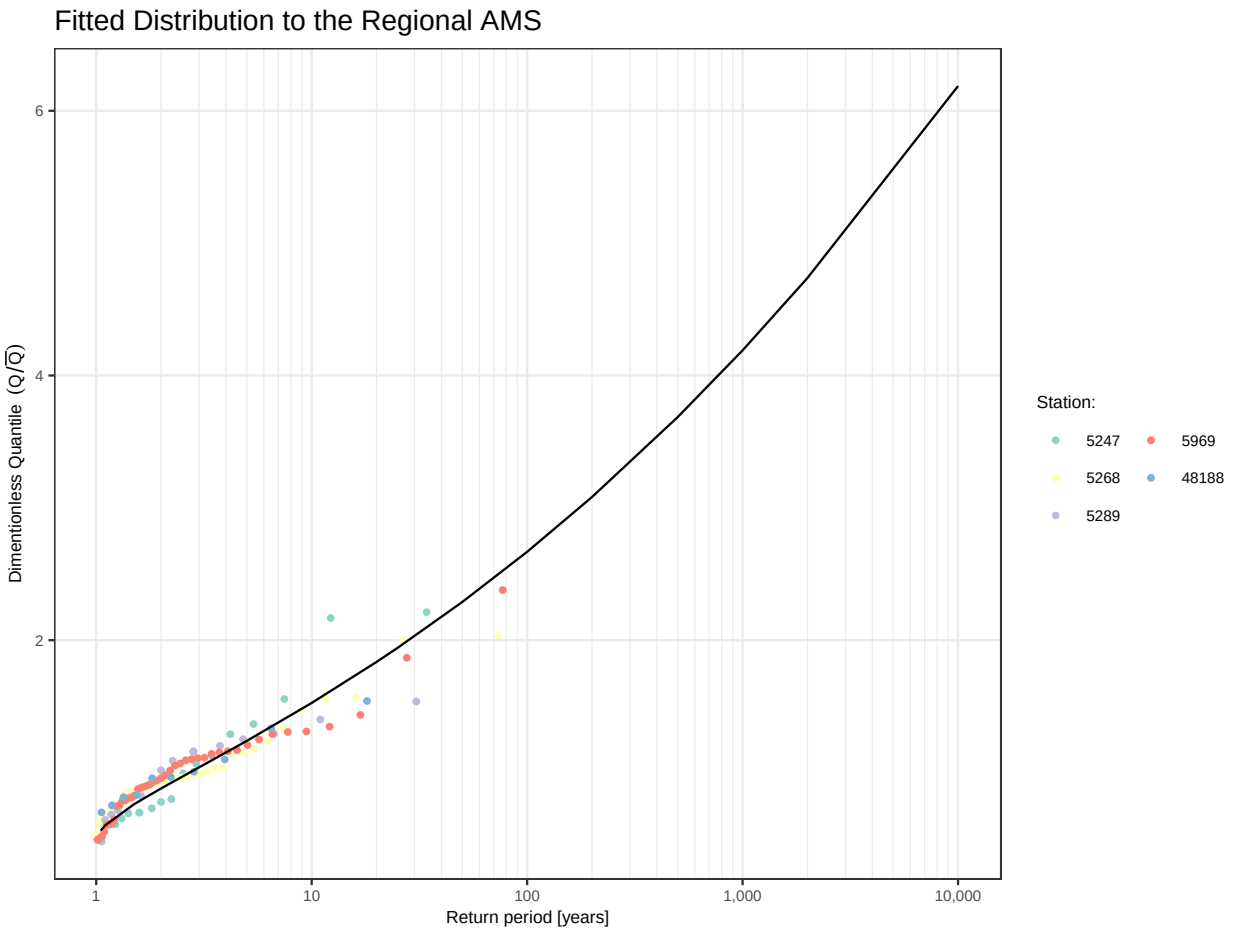
Heterogeneity measures (based on 10000 simulations) -0.58 -0.94 -0.23

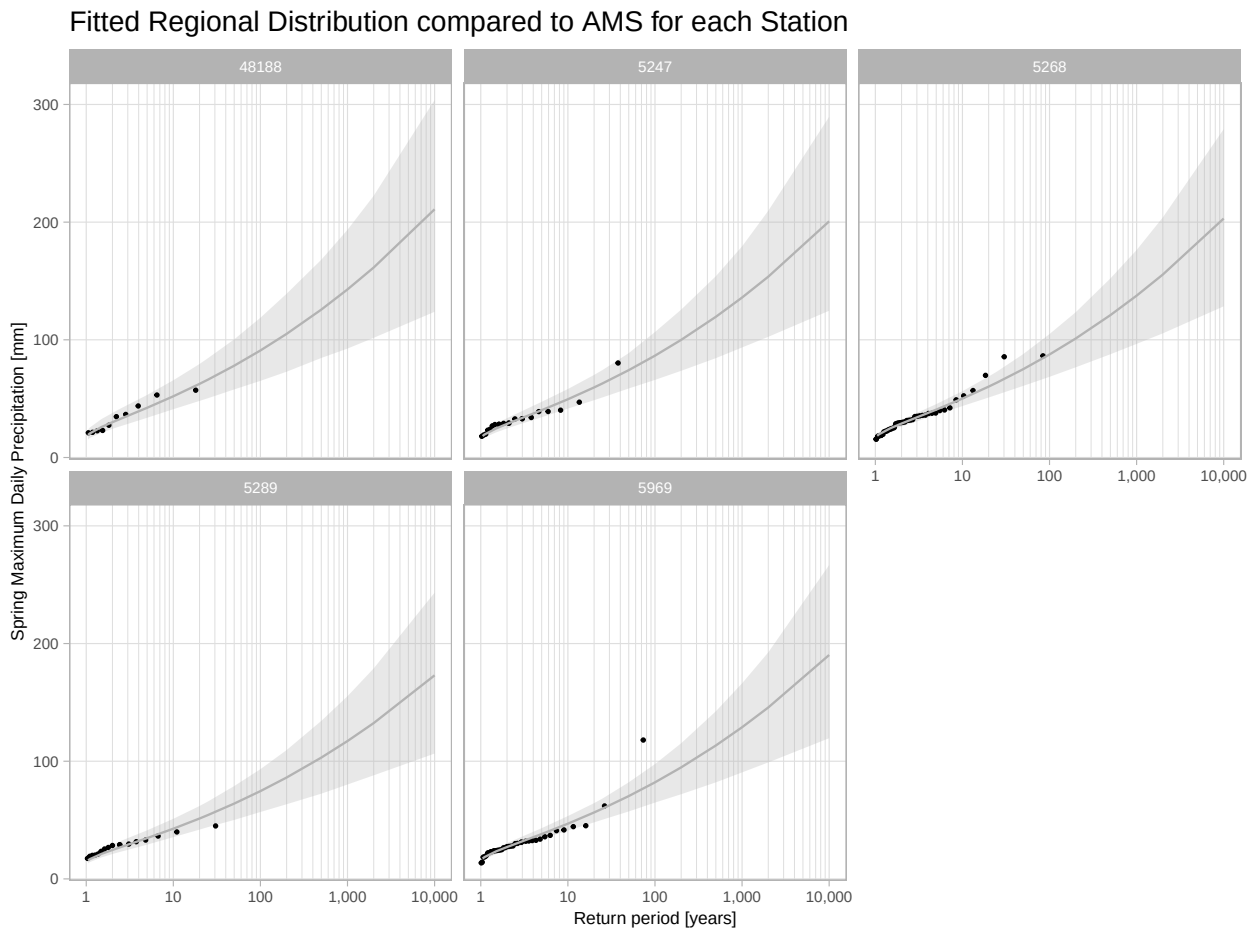
Goodness-of-fit measures (based on 10000 simulations) glo gev gno pe3 gpa -1.03 -1.46 -1.89 -2.63 -2.72

1. Discordancy measure check: - Condition: D < Dcrit In this case, max(D) was 1.32 <= 1.33
2. Homogeneous region check: - Conditions:
   - H < 1 - homogeneous region
   - 1 < H < 2 - possibly heterogeneous region
   - H > 2 - definitely heterogeneous region

   In this case, H was -0.58 (first measures of regional heterogeneity) which confirms the selected region is homogeneous.
3. Goodness-of-fit measure - Condition: |Z| < 1.645 Smallest Z was |Z| = 1.03 for the generalized logistic distribution. However, the Generalized Normal distribution was selected for the region for consistency with the previous analysis.

The graphs below show the selected distribution fitness to the regional AMS, and relative to each Station.





6.5 Results for the Matawinie Site

6.5.1 Daily Storms

The frequency depths for the site location were determined from the fitted distribution and the MAP covariate approximation. A summary table of the resulting frequency depths of daily precipitation at the Matawinie site follows.

Table 6.4: Resulting Frequency Depths of Daily Precipitation at the Matawinie Site

Return Period [Years]	Daily Precipitation [mm]
2	49.8
2.3	53
5	66.9
10	78.8
20	90.6
25	94.4
50	106.3
100	118.6
200	131.2
500	148.5
1000	162.1

Return Period [Years]	Daily Precipitation [mm]
2000	176.2
10000	211.1

6.5.2 Spring Daily Storms

The frequency depths for the site location were determined from the fitted distribution and the MAP covariate approximation. A summary table of the resulting frequency depths of daily precipitation at the Matawinie site follows.

Table 6.5: Resulting Frequency Depths of Daily Spring Precipitation at the Matawinie Site

Return Period [Years]	Daily Precipitation [mm]
2	28.1
2.3	30.1
5	39.6
10	48.8
20	58.7
25	62.1
50	73.2
100	85.3
200	98.5
500	117.9
1000	134
2000	151.5
10000	197.8

Chapter 7

IDF Generation

The Intensity-Duration-Frequency (IDF) and Precipitation-Duration-Frequency (PDF) relationships link daily storms and short-duration storms, ranging from 5 minutes to 24 hours.

For this project, hourly records are limited to NMG Stations (Site and SoftdB) Saint Michel des Saints Station (ID 48188). There are no short timestep records (below 1 hour) available at the time of this study.

7.1 ECCC Regression Coefficients

ECCC has published IDF analysis results for QAd data from Saint Michel des Saints Station (ID 48188) between 1970 and 2021 and Saint Donat Station (ID 5269) between 1970 and 1997. Data was retrieved from https://climatedata.ca/download/#idf-download. This analysis includes intensity-duration-frequency relationships for durations between 5 minutes and 24 hours.

The regression coefficients relative to daily precipitation derived from ECCC Saint Michel des Saints Station (ID 48188) IDF analysis are selected as analog to site due to proximity between locations, and are presented in the following table.

Table 7.1: IDF Coefficients Relative to 24-hour Precipitation based on ECCC data

	5	10	15	30	60	120	360	720	1440
2yrs	0.154	0.22	0.266	0.339	0.45	0.555	0.75	0.866	1
2.3yrs	0.155	0.222	0.27	0.347	0.457	0.563	0.756	0.872	1
5yrs	0.158	0.23	0.284	0.374	0.481	0.59	0.777	0.893	1
10yrs	0.159	0.235	0.292	0.389	0.494	0.605	0.788	0.905	1
20yrs	0.16	0.238	0.298	0.4	0.503	0.615	0.797	0.913	1
25yrs	0.161	0.239	0.299	0.402	0.505	0.618	0.799	0.915	1
50yrs	0.161	0.241	0.303	0.41	0.512	0.626	0.805	0.921	1
100yrs	0.162	0.243	0.306	0.416	0.517	0.632	0.809	0.926	1
200yrs	0.162	0.245	0.309	0.421	0.522	0.637	0.813	0.93	1
500yrs	0.163	0.246	0.312	0.427	0.526	0.643	0.818	0.934	1
1000yrs	0.163	0.247	0.313	0.43	0.529	0.646	0.82	0.937	1
2000yrs	0.164	0.248	0.315	0.433	0.532	0.649	0.823	0.939	1
10000yrs	0.164	0.25	0.318	0.439	0.537	0.655	0.827	0.943	1

7.2 Site-Specific Regression Coefficients

Typically for a site, a minimum period of records of 10 years is relied upon for IDF calculations using measurements with a time step that matches the smallest increment for the storm duration, which can then be incorporated into larger time steps/storm durations. One value per year is typically selected for this approach.

Due to the short period of record available on site, an alternative approach was developed to define site-specific IDF regression coefficients. All the significant storms on record at the NMG station were compiled, and coefficients were derived from the full storm dataset analysis. The following graph showcases the correlations found between short duration storms and daily precipitation, and the following table compiles the corresponding site-specific regression coefficients.

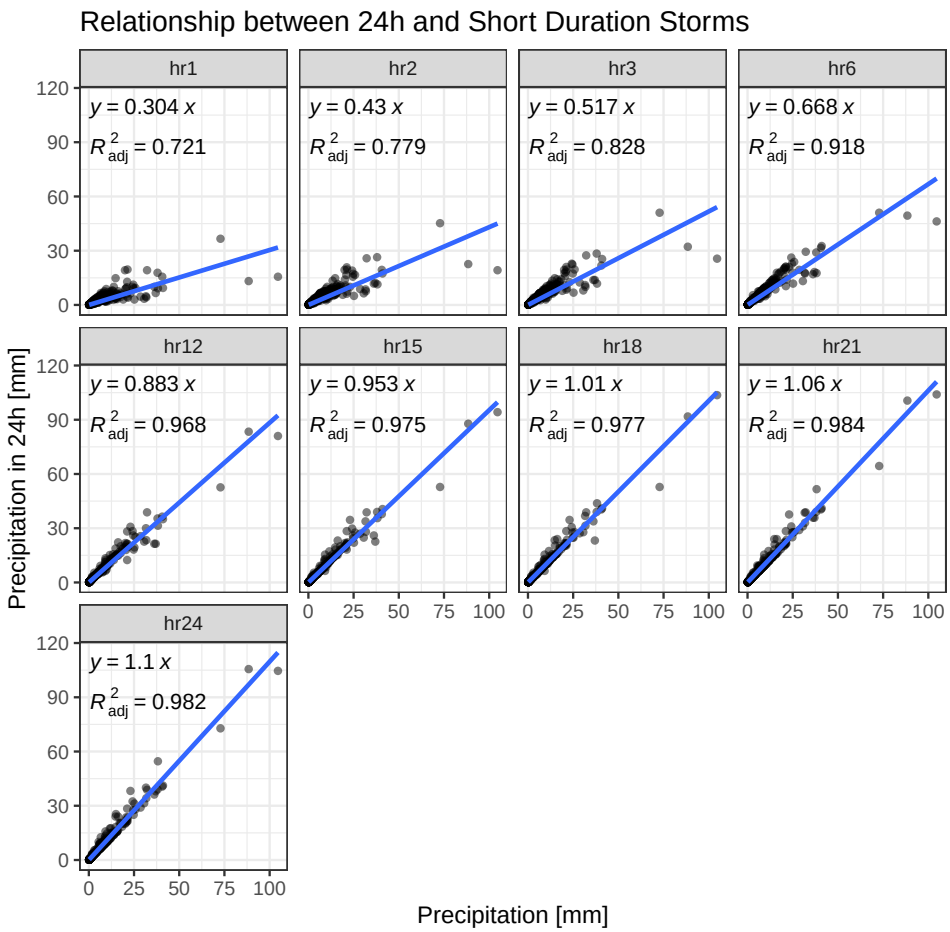


Table 7.2: IDF Coefficients Relative to Daily Precipitation based on Site data (continued below)

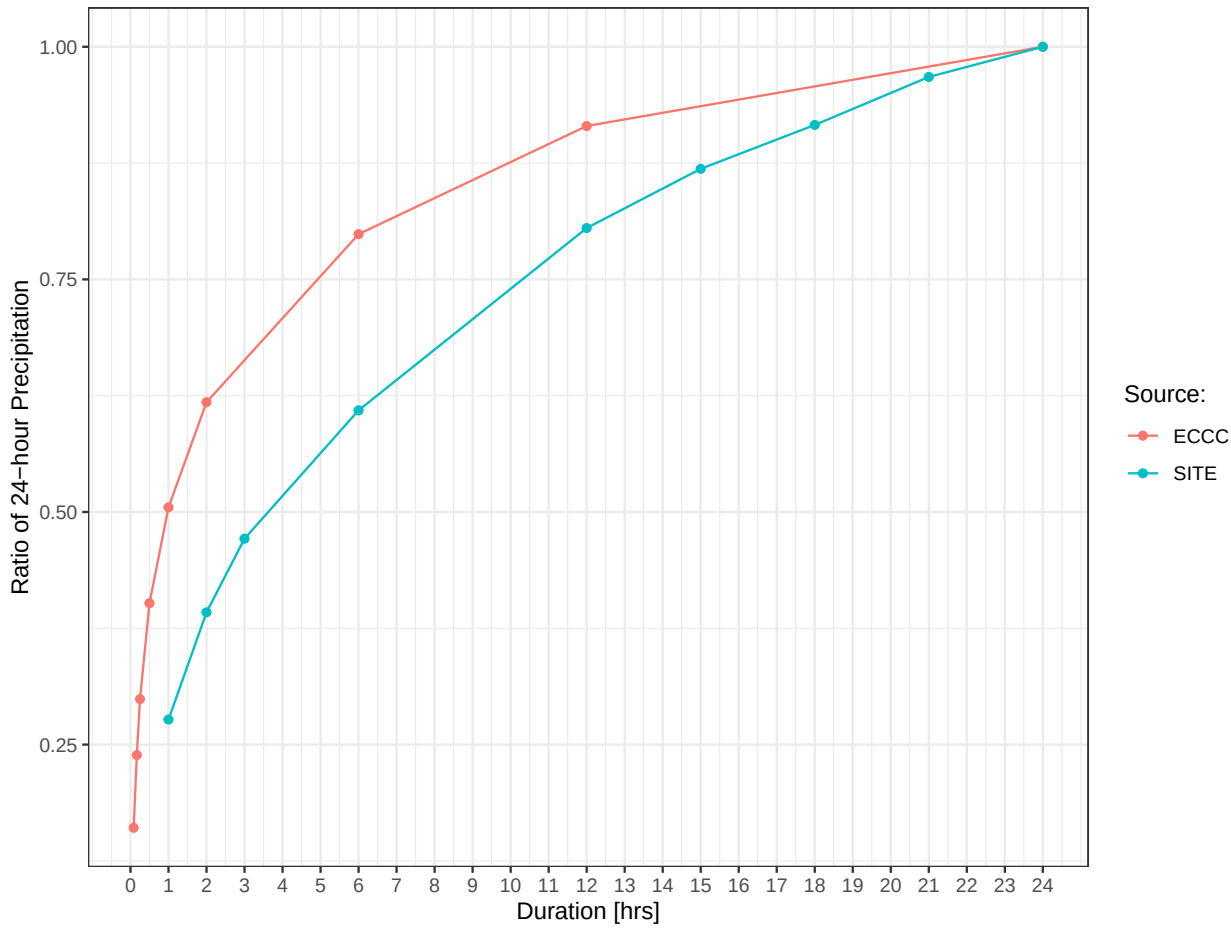
	hr1	hr2	hr3	hr6	hr12	hr15	hr18
day_1	0.3038	0.4303	0.5171	0.6684	0.8834	0.9532	1.005

	hr21	hr24	hr48	hr72
day_1	1.062	1.097	1.087	1.022

7.3 Comparison Between Both Methods

Both methods have merits in defining the project IDF tables. The ECCC coefficients result from the traditional approach and are based on long records of storm patterns registered at the Saint Michel des Saints station, that is located 7km away and 200m below site location. The site specific coefficients are more likely to be representative of the site location, however the period of record they are based on is short (4 years) and lacks short duration resolution (under 1 hour).

The figure below showcases these coefficients relative to 24-hour precipitation.



The ECCC coefficients result in stronger short duration intensities, have a better timestep resolution, and are more conservative. The ECCC coefficients are selected for IDF and PDF development for the project.

7.4 IDF and PDF Results

The expression used to form the IDF curves is shown below, as presented by Sherman (Sherman 1931).

$$i(t, T) = a/(T + b)^c$$

Where:

- T represents the storm duration in hrs.

- t is the return period in years.
- The parameters a, b and c were calculated from previous analysis, depend on the return period, and are presented in the table below.

Table 7.4: IDF Parameters for the Project

RP	a	b	c
2	28.81	0.177	0.787
2.33	31.41	0.19	0.795
5	43.07	0.229	0.82
10	52.98	0.251	0.834
20	62.79	0.266	0.843
25	65.96	0.27	0.846
50	75.94	0.28	0.852
100	86.17	0.289	0.858
200	96.69	0.296	0.862
500	111.1	0.303	0.867
1000	122.5	0.308	0.87
2000	134.3	0.312	0.873
10000	163.4	0.32	0.877

Intensity-Duration-Frequency (IDF) curves and summary IDF and Precipitation-Duration-Frequency (PDF) tables for the Project are presented below. Note that the daily storm results presented in Section 6.5 were multiplied by a factor of 1.13 to obtain 24-hour estimates as recommended by (WMO 2009).

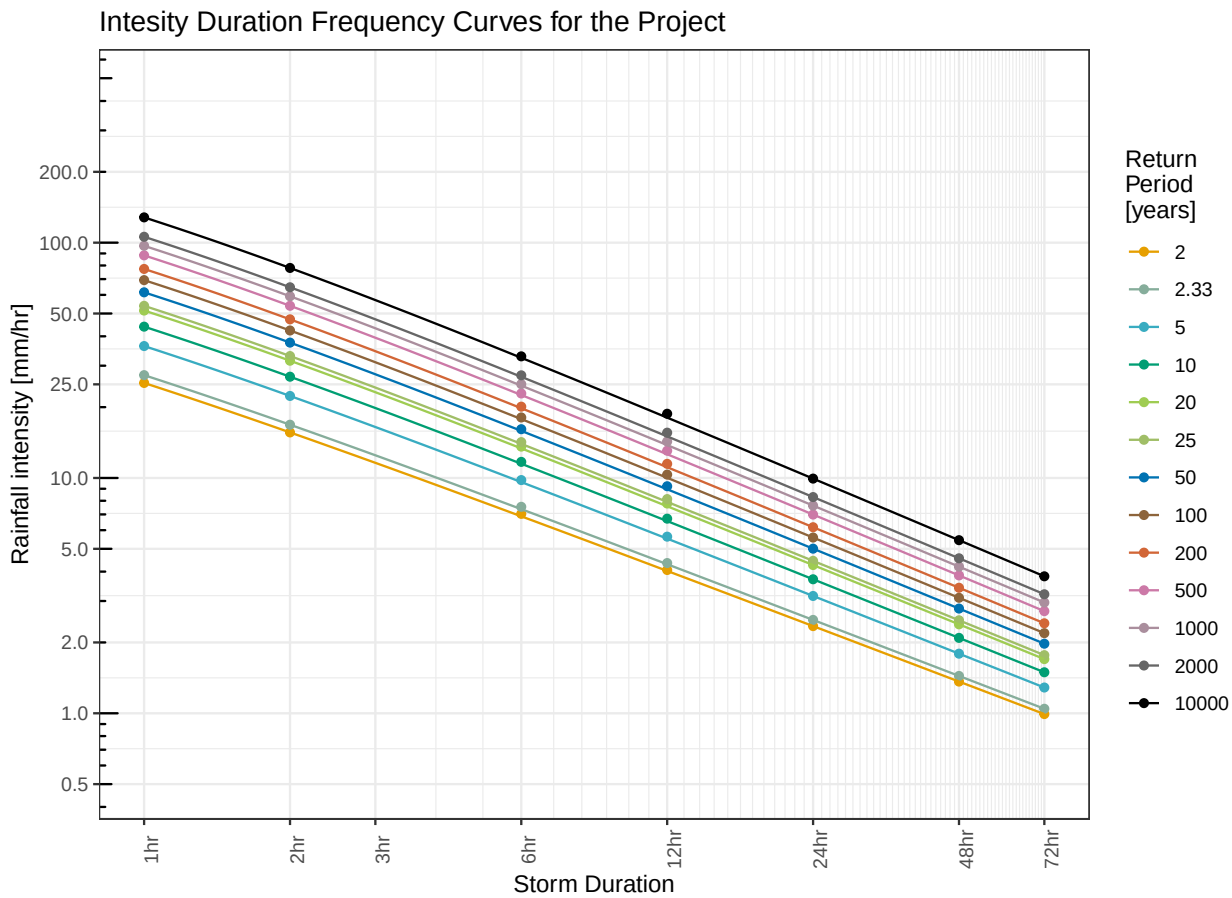


Table 7.5: Precipitation Intensity-Duration-Frequency (IDF) for the Site [mm/hour]

Duration	2 yr	2.33 yr	5 yr	10 yr	20 yr	25 yr	50 yr	100 yr	200 yr	500 yr	1000 yr	2000 yr	10000 yr
5min	83.1	88.2	111.8	132.2	152.6	159.2	179.9	201.2	223.1	253.3	277	301.7	362.5
10min	66.8	71.4	92.1	109.8	127.4	133	150.9	169.2	188	213.9	234.2	255.3	307.4
15min	56.3	60.4	78.8	94.3	109.8	114.7	130.4	146.5	163	185.6	203.5	222	267.6
30min	39.2	42.2	55.8	67.3	78.6	82.3	93.8	105.6	117.7	134.4	147.5	161	194.5
1hr	25.3	27.4	36.4	44	51.5	53.9	61.5	69.3	77.3	88.3	97	106	128.1
2hr	15.6	16.8	22.3	26.9	31.5	33	37.6	42.4	47.2	53.9	59.2	64.6	78.1
3hr	11.6	12.5	16.5	19.8	23.1	24.2	27.6	31	34.6	39.4	43.3	47.2	57
6hr	6.9	7.4	9.6	11.5	13.4	14	15.9	17.8	19.8	22.5	24.7	26.9	32.4
12hr	4	4.3	5.5	6.6	7.6	7.9	9	10	11.1	12.6	13.8	15	18
24hr	2.3	2.5	3.2	3.7	4.3	4.4	5	5.6	6.2	7	7.6	8.3	9.9
48hr	1.4	1.4	1.8	2.1	2.4	2.5	2.8	3.1	3.4	3.9	4.2	4.6	5.4
72hr	1	1	1.3	1.5	1.7	1.8	2	2.2	2.4	2.7	3	3.2	3.8

Table 7.6: Precipitation-Duration-Frequency (PDF) for the Site [mm]

Duration	2 yr	2.33 yr	5 yr	10 yr	20 yr	25 yr	50 yr	100 yr	200 yr	500 yr	1000 yr	2000 yr	10000 yr
5min	6.9	7.4	9.3	11	12.7	13.3	15	16.8	18.6	21.1	23.1	25.1	30.2
10min	11.1	11.9	15.4	18.3	21.2	22.2	25.1	28.2	31.3	35.6	39	42.6	51.2
15min	14.1	15.1	19.7	23.6	27.4	28.7	32.6	36.6	40.7	46.4	50.9	55.5	66.9
30min	19.6	21.1	27.9	33.7	39.3	41.2	46.9	52.8	58.9	67.2	73.7	80.5	97.2
1hr	25.3	27.4	36.4	44	51.5	53.9	61.5	69.3	77.3	88.3	97	106	128.1
2hr	31.2	33.7	44.6	53.9	63	66	75.2	84.7	94.5	107.8	118.4	129.3	156.2
3hr	34.8	37.5	49.4	59.5	69.4	72.7	82.8	93.1	103.7	118.3	129.8	141.7	171.1
6hr	41.2	44.2	57.6	69	80.2	83.8	95.1	106.8	118.7	135.2	148.1	161.5	194.5
12hr	48.3	51.6	66.3	78.7	91	95	107.4	120.2	133.3	151.4	165.6	180.3	216.6
24hr	56.3	59.8	75.7	89.1	102.4	106.7	120.2	134	148.2	167.8	183.2	199.1	238.5
48hr	65.5	69.2	86	100.4	114.6	119.3	133.8	148.6	164	185	201.6	218.8	261.2
72hr	71.4	75.2	92.6	107.5	122.4	127.2	142.2	157.7	173.7	195.6	212.9	230.8	275.1

Chapter 8

Probable Maximum Precipitation

The World Meteorological Organization (WMO) defines probable maximum precipitation (PMP) as the greatest depth of precipitation for a given duration meteorologically possible for a design watershed or a given storm area at a particular location at a particular time of year.

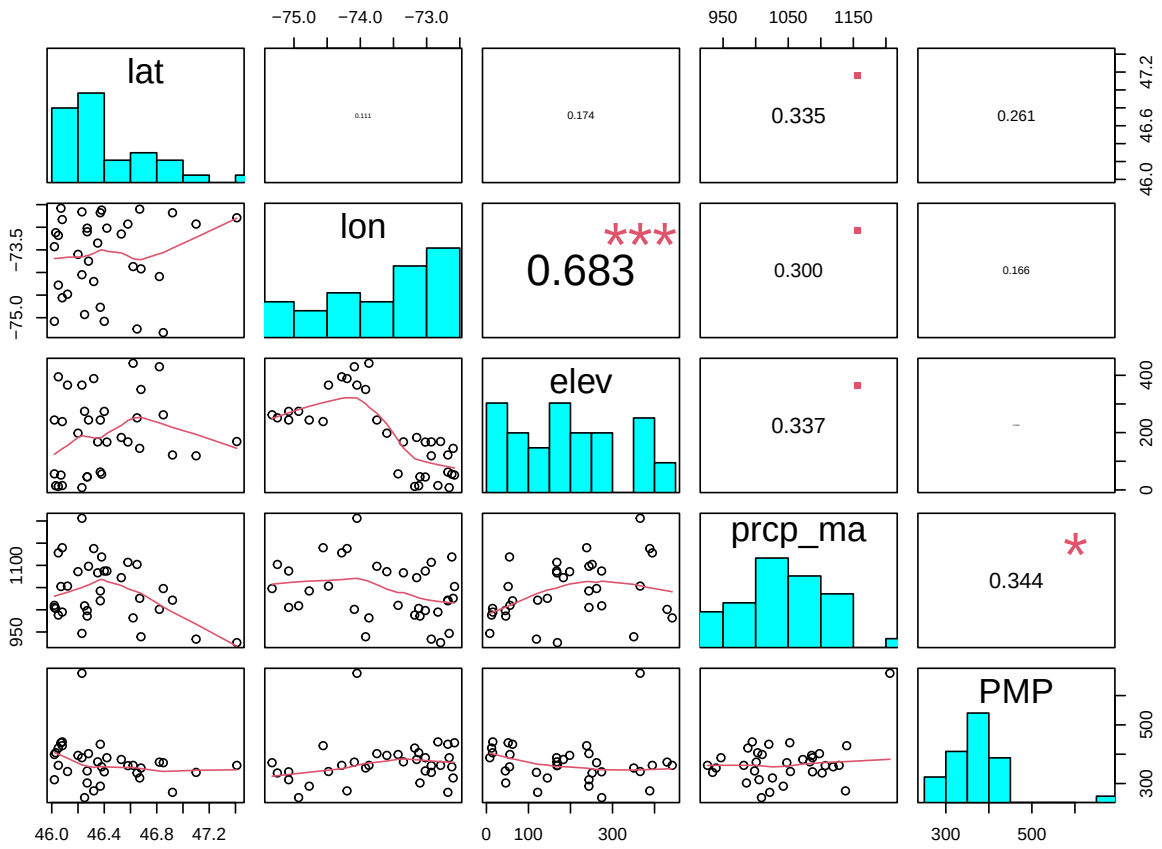
The meteorological moisture maximization method for PMP determination requires a detailed analysis of regional storm events, with characterization of atmospheric moisture conditions during storms and maximization of moisture conditions based on historical conditions. This type of study requires significant local meteorology expertise to transpose storm events to the site.

Hershfield's statistical procedure is recognized by the World Meteorological Organization (WMO 2009) and widely used for estimating probable maximum precipitation (PMP) at a given location based on local records. The weakness in this approach is that it does not consider that larger events may have occurred in the region, which could theoretically be expected to occur at the site as well.

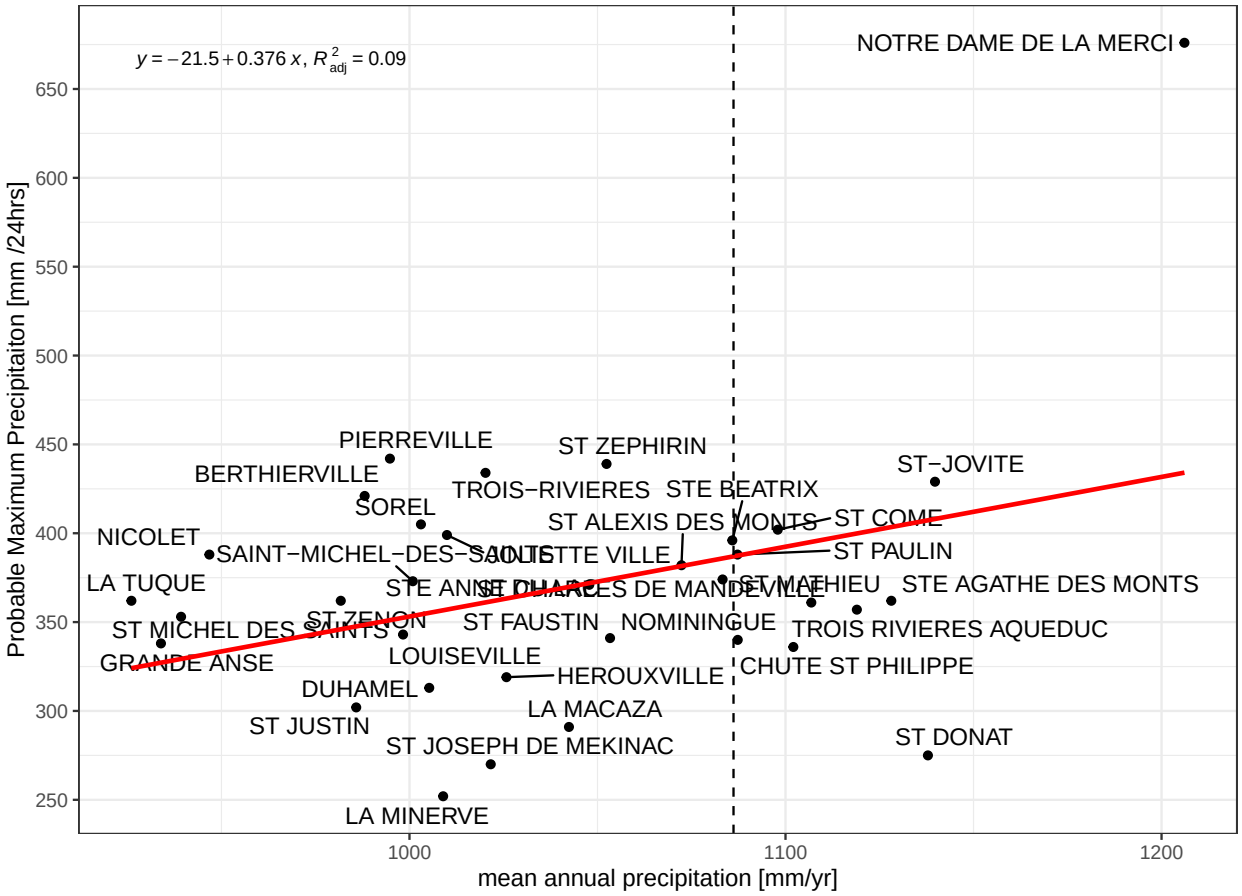
As an alternative to meteorological moisture maximization methods, this study attempts to extend the statistical method by calculating the statistical Hershfield PMP across all stations within the area of interst defined in **Section 2**. Through this regional approach, the statistical PMP results have the potential to capture larger storm events that may have bypassed the site area.

This section contains an estimate of PMP in the Project area based on historical regional data.

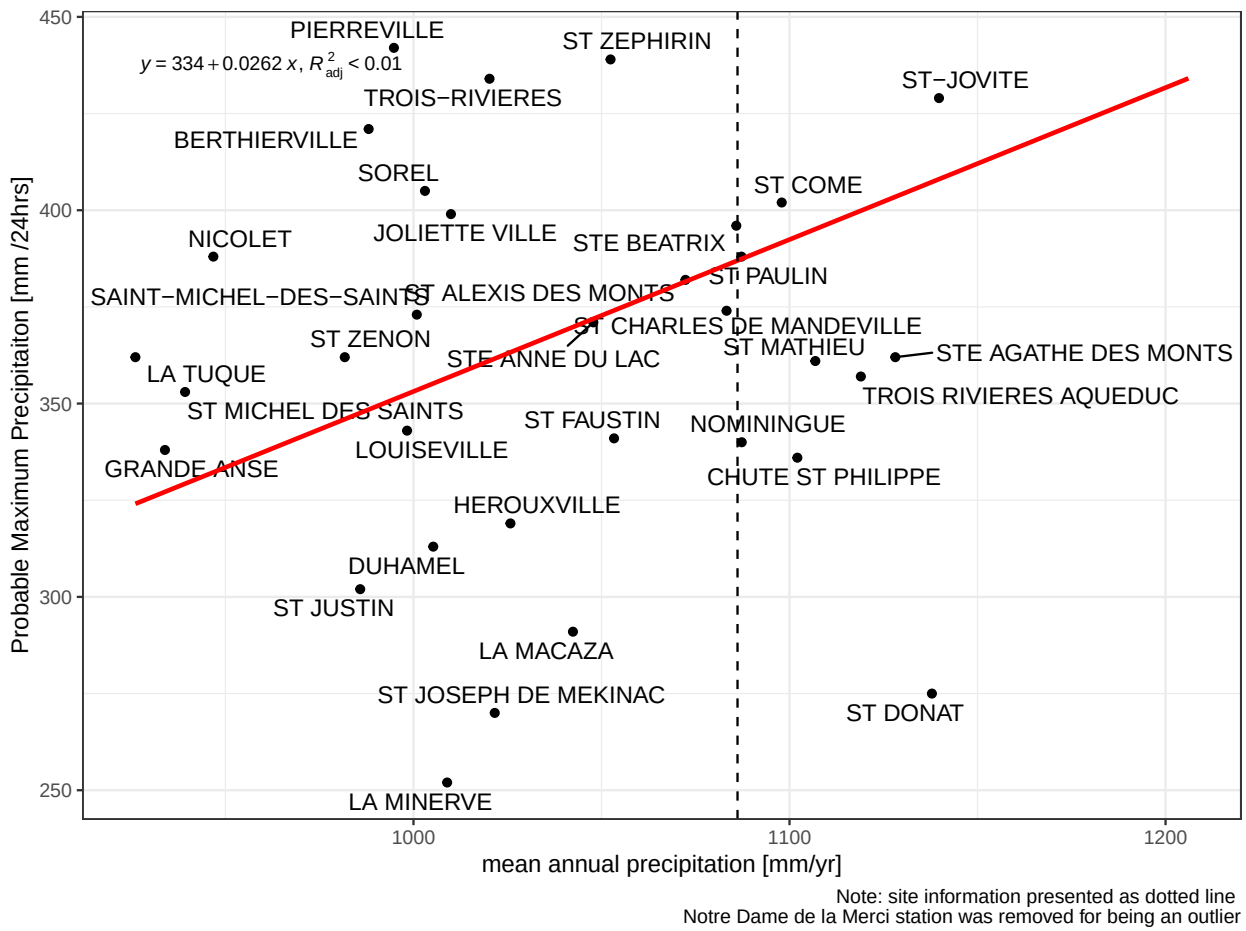
24-hour PMP was calculated for all ECCC stations. To understand PMP patterns within the region, the correlation matrix below was developed including geographical and climatic parameters. Significant correlations could not be identified from this plot. Mean annual precipitation was the only parameter that showed some correlation to PMP.



24-hour PMP versus mean annual precipitation was plotted together with site data in the following figure. Notre Dame de la Merci station is an outlier and was removed from the analysis, as shown in the plots below.

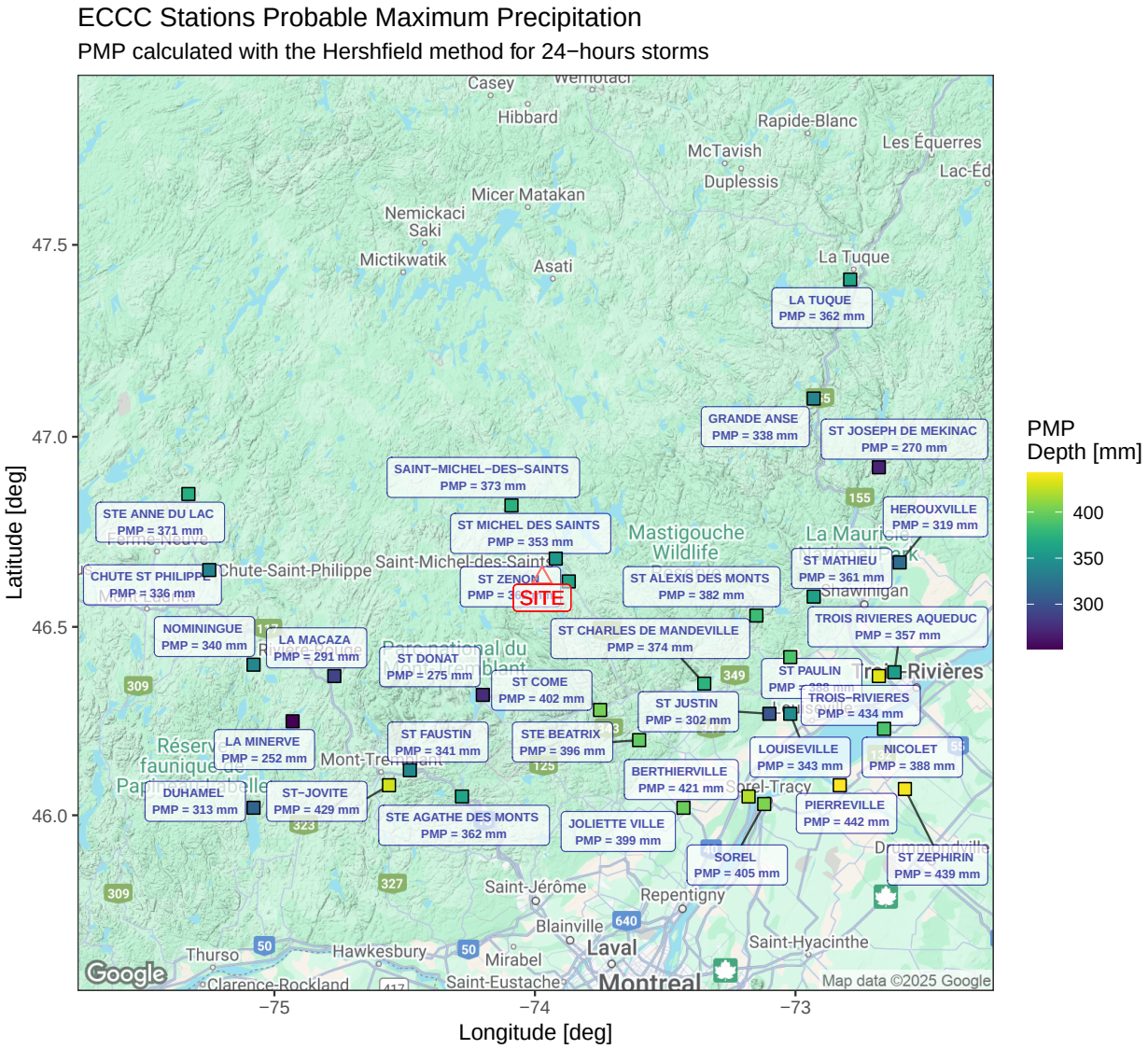


Note: site information presented as dotted line

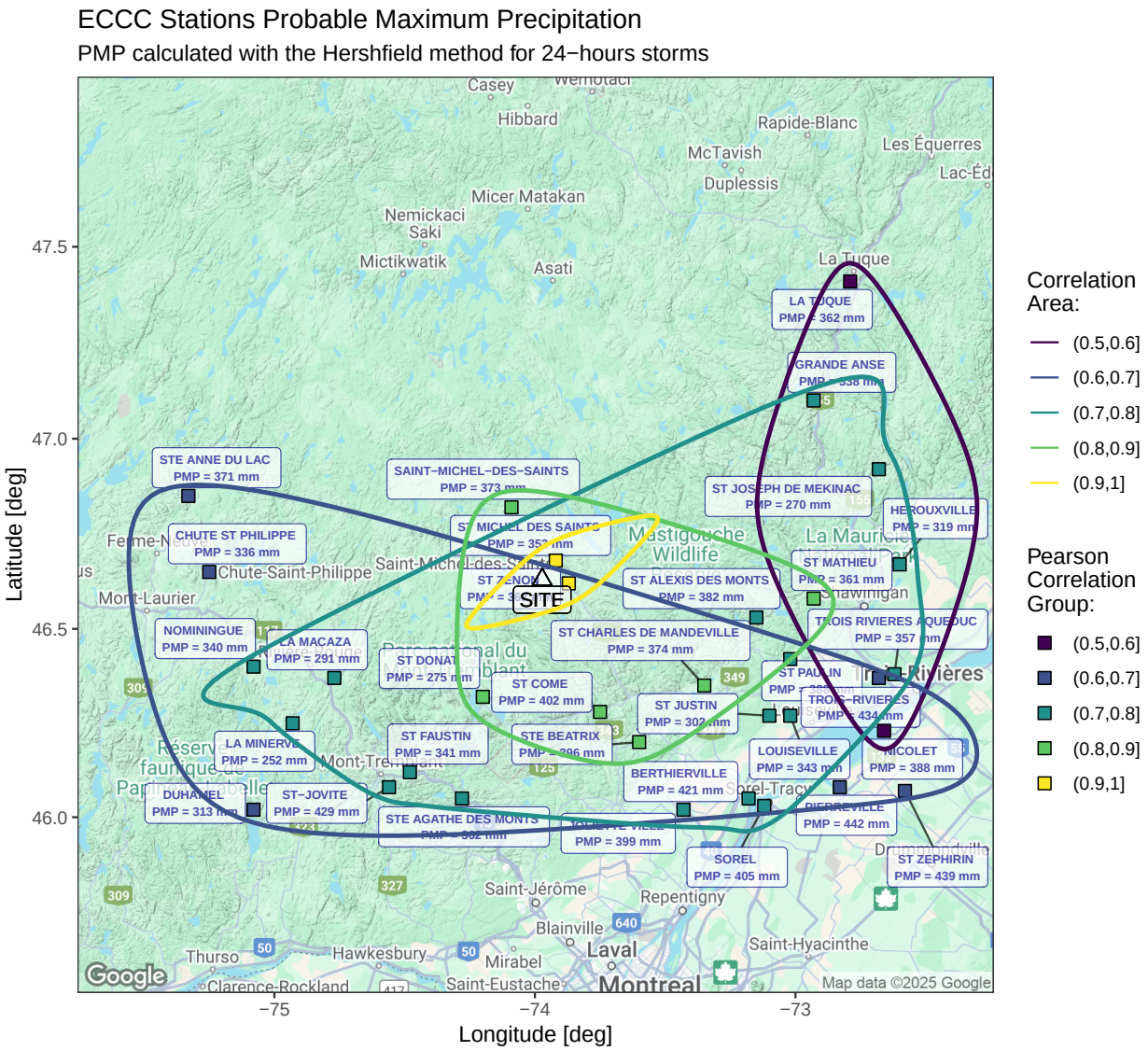


Note: site information presented as dotted line
Notre Dame de la Merci station was removed for being an outlier

Regional 24-hour PMP results are represented in the following map. The regional results range from 252mm to 442mm. The higher values seem to be concentrated around the Saint-Laurent river, and are likely following different climate patterns to be representative of the PMP on Site.



By further comparing daily precipitation data correlation between site and ECCC stations with PMP values, stations likely to be located in different climates can be identified. Stations showing a correlation coefficient higher than 0.8 can be considered representative of site precipitation. The most conservative PMP value from those stations is Saint Come with a 24-hour PMP value of **402 mm**. This is the recommended 24-hour PMP value for the project using the Hershfield method.


ECCC Stations Probable Maximum Precipitation
PMP calculated with the Hershfield method for 24−hours storms
Latitude [deg]
Longitude [deg]
47.5
47.0
46.5
46.0
−75
−74
−73
SITE
LA TUQUE
PMP = 362 mm
GRANDE ANSE
PMP = 338 mm
ST JOSEPH DE MEKINAC
PMP = 270 mm
HEROUXVILLE
PMP = 319 mm
ST MATHIEU
PMP = 361 mm
TROIS RIVIERES AQUEDUC
PMP = 357 mm
TROIS-RIVIERES
PMP = 434 mm
NICOLET
PMP = 388 mm
ST ZEPHIRIN
PMP = 439 mm
PIERREVILLE
PMP = 442 mm
LOUISEVILLE
PMP = 343 mm
BERTHIERVILLE
PMP = 421 mm
SOREL
PMP = 405 mm
ST ALEXIS DES MONTS
PMP = 382 mm
ST CHARLES DE MANDEVILLE
PMP = 374 mm
ST JUSTIN
PMP = 302 mm
ST COME
PMP = 402 mm
STE BEATRIX
PMP = 396 mm
ST FAUSTIN
PMP = 341 mm
STE AGATHE DES MONTS
PMP = 362 mm
ST−JOVITE
PMP = 429 mm
DUHAMEL
PMP = 313 mm
LA MINERVE
PMP = 252 mm
NOMININGUE
PMP = 340 mm
LA MACAZA
PMP = 291 mm
ST DONAT
PMP = 275 mm
CHUTE ST PHILIPPE
PMP = 336 mm
STE ANNE DU LAC
PMP = 371 mm
SAINT−MICHEL−DES−SAINTS
PMP = 373 mm
ST MICHEL DES SAINTS
PMP = 352 mm
ST ZENON
PMP = 3
Correlation Area:
(0.5,0.6]
(0.6,0.7]
(0.7,0.8]
(0.8,0.9]
(0.9,1]
Pearson Correlation Group:
(0.5,0.6]
(0.6,0.7]
(0.7,0.8]
(0.8,0.9]
(0.9,1]
Map data ©2025 Google

Chapter 9

Output

Output of this code has been backed up and saved as an rds file in the **/01_Data/rds** project folder.

References

Gelaro, Ronald, Will McCarty, Max J. Suárez, Ricardo Todling, Andrea Molod, Lawrence Takacs, Cynthia A. Randles, et al. 2017. "The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2)." *Journal of Climate* 30 (14): 5419–54. https://doi.org/10.1175/jcli-d-16-0758.1.

Hersbach, Hans, Bill Bell, Paul Berrisford, Shoji Hirahara, András Horányi, Joaquín Muñoz-Sabater, Julien Nicolas, et al. 2020. "The ERA5 Global Reanalysis." *Quarterly Journal of the Royal Meteorological Society* 146 (730): 1999–2049. https://doi.org/10.1002/qj.3803.

Hosking, J. R. M., and James R. Wallis. 1997. "Regional Frequency Analysis," April. https://doi.org/10.1017/cbo9780511529443.

Muñoz-Sabater, Joaquín, Emanuel Dutra, Anna Agustí-Panareda, Clément Albergel, Gabriele Arduini, Gianpaolo Balsamo, Souhail Boussetta, et al. 2021. "ERA5-Land: A State-of-the-Art Global Reanalysis Dataset for Land Applications." *Earth System Science Data* 13 (9): 4349–83. https://doi.org/10.5194/essd-13-4349-2021.

Papalexiou, Simon Michael, and Demetris Koutsoyiannis. 2013. "Battle of Extreme Value Distributions: A Global Survey on Extreme Daily Rainfall." *Water Resources Research* 49 (1): 187–201. https://doi.org/10.1029/2012wr012557.

Sherman, Charles W. 1931. "Frequency and Intensity of Excessive Rainfalls at Boston, Massachusetts." *Transactions of the American Society of Civil Engineers* 95 (1): 951–60. https://doi.org/10.1061/taceat.0004286.

Thornton, M. M., R. Shrestha, Y. Wei, P. E. Thornton, and S-C. Kao. 2022. "Daymet: Daily Surface Weather Data on a 1-Km Grid for North America, Version 4 R1," November. https://doi.org/10.3334/ORNLDAAC/2129.

WMO. 2009. *WMO No. 1045 Manual on Estimation of Probable Maximum Precipitation (PMP)*. Geneva: WMO.

Appendix F Relative Humidity Detailed Analysis

4. NMG - Matawinie Tdew and RH Analysis

CAPR003306

Camilo Gallard

February 12, 2025

Abstract

This report compiles the dew point temperature and relative humidity anlaysis that was carried out by SRK Consulting (Canada) Inc. for the Nouveau Monde Graphite Matawinie Site in 2024 to support Engineering Design. The data compilation and subsequent analysis was conducted in the R Software environment.

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Chapter 1

Glossary

- **AMS**: Annual Maximum Series.
- **Daymet**: Reanalysis tool developed by the Oak Ridge National Laboratory and supported by NASA (Thornton et al. 2022).
- **ECCC**: Environment and Climate Change Canada.
- **ERA5**: Reanalysis tool developed by the European Centre for Medium-Range Weather Forecasts (Hersbach et al. 2020).
- **ERA5-Land**: Reanalysis tool based on ERA5 but for Land surfaces and a smaller grid, and developed by the European Centre for Medium-Range Weather Forecasts (Muñoz-Sabater et al. 2021).
- **ET**: Evapotranspiration
- **ET0**: Reference Evapotranspiration
- **IDF**: Intensity-Duration-Frequency (IDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
- **KST**: Kolmogorov–Smirnov Test.
- **MAAT**: Mean Annual Air Temperature.
- **MAP**: Mean Annual Precipitation.
- **MERRA2**: Modern-Era Retrospective analysis from Research and Applications, Version 2, is a global climate reanalysis model from the U.S. National Aeronautics and Space Administration (Gelaro et al. 2017).
- **NMG**: Nouveau Monde Graphite.
- **PCC**: Pearson Correlation Coefficient.
- **PDF**: Precipitation-Duration-Frequency (PDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
- **PMP**: Probable Maximum Precipitation.
- **RH**: Relative Humidity.

- **SRAD**: Shortwave (solar) radiation. Incident shortwave radiation flux density in watts per square meter.
- **SRK**: SRK Consulting (Canada) Inc.
- **SSR**: Surface net shortwave (solar) radiation. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth (both direct and diffuse) minus the amount reflected by the Earth's surface (which is governed by the albedo).
- **SSRD**: Surface short-wave (solar) radiation downwards. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth. This parameter comprises both direct and diffuse solar radiation.
- **Tavg**: Mean or Average Air Temperature over a given temporal unit (day, month, year…).
- **Tdew**: Mean or Average Dew Point Temperature over a given temporal unit (day, month, year…).
- **Tmax**: Maximum Air Temperature over a given temporal unit (day, month, year…).
- **Tmin**: Minimum Air Temperature over a given temporal unit (day, month, year…).

Chapter 2

General Parameters

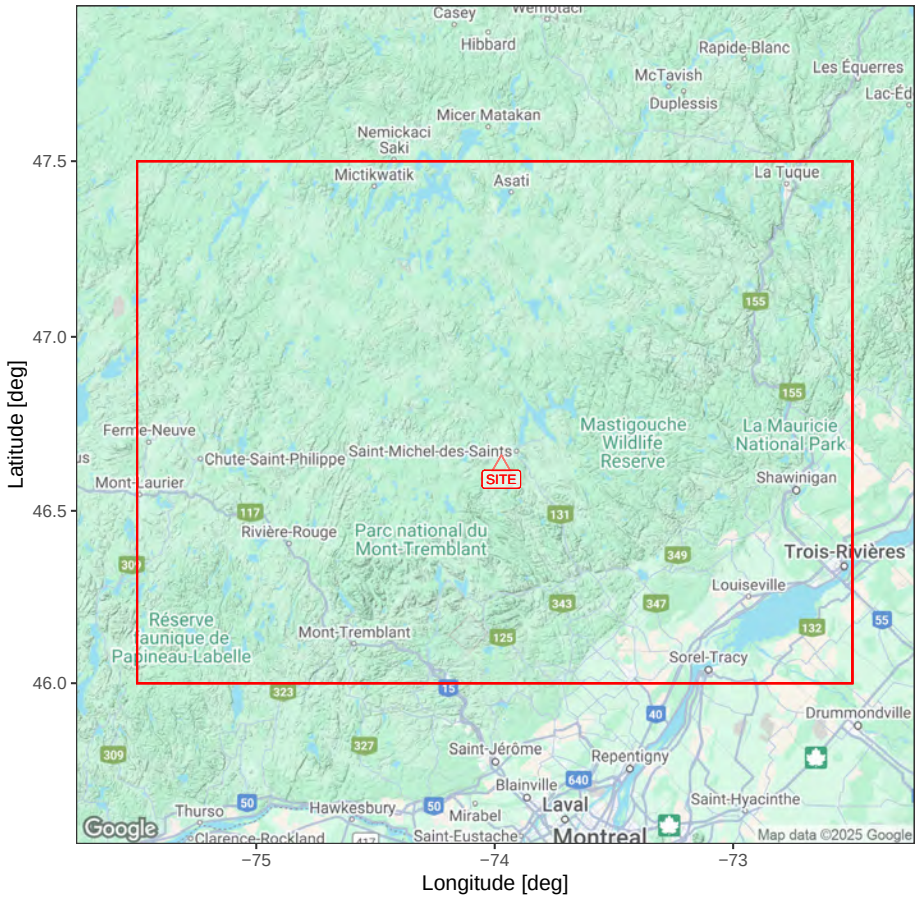
The NMG Matawinie site is located in southern Quebec, 125 km north of Montreal. Site latitude is 46.63 degrees, and longitude is -73.97 degrees, at an elevation of 562 masl. These coordinates were selected to match the location of the meteorological station on site.

For the purpose of this meteorological analysis, an area of interest was defined around site to capture regional data and climate trends, and was defined as the region between:

- 46° and 47.5° Latitude
- -75.5° and -72.5° Longitude

Site Location and Area of Interest for this Study

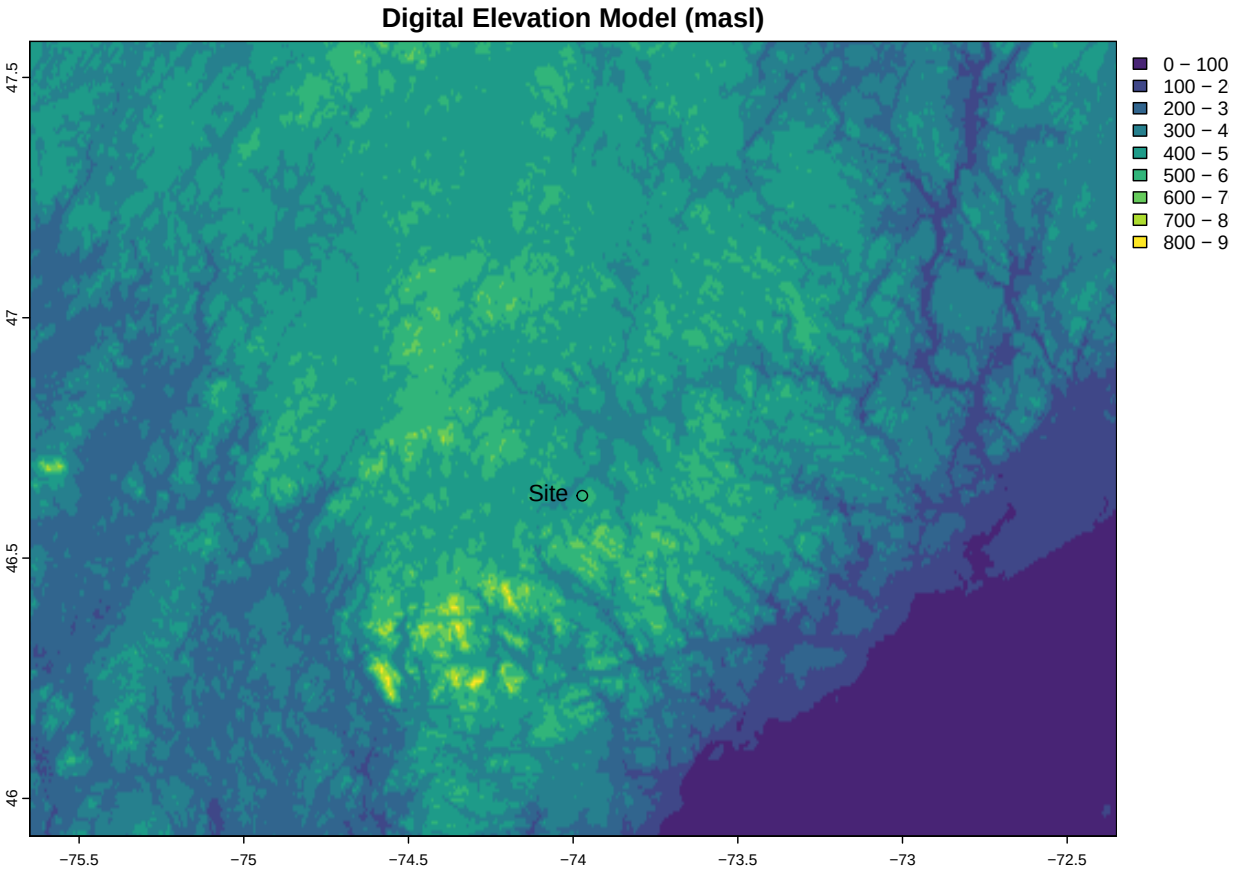
Area of interest covers a distance of up to 125km from Site



Chapter 3

Digital Elevation Model

Digital elevation model from the region was downloaded from the Shuttle Radar Topography Mission (SRTM) dataset. The SRTM database contains global elevation data with 3 arc-second (90 m) spatial resolution, which is deemed sufficient for climate analysis.



Chapter 4

Thermodynamic Functions

Dew point temperature, relative humidity and temperature are related trough the following equations based on the Magnus formula (Magnus 1844):

$$T_{dew} = \frac{\lambda * (ln(\frac{RH}{100}) + \frac{\beta * T}{\lambda + T})}{\beta - ln(\frac{RH}{100}) + \frac{\beta * T}{\lambda + T}}$$

$$RH = 100 * \frac{e^{\frac{\beta * T_{dew}}{\lambda + T_{dew}}}}{e^{\frac{\beta * T}{\lambda + T}}}$$

Where:

- T is temperature in °C
- T_{dew} is dew point temperature in °C
- RH is relative humidity in %
- = 243.04 °C and = 17.625 are the revised Magnus coefficients (Alduchov and Eskridge 1996)

Vapor pressure is related to Relative Humidity trough the following equation:

$$RH = \frac{VP}{VP_{S(T)}} * 100$$

Where:

- RH is relative humidity in %
- VP is the measured vapor pressure
- $VP_{S(T)}$ is the saturation vapor pressure at temperature T

Saturation vapor pressure $VP_{S(T)}$ is calculated for a given temperature by using the Clausius-Clapeyron relation:

$$VP_{S(T)} = VP_{S(T_0)} * exp(\frac{L}{R_w} * (\frac{1}{T_0} - \frac{1}{T}))$$

Where:

- T is temperature in K
- $VP_{S(T)}$ is the saturation vapor pressure at temperature T
- $VP_{S(To)}$ = 6.11 hPa is the saturation vapor pressure at the reference temperature T_0 = 273.15 K
- L = 2.5 × 10^6 J/kg is the latent heat of evaporation for water
- R_w = 461.52 J/(kgK) is the specific gas constant for water vapor

Chapter 5

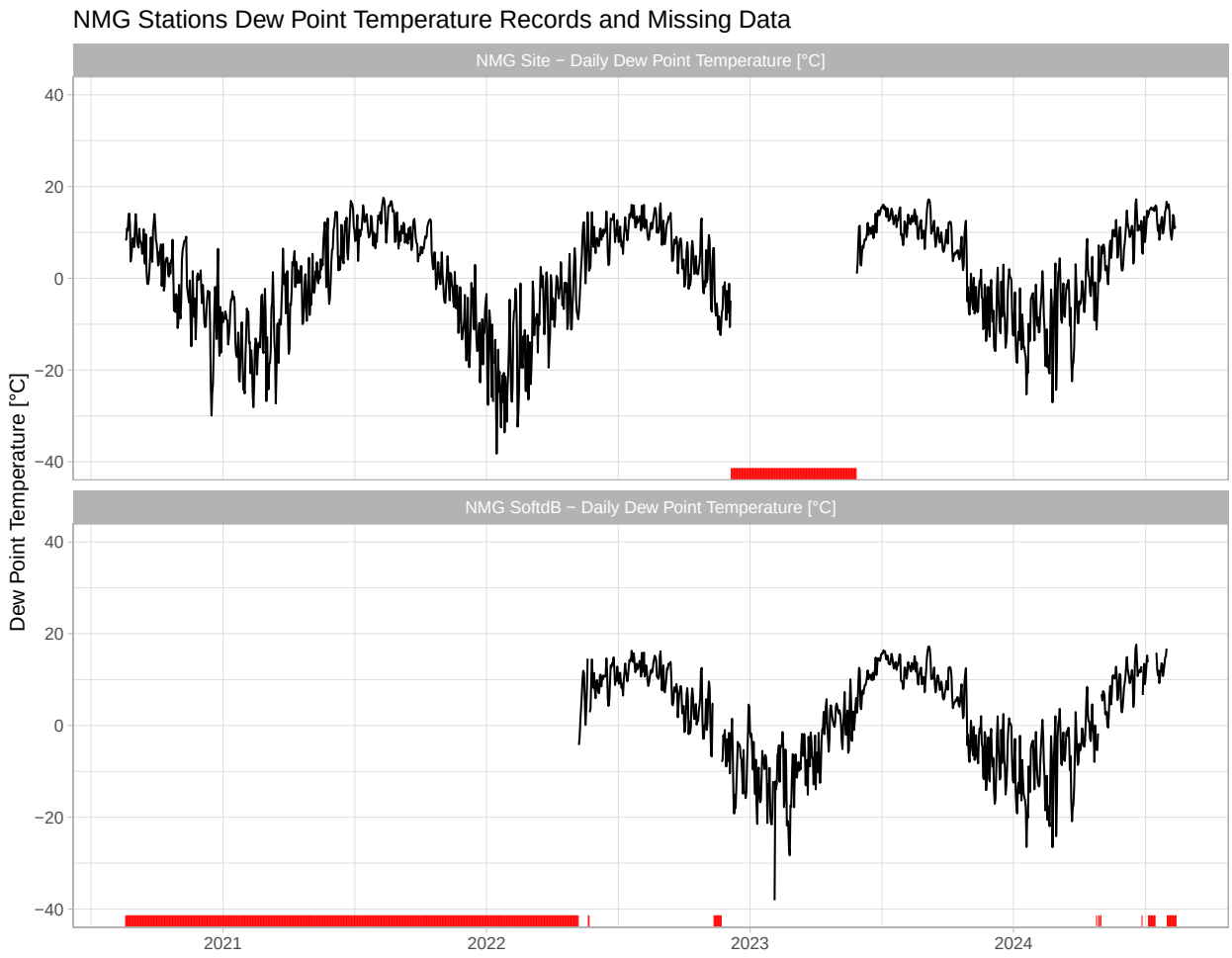
NMG Data

Site data is collected by NMG from two meteorological stations. The first station is located on Site, and the second station, called SoftdB, is located 1.5 km north at the following address: 200 Chemin des Hauteurs, Saint-Michel-des-Saints.

Note: SoftdB data is different from ECCC station 48188 data, so both records were kept.

5.1 NMG Dew Point Temperature

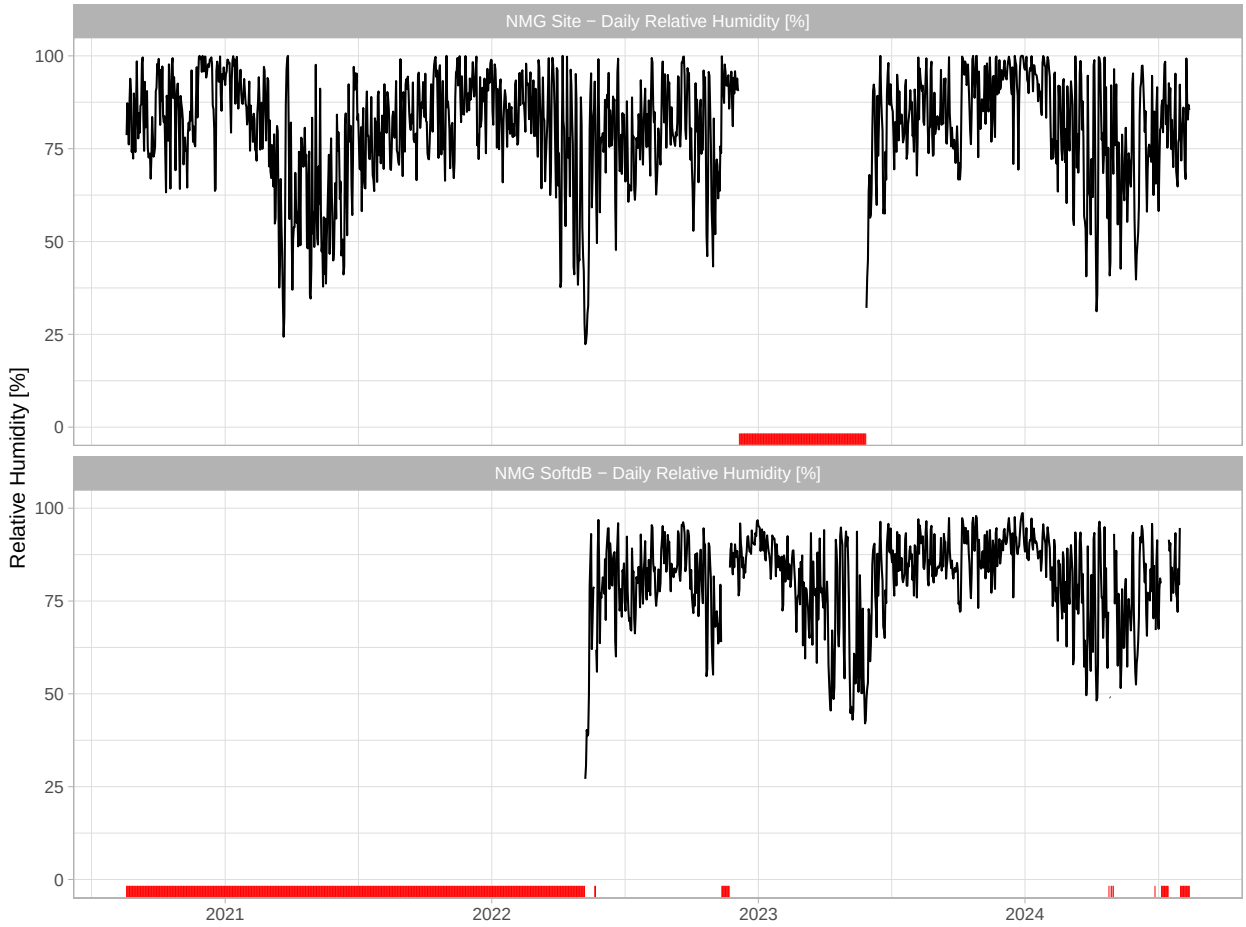
The following graph summarizes NMG dew point temperature calculated with relative humidity and temperature records with the previous relationships. Dew point temperature is not measured on site.



5.2 NMG Realtive Humidity

The following graph summarizes available NMG relative humidity data.

NMG Stations Relative Humidity Records and Missing Data



Chapter 6

ECCC Relative Humidity and Dew Point Temperature Data

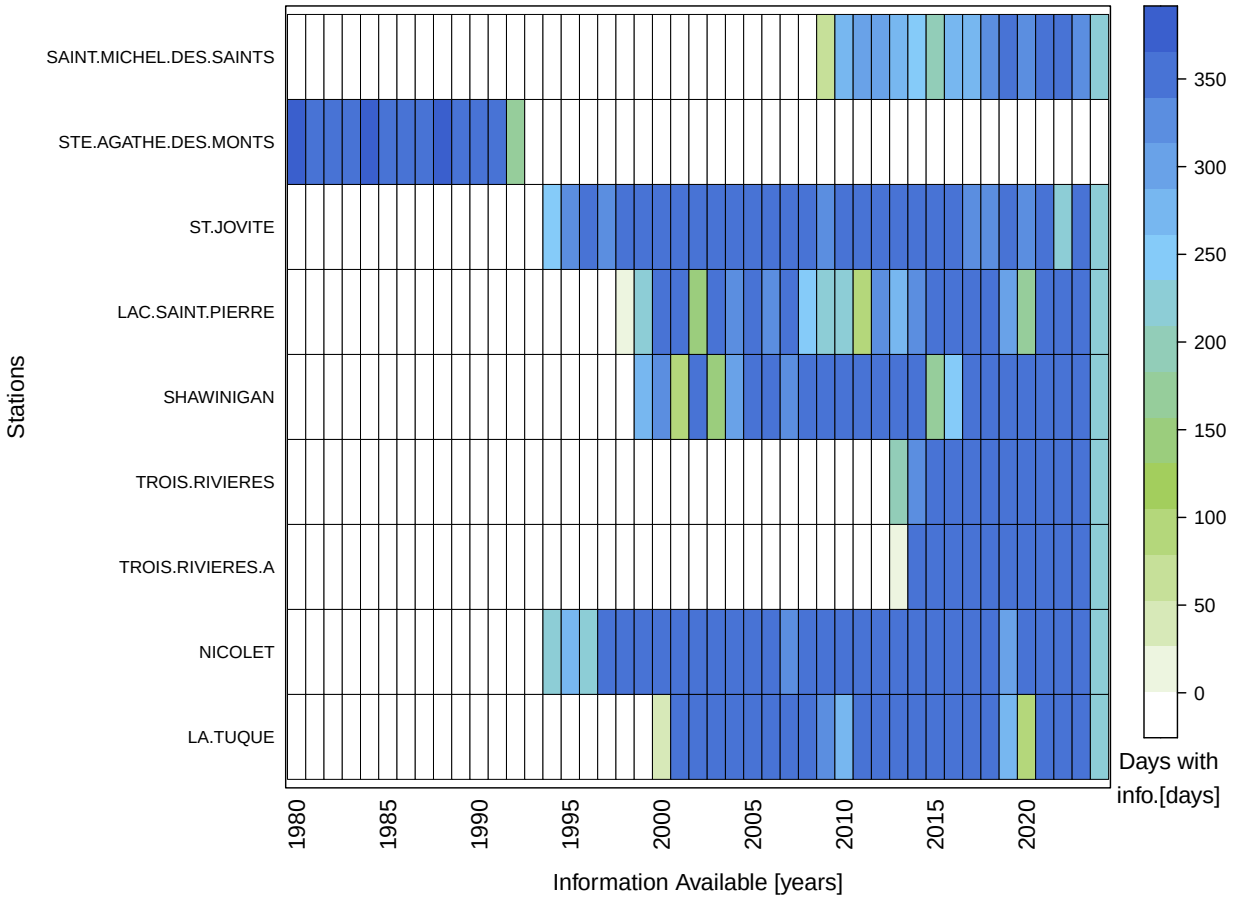
Environment and Climate Change Canada (ECCC) data was downloaded and prepared for analysis . The information is captured on a daily or hourly timestep when available. No complementary/redundant stations were detected so patching was not required for stations within the area of interest.

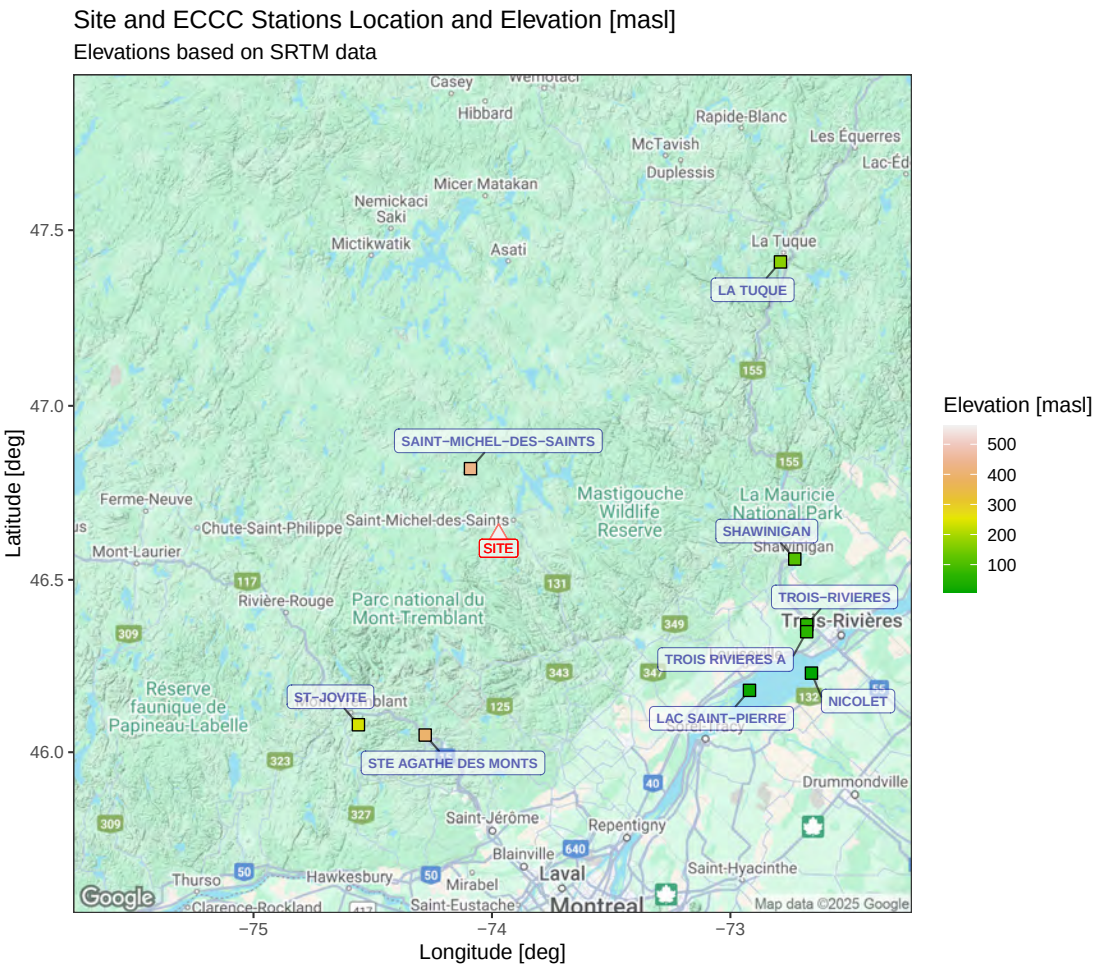
6.1 ECCC Dew Point Temperature

The following figures show:

1. Data availability over time at each station (only records from 1980 to 2023 were considered for this analysis).
2. Selected ECCC stations location and elevation.

Refer to the "eccc_read.r" for pre-processing details.

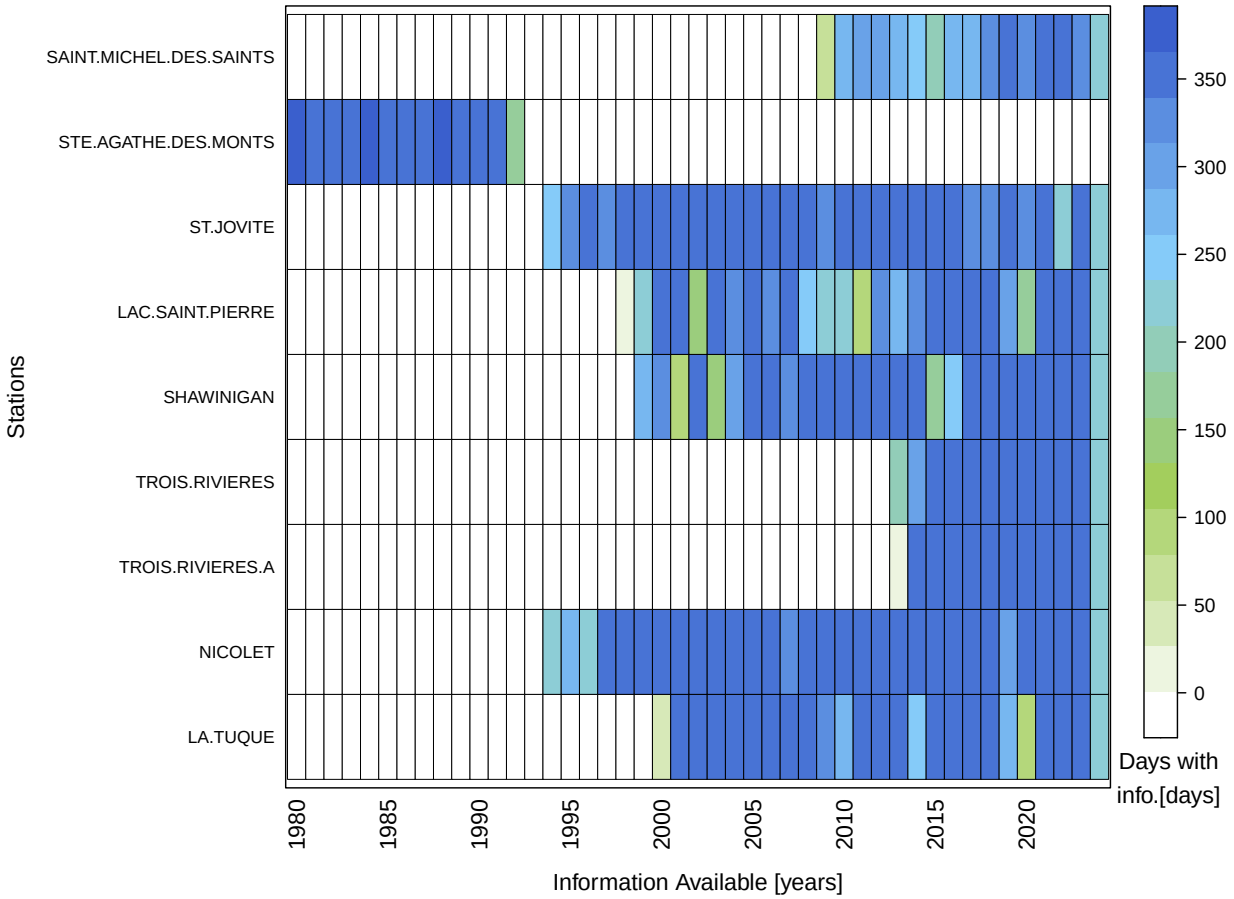

SAINT.MICHEL.DES.SAINTS
STE.AGATHE.DES.MONTS
ST.JOVITE
LAC.SAINT.PIERRE
SHAWINIGAN
TROIS.RIVIERES
TROIS.RIVIERES.A
NICOLET
LA.TUQUE
Stations
1980
1985
1990
1995
2000
2005
2010
2015
2020
Information Available [years]
350
300
250
200
150
100
50
0
Days with
info.[days]



6.2 ECCC Relative Humidity

The following figure shows data availability over time at each station (only records from 1980 to 2023 were considered for this analysis).

Refer to the "eccc_read.r" for pre-processing details.



Note that the ECCC stations that have relative humidity records are the same ones that have dew point temperature records, and the records are overlapping. ECCC may be calculating one with the other, depending on which one is measured at each station.

Chapter 7

Regional Analysis

There are only nine ECCC stations with relative humidity and dew point temperature records in the area of interest for the Project and only one of them is located within 50km of the project. All ECCC and NMG stations were considered for the following analysis.

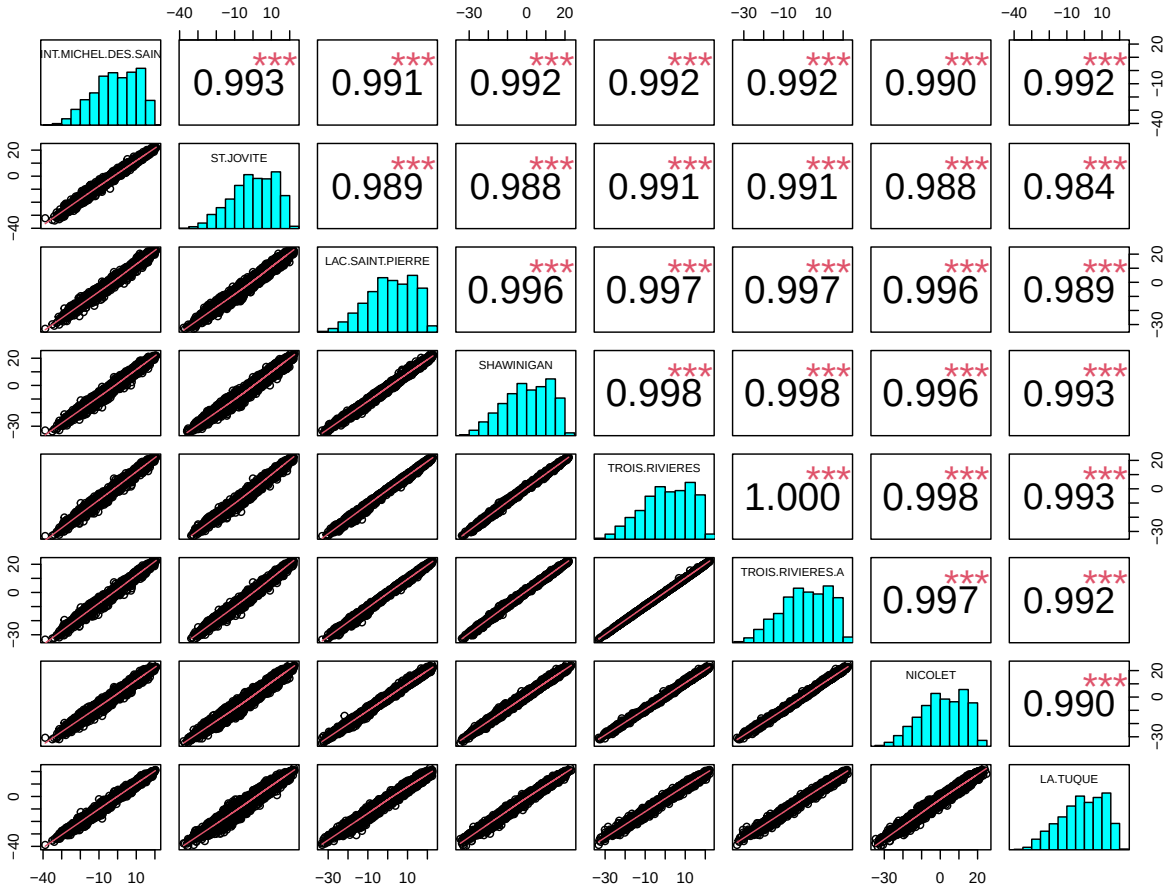
7.1 ECCC and NMG Stations data correlations

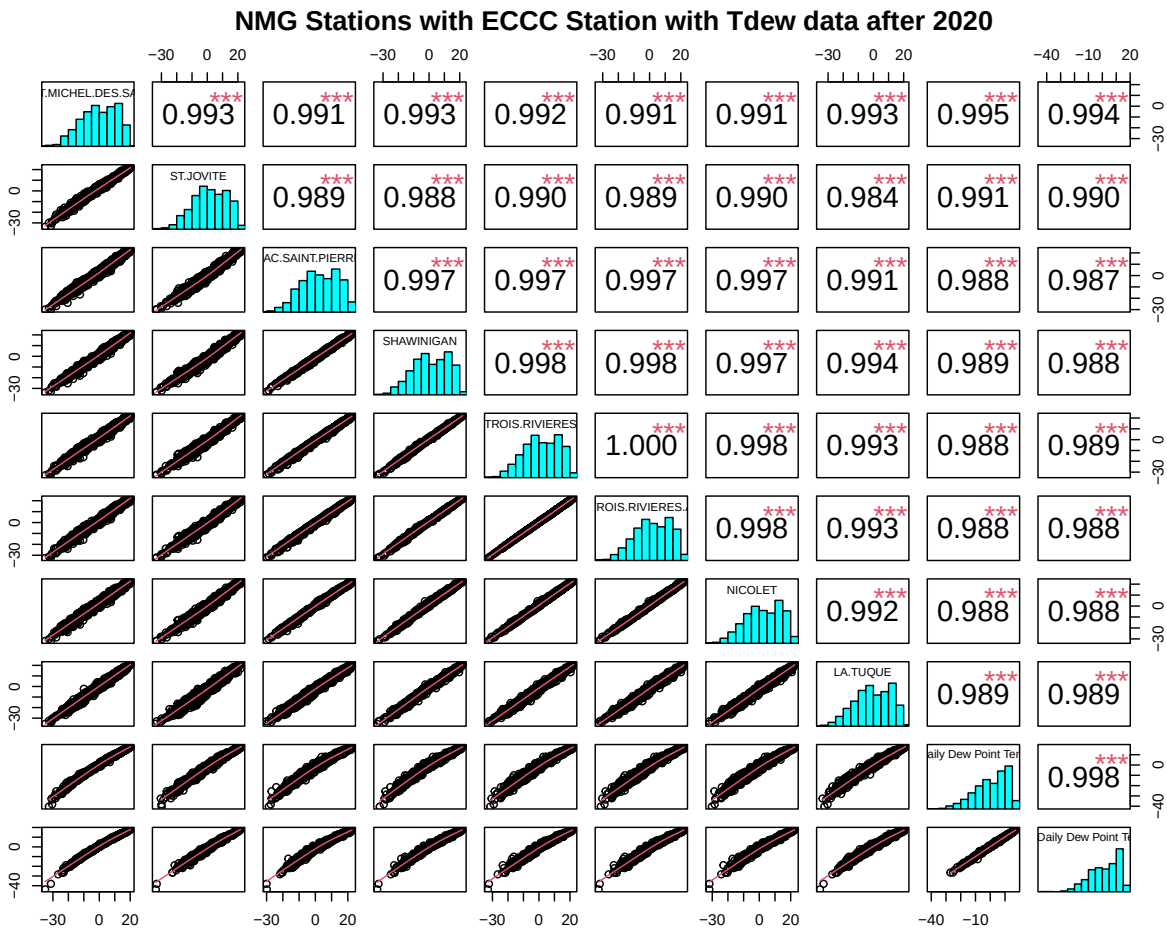
The following visualizations are correlation matrix between daily average air temperature records from stations close to site. On the top right quadrant, the (absolute) value of the correlation is presented together with the result of the Pearson's product moment correlation coefficient as stars. On bottom-left quadrant the bivariate scatterplots, with a fitted line are presented. On the diagonal there is an histogram of each variable.

7.1.1 Dew Point Temperature

All daily dew point temperature records have excellent correlation between each other.

ECCC Stations with Tdew data between 1995 and 2023

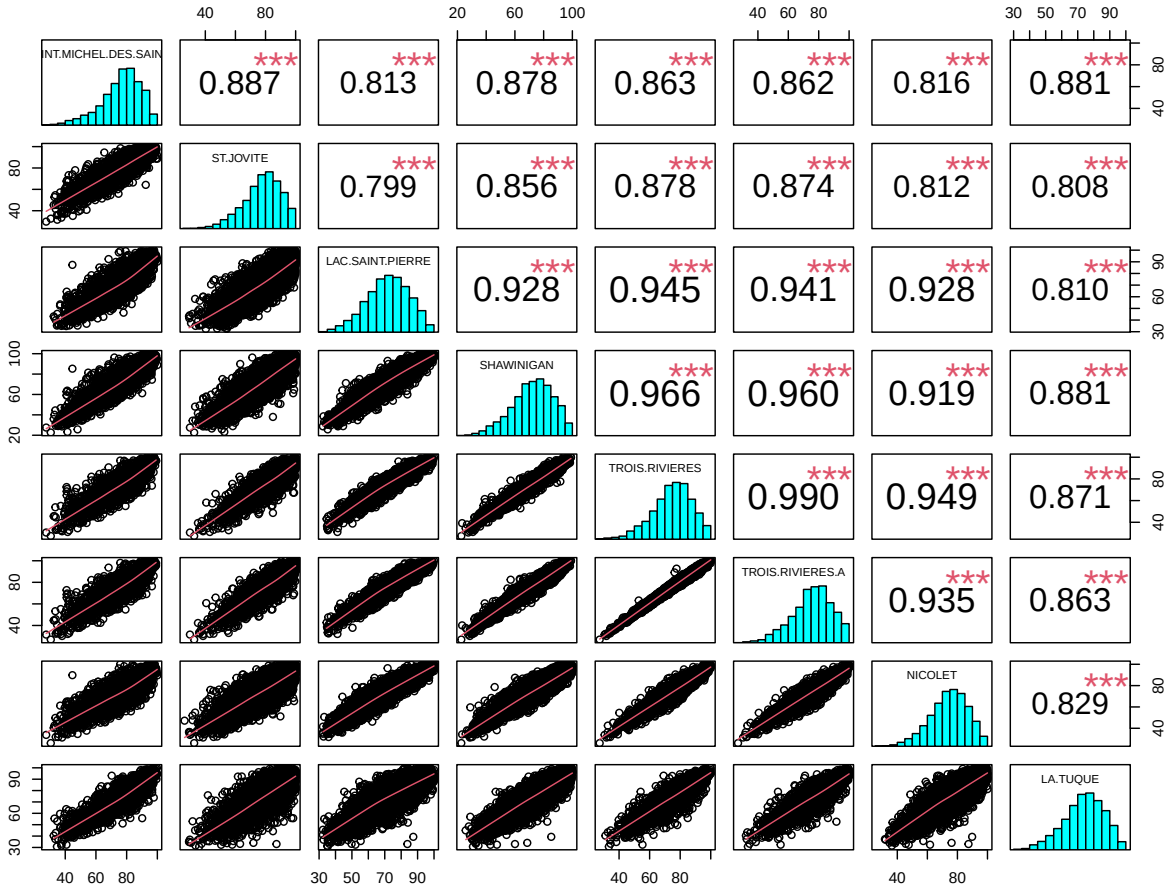


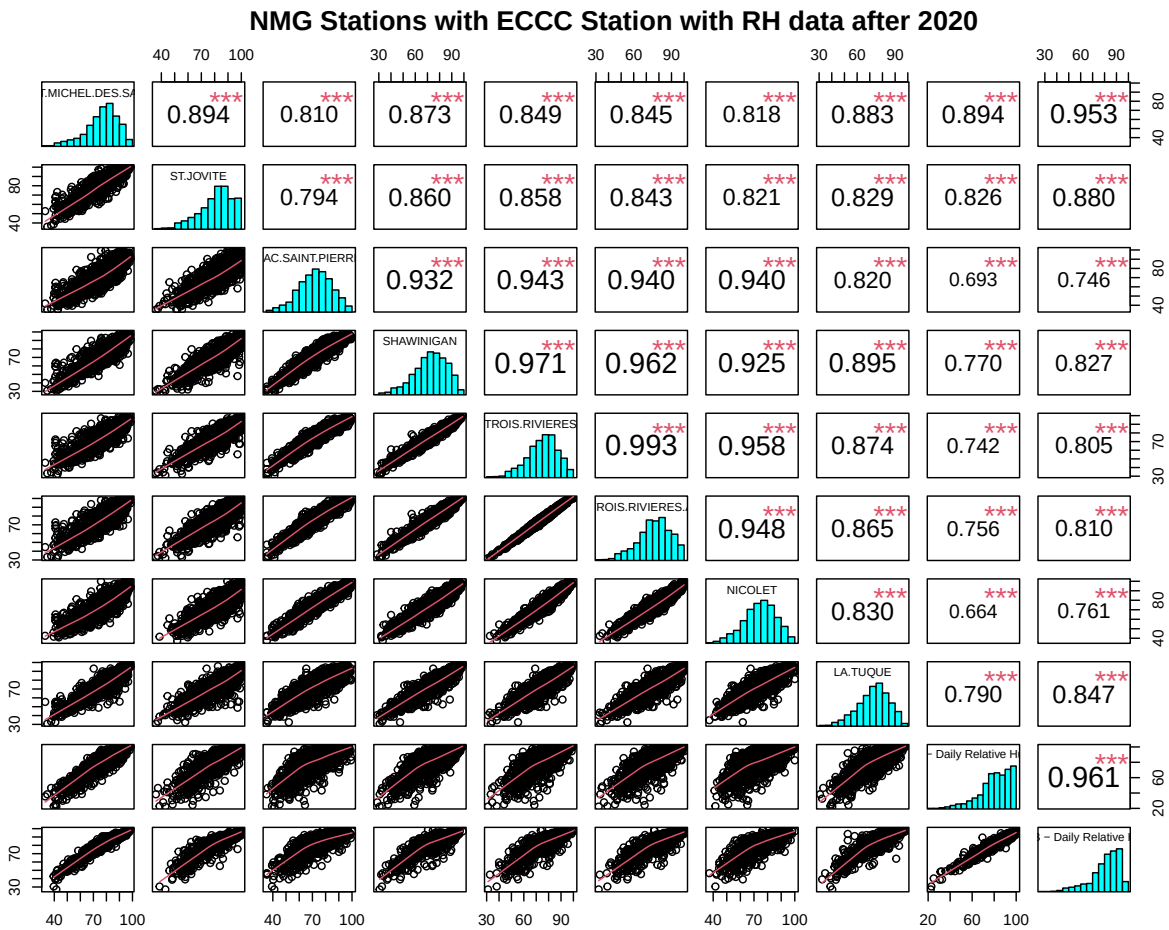


7.1.2 Relative Humidity

For relative humidity good correlations are also generally observed. Note that the NMG Site station has excellent correlation with ECCC Saint Michel des Saints station, and slightly lower correlations with all other ECCC stations.

ECCC Stations with RH data between 1995 and 2023





7.2 Reanalysis Evaluation Against Station Records - Dew Point Temperature

7.2.1 Station to Climate Model - Tdew Monthly Correlations

Monthly correlations between station and climate model data at each location help comparing model coherence with measured data and highlight seasonal bias. Monthly analysis allows inclusion of the NMG stations records.

The main findings of this section are summarized below:

- All the climate models present strong correlation with ECCC station data. The strongest appear to be ERA5-Land and ERA5.
- NMG station records are short, but have excellent correlation with all the climate models.

7.2.1.1 Tdew Functions Definition

A function is defined to compare monthly station records against data produced for the same location by all four climate models included in this study.

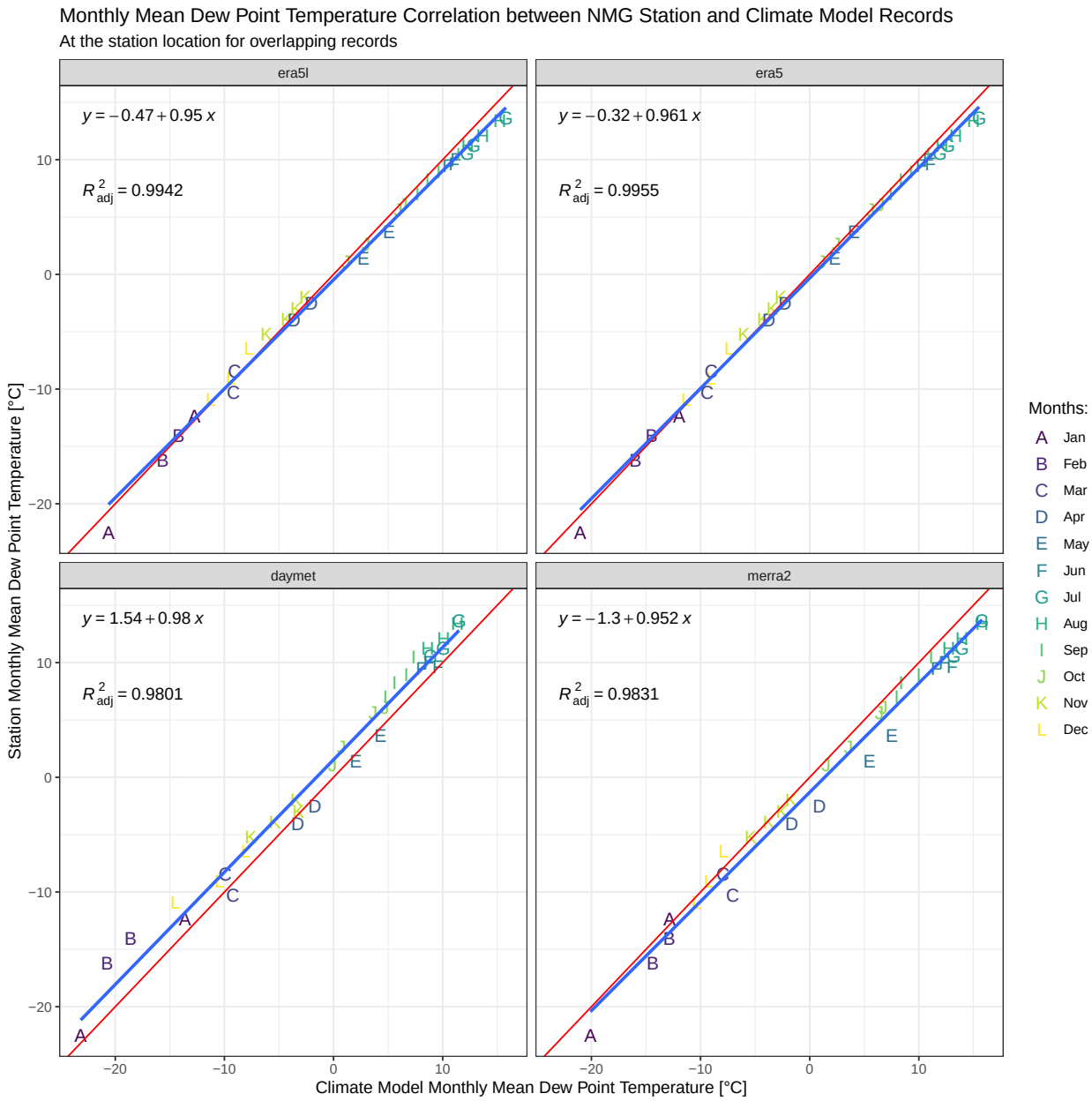
- Dew Point Temperature was calculated for Daymet.

- Monthly dew point temperature results are summarized in a table comparing climate model results to station records for the same overlapping record period.
- The plot shows correlation between each station monthly data and all four climate models for the same overlapping record period.

7.2.1.2 Tdew Monthly Correlations for NMG Site

Table 7.1: Monthly Summary of Reanalysis Data matching Observed Data at NMG Site

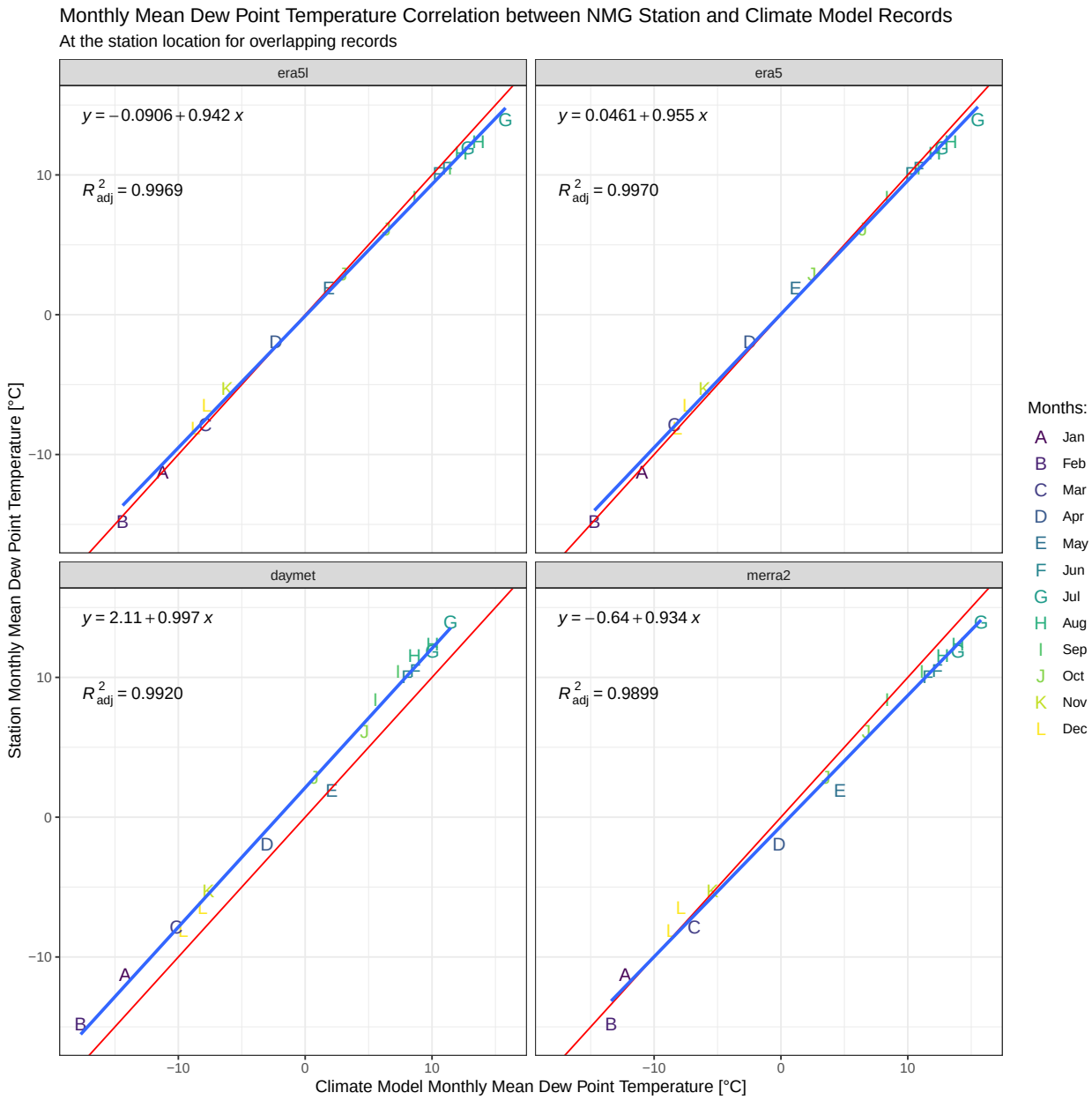
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-16.7	-14.9	-9.1	-2.8	3.9	10.9	13.6	13.7	9.4	4.1	-4.1	-9.5	-0.1
era5	-16.5	-15.2	-9.2	-3	3.2	10.7	13.4	13.5	9	3.9	-4.1	-9.2	-0.3
daymet	-18.4	-19.7	-9.6	-2.5	3.2	8.8	10.1	10	6.1	2.2	-4.9	-11	-2.1
merra2	-16.5	-13.6	-7.5	-0.4	6.5	12.3	14.3	14.2	9.4	4.6	-3.3	-9.2	0.9
station	-15.6	-13.6	-8.5	-2.8	3.7	9.9	12.2	12.3	8.7	3.9	-3.5	-8.8	-0.2



7.2.1.3 Tdew Monthly Correlations for NMG SoftdB

Table 7.2: Monthly Summary of Reanalysis Data matching Observed Data at NMG SoftdB

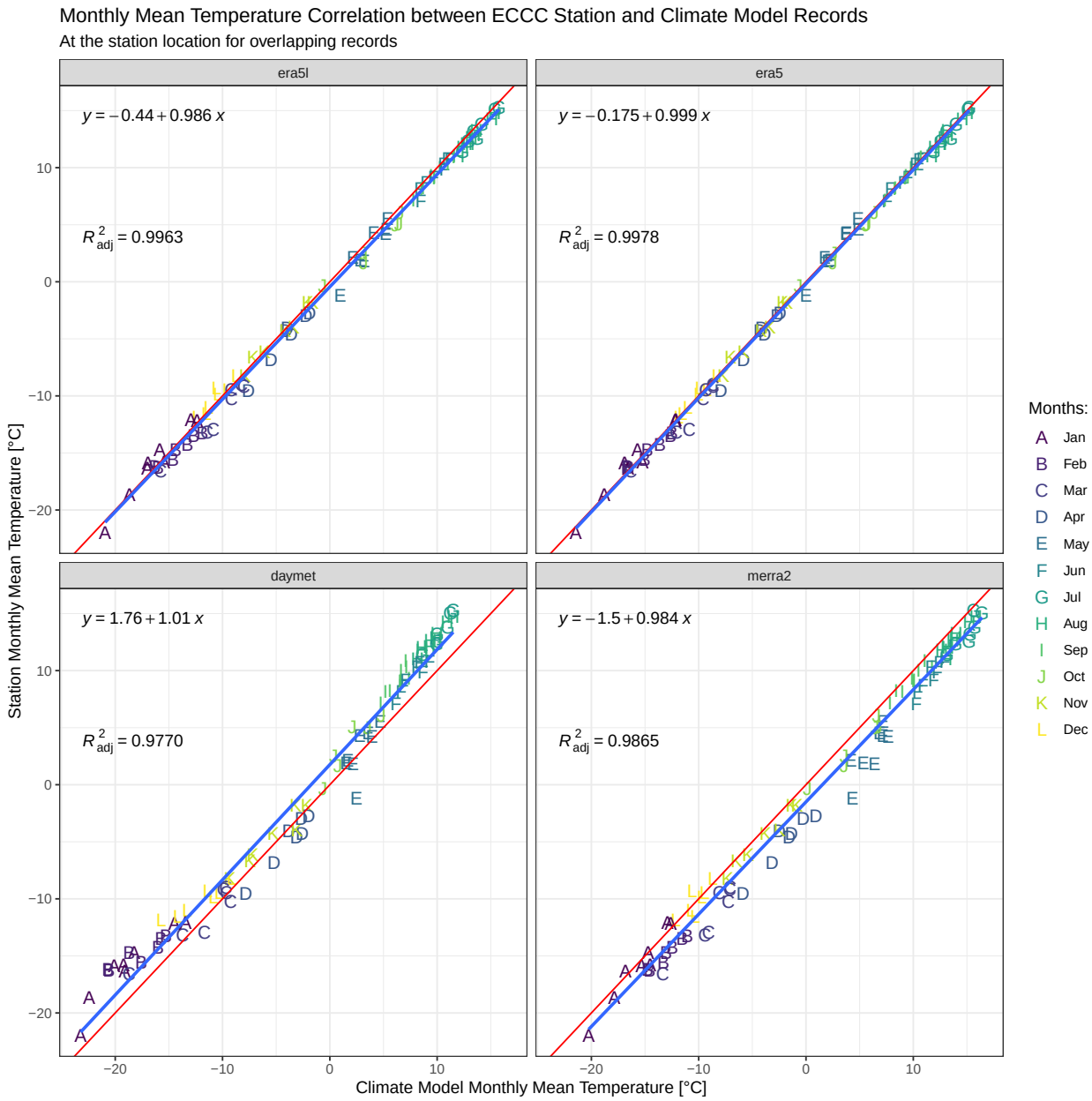
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-11.2	-14.4	-7.9	-2.3	1.9	10.9	14.3	13	10	4.7	-6.2	-8.2	0.4
era5	-11	-14.7	-8.4	-2.5	1.2	10.5	14.1	12.8	9.6	4.5	-6	-7.8	0.2
daymet	-14.2	-17.7	-10.2	-3	2.1	8.4	10.8	9.3	6.4	2.7	-7.6	-8.8	-1.8
merra2	-12.3	-13.4	-6.8	-0.1	4.7	12	14.9	13.4	9.7	5.2	-5.4	-8.3	1.1
station	-11.7	-12.8	-7.1	-1.7	4.3	10.6	13	12	9.4	4.5	-5.3	-7.3	0.7



7.2.1.4 Monthly Correlations for SAINT-MICHEL-DES-SAINTS

Table 7.3: Monthly Summary of Reanalysis Data matching Observed Data at ST MICHEL DES SAINTS

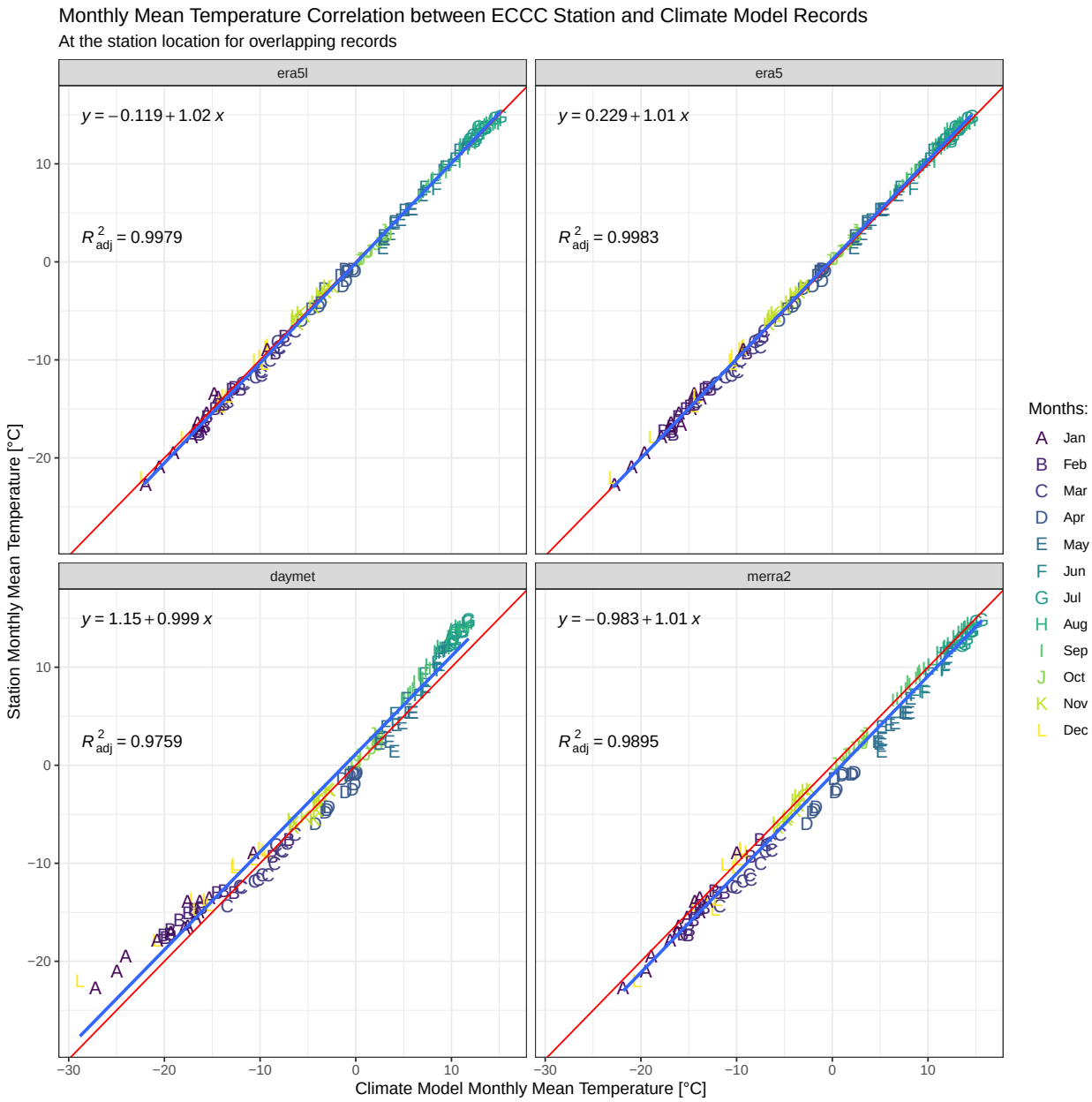
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-16.3	-14.2	-10.4	-4.1	3.6	9.9	14	13.4	9.6	4.1	-4.6	-10.7	-0.5
era5	-16.1	-14.5	-10.8	-4.4	2.9	9.5	13.6	13.1	9.2	3.7	-4.6	-10.3	-0.7
daymet	-18.8	-17.8	-11.8	-3.9	2.9	7.6	10.3	9.6	6.3	1.8	-5.4	-12.1	-2.6
merra2	-15.6	-13	-8.8	-2	6.1	11.6	15	13.9	9.8	4.5	-3.9	-10.2	0.6
station	-15.9	-14.4	-11	-4.7	3.3	9.6	13.6	12.8	9.2	3.3	-4.7	-10.2	-0.8



7.2.1.5 Monthly Correlations for STE AGATHE DES MONTS

Table 7.4: Monthly Summary of Reanalysis Data matching Observed Data at ST ZENON

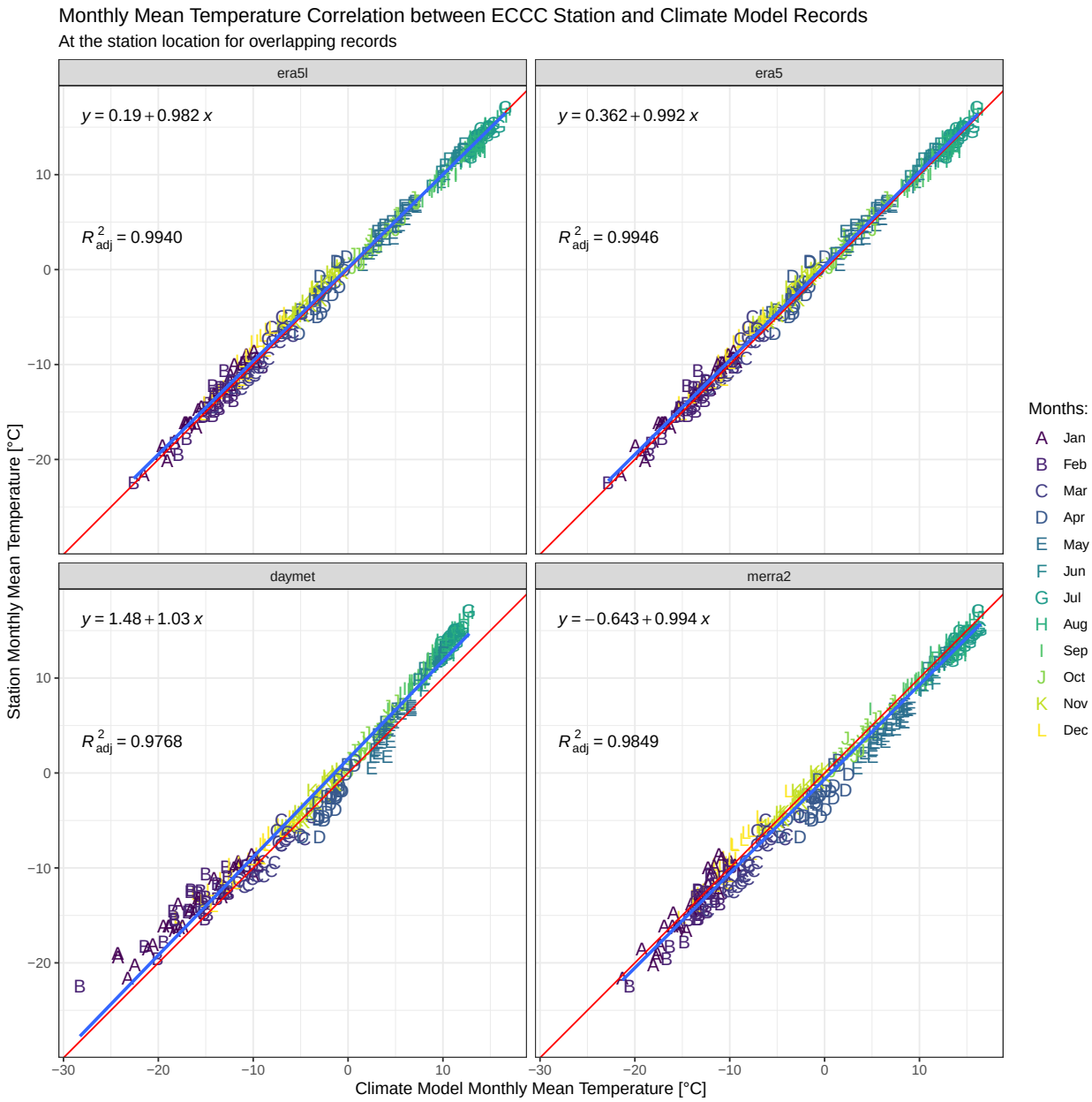
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-16.1	-13.6	-9.5	-2.2	4.4	9.6	13.2	12.8	8.1	2	-4.5	-12.7	-0.7
era5	-16.4	-14.1	-9.9	-2.4	4	9.5	13	12.5	7.8	1.4	-4.8	-13.1	-1
daymet	-18.8	-15.7	-9.5	-1.3	4.2	8.2	10.7	10.1	6.3	1.3	-4.5	-14.9	-2
merra2	-15.8	-12.8	-8.2	0.1	6.4	11.1	14.3	13	8.1	2.3	-3.9	-11.8	0.2
station	-16.3	-15	-9.9	-3.2	3.6	10.1	13.3	12.7	8.2	1.7	-4.2	-12.7	-1



7.2.1.6 Monthly Correlations for ST-JOVITE

Table 7.5: Monthly Summary of Reanalysis Data matching Observed Data at SAINT-MICHEL-DES-SAINTS

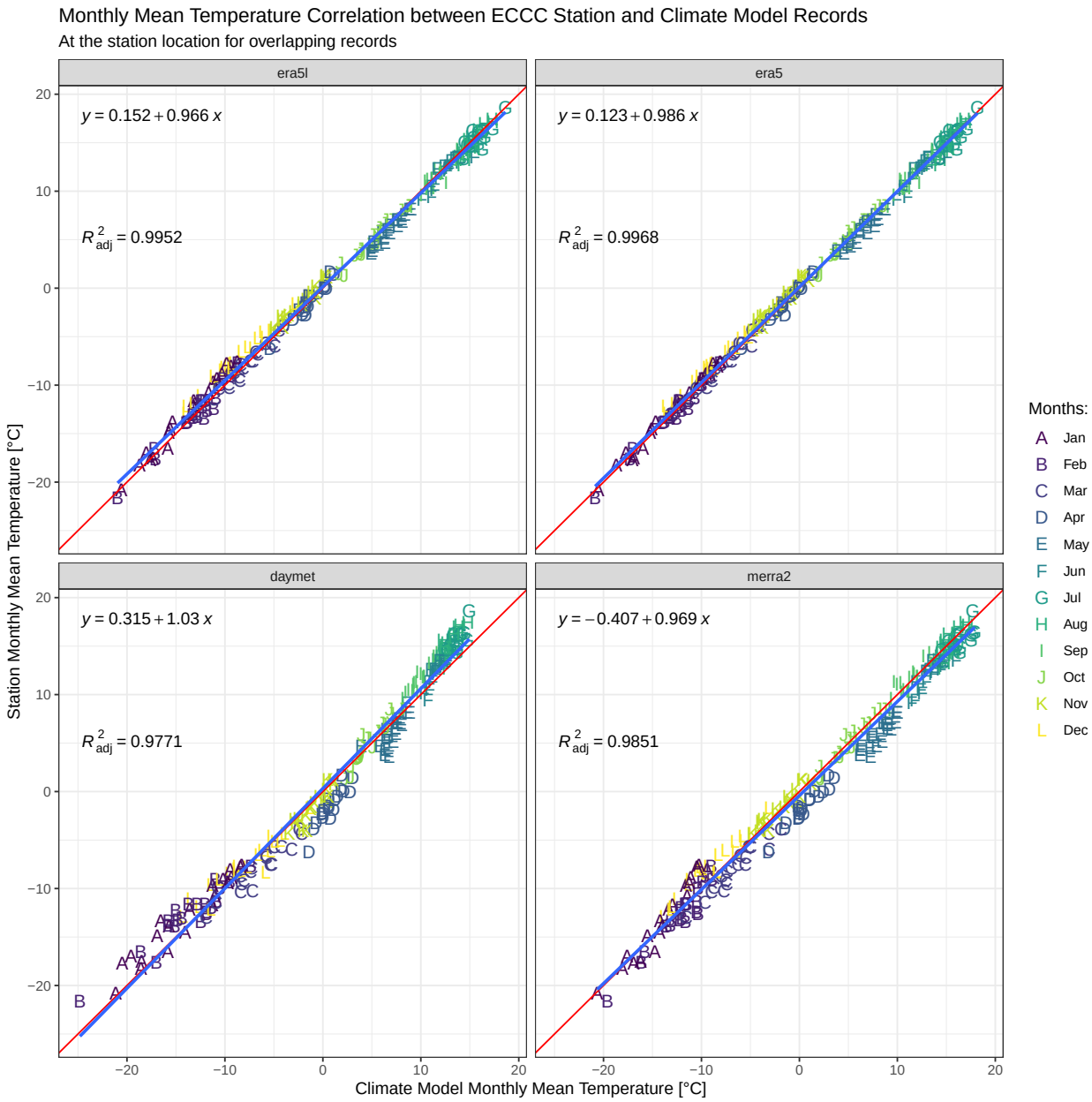
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-14.7	-13.8	-9	-2.9	4.7	11.3	14.3	13.7	10	3.4	-3.5	-10.2	0.3
era5	-14.6	-13.9	-9.2	-3.2	4.3	11.1	14.1	13.4	9.7	3.1	-3.6	-10	0.1
daymet	-16.2	-15.7	-8.7	-1.7	4.4	9.1	11.1	10.4	7.2	2.3	-3.5	-10.6	-1
merra2	-14.2	-12.7	-7.4	-0.6	6.6	12.3	14.9	13.8	9.8	3.7	-2.9	-9.9	1.1
station	-14	-13.6	-9	-2.6	4.8	11.5	14.4	13.5	9.8	3.6	-2.8	-9.2	0.5



7.2.1.7 Monthly Correlations for LAC SAINT-PIERRE

Table 7.6: Monthly Summary of Reanalysis Data matching Observed Data at ST DONAT

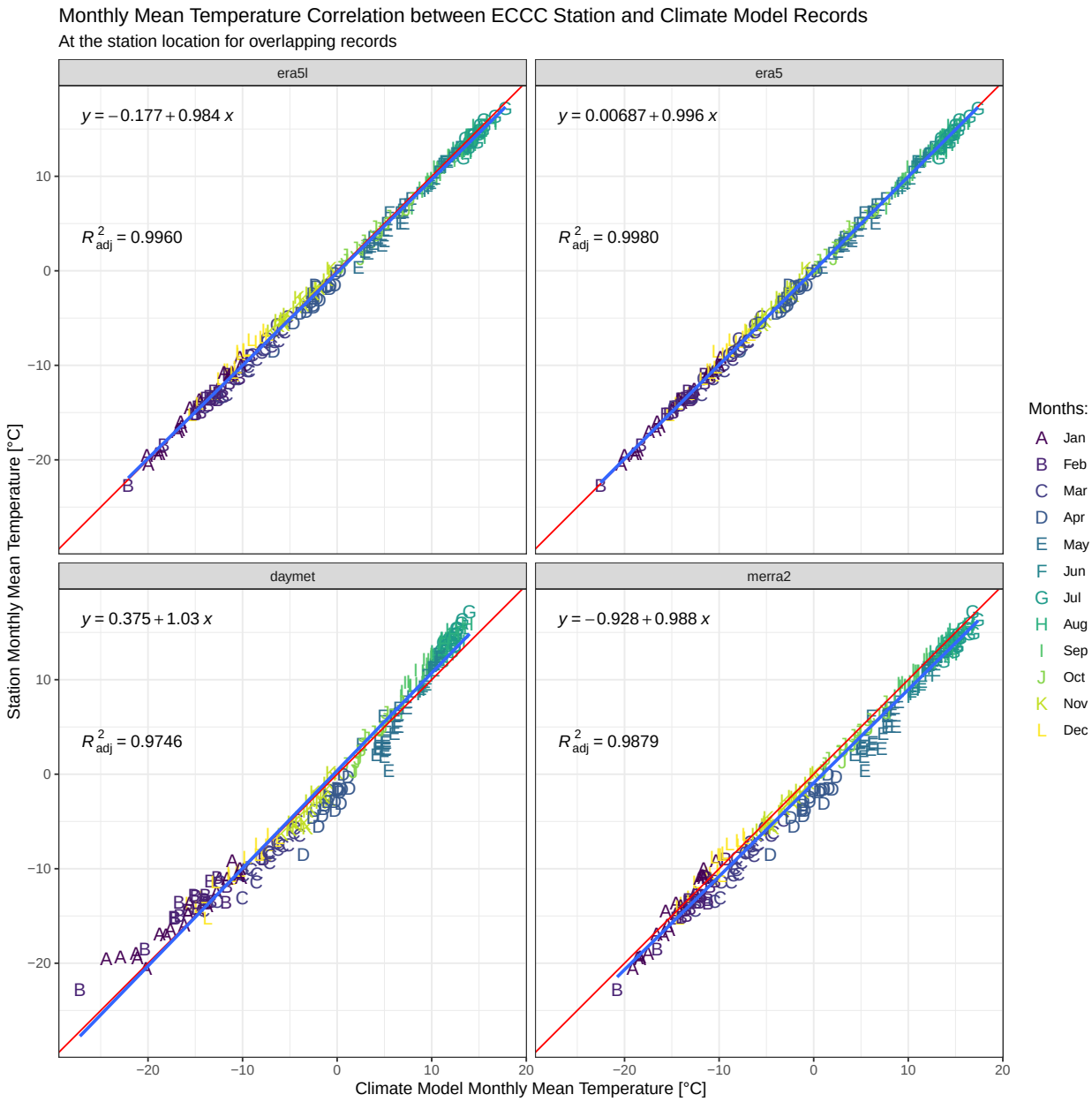
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-13.8	-12.8	-7.8	-1.5	6.8	12.5	15.7	15.3	11.6	5.1	-2.1	-9.1	1.6
era5	-13.3	-12.7	-8	-1.5	6.5	12.3	15.6	15.1	11.3	4.8	-1.9	-8.6	1.6
daymet	-14	-13.7	-6.7	0.8	7	11.3	13.5	12.9	9.7	4.7	-0.9	-8.1	1.4
merra2	-13.7	-12.2	-6.6	0.6	8.2	13.3	16.2	15.3	11.2	5	-1.7	-9	2.2
station	-12.8	-12.5	-7.8	-1.4	6.2	12.1	15.5	15.1	11.4	5.1	-1.4	-7.7	1.8



7.2.1.8 Monthly Correlations for SHAWINIGAN

Table 7.7: Monthly Summary of Reanalysis Data matching Observed Data at ST COME

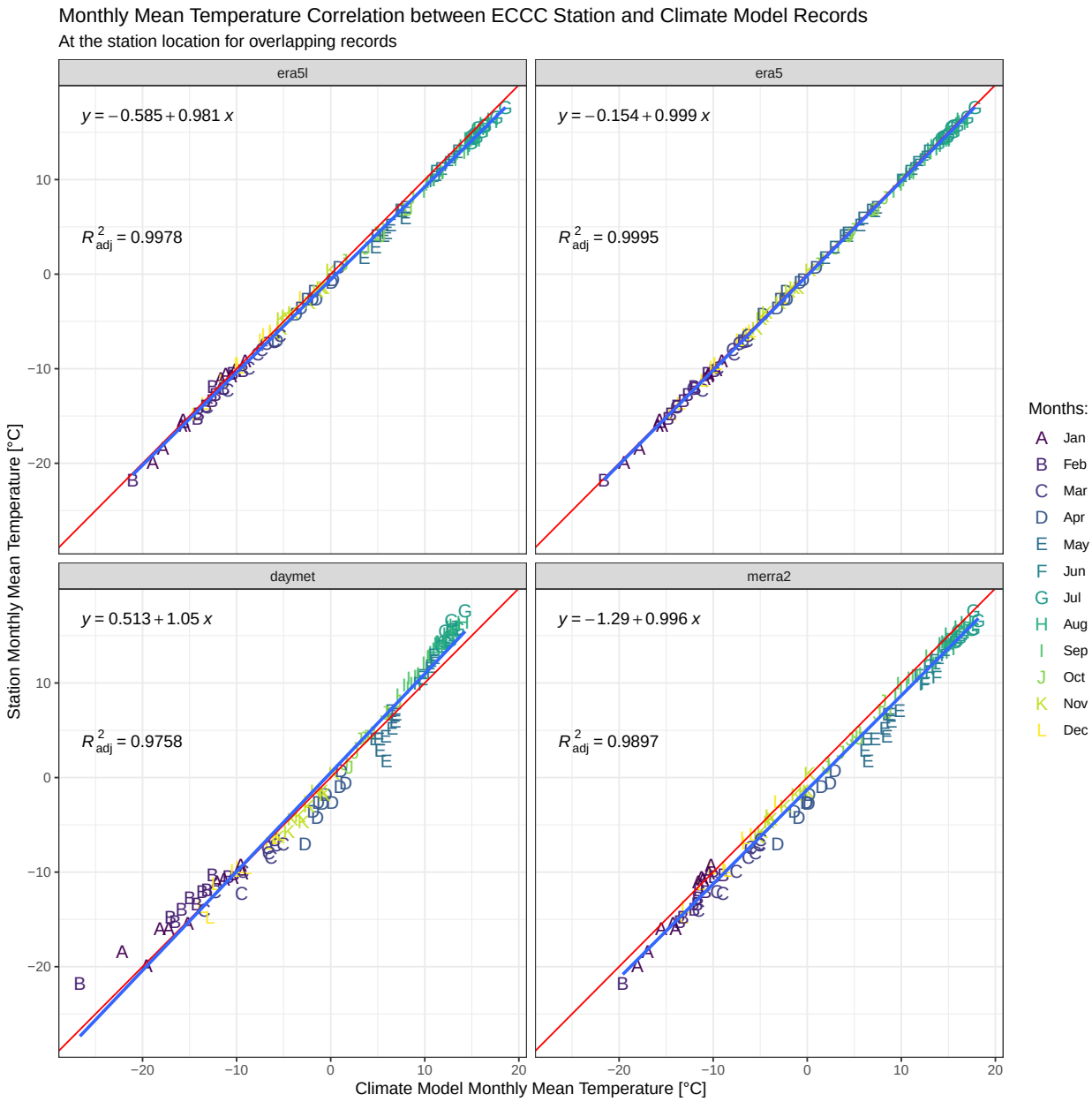
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-14.9	-13.6	-8.5	-2.2	5.2	11.4	14.7	14.1	10.4	3.6	-3.8	-10.7	0.5
era5	-14.7	-13.8	-8.9	-2.6	4.5	11	14.6	14	10.1	3.4	-3.7	-10.3	0.3
daymet	-15.7	-15.1	-7.8	-0.6	5.5	10	12.3	11.7	8.4	3.3	-2.7	-10.2	-0.1
merra2	-14.6	-12.9	-7.4	-0.2	6.8	12.3	15.3	14.4	10.3	4	-3	-10.4	1.2
station	-14.4	-13.7	-8.9	-2.8	4.5	11	14.5	13.9	10.2	3.6	-3.4	-9.9	0.4



7.2.1.9 Monthly Correlations for TROIS-RIVIERES

Table 7.8: Monthly Summary of Reanalysis Data matching Observed Data at NOTRE DAME DE LA MERCI

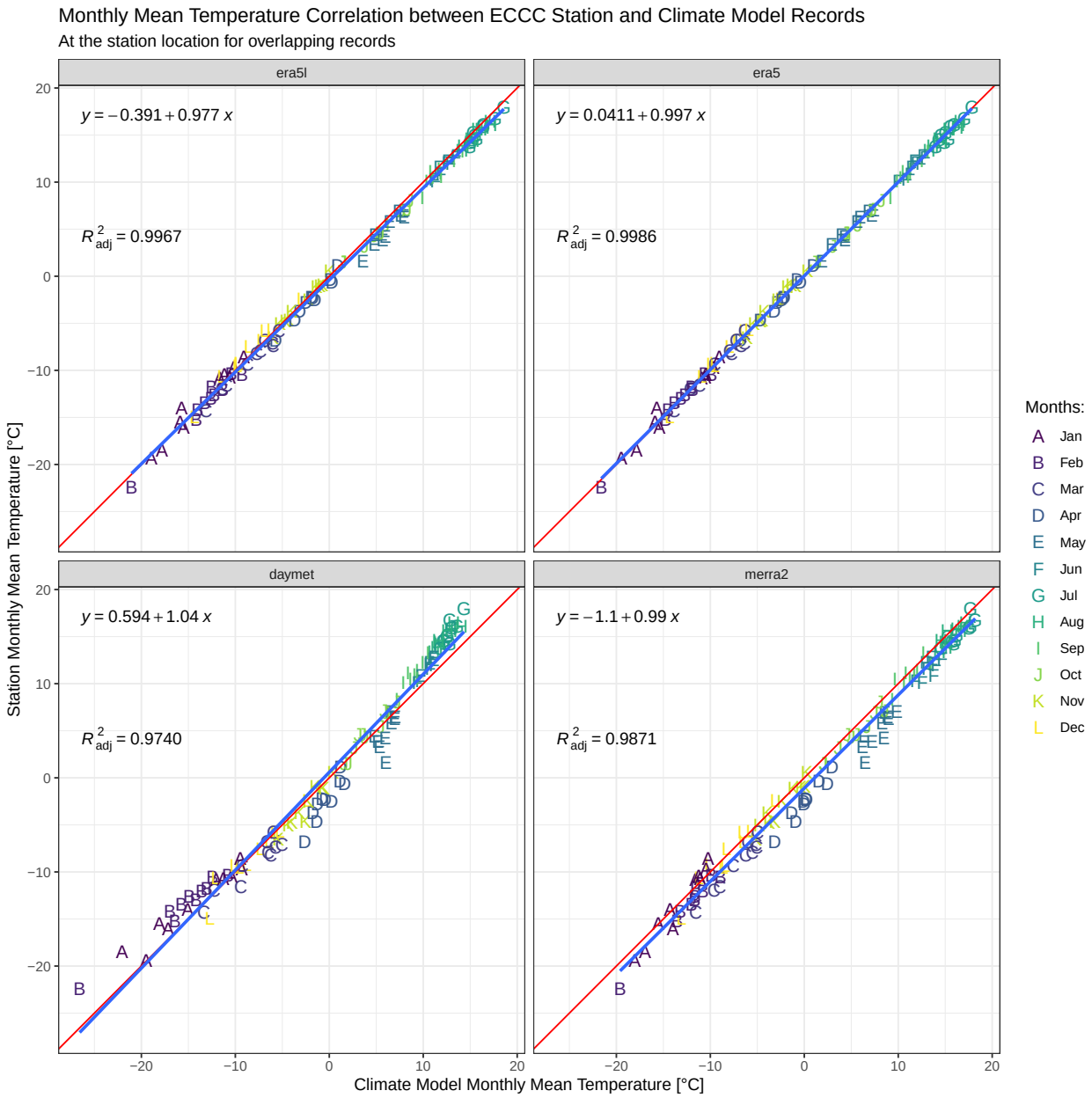
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-13.6	-13.1	-8.3	-1.9	6.2	12.2	16.1	15.6	11.7	5.2	-3	-9.1	1.5
era5	-13.5	-13.5	-8.9	-2.4	5	11.5	15.5	15	11.1	4.6	-3.2	-9	1
daymet	-14.5	-15.6	-8.1	-0.5	6	10.3	12.8	12.3	8.9	4	-2.5	-8.8	0.4
merra2	-13.3	-12.3	-7.1	0.2	7.9	13.2	16.5	15.6	11.3	5.2	-2.5	-8.6	2.2
station	-13.5	-13.3	-8.9	-2.4	5.2	11.5	15.4	14.8	10.8	4.4	-3.2	-9	1



7.2.1.10 Monthly Correlations for TROIS RIVIERES A

Table 7.9: Monthly Summary of Reanalysis Data matching Observed Data at STE BEATRIX

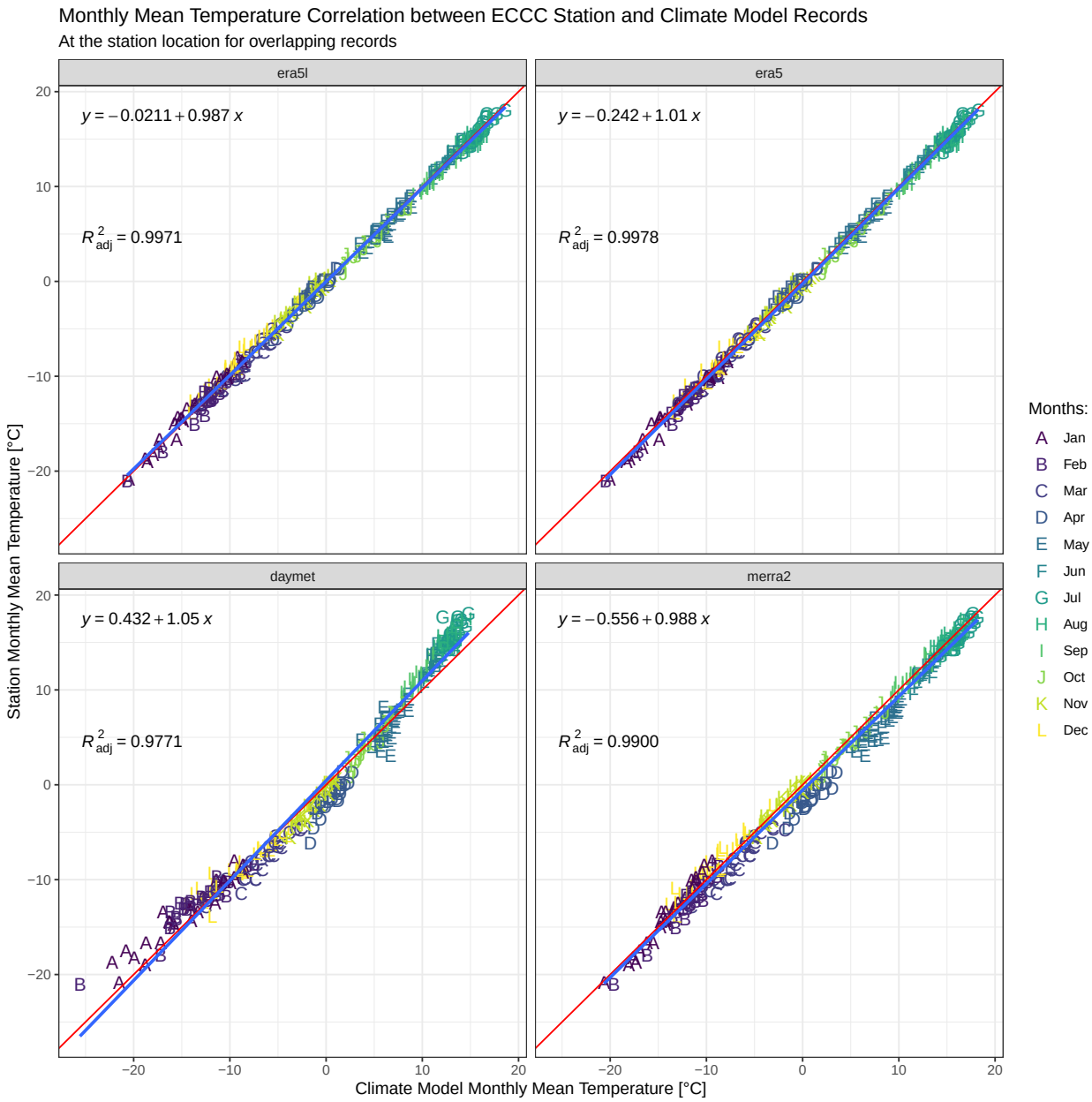
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-13.6	-13.1	-8.3	-1.9	6.2	12.3	16.1	15.7	11.7	5.2	-2.9	-8.7	1.6
era5	-13.5	-13.5	-8.9	-2.4	5	11.7	15.5	15.1	11	4.7	-3.1	-8.4	1.1
daymet	-14.4	-15.5	-8	-0.4	6.1	10.5	12.8	12.4	8.9	4.1	-2.4	-8	0.5
merra2	-13.3	-12.3	-7.1	0.2	7.9	13.3	16.5	15.6	11.3	5.4	-2.4	-8.2	2.2
station	-13.1	-13.1	-8.6	-2.3	5.3	11.8	15.6	15	11	4.7	-3	-8.2	1.3



7.2.1.11 Monthly Correlations for NICOLET

Table 7.10: Monthly Summary of Reanalysis Data matching Observed Data at ST CHARLES DE MANDEVILLE

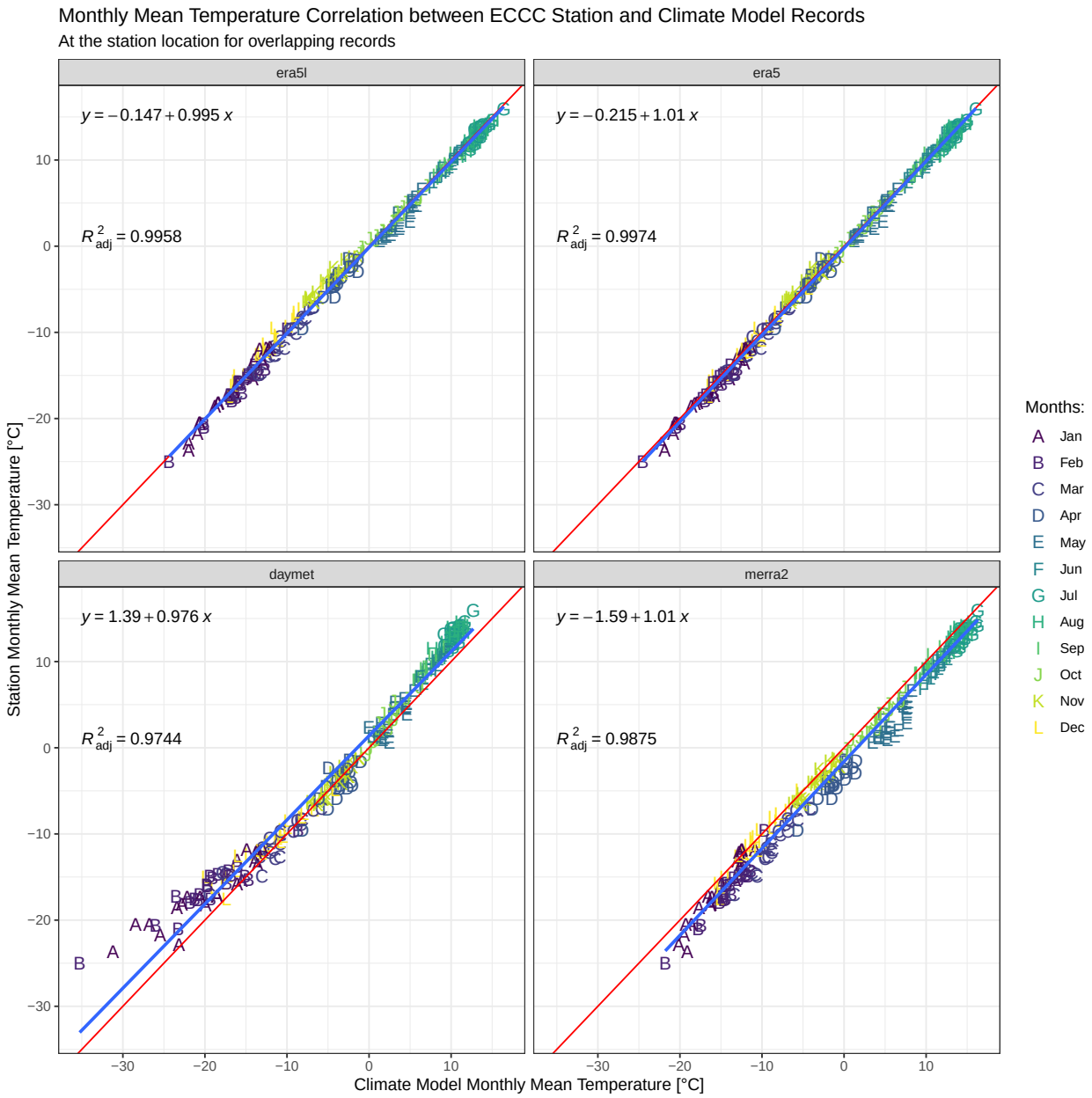
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-13.8	-12.2	-7.7	-1.4	6.5	12.6	15.9	15.3	11.5	4.6	-2.3	-9.1	1.7
era5	-13.1	-11.9	-7.6	-1.4	6.4	12.5	15.9	15.3	11.5	4.7	-1.8	-8.3	1.8
daymet	-14.4	-13.5	-6.7	0.5	6.5	11	13.2	12.6	9.4	4.4	-1.2	-8.5	1.1
merra2	-13.7	-11.8	-6.5	0.7	7.9	13.4	16.3	15.3	11.2	4.6	-1.9	-9.1	2.2
station	-13.4	-12.4	-7.8	-1.4	6.2	12.5	15.9	15.1	11.2	4.4	-2.1	-8.4	1.7



7.2.1.12 Monthly Correlations for LA TUQUE

Table 7.11: Monthly Summary of Reanalysis Data matching Observed Data at ST ALEXIS DES MONTS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	-16.6	-15.8	-10.6	-3.8	3.9	10.1	13.5	13.1	9.5	2.6	-4.7	-12	-0.9
era5	-16.2	-15.8	-10.7	-3.8	3.6	10	13.5	13	9.4	2.7	-4.2	-11.4	-0.8
daymet	-19.6	-19.6	-11.5	-3.5	2.7	8	10.6	10.1	7.1	2.1	-4.1	-12.7	-2.5
merra2	-15.5	-14	-8.5	-1.1	6.2	11.7	14.6	13.9	10.1	3.6	-3.4	-11.1	0.5
station	-16.6	-16.2	-11	-4	3.3	9.8	13.3	12.8	9.4	2.9	-4	-11.4	-1

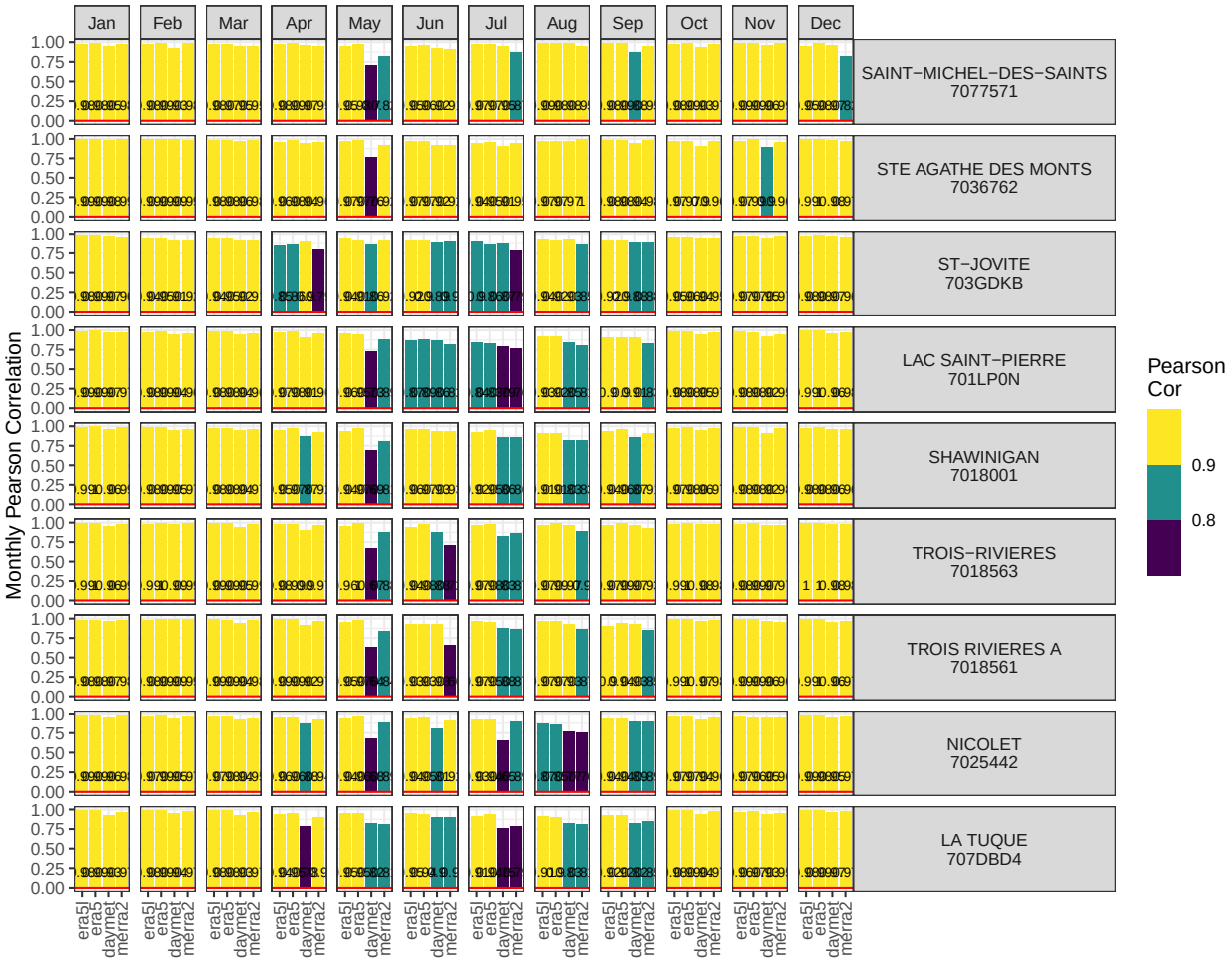


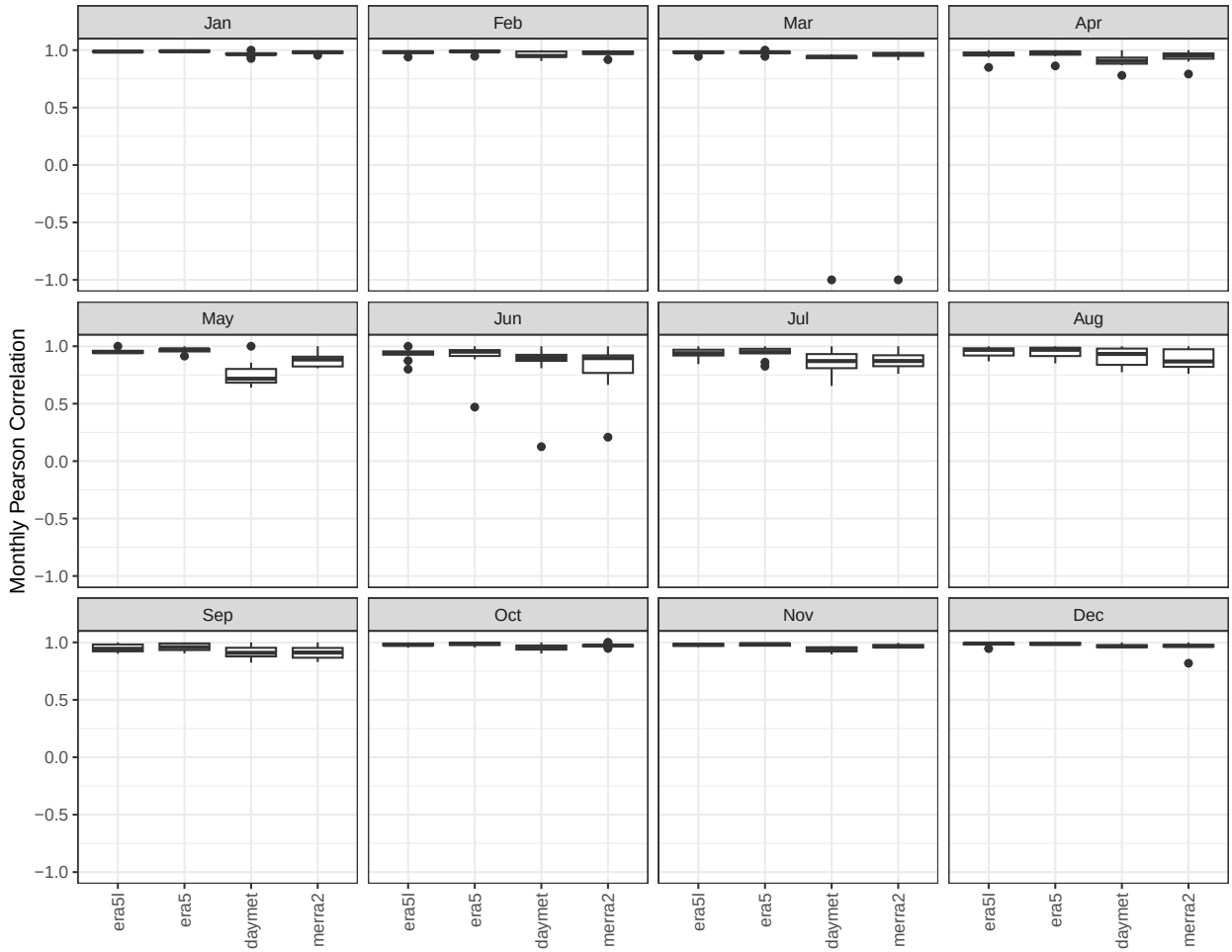
7.2.2 Monthly Pearson Correlation Coefficient for Tdew

The Pearson correlation coefficient (PCC) is a correlation coefficient that measures linear correlation (and linear only) between two sets of data. It represents a normalized measurement of the covariance, such that the result always has a value between −1 and 1. A value of 0 represents no linear correlation between both datasets. A value of 1 represents perfect positive linear correlation, and a value of -1 perfect negative linear correlation.

Monthly data reviewed in the previous section is summarized in the following figures that represent PCC monhtly for ECCC stations versus climate models comparisons.

ERA5 and ERA5-Land generally presents the better Pearson correlations with station data year round.


Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
SAINT−MICHEL−DES−SAINTS
7077571
STE AGATHE DES MONTS
7036762
ST−JOVITE
703GDKB
LAC SAINT−PIERRE
701LP0N
SHAWINIGAN
7018001
TROIS−RIVIERES
7018563
TROIS RIVIERES A
7018561
NICOLET
7025442
LA TUQUE
707DBD4
Monthly Pearson Correlation
1.00
0.75
0.50
0.25
0.00
era5
era3
daymet
merra2
Pearson
Cor
0.9
0.8



7.3 Reanalysis Evaluation Against Station Records - Relative Humidity

7.3.1 Station to Climate Model - RH Monthly Correlations

Monthly correlations between station and climate model data at each location help comparing model coherence with measured data and highlight seasonal bias. Monthly analysis allows inclusion of the NMG stations records.

The main findings of this section are summarized below:

- All the climate models present strong correlation with ECCC station data. The strongest appear to ERA5-Land and ERA5.
- NMG station records are short, but have generally good correlation with ERA5-Land and ERA5.

7.3.1.1 RH Functions Definition

A function is defined to compare monthly station records against data produced for the same location by all four climate models included in this study.

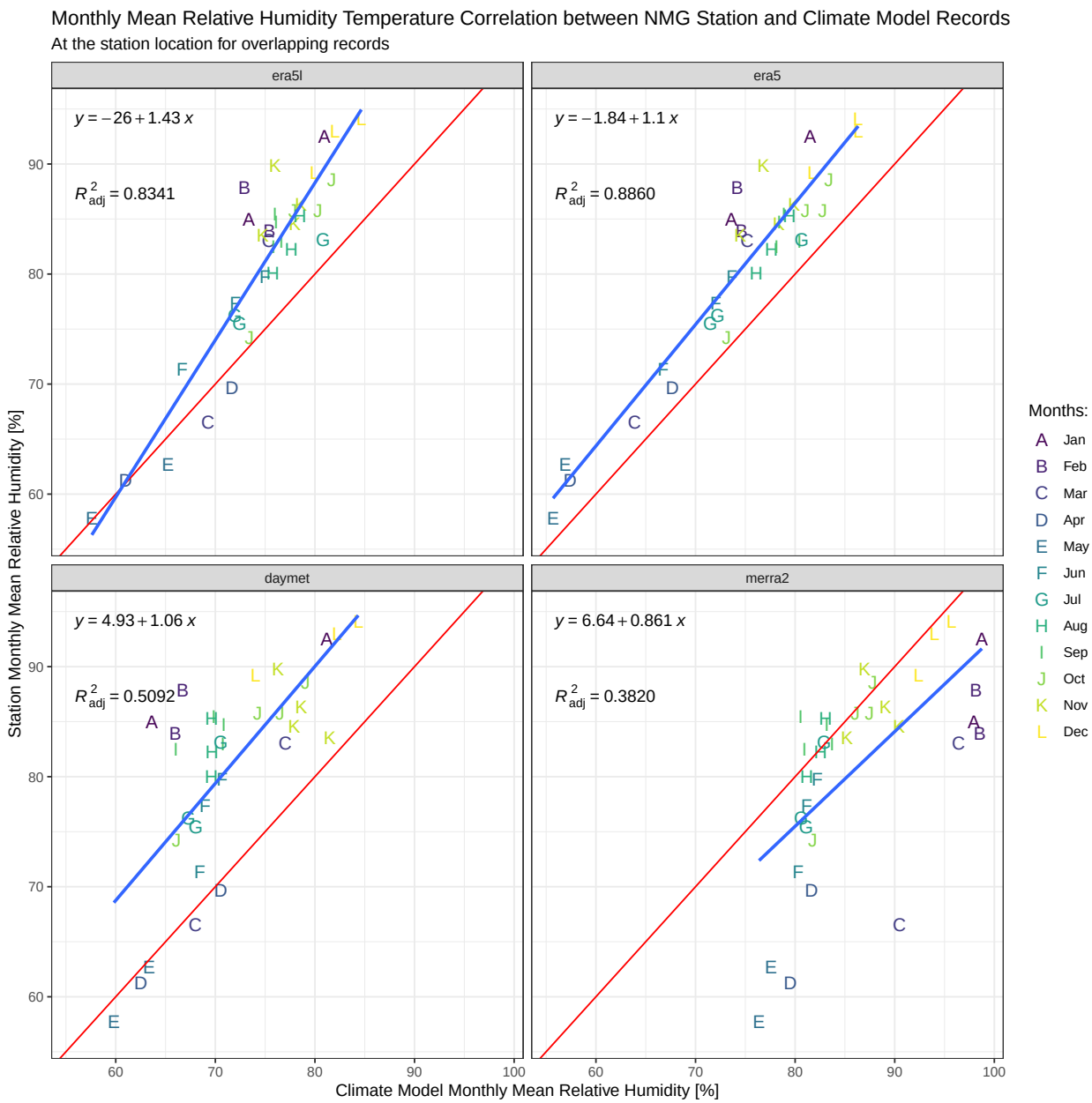
- Monthly relative humidity results are summarized in a table comparing climate model results to station records for the same overlapping record period.

- The plot shows correlation between each station monthly data and all four climate models for the same overlapping record period.

7.3.1.2 RH Monthly Correlations for NMG Site

Table 7.12: Monthly Summary of Reanalysis Data matching Observed Data at NMG Site

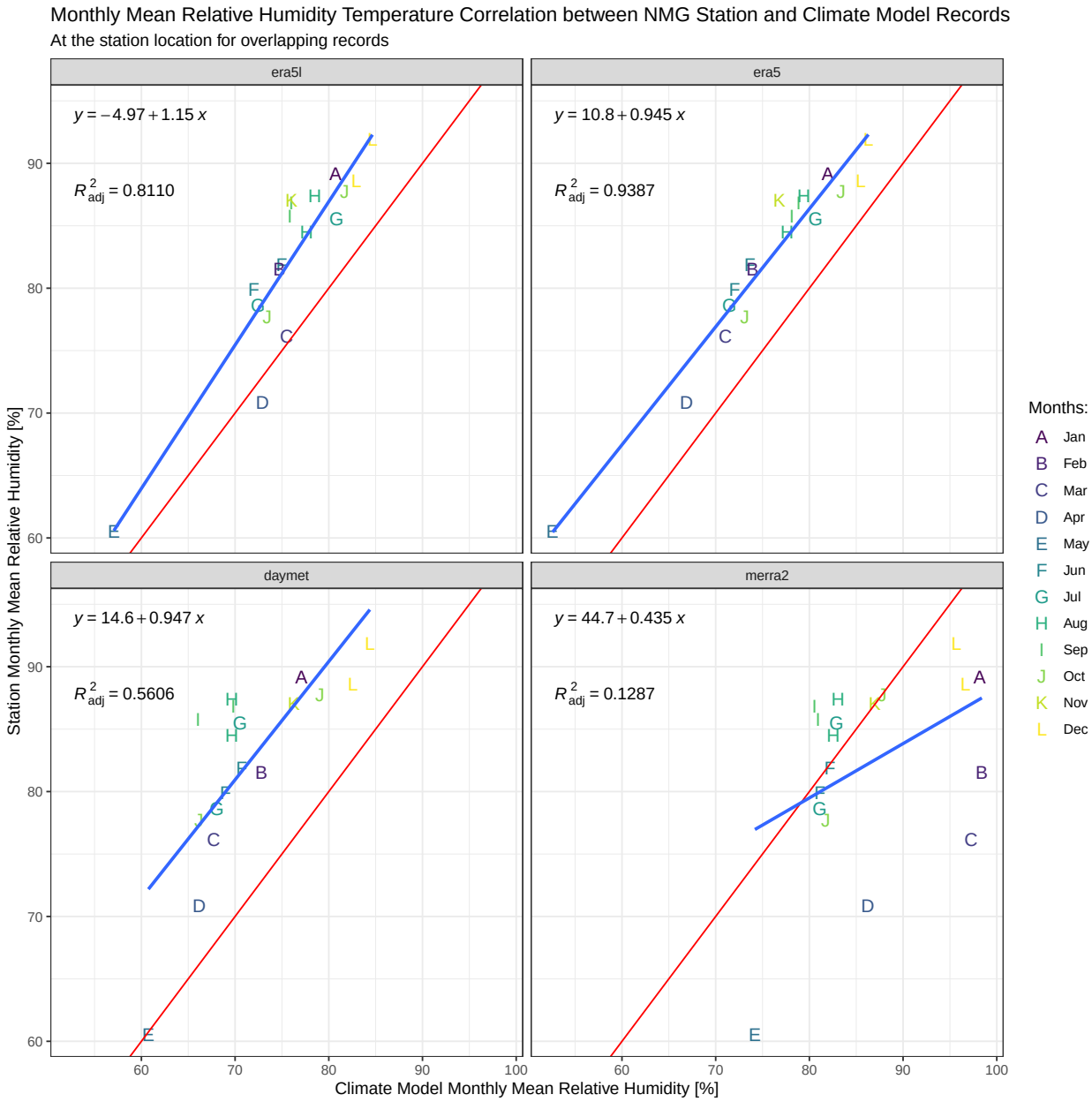
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	77.2	74.2	72.3	66.3	61.4	71.2	75.1	77.3	76.1	78.3	76.8	82.2	74
era5	77.5	74.4	69.5	62.6	56.3	70.8	74.8	77.7	79	80.1	77.4	84.8	73.7
daymet	72.4	66.3	72.5	66.5	61.6	69.4	68.6	69.6	69.4	74	78.6	80.2	70.8
merra2	98.4	98.4	93.4	80.6	77	81.2	81.5	82.3	82.1	85.8	87.9	94	86.9
station	90.6	84.8	74.8	67.7	63.6	76	78.9	82.6	83.9	83.6	86.1	92.1	80.4



7.3.1.3 RH Monthly Correlations for NMG SoftdB

Table 7.13: Monthly Summary of Reanalysis Data matching Observed Data at NMG SoftdB

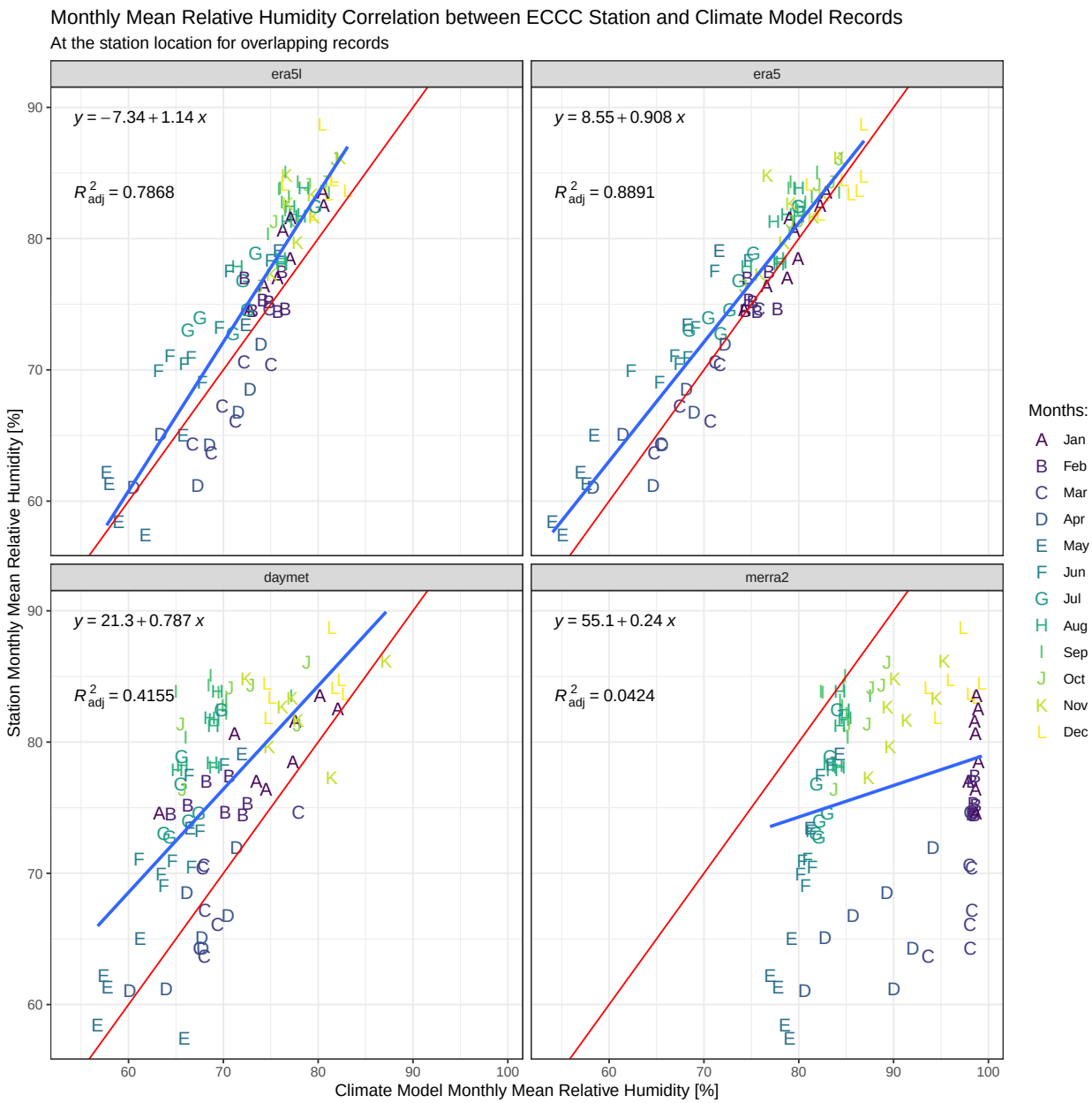
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	80.7	74.7	75.5	72.9	57.1	73.5	76.6	78.1	75.9	77.6	76	83.8	75.2
era5	82	73.9	71	66.9	52.6	72.8	76.1	78.5	78.5	78.2	76.8	85.9	74.4
daymet	77.1	72.8	67.7	66.2	60.7	69.9	69.3	69.7	67.9	72.6	76.2	83.5	71.1
merra2	98.2	98.4	97.3	86.3	74.2	81.7	82	82.8	80.8	84.8	87	96.2	87.5
station	89.5	81.2	75.3	71.6	66.2	80.3	82.1	86	86.3	82.7	87.1	90.3	81.5



7.3.1.4 RH Monthly Correlations for SAINT-MICHEL-DES-SAINTS

Table 7.14: Monthly Summary of Reanalysis Data matching Observed Data at SAINT-MICHEL-DES-SAINTS

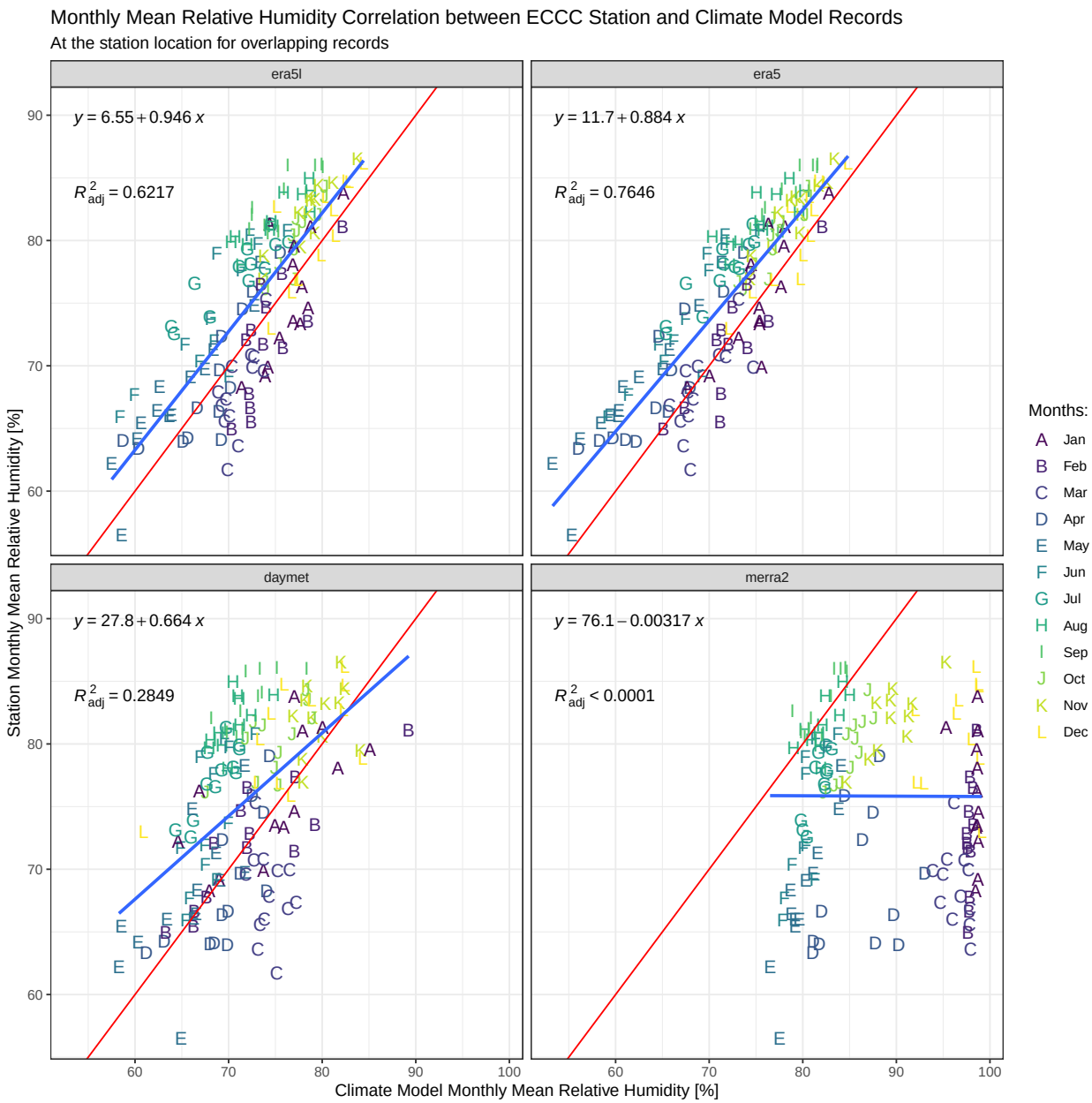
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	76.8	74.7	71.2	68.3	64.3	67.9	71.8	76.4	76.9	78	78.2	80.6	73.8
era5	79.2	75.6	69.6	65.6	60.3	68.2	73.2	78.3	80.6	80.5	79.8	84.9	74.6
daymet	75	69.2	69.5	66.8	62.5	65.4	66.1	68.3	69.5	71.9	78.2	79	70.1
merra2	98.6	98.5	97.5	87.8	79.6	81.3	82.6	84.3	84.6	86.9	91.1	96.8	89.1
station	79.4	75.4	68.3	65.9	65.8	73	76.7	80.4	83.3	82.3	82.2	84.4	76.4



7.3.1.5 RH Monthly Correlations for STE AGATHE DES MONTS

Table 7.15: Monthly Summary of Reanalysis Data matching Observed Data at STE AGATHE DES MONTS

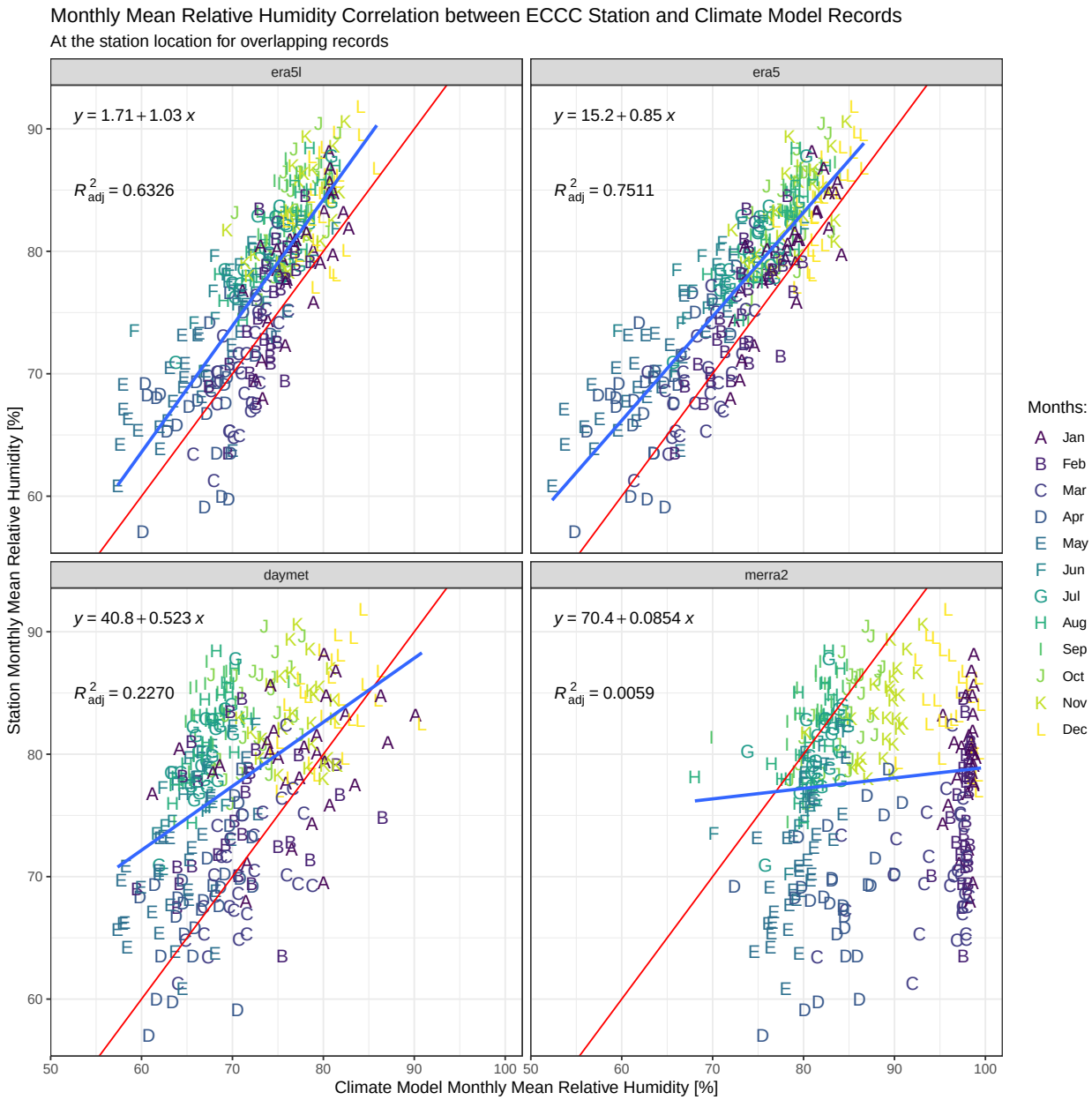
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	76.5	74.2	71.1	67.9	64.4	68.2	70.8	74.8	75.9	77.2	78.5	79.5	73.3
era5	75.4	72.5	69.1	64.5	61.4	67.6	71	75.5	78.1	77	79	79.5	72.6
daymet	74.7	72.5	74.3	69.6	65.6	68.1	68.6	70.4	72.4	74.7	79.9	76.7	72.3
merra2	98.4	97.9	96.4	86.1	80	80.4	81.7	82.1	82	85.2	89.6	96.6	88
station	76.2	73.2	70.5	68.2	67.1	74.3	76.8	80.6	82.8	79.5	82	80.4	76



7.3.1.6 RH Monthly Correlations for ST-JOVITE

Table 7.16: Monthly Summary of Reanalysis Data matching Observed Data at ST-JOVITE

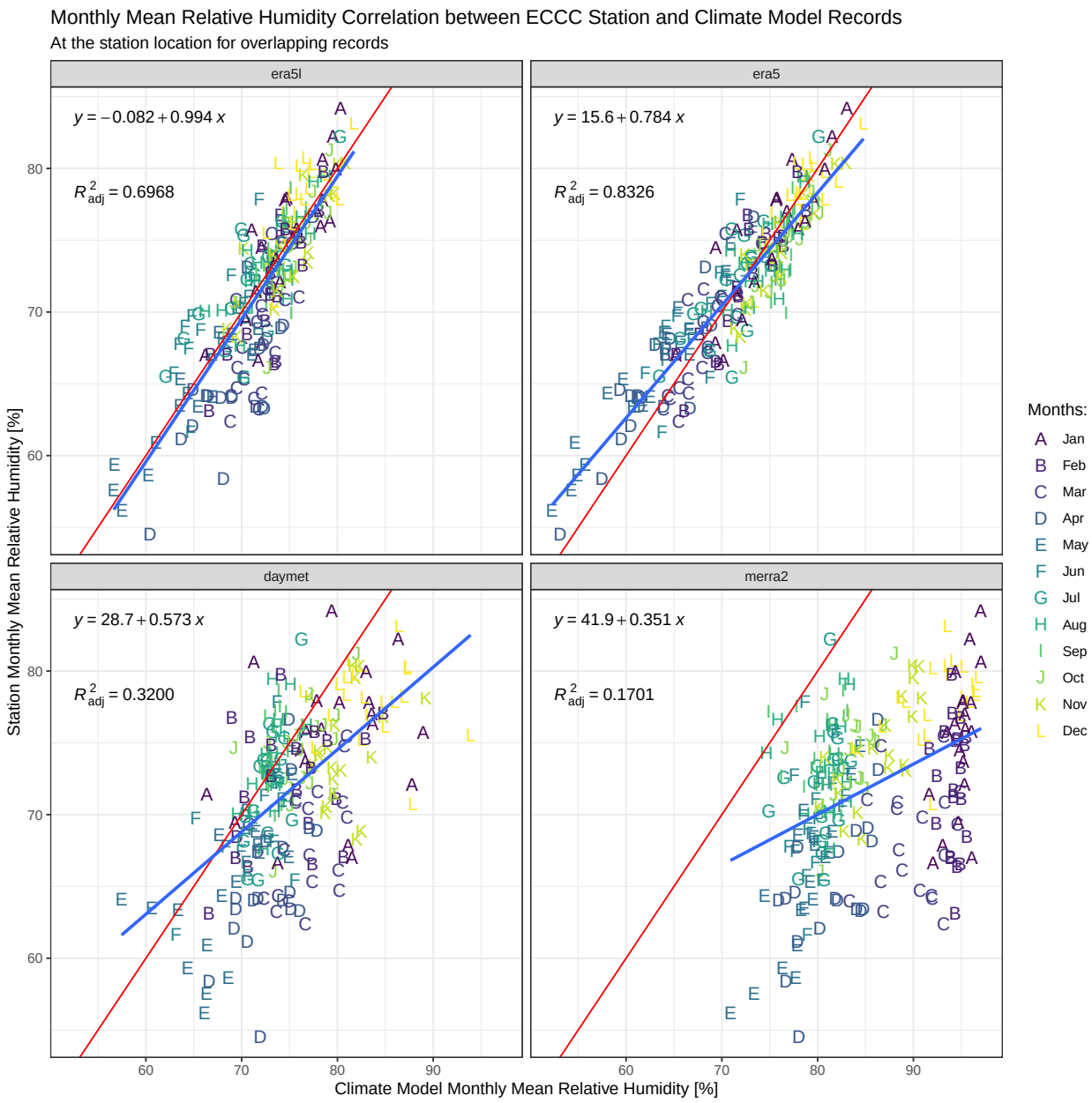
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	77.3	73.9	71	67.4	65.4	71.2	74.2	75.4	75.8	76.9	77.4	80.1	73.8
era5	78	73.3	68.8	63.4	62.2	70.5	74.5	76.7	78.5	78.4	78.8	82.2	73.8
daymet	77	71.3	71.2	66.8	63.5	66.4	67	67.2	68.4	72.7	77.4	80.6	70.8
merra2	98	97.6	94.6	83.8	79.1	80.6	81.6	80.9	81	84.7	88.8	96.5	87.3
station	79.6	74.9	70.3	68.5	69.8	77.8	80.2	81.6	83.7	83.4	83.2	84	78.1



7.3.1.7 RH Monthly Correlations for LAC SAINT-PIERRE

Table 7.17: Monthly Summary of Reanalysis Data matching Observed Data at LAC SAINT-PIERRE

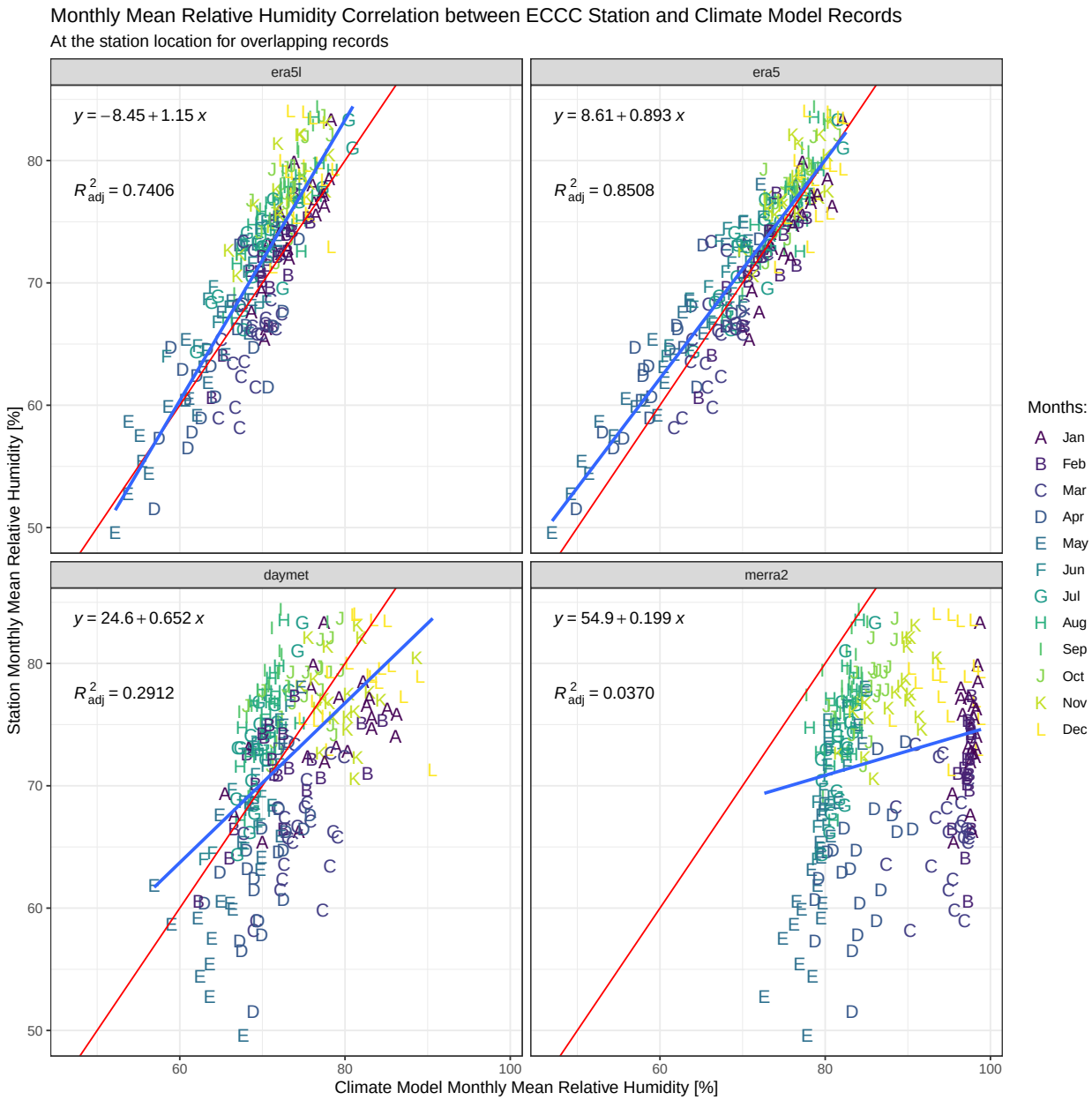
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	75	73.3	71.7	69.5	65.9	68.2	70.7	73.2	73.8	75.3	74.9	76.6	72.3
era5	75.1	72.2	67.9	63	62	67.5	71.4	74.5	76.4	76.5	76.1	78.4	71.7
daymet	79.3	75	76.9	72.9	68.5	71.7	72.9	73.2	73.2	76.4	80.7	83.6	75.3
merra2	94.9	94.2	90	81.5	78.6	79.8	80.6	80.8	80.4	83.5	86.4	92.8	85.3
station	75.2	72.1	68.1	65.2	65.4	69.6	72.1	73.5	74.2	74.3	74.4	78.1	71.8



7.3.1.8 RH Monthly Correlations for SHAWINIGAN

Table 7.18: Monthly Summary of Reanalysis Data matching Observed Data at SHAWINIGAN

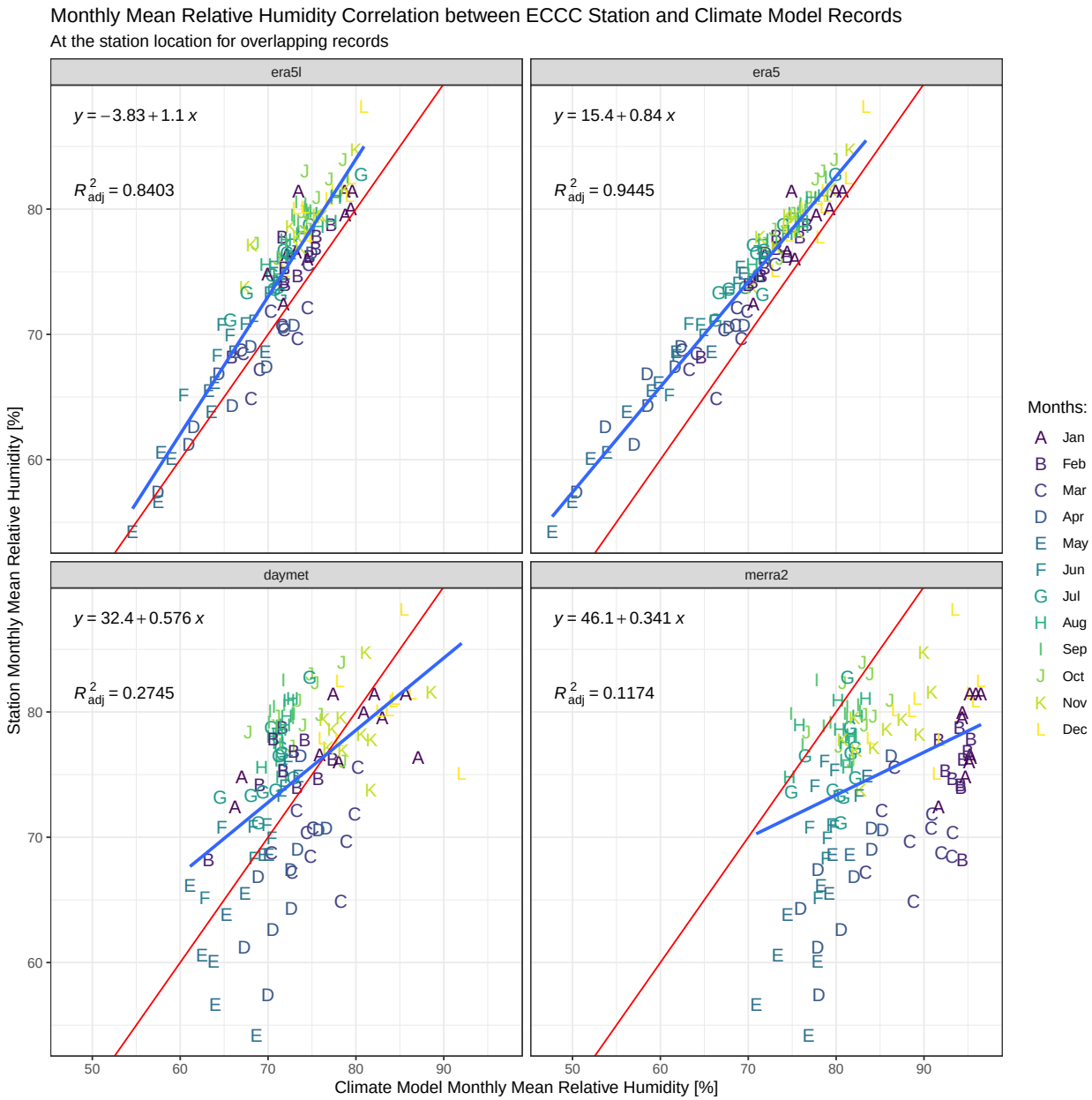
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	73.7	71.2	68.7	64.8	62.6	68	70.5	72.3	72.7	73.3	72.8	75.2	70.5
era5	75.6	72.1	67.4	60.6	59.9	67.9	72.1	74.9	76.5	76.2	75.8	78.9	71.5
daymet	78	72.8	74.3	70.2	66.7	69.3	69.9	70.5	71.1	75.2	79.9	82.2	73.3
merra2	97.5	97.3	94.6	84.1	79.2	80.6	81.9	82.3	82.3	85.3	88.2	95.2	87.4
station	74.4	71.1	66.1	63.3	63.5	70.5	73.2	75.7	78.1	78	77.3	78.7	72.5



7.3.1.9 RH Monthly Correlations for TROIS-RIVIERES

Table 7.19: Monthly Summary of Reanalysis Data matching Observed Data at TROIS-RIVIERES

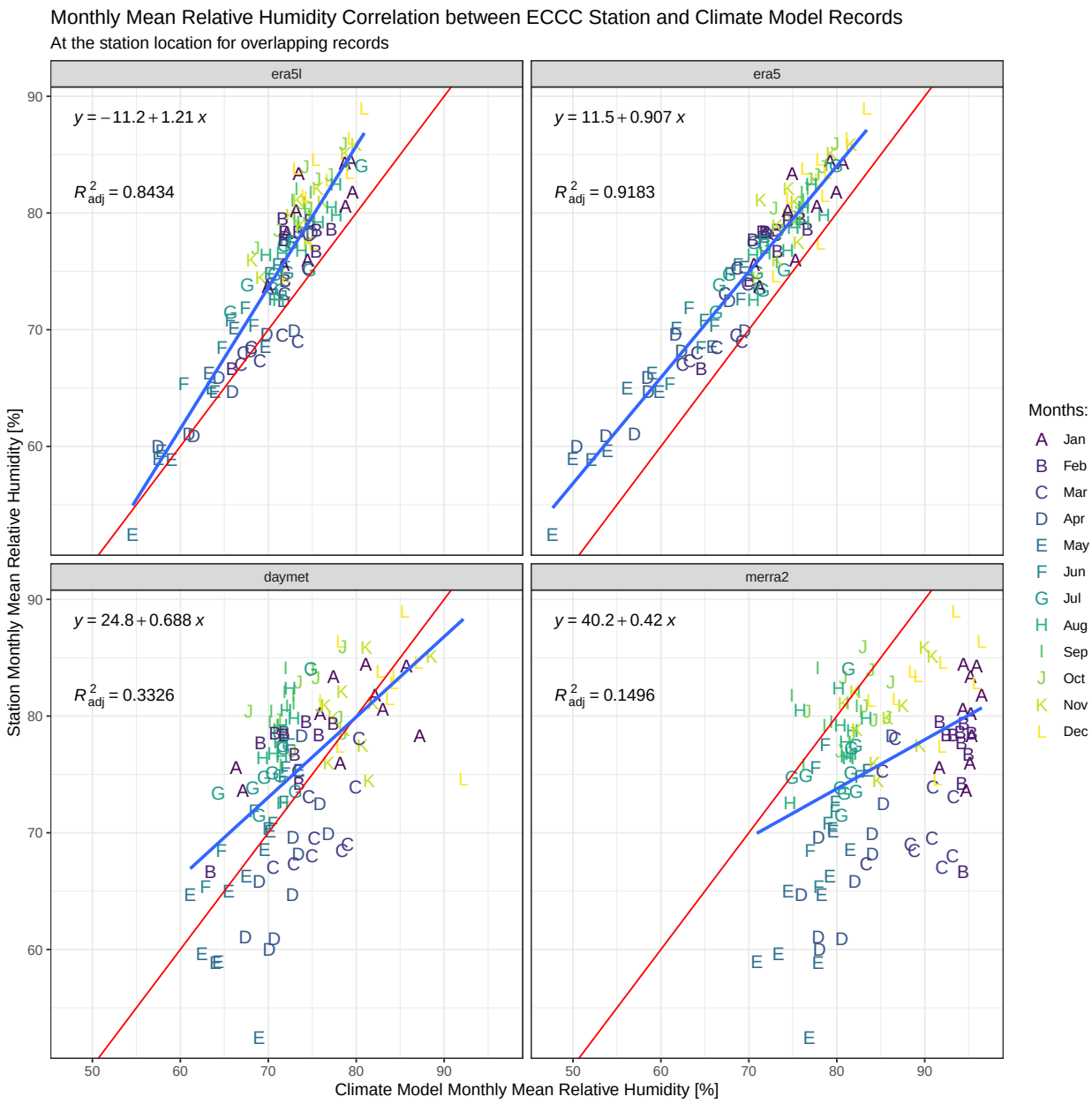
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	75.2	72.9	70.7	66.8	62.7	67.5	71.7	74.2	74.1	74.2	74	76.3	71.7
era5	75.6	72.2	67.3	61.2	57.6	65.9	70.9	74.3	76.1	75.6	74.9	78.2	70.8
daymet	78.3	72	75.8	72.2	66.6	69.2	70.4	71.4	71.6	74.2	80.1	83.2	73.7
merra2	94.8	93.9	89.2	81.2	77.6	79.1	80.2	80.3	79.6	82.3	85.6	91.3	84.6
station	78.1	75.2	70	66.6	64.4	71.5	75.7	78.2	79.9	80.1	78.8	80.5	74.9



7.3.1.10 RH Monthly Correlations for TROIS RIVIERES A

Table 7.20: Monthly Summary of Reanalysis Data matching Observed Data at TROIS RIVIERES A

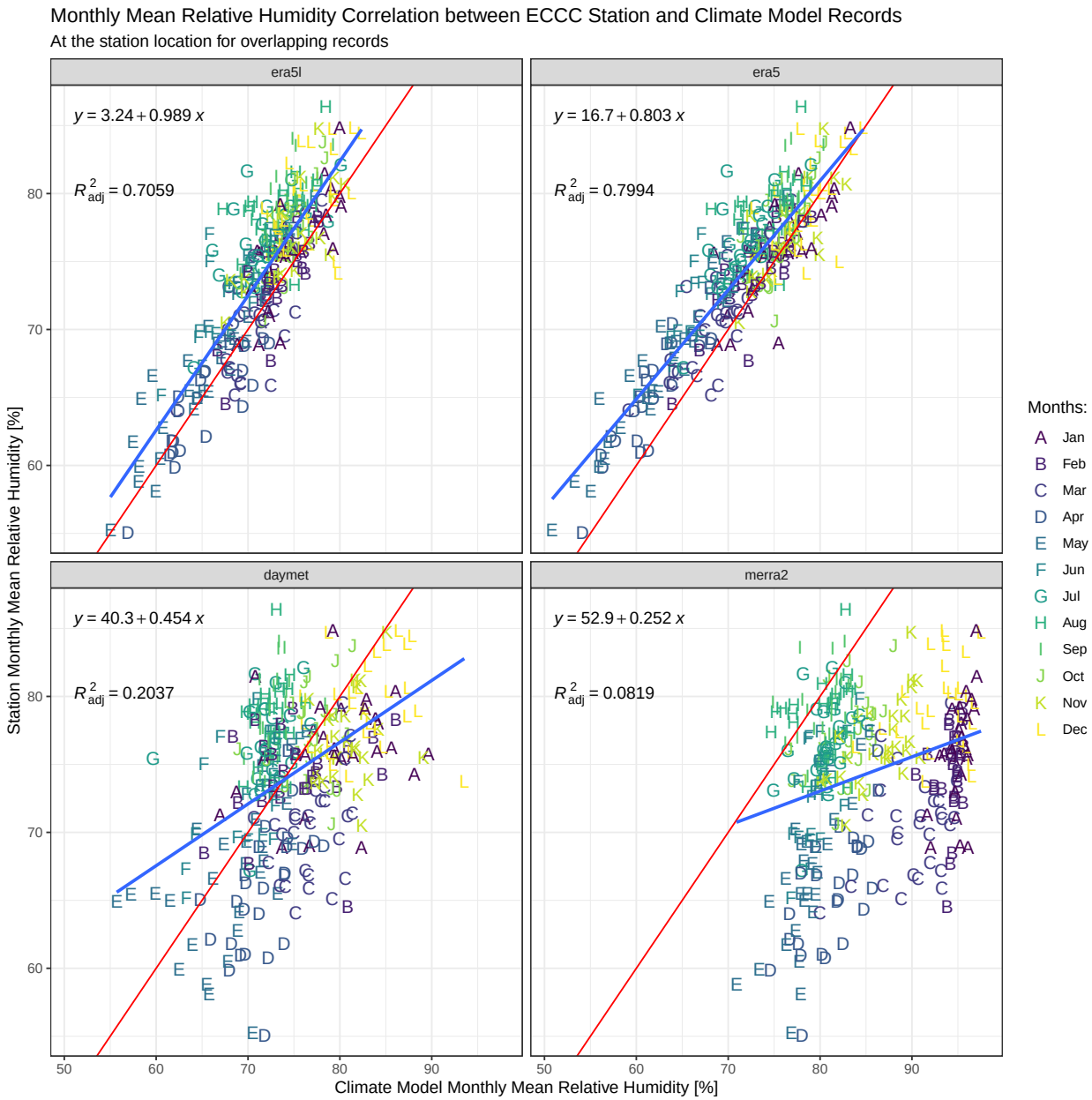
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	75.2	72.9	70.7	66.8	62.7	67.9	71.8	74.1	74.1	74.2	74.2	76.1	71.7
era5	75.6	72.2	67.3	61.2	57.6	66.4	71.1	74.2	76.1	75.8	75	78.1	70.9
daymet	78.4	72.1	75.9	72.3	66.7	69.4	70.4	71.5	71.7	74.6	80.2	83.3	73.9
merra2	94.8	93.9	89.2	81.2	77.6	79.1	80.2	80.1	79.5	82.6	85.8	91	84.6
station	79.9	76.8	71	67.1	64.5	72	75.8	78.1	80.6	81.3	80.2	82.5	75.8



7.3.1.11 RH Monthly Correlations for NICOLET

Table 7.21: Monthly Summary of Reanalysis Data matching Observed Data at NICOLET

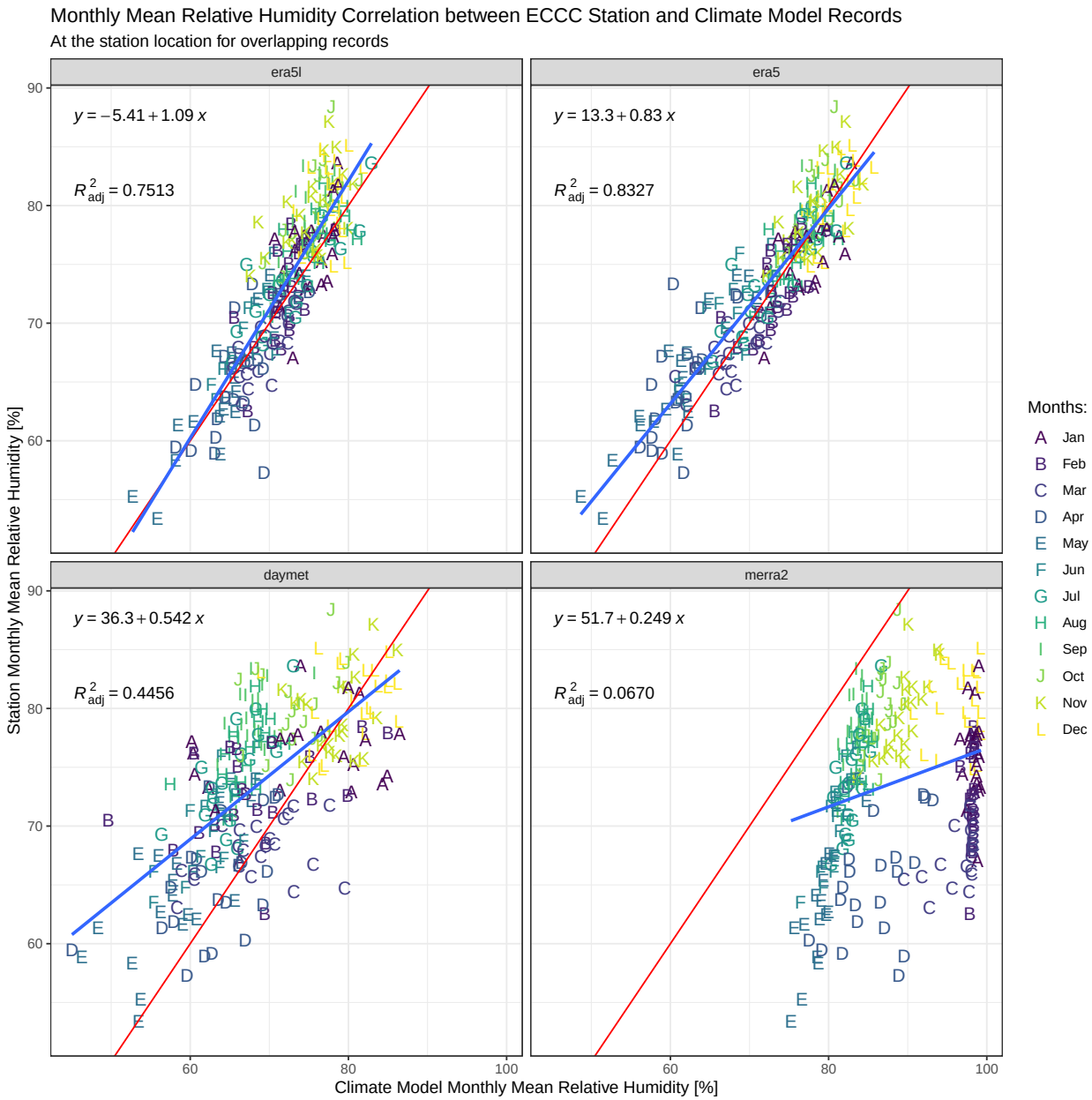
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	75	73.5	70.7	66.1	64.7	68.9	71.7	73.3	73.8	74.2	74.5	76.5	71.9
era5	75.6	73.2	68.4	62.3	61.8	68.1	71.9	74.2	76.1	75.6	76.2	78.7	71.8
daymet	79.4	75.3	76.9	71.7	68	70.7	72	72.6	72.9	76.5	80.9	82.9	75
merra2	95.1	94.2	90.2	81.5	78.6	79.8	80.6	80.4	80.3	83	86.7	93.2	85.3
station	76.1	74.3	70.4	65.7	66.6	73.2	76.5	78.3	78.8	76.9	76.8	79.4	74.4



7.3.1.12 RH Monthly Correlations for LA TUQUE

Table 7.22: Monthly Summary of Reanalysis Data matching Observed Data at LA TUQUE

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
era5l	75.4	72	69.5	66.1	64.3	68.6	73.3	75.2	75.1	75.8	75.3	77.9	72.4
era5	77.4	73.3	68.2	61.9	60.4	67.5	73.4	76.2	77.7	78.1	78.2	80.9	72.8
daymet	73.9	68	68.4	63.1	58.1	62.8	65.4	66.9	67.9	73.1	78.5	80.7	68.9
merra2	98.4	98.2	96.7	85.7	79.5	80.8	83	83.9	83.6	86.6	89.4	96.7	88.5
station	76.1	72.5	67.8	65.1	64.4	69.8	74	76.4	79.1	79.8	79.4	80.6	73.7



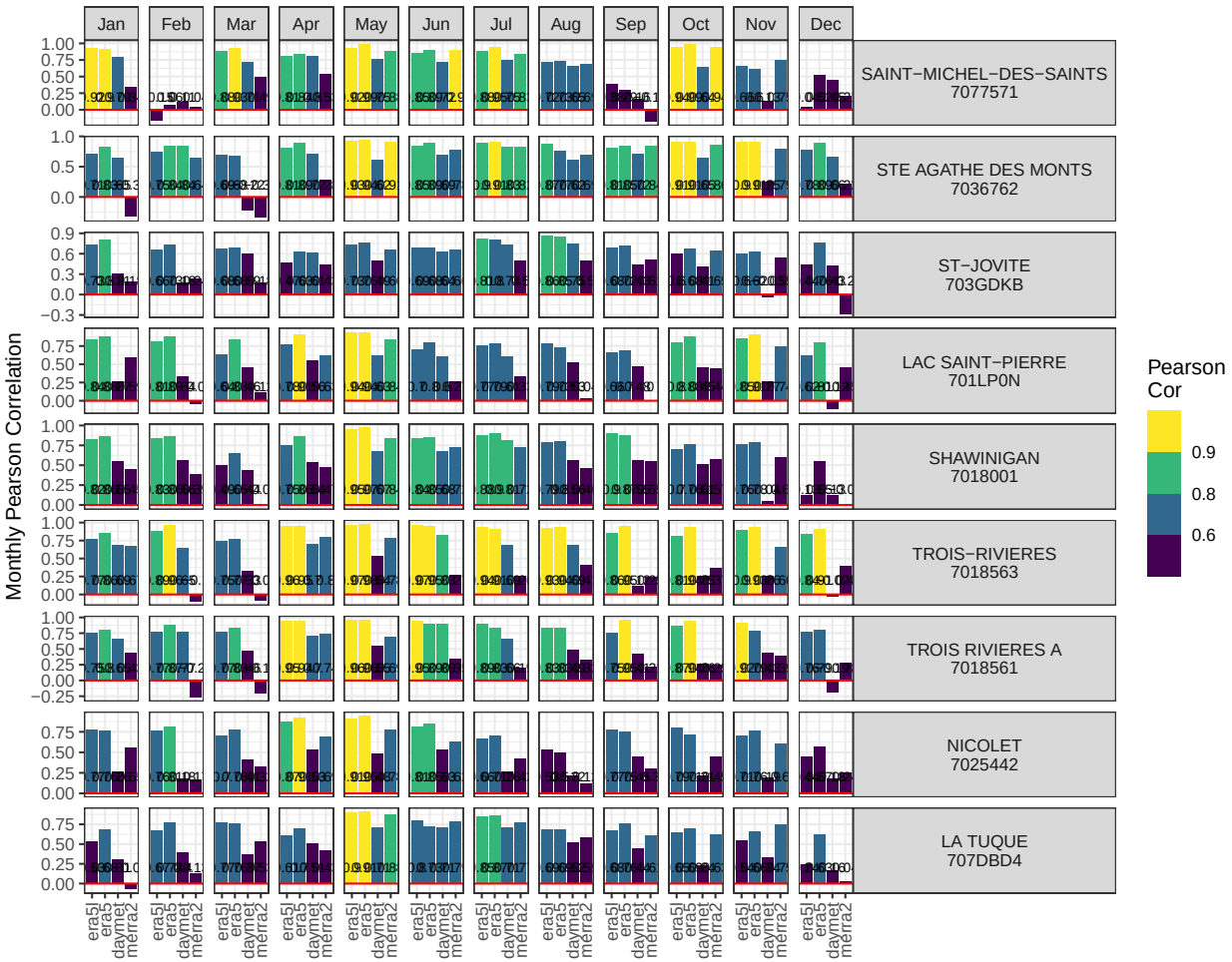
7.3.2 Monthly Pearson Correlation Coefficient for RH

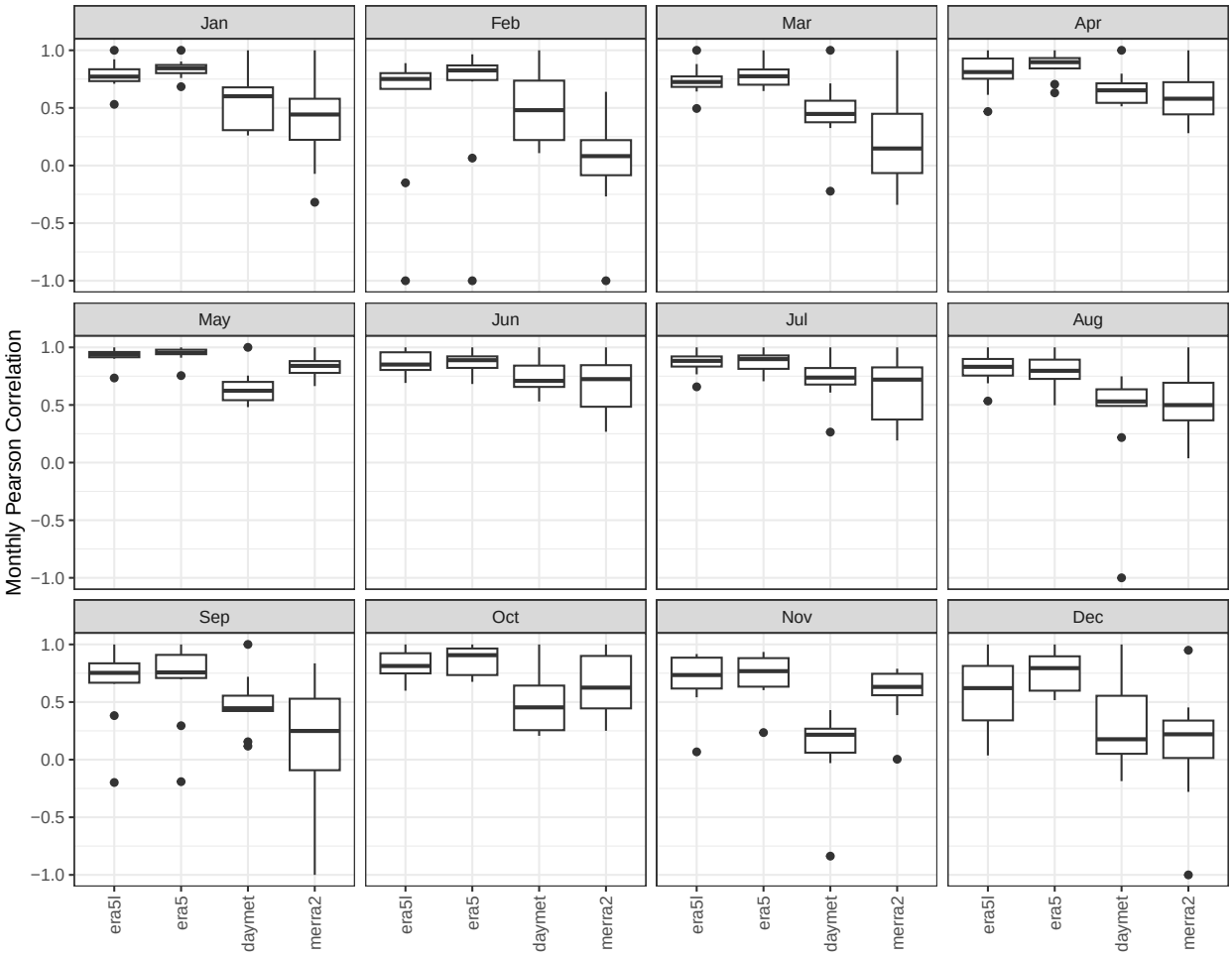
The Pearson correlation coefficient (PCC) is a correlation coefficient that measures linear correlation (and linear only) between two sets of data. It represents a normalized measurement of the covariance,

such that the result always has a value between −1 and 1. A value of 0 represents no linear correlation between both datasets. A value of 1 represents perfect positive linear correlation, and a value of -1 perfect negative linear correlation.

Monthly data reviewed in the previous section is summarized in the following figures that represent PCC monhtly for ECCC stations versus climate models comparisons.

ERA5 generally presents the best Pearson correlations with station data, closely followed by ERA5-Land.




Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Monthly Pearson Correlation
1.0
0.5
0.0
−0.5
−1.0
era5l
era5
daymet
merra2

Chapter 8

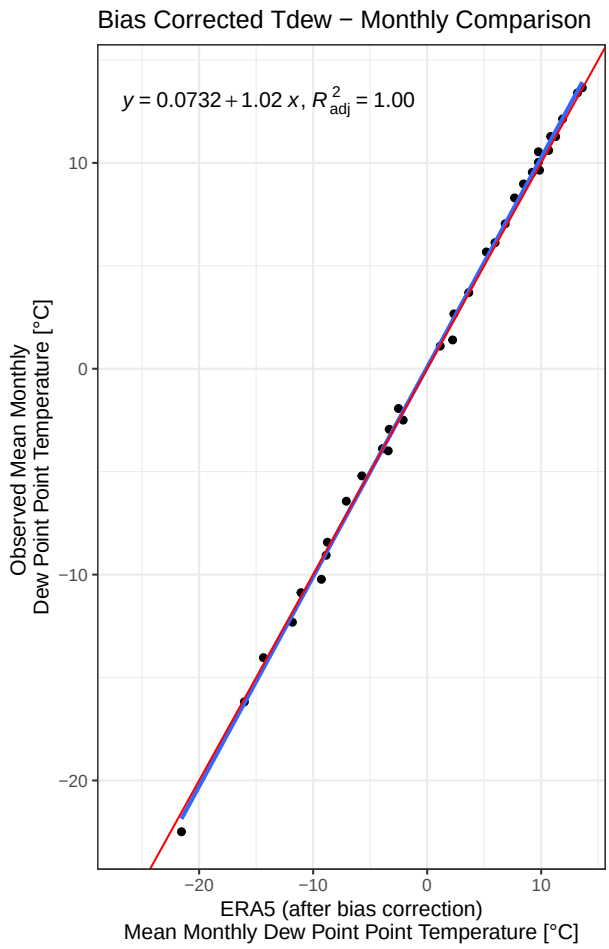
Site Timeseries Selection and Results

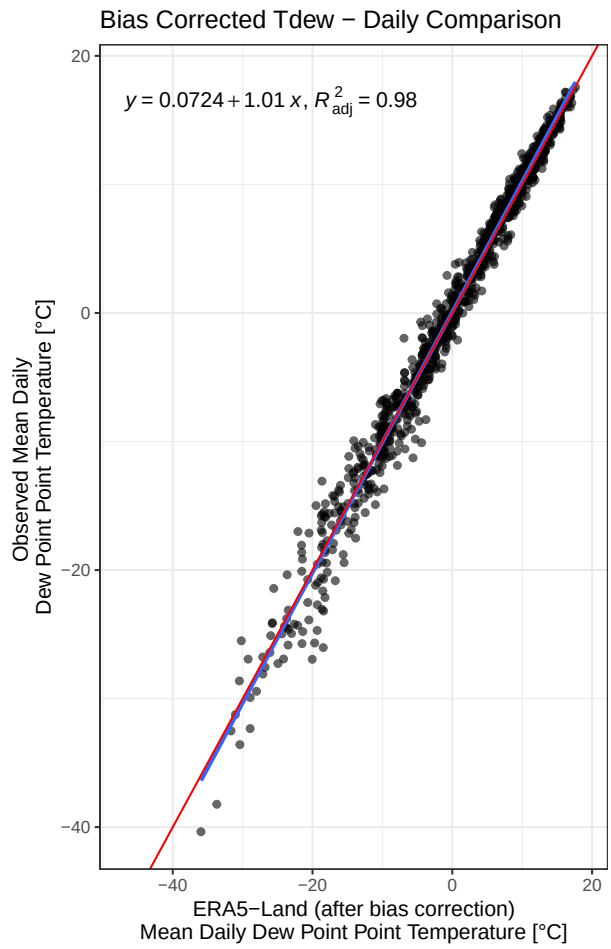
Based on the previous analysis, ERA5 is the dataset most likely to be the most representative of dew point temperature and relative humidity on site for the analysis period.

8.1 Dew Point Temperature

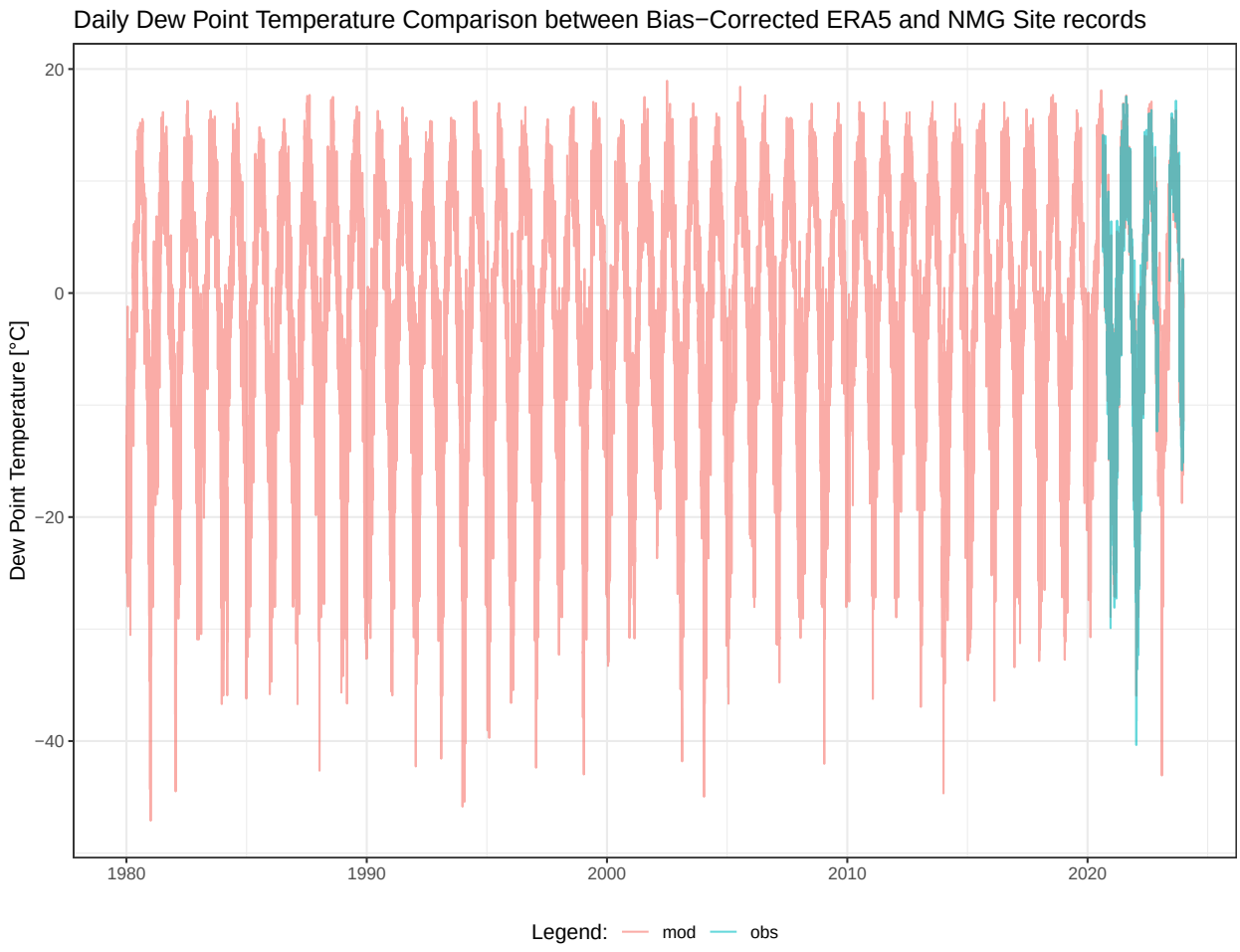
Slight correlation offsets can be observed in **Section 7.2** between dew point temperature for Site and ERA5 data, particularly in summer months. The Project dew point temperature timeseries was generated by bias correcting ERA5 records to Site timeseries by using the Quantile Delta Mapping (QDM) method. QDM bias correction is an algorithm commonly used to correct systematic distributional biases in outputs from climate models. The purpose is that the distributional properties would more closely match those of historical observations.

Bias correction results are compared to site data in the following figure, and show improved correlation compared to non bias-corrected data (see **Section 7.2.1.2**).



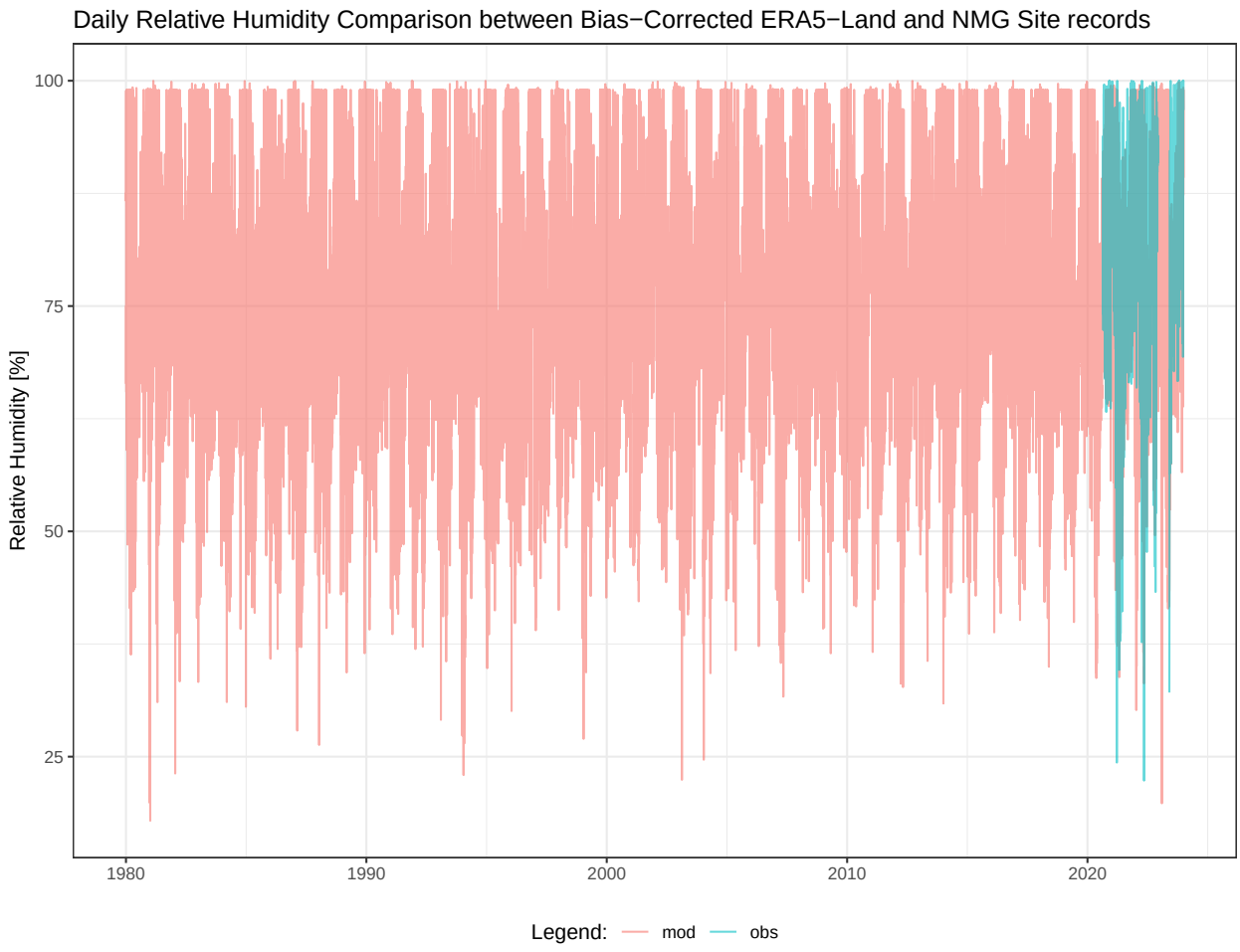


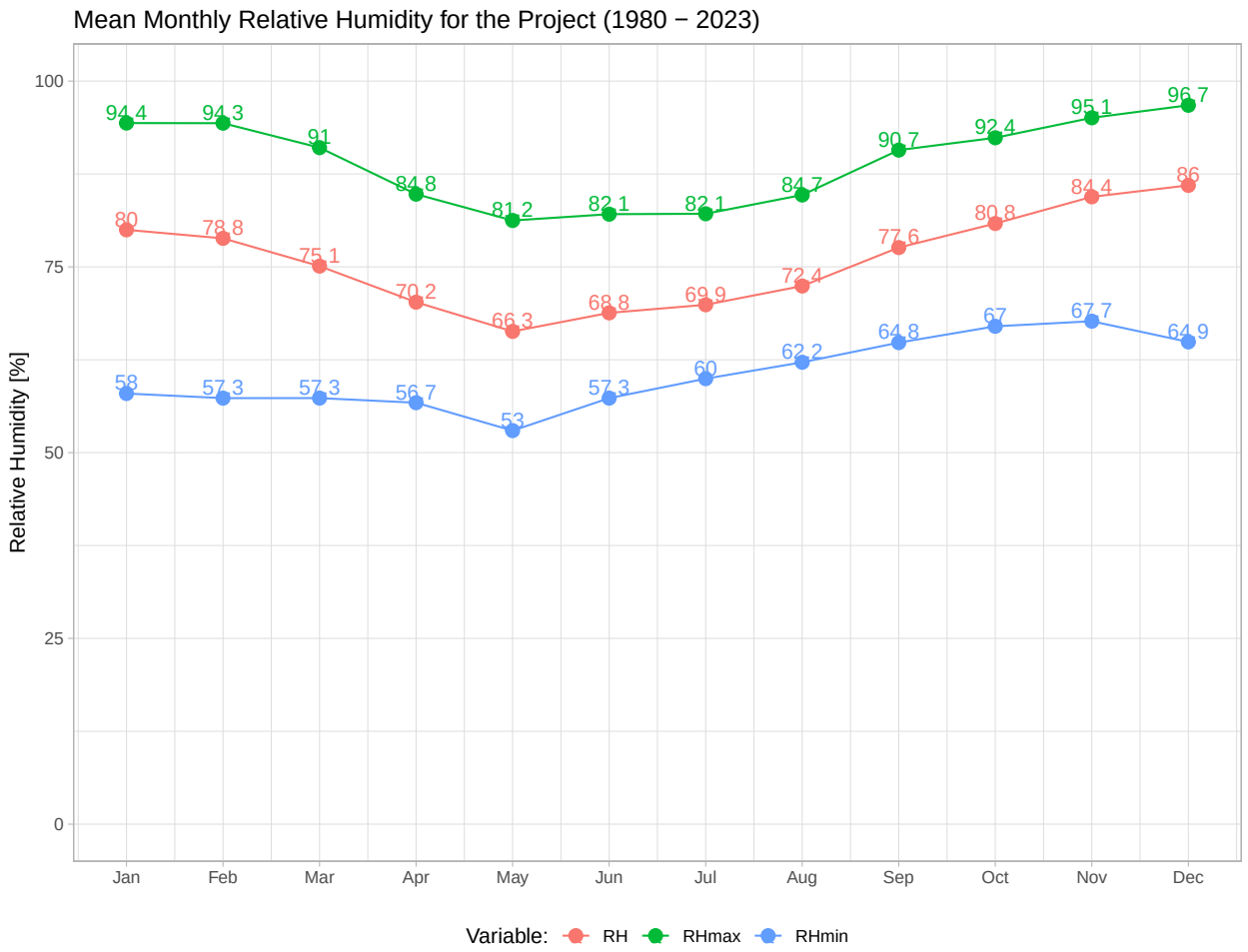
Dew point temperature final timeseries and normals for the Matawinie Project are represented in the following two figures respectively. Maximum and Minimum dew point temperatures were also estimated based on ERA5 hourly data.


Daily Dew Point Temperature Comparison between Bias−Corrected ERA5 and NMG Site records
Dew Point Temperature [°C]
20
0
−20
−40
1980
1990
2000
2010
2020
Legend:
mod
obs

8.2 Relative Humidity

The project timeseries for relative humidity was calculated from the project dew point temperature and mean temperature as detailed in **Section 4**. Relative humidity final timeseries and normals for the Matawinie Project are represented in the following two figures respectively.


Daily Relative Humidity Comparison between Bias−Corrected ERA5−Land and NMG Site records
Relative Humidity [%]
100
75
50
25
1980
1990
2000
2010
2020
Legend:
mod
obs


Mean Monthly Relative Humidity for the Project (1980 − 2023)
Relative Humidity [%]
100
75
50
25
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
94.4
94.3
91
84.8
81.2
82.1
82.1
84.7
90.7
92.4
95.1
96.7
80
78.8
75.1
70.2
66.3
68.8
69.9
72.4
77.6
80.8
84.4
86
58
57.3
57.3
56.7
53
57.3
60
62.2
64.8
67
67.7
64.9
Variable:
RH
RHmax
RHmin

Chapter 9

Outputs

Output of this code has been backed up and saved as an rds file in the **/01_Data/rds** project folder.

References

Alduchov, Oleg A., and Robert E. Eskridge. 1996. "Improved Magnus Form Approximation of Saturation Vapor Pressure." *Journal of Applied Meteorology* 35 (4): 601–9. https://doi.org/10.1175/1520-0450(1996)035%3C0601:imfaos%3E2.0.co;2.

Gelaro, Ronald, Will McCarty, Max J. Suárez, Ricardo Todling, Andrea Molod, Lawrence Takacs, Cynthia A. Randles, et al. 2017. "The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2)." *Journal of Climate* 30 (14): 5419–54. https://doi.org/10.1175/jcli-d-16-0758.1.

Hersbach, Hans, Bill Bell, Paul Berrisford, Shoji Hirahara, András Horányi, Joaquín Muñoz-Sabater, Julien Nicolas, et al. 2020. "The ERA5 Global Reanalysis." *Quarterly Journal of the Royal Meteorological Society* 146 (730): 1999–2049. https://doi.org/10.1002/qj.3803.

Magnus, Gustav. 1844. "Versuche Über Die Spannkräfte Des Wasserdampfs." *Annalen Der Physik* 137 (2): 225–47. https://doi.org/10.1002/andp.18441370202.

Muñoz-Sabater, Joaquín, Emanuel Dutra, Anna Agustí-Panareda, Clément Albergel, Gabriele Arduini, Gianpaolo Balsamo, Souhail Boussetta, et al. 2021. "ERA5-Land: A State-of-the-Art Global Reanalysis Dataset for Land Applications." *Earth System Science Data* 13 (9): 4349–83. https://doi.org/10.5194/essd-13-4349-2021.

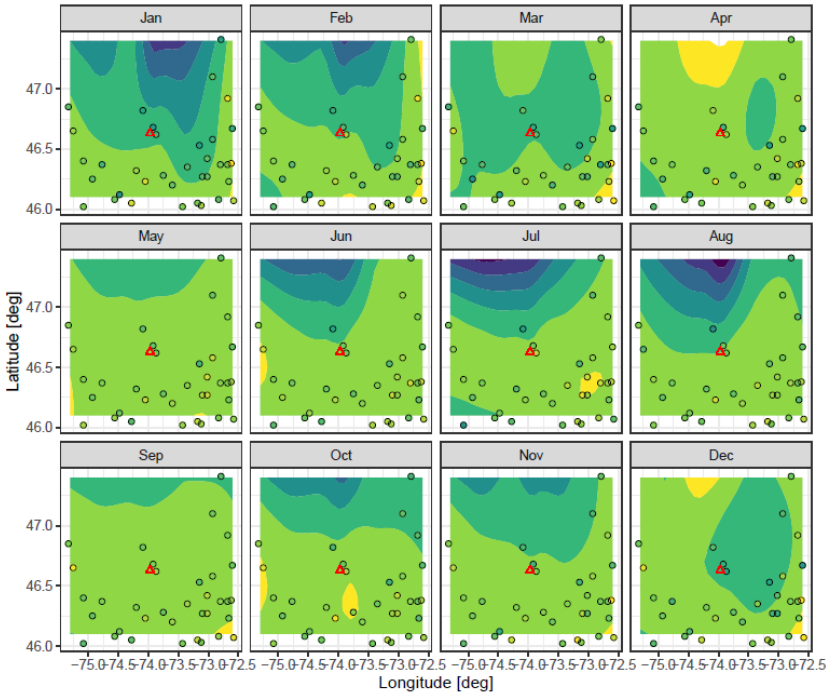
Thornton, M. M., R. Shrestha, Y. Wei, P. E. Thornton, and S-C. Kao. 2022. "Daymet: Daily Surface Weather Data on a 1-Km Grid for North America, Version 4 R1," November. https://doi.org/10.3334/ORNLDAAC/2129.

FINAL

Baseline Climate Analysis

Matawinie, Quebec, Canada

Nouveau Monde Graphite



SRK Consulting (Canada) Inc. ▪ CAPR003306 ▪ April 8, 2025

srk consulting

FINAL

Matawinie Meteorological Baseline

Matawinie, Quebec, Canada

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Useful Definitions

This list contains definitions of symbols, units, abbreviations, and terminology that may be unfamiliar to the reader.

AMS	Annual Maximum Series.
Daymet	Reanalysis tool developed by the Oak Ridge National Laboratory and supported by NASA.
ECCC	Environment and Climate Change Canada.
ERA5	Reanalysis tool developed by the European Centre for Medium-Range Weather Forecasts.
ERA5-Land	Reanalysis tool based on ERA5 but for Land surfaces and a smaller grid and developed by the European Centre for Medium-Range Weather Forecasts.
ET	Evapotranspiration
ET_0	Reference Evapotranspiration
IDF	Intensity-Duration-Frequency (IDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
KST	Kolmogorov–Smirnov Test.
MAAT	Mean Annual Air Temperature.
MAP	Mean Annual Precipitation.
MERRA2	Modern-Era Retrospective analysis from Research and Applications, Version 2, is a global climate reanalysis model from the U.S. National Aeronautics and Space Administration.
NMG	Nouveau Monde Graphite.
PCC	Pearson Correlation Coefficient.
PDF	Precipitation-Duration-Frequency (PDF) curves and tables are tools that describe the likelihood of a range of extreme rainfall events.
PMP	Probable Maximum Precipitation.
RH	Relative Humidity.
SRAD	Shortwave (solar) radiation. Incident shortwave radiation flux density in watts per square meter.
SRK	SRK Consulting (Canada) Inc.
SSR	Surface net shortwave (solar) radiation. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth (both direct and diffuse) minus the amount reflected by the Earth's surface (which is governed by the albedo).
SSRD	Surface short-wave (solar) radiation downwards. This parameter is the amount of solar radiation (also known as shortwave radiation) that reaches a horizontal plane at the surface of the Earth. This parameter comprises both direct and diffuse solar radiation.
Tavg	Mean or Average Air Temperature over a given temporal unit (day, month, year...).
Tdew	Mean or Average Dew Point Temperature over a given temporal unit (day, month, year...).
Tmax	Maximum Air Temperature over a given temporal unit (day, month, year...).
Tmin	Minimum Air Temperature over a given temporal unit (day, month, year...).

Executive Summary

This report documents the historical meteorological data analysis, and the climatic baseline prepared by SRK for the Matawinie Site. This report sets the foundation for the climate change analysis by defining an historical baseline for the project and provides climatic inputs for the surface water management, overburden stockpile and co-disposal facility engineering design projects.

The investigation reviewed site climate records complemented with data from regional stations and gridded models of historical climate, also called climate reanalysis. The objectives of the analysis were to generate long-term, gapless timeseries for the climatic parameters of interest for the project to characterise its past climate and define the meteorological baseline.

For each climatic parameter of interest, SRK generated correlation matrices, applied statistical methods, and performed qualitative analyses to identify and select the most reliable source, or sources, to be used for patching and extending the site time series. The selected data was bias corrected using different methods to better represent site climate.

This report describes the scientific methods that were applied and summarises the extended synthetic records that were obtained in the form of mean monthly and mean annual values. The baseline period was defined from 1994 to 2023, to represent the latest available 30-year interval recommended by (WMO, 2017) to establish climate normals. Moreover, SRK developed an Intensity-Duration-Frequency (IDF) curve for the site and estimated the Probable Maximum Precipitation (PMP).

1 Introduction

Nouveau Monde Graphite Inc. (NMG) (the Client) asked SRK Consulting (Canada) Inc. (SRK) to support their engineering design, water management strategy and water balance for the Matawinie Mine (the Site) as a part of the Surface Water Management, Overburden Stockpile and Co-disposal Facility Engineering project initiated in 2023. As a part of its preliminary works, SRK performed a review of the existing hydrology analysis for the Site with a focus on orographic effects (SRK, 2023). As a part of this study, SRK recommended the development of a site-specific climatical and hydrological study for the Matawinie Site to update existing data and fill data gaps for the ongoing and future engineering projects.

In 2024, SRK completed a thorough review of the local and regional climate around the Site and defined baseline conditions for the project. The data compilation and subsequent analysis was conducted in the R Software environment.

The present report describes available data considered during the analysis. It then outlines the main scientific methods applied to study climatic data and develop long term daily timeseries representative of the Site. Finally, summaries of the main results of this investigation are presented to characterize baseline climatic conditions at the Matawinie site for multiple climatic parameters.

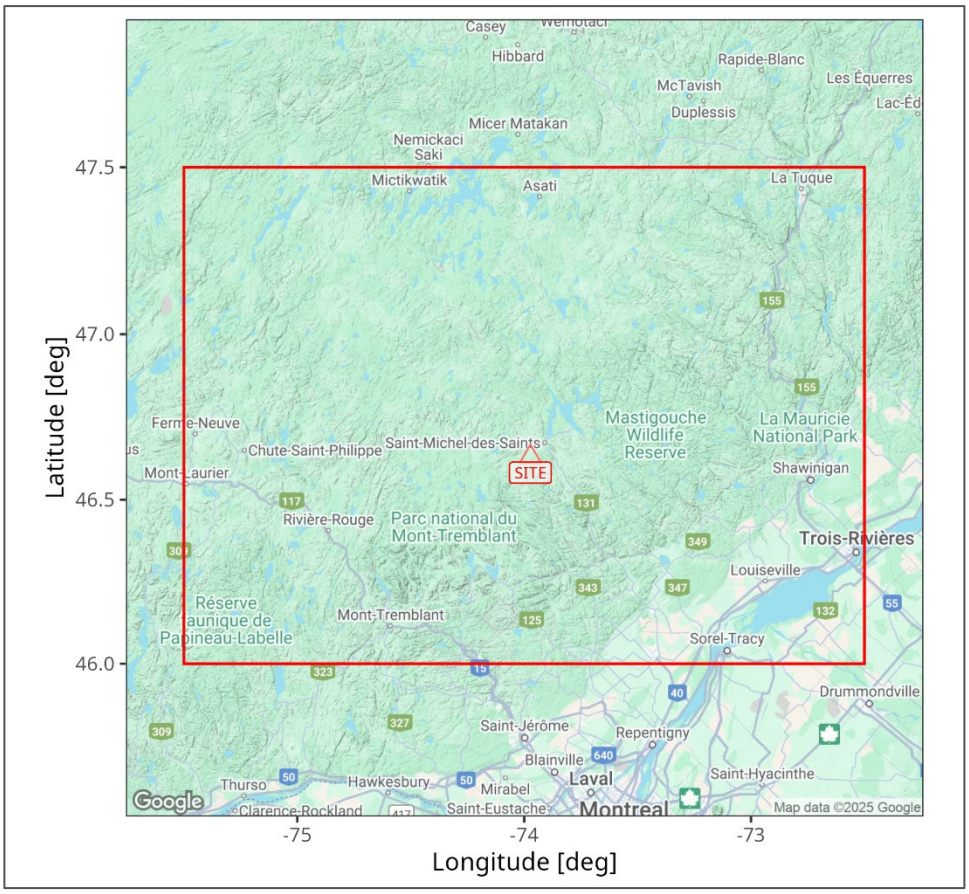
2 Project Area

The NMG Matawinie site is located in southern Quebec, 125 km north of Montreal. Site latitude is 46.63 degrees, and longitude is -73.97 degrees, and covers elevations ranging from 480 masl to 580 masl. For the purpose of this meteorological analysis, an area of interest was defined around site to capture regional data and climate trends, and was defined as the region between:

- 46° and 47.5° Latitude
- -75.5° and -72.5° Longitude

This area of interest covers a distance of up to 125 km from site and is represented in **Figure 2-1** below.

Figure 2-1: Site Location and Area of Interest



Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/01_Temperature_v04.pdf

3 Available Meteorological Data

3.1 Project Data

Site data is collected by NMG from two meteorological stations. The first station is located on Site at an elevation of 562 masl, and the second station, called SoftdB, is located 1.5 km north at the following address: 200 Chemin des Hauteurs, Saint-Michel-des-Saints. NMG stations locations are compiled in **Table 3-1** below.

Table 3-1: Summary of NMG meteorological stations

Station Name	Latitude (°)	Longitude (°)	Elevation (masl)	Period of Record	Parameters
NMG Site	46.63	-73.97	562	2020-Present	T, RH, WS, WD, Pp, SR
NMG SoftdB	46.65	-73.96	471	2022-Present	T, P, RH, WS, WD, Pp

Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/01_Temperature_v04.pdf

Notes: T=air temperature, P = atmospheric pressure, RH = relative humidity, WS = wind speed, WD = wind direction, Pp = precipitation, EV = evaporation, SR = solar radiation

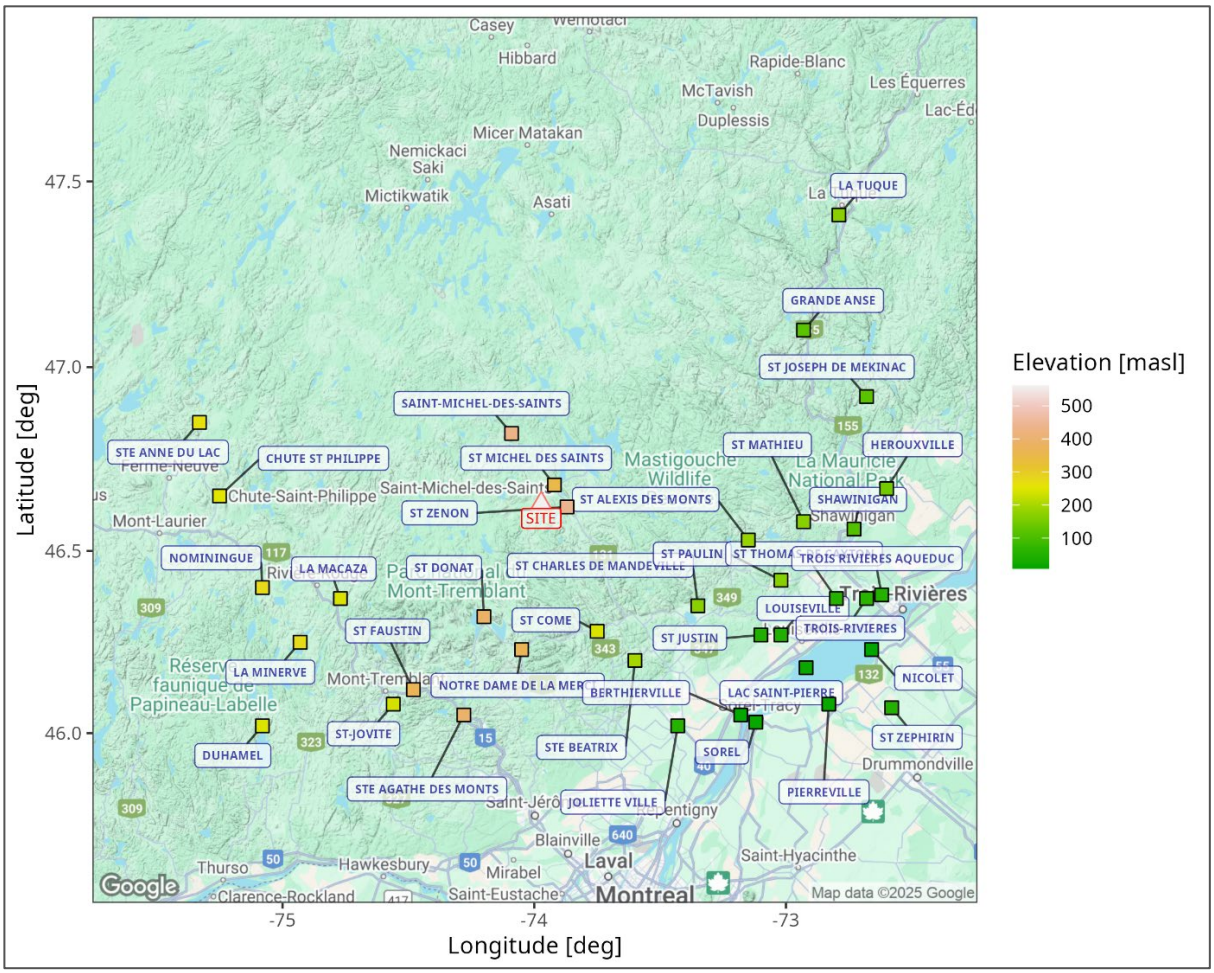
For the purpose of this study, the Site location was assimilated to the location of its meteorological station.

3.2 Regional ECCC Data

Regional meteorological data for Quebec is available from private as well as provincial and federal government sources. Within the area of interest of this project, there are over 40 regional meteorological stations monitored by the Meteorological Service of Canada (MSC). This division of Environment and Climate Change Canada provides public historical meteorological data and information.

Figure 3-1 illustrates the locations of selected regional meteorological stations with respect to the Project. **Table 3-2** presents the metadata for these regional stations.

Figure 3-1: Site and ECCC Stations Location and Elevation [masl]



Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/01_Temperature_v04.pdf

Notes: Elevations based on SRTM data

Table 3-2: ECCC Regional Meteorological Stations Description

Station Name	Latitude [°]	Longitude [°]	Elevation [masl]	Distance to Site [km]
ST MICHEL DES SAINTS	46.68	-73.92	350.5	7
ST ZENON	46.62	-73.87	442	8
SAINT-MICHEL-DES-SAINTS	46.82	-74.09	429.9	23
ST DONAT	46.32	-74.2	388.6	39
ST COME	46.28	-73.75	244	42
NOTRE DAME DE LA MERCI	46.23	-74.05	365.8	45
STE BEATRIX	46.2	-73.6	198	56

Station Name	Latitude [°]	Longitude [°]	Elevation [masl]	Distance to Site [km]
ST CHARLES DE MANDEVILLE	46.35	-73.35	168	57
ST ALEXIS DES MONTS	46.53	-73.15	183	64
LA MACAZA	46.37	-74.77	244	68
STE AGATHE DES MONTS	46.05	-74.28	395	69
ST FAUSTIN	46.12	-74.48	366	69
ST-JOVITE	46.08	-74.56	239	76
ST PAULIN	46.42	-73.02	167	76
ST JUSTIN	46.27	-73.1	46	78
JOLIETTE VILLE	46.02	-73.43	56	80
ST MATHIEU	46.58	-72.93	168	80
LOUISEVILLE	46.27	-73.02	45	83
LA MINERVE	46.25	-74.93	274	85
NOMININGUE	46.4	-75.08	274	89
BERTHIERVILLE	46.05	-73.18	12	89
SOREL	46.03	-73.12	15	93
ST THOMAS DE CAXTON	46.37	-72.8	53	94
LAC SAINT-PIERRE	46.18	-72.92	16	95
GRANDE ANSE	47.1	-72.93	119	95
SHAWINIGAN	46.56	-72.73	110	95
CHUTE ST PHILIPPE	46.65	-75.25	252	98
TROIS-RIVIERES	46.37	-72.68	62	103
ST JOSEPH DE MEKINAC	46.92	-72.68	122	104
TROIS RIVIERES A	46.35	-72.68	61	104
HEROUXVILLE	46.67	-72.6	145	105
STE ANNE DU LAC	46.85	-75.33	262	106
PIERREVILLE	46.08	-72.83	15	107
TROIS RIVIERES AQUEDUC	46.38	-72.62	55	107
DUHAMEL	46.02	-75.08	244	109
NICOLET	46.23	-72.66	8	110
TROIS-RIVIERES	46.35	-72.52	6	115
ST ZEPHIRIN	46.07	-72.58	52	124
LA TUQUE S	47.4	-72.78	168	125
LA TUQUE	47.41	-72.79	169	125

Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/01_Temperature_v04.pdf

3.3 Reanalysis Meteorological Datasets

Datasets from climatic gridded models are generated by scientific methods that develop comprehensive records of historical weather and climate. A collection of algorithms is used to interpolate and extrapolate from actual observations to generate gridded estimates of meteorological parameters. This combination of observations and numerical or statistical modelling based on Earth system characteristics is used to generate a synthetic data series over instrumented and un-instrumented regions. These models are also known as climate reanalysis. Climate reanalysis products typically extend historically over several decades or longer and can cover the entire globe from the Earth's surface to well above the stratosphere.

The datasets from the following models were evaluated in this analysis:

- Daymet is a reanalysis tool developed by the Oak Ridge National Laboratory and supported by NASA, Daymet provides long-term, continuous, gridded estimates of daily weather and climatology in North America (Thornton et al. 2022) including variables such as daily maximum and minimum temperatures, precipitation, and shortwave radiation. Daymet uses a set of spatial interpolation algorithms to estimate weather and climate patterns at a 1 km spatial resolution.
- ERA-5 is the fifth-generation atmospheric reanalysis of the global climate published by the European Centre for Medium-Range Weather Forecasts (Hersbach, 2020). ERA-5 includes sub-daily data from 1979 to present (2024) for the world, based on a 0.25° resolution.
- ERA-5 Land is a replay of the land component of the ERA5 climate reanalysis, forced by meteorological fields from ERA5 (Muñoz-Sabater, 2021). This dataset has been carried out by the ECMWF and includes hourly daily data from 1950 to present (2024) for the world at a 0.1° resolution (9 km).
- MERRA-2 is the second generation of the National Aeronautics and Space Administration's (NASA) atmospheric reanalysis dataset. MERRA-2 provides daily hindcast estimations from 1980 to 2022 for the world at a 0.5° resolution (GMAO, 2015). Hourly data are available from 2001 to 2024.

3.4 Other Datasets

Other datasets that were consulted to complement the analysis include:

- Canadian historical water equivalent of snow cover dataset version 6 (CanSWE6) (Vionnet et al. 2024) for regional snowpack records.
- NASA Shuttle Radar Topography Mission (SRTM) (NASA, 2013) for elevations

4 Analysis Methodology

4.1 General Approach

SRK completed a thorough review of the local and regional climate around the Site to define baseline conditions for the project. The data compilation and subsequent analysis was conducted in the R Software environment. The complete analysis for each parameter is presented in the appendices of this report.

Even though each climatic parameter follows a specific approach, the methodology aimed to cover the following aspects for all parameters:

- Site data review and gaps evaluation,
- Regional data review,
- Reanalysis data comparison to measured data.
- Selection of the most representative datasets (sources) of the Site location climate by comparing available datasets.
- Definition of the Project timeseries by correcting data of the selected source(s),
- Computation of complementary parameters that are derived from the Project timeseries.

The results are presented below with two reporting periods

4.2 Reporting Periods

Two distinct reporting periods are presented in this study:

- 1994 to 2023: This timeframe represents the most recent 30 years-period, that is suitable for establishing up to date climate normals in accordance with the World Meteorological Organization guidelines (WMO, 2017).
- 1985 to 2014: This period aligns with the definition of the historical period within the Global Circulation Models (GCMs) results published by the Intergovernmental Panel on Climate Change (IPCC) on their sixth assessment report (AR6) released in 2021 (IPCC 2021). This period is relevant for the climate change assessment that is part of this project and is detailed in (SRK 2025).

4.3 Specific Methods

The following subsections describe the scientific methods used to generate the synthetic records at Matawinie. They are also described in the appendices when used.

4.3.1 Pearson Correlation

The available datasets are compared between each other, and to site records to evaluate their similarity. The Pearson correlation coefficient is typically denoted using "r" or ρ; it is an evaluation of the collinearity between two variables. The Pearson correlation coefficient represents how well two sets of data correlate to each other relative to a straight line when plotted on a graph. A perfectly increasing linear trend will be associated to r = 1 and a perfectly decreasing linear trend to r = -1.

4.3.2 Correlation Matrices

Correlation matrices are used to simultaneously evaluate the dependence of multiple variables on each other. The results produce a correlation factor, with the Pearson correlation coefficient (r) used as default to provide pairwise information. Depending on the specific methodology, the correlation values range from 0 to 1, or from -1 to 1. High correlation values between a pair of values suggest that one of those variables can be used to represent the other. This methodology helped selecting statistically significant parameters that could be used in the development of empirical methods in the gap-filling and record-extension processes.

4.3.3 Linear Regression

This methodology allows adjustment of the information using a linear slope and interception equation to match observed/local records. This procedure, also called bias correction through linear regression, is typically suitable for gap-filling statistically dependent variables such as temperature related variables.

4.3.4 LOESS Regression

LOESS (Locally Estimated Scatterplot Smoothing) regression is a non-parametric technique used to fit a smooth curve to a set of data points. It is particularly useful for modeling complex relationships without assuming a specific functional form.

4.3.5 Quantile Delta Mapping

Quantile Delta Mapping (QDM) bias correction is an algorithm commonly used to correct systematic distributional biases in outputs from climate models. The algorithm goal is to make the distributional properties of bias corrected, modelled data match those of historical observations more closely (Cannon A. S., 2015).

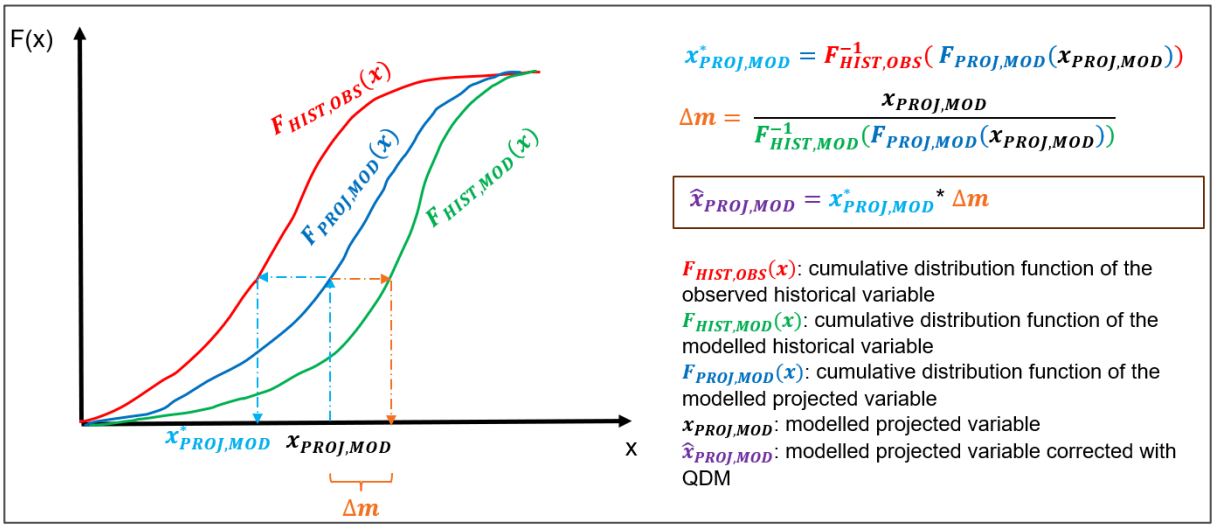
QDM adjusts the empirical cumulative distribution of climatic values by removing the systematic error of raw data. The algorithm combines the following two steps in sequence over the modelled values, as illustrated in **Figure 4-1**:

- A function dependent on the quantile is determined by equating the cumulative distributions of the observed data and the modeled data. This function is then used to adjust the modeled data so that it matches the distribution of the observed data (i.e., obtaining $x^*_{PROJ,MOD}$ from $x_{PROJ,MOD}$).

- The previously obtained value $x^*_{PROJ,MOD}$ is then multiplied by the relative change Δm, which represents the difference between the modeled values and the observed values. This results in the corrected value $\hat{x}_{PROJ,MOD}$ using the QDM method (Cannon A. S., 2015).

This method preserves relative changes in simulated quantiles from climate. QDM multiplies observed values by the ratio of the modelled values (period of interest divided by calibration period) at the same quantiles (Freitas, 2021).

Figure 4-1: Representation of the Quantile Delta Mapping Method



Sources: Representation of quantile delta mapping method (SRK)

4.3.6 Frequency Analysis

Frequency analysis is a process used to estimate the frequency of occurrence of a value based on a long-term time series. The frequencies of occurrence are often depicted by their return periods, that showcase how long it takes, on average, for an event to occur.

The historical information is adjusted into a probabilistic distribution, and the most suitable distribution is selected. In this case, the frequency analysis was prepared considering the following probabilistic distributions: normal, log-normal, generalized extreme value (GEV), Gumbel, Pearson III, and log-Pearson III. The selection of the distribution parameters can be prepared with the L-moments methodology. The L-moments approach is more resistant to the influence of outliers than typical moment estimations (Laio, 2009).

4.3.7 Probable Maximum Precipitation, Statistical Approach

The probable maximum precipitation (PMP) is an estimation of the maximum amount of rainfall that could occur within a specific geographic area over a given duration, typically ranging from a few hours to a few days.

The PMP was estimated by a regional approach of the statistical method (Hershfield Method) (WMO, 2009). The Hershfield method involves estimating the theoretical maximum precipitation for a location and duration based on historical rainfall data. The WMO (2009) methodology also incorporates adjustments for uncertainty related to sample size, scaling up the PMP estimate for smaller datasets.

5 Air Temperature

The complete air temperature analysis for the project is presented in **Appendix A**.

5.1 Air Temperature Analysis Findings

The main findings of the temperature analysis were:

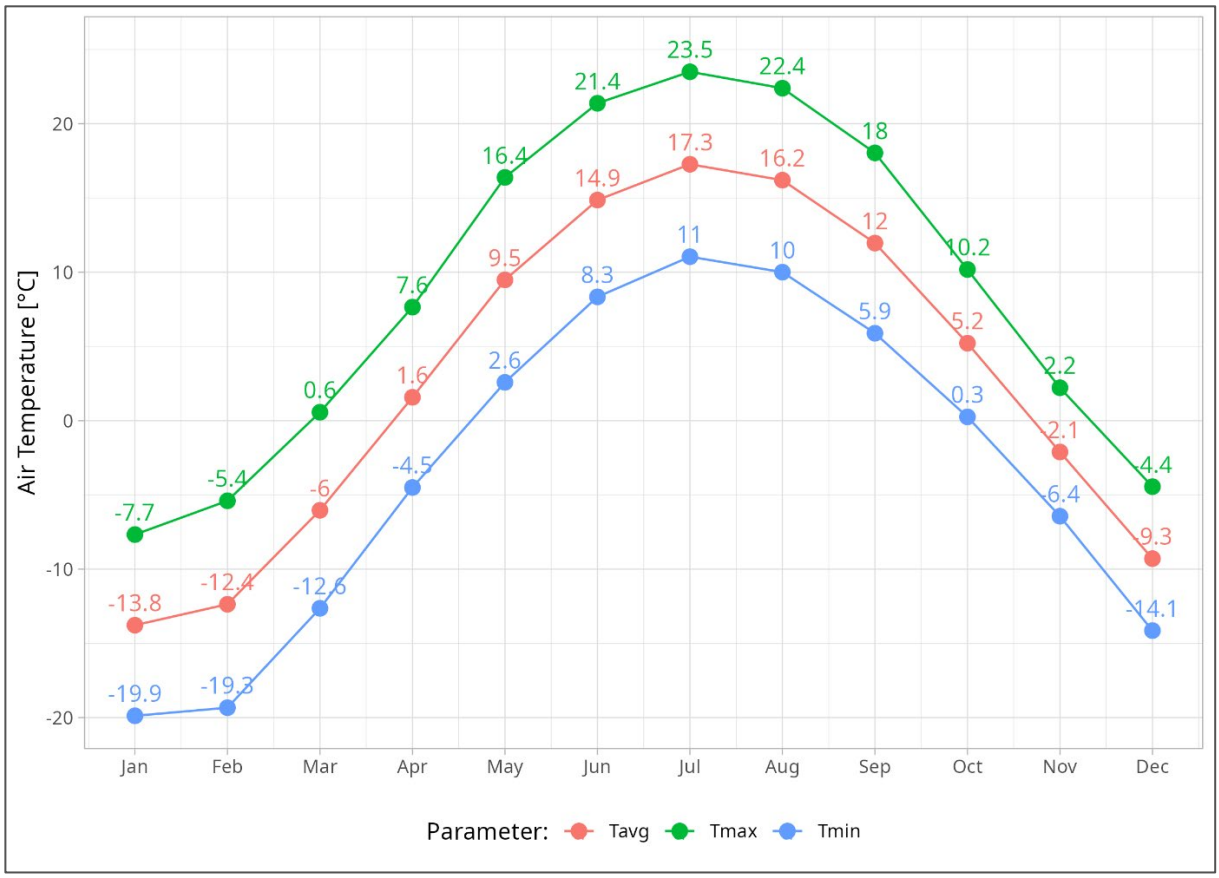
- Most data sources in proximity of site presented excellent temperature correlations between each other (both site, and reanalysis products).
- A temperature gradient was identified in the Project region, and is described in **Appendix A**.
- Daymet was selected as the source dataset for Site temperature without requiring bias correction.
- A statistically significant increasing trend was found for mean annual temperature from the synthetic timeseries for the Project. This suggests climate change adjustments are important to consider for long term projects within the site.

5.2 Air Temperature Analysis Results

Mean monthly and annual values were calculated from the project time series for maximum, mean and minimum air temperature. Mean temperature values are presented monthly in **Figure 5-1** for the 1994-2023 reporting period. Values are presented for each reporting period in **Table 5-1**.

The site displays air temperature variation throughout the year typically ranging between -20°C and 24°C for mean monthly temperature. The coldest months on average are January and February; while the hottest months are, July, and August.

Figure 5-1: Average Air Temperature for the Project by Month (1994-2023)



Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/01_Temperature_v04.pdf

Table 5-1: Project Mean Monthly and Annual Air Temperature [°C]

Period	Air Temp.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1994 – 2023	Max	-7.7	-5.4	0.6	7.7	16.4	21.4	23.5	22.4	18.0	10.2	2.2	-4.5	8.7
	Mean	-13.8	-12.4	-6.0	1.6	9.5	14.9	17.3	16.2	12.0	5.2	-2.1	-9.3	2.8
	Min	-19.9	-19.3	-12.6	-4.5	2.6	8.3	11.0	10.0	5.9	0.3	-6.4	-14.1	-3.2
1985 – 2014	Max	-7.8	-5.5	0.7	8.2	16.4	21.2	23.4	22.2	17.3	9.6	2.1	-5.0	8.6
	Mean	-14.2	-12.7	-6.3	2.0	9.5	14.6	17.0	15.8	11.3	4.7	-2.3	-10.4	2.4
	Min	-20.5	-19.9	-13.2	-4.1	2.6	8.0	10.6	9.5	5.3	-0.2	-6.7	-15.8	-3.7

Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/01_Temperature_v04.pdf

6 Wind

The complete wind analysis for the project is presented in **Appendix B**.

6.1 Wind Analysis Findings

The main findings of the wind analysis were:

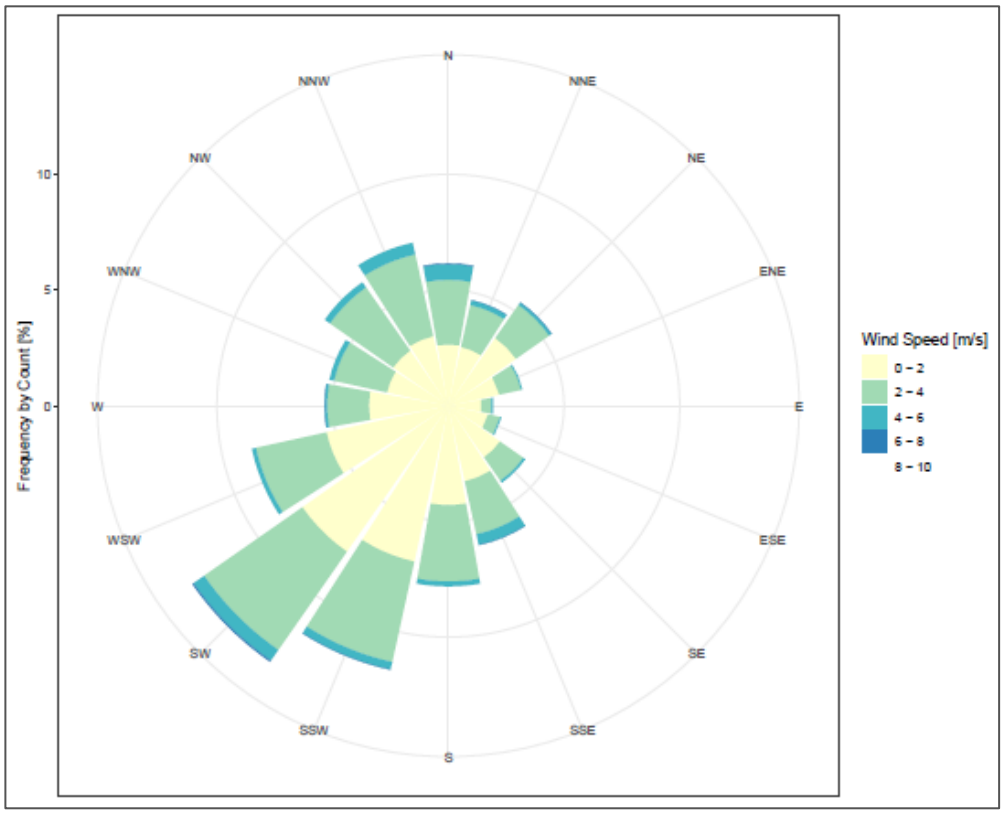
- None of the data sources provides wind direction patterns that are consistent with site data. The NMG Site station wind rose was selected as the reference for the project.
- For wind speed, the ERA5-Land dataset was the most representative of Site and was selected as the source dataset for Project wind speed. The dataset was corrected to site data with the quantile delta mapping method, and was offset by four hours to improve the correlation.

6.2 Wind Analysis Results

6.2.1 Wind Direction

Winds at the Project are predominantly from the southwest (i.e., travelling in the valley direction). **Figure 6-1** illustrates the wind rose representing wind speed data for the NMG Site Station.

Figure 6-1: Project Wind Rose (based on NMG Site Station data)



Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/02_Wind_v05.pdf

Notes: Wind direction count (%) is represented per origin (not direction)

6.2.2 Wind Speed

Wind speeds at the Project are generally low (less than 4 m/s). Mean monthly and annual values were calculated from the synthetic time series. Wind speed values are presented for each reporting period in **Table 6-1**.

Table 6-1: Mean Monthly and Annual Wind Speed at the Site [m/s].

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1994 – 2023	1.5	1.6	1.7	1.7	1.6	1.4	1.3	1.2	1.4	1.6	1.6	1.5	1.5
1985 – 2014	1.5	1.5	1.6	1.7	1.6	1.4	1.3	1.2	1.5	1.6	1.6	1.5	1.5

Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/02_Wind_v05.pdf

6.2.3 Wind Speed Frequency Analysis

A frequency analysis was completed on maximum hourly wind speed from the Project wind speed timeseries. The Gumbel distribution was selected to fit the hourly extended records. Results from the frequency analysis are presented in **Table 6-2**. The full 1980-2023 records were used for the frequency analysis.

Table 6-2: Project Wind Speed Frequency Analysis Results [m/s]

Return Period [years]	Sustained Mean Wind Speed (1hour) [m/s]
2	6.6
2.3	6.6
5	6.9
10	7.1
20	7.3
25	7.4
50	7.5
100	7.7
200	7.9
500	8.1
1000	8.3

Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/02_Wind_v05.pdf

7 Precipitation

The precipitation analysis for the project is presented in **Appendix C** (precipitation analysis), **Appendix D** (snow cover review), and **Appendix E** (storm event analysis).

7.1 Precipitation Analysis Findings

The main findings of the precipitation analysis were:

- Based on regional analysis, Daymet is the most reliable reanalysis source for precipitation near the project location, and accurately captures orographic effects in the region.
- Overprediction bias was generally observed when comparing Daymet to observed data (both at site and at ECCC stations), even after bias correction by quantile delta mapping. This was consistent with snowpack modelling completed as verification (see **Appendix D**).
- Daymet precipitation overprediction bias appeared to be more significant for snowfall than rainfall. Monthly correction factors were developed to adjust the Daymet dataset and provide a more likely representation of precipitation at Site.
- Best fit coefficients for Daymet to measured precipitation transformations on a monthly basis were mapped using the loess regression. The Project timeseries was generated by applying these monthly coefficients to Daymet data bias-corrected to site. These results aligned well with the findings from previous SRK work (SRK 2023).

The main findings of the storm event analysis were:

- Reanalysis products tend to miss or underpredict the larger precipitation events on record within the area of interest, so the framework of regional frequency analysis with L-moments proposed by Hosking & Wallis (Hosking and Wallis 1997) was followed to determine daily storm depths.
- For the Intensity-Duration-Frequency curves generation, short duration storm coefficients were picked from the results published by ECCC for the Saint-Michel-des-Saints station. A site-specific analysis was also completed, but the obtained coefficients were less conservative and had a lower temporal resolution therefore were not selected.

7.2 Precipitation Analysis Results

7.2.1 Precipitation Normals

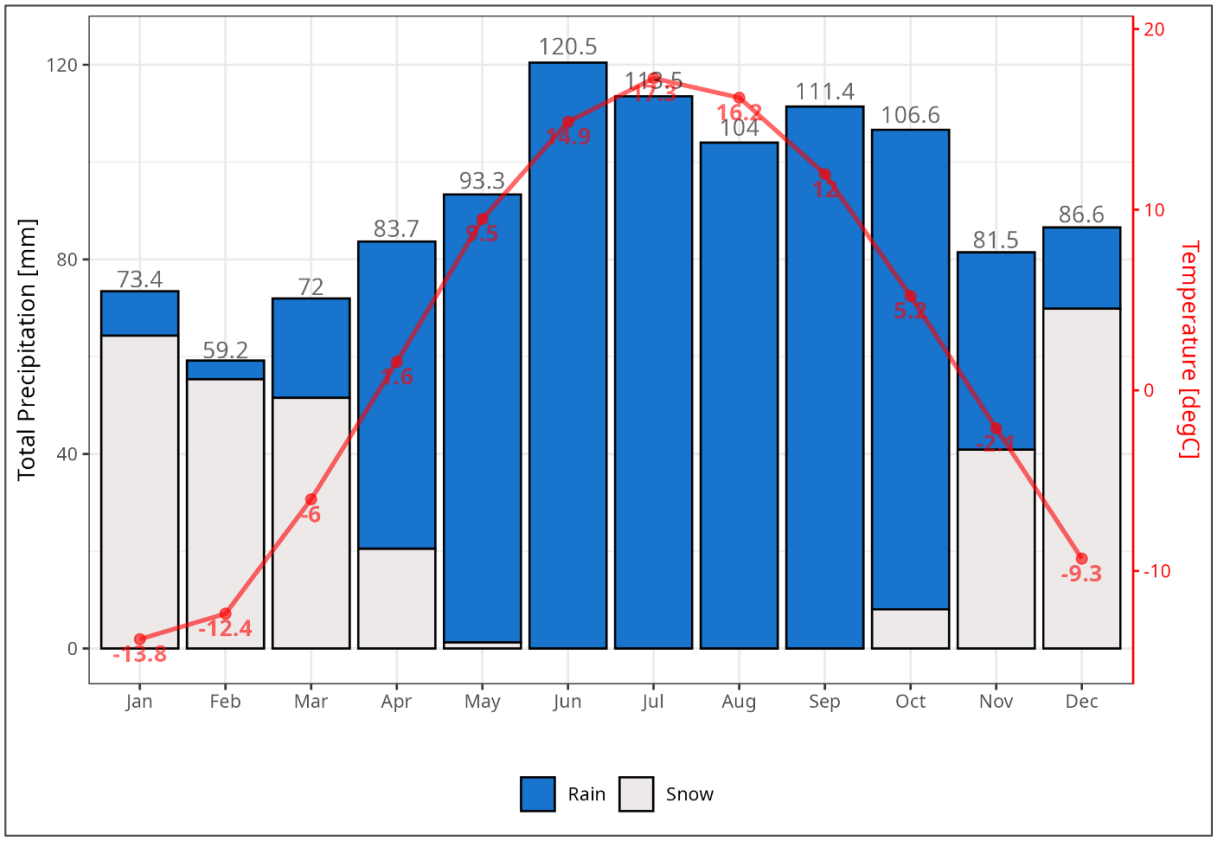
Mean monthly and annual values of precipitation were calculated from the project time series. Snowfall and rainfall were estimated with the daily average temperature (snow when $T_{avg} \leq 0$, rain otherwise). Monthly and annual precipitation values are presented for each reporting period in **Table 7-1**, and the project climatogram for the 1994-2023 period is presented in **Figure 7-1**.

Table 7-1: Project Mean Monthly and Annual Precipitation [mm]

Period	Par.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1994 – 2023	Precip.	73	59	72	84	93	121	114	104	111	107	82	87	1106
	Rain	9	4	20	63	92	121	114	104	111	99	41	17	794
	Snow	64	55	52	21	1	0	0	0	0	8	41	70	312
1985 – 2014	Precip.	73	53	66	75	94	116	113	103	114	101	84	78	1069
	Rain	9	3	18	57	93	116	113	103	114	94	42	11	772
	Snow	64	50	48	18	1	0	0	0	0	7	42	67	298

Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/03_Precipitation_v07.pdf

Figure 7-1: Climatogram for the Matawinie Project for the 1994-2023 Period



Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/03_Precipitation_v07.pdf

7.2.2 Annual Precipitation Frequency Analysis

An incremental frequency analysis was completed on monthly precipitation from the Project precipitation timeseries. The **Table 7-2** presents return periods and corresponding monthly and annual precipitation values for the Project.

Table 7-2: Project Monthly and Annual Precipitation Frequency Analysis Results [mm]

Return Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
10000 Wet	40	104	156	99	153	259	54	76	205	110	79	109	1444
2000 Wet	48	100	145	102	148	235	69	87	186	115	80	106	1421
1000 Wet	52	99	139	103	146	223	76	92	177	117	80	104	1408
500 Wet	56	97	132	105	143	211	83	98	168	119	81	102	1393
200 Wet	61	93	123	106	139	193	93	105	154	121	81	99	1368
100 Wet	65	90	115	106	135	179	100	110	144	122	82	97	1345
50 Wet	69	87	107	106	130	165	106	115	134	123	82	94	1318
25 Wet	73	82	98	105	125	151	112	119	124	123	83	91	1286
20 Wet	74	81	95	105	123	146	114	120	121	123	83	90	1274
10 Wet	76	76	86	102	116	133	118	122	112	121	83	88	1232
5 Wet	77	69	76	97	108	120	121	121	106	117	83	85	1181
2.3 Wet	74	60	66	87	97	108	119	114	104	110	84	81	1103
2 Average	72	58	64	84	94	107	118	111	104	107	84	80	1083
3 Dry	68	53	60	76	87	104	113	102	108	100	84	79	1035
5 Dry	62	48	58	68	81	104	108	93	114	94	84	78	991
10 Dry	56	43	56	59	75	105	101	82	121	86	84	77	946
20 Dry	49	40	56	52	70	107	95	71	129	80	84	77	910
25 Dry	48	39	56	50	69	108	93	68	131	78	84	77	900
50 Dry	42	36	56	43	65	111	88	60	138	72	84	76	871
100 Dry	37	33	57	38	62	114	83	51	145	67	84	76	846
200 Dry	32	31	57	32	59	116	78	44	151	63	84	76	824
500 Dry	26	29	58	26	56	120	72	34	160	57	84	76	798
1000 Dry	22	27	59	22	53	123	68	28	165	53	83	76	780
2000 Dry	18	26	60	18	51	126	64	21	171	50	83	76	764
10000 Dry	9	22	62	9	47	132	56	7	183	42	83	76	729

Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/03_Precipitation_v07.pdf

7.2.3 Precipitation Depth-Duration-Frequency

A frequency analysis was completed on storm events from the neighboring ECCC stations to the Site. This analysis followed the framework of regional frequency analysis with L-moments (Hosking 1997) instead of selecting a single analogue station for site. Daily storm depths were corrected by multiplying by a factor of 1.13 to obtain 24-hour storm depth estimates (WMO 2009). This accounts for timestep measurement limitations.

Intensity-Duration-Frequency (IDF) curves and Precipitation Depth-Duration-Frequency (PDF) tables were developed from the 24-hour frequency analysis results and ECCC regression coefficients for short duration storms. The resulting precipitation depth-duration-frequency values for the project are presented in **Table 7-3**.

Table 7-3: Project Precipitation Depth-Duration-Frequency Results

Duration	Precipitation [mm] for Different Return Periods [years]												
	2	**2.3**	**5**	**10**	**20**	**25**	**50**	**100**	**200**	**500**	**1000**	**2000**	**10000**
5min	7	7	9	11	13	13	15	17	19	21	23	25	30
10min	11	12	15	18	21	22	25	28	31	36	39	43	51
15min	14	15	20	24	27	29	33	37	41	46	51	56	67
30min	20	21	28	34	39	41	47	53	59	67	74	81	97
1hr	25	27	36	44	52	54	62	69	77	88	97	106	128
2hr	31	34	45	54	63	66	75	85	95	108	118	129	156
3hr	35	38	49	60	69	73	83	93	104	118	130	142	171
6hr	41	44	58	69	80	84	95	107	119	135	148	162	195
12hr	48	52	66	79	91	95	107	120	133	151	166	180	217
24hr	56	60	76	89	102	107	120	134	148	168	183	199	239
48hr	66	69	86	100	115	119	134	149	164	185	202	219	261
72hr	71	75	93	108	122	127	142	158	174	196	213	231	275

Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/03b_StormAnalysis_v05

7.2.4 Spring Storms

A frequency analysis was also completed on spring storm events from the neighboring ECCC stations to the Site following the same methodology described in the previous section (Hosking 1997). Daily storm depths were also corrected by multiplying by a factor of 1.13 to obtain 24-hour storm depth estimates (WMO 2009). The resulting spring storm depths are presented in **Table 7-4**.

Table 7-4: Project Spring Precipitation Frequency Analysis Results [mm]

Return Period [years]	24-hour Spring Precipitation [mm]
2	32
2.3	34
5	45
10	55
20	66
25	70
50	83
100	96
200	111
500	133
1000	151
2000	171
10000	224

Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/03b_StormAnalysis_v05

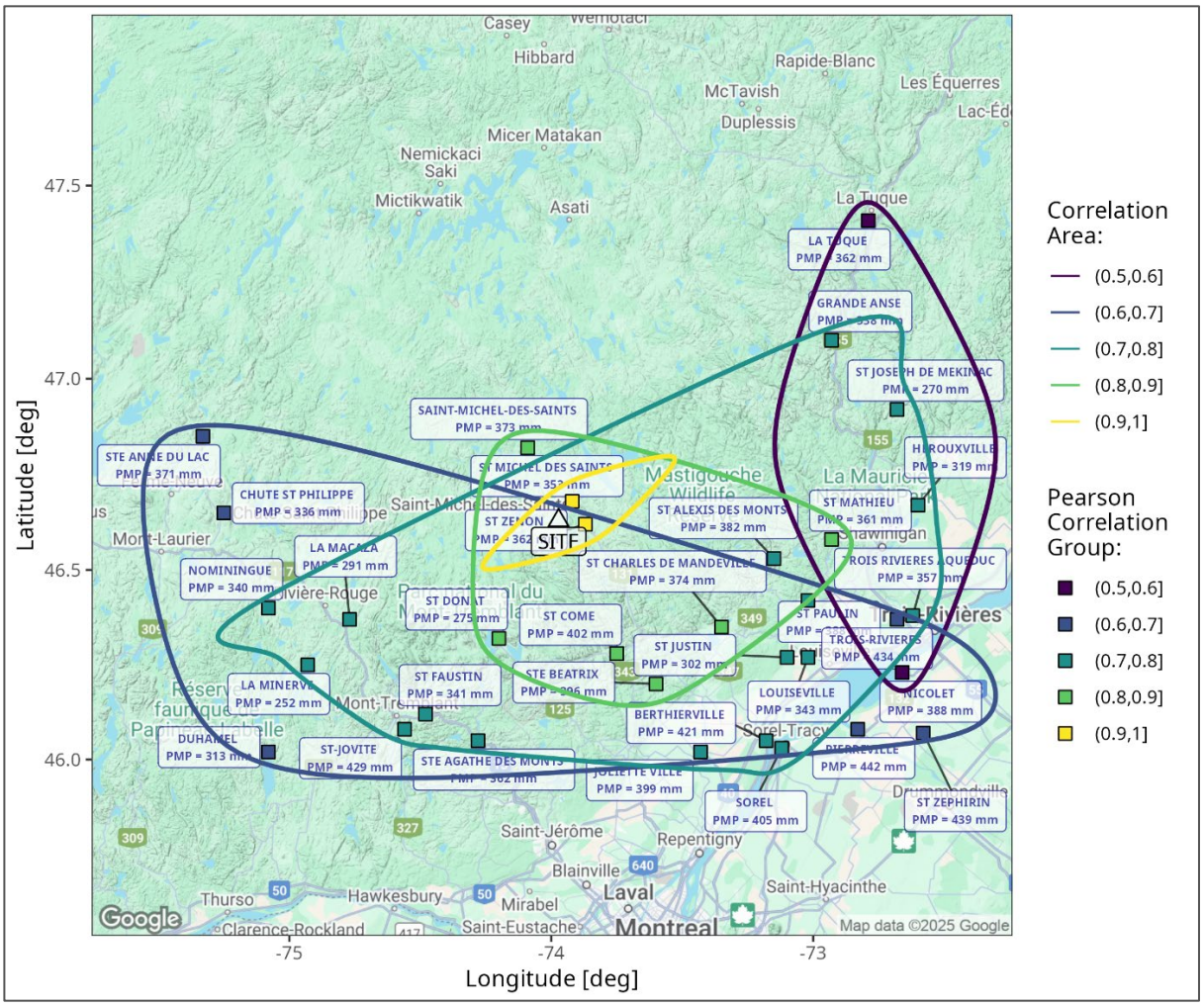
7.2.5 Probable Maximum Precipitation

The PMP for the project was estimated by a regional application of the local statistical method (Hershfield Method). The local statistical PMP value was calculated for all the stations within the area of interest of the project. Daily precipitation records from all the stations were linked to site records through a Pearson correlation calculation and grouped to identify stations most likely to share storm patterns with the site location. The group corresponding to a Pearson correlation coefficient higher than 0.8 was selected as it matches well with previous analysis findings of similar climate within 50 km of Site. The highest PMP value within that group is found at the Saint-Come station, and was selected as the Project PMP:

- PMP = 402 mm in 24 hours.

The station grouping and PMP values are presented in **Figure 7-2**.

Figure 7-2: ECCC Stations PMPs and Correlation Groups



Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/03b_StormAnalysis_v05

Notes: PMP calculated with the Hershfield method for 24-hours storms

8 Relative Humidity

The complete relative humidity and dew point temperature analysis for the project is presented in **Appendix F**.

8.1 Relative Humidity Findings

The main findings of the relative humidity and dew point temperature analysis were:

- All data sources available within the area of interest presented excellent dew point temperature correlations (R^{2*}≥0.95) between each other (both site, and reanalysis products).
- All the station data available within the area of interest (NMG and ECCC) presented very good relative humidity correlations (R^{2*}≥0.8) between each other. The ERA5 and ERA5-Land reanalysis products presented very good correlations with site data.
- ERA5 was the selected source for the dew point temperature timeseries for the project after being bias corrected to site data. Relative humidity was calculated from the resulting dew point temperature timeseries.

8.2 Relative Humidity Results

Mean monthly and annual values for relative humidity were calculated from the project time series. Values are presented for each reporting period in **Table 8-1**.

Table 8-1: Mean Monthly and Annual Relative Humidity for the Project [%].

Period	RH.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1994 – 2023	Max	95	95	91	85	81	82	82	85	91	93	95	97	89
	Mean	80	79	75	70	66	69	70	72	77	81	85	88	76
	Min	59	58	58	56	53	58	60	62	65	68	69	68	61
1985 – 2014	Max	94	94	91	84	82	82	82	85	91	92	95	97	89
	Mean	80	78	75	70	67	69	70	72	78	81	84	87	76
	Min	58	57	57	56	54	57	60	62	65	67	67	65	60

Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/04_Tdew_RH_v02.pdf

9 Solar Radiation

The solar radiation analysis focused on the surface short-wave (solar) radiation downwards (SSRD) parameter. The complete solar radiation analysis for the project is presented in **Appendix G**.

9.1 Solar Radiation Findings

The main findings of the solar radiation and dew point temperature analysis were:

- Selected reanalysis sources (Daymet and ERA5-Land) have consistent data for SSRD at the site location.
- There was a marked discrepancy between NMG site data and reanalysis records (and usual values), likely due to Site station pyranometer measuring inaccuracies. This ruled out the use of bias correction.
- Regardless of this, both reanalysis sources present good correlations with site data. Daymet was considered the most likely to be representative of solar radiation on site.

9.2 Solar Radiation Results

Cumulative monthly and annual values were calculated for an average year from the project surface short-wave radiation downwards time series extracted from the Daymet dataset. Values are presented for each reporting period in **Table 9-1**.

Table 9-1: Monthly and Annual Solar Radiation Downwards for the Project [MJ/m^2].

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1994 – 2023	169	271	473	641	793	677	613	534	386	240	151	129	5078
1985 – 2014	168	270	469	632	769	670	615	531	375	239	151	132	5022

Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/05_Solar_Radiation_v01.pdf

10 Evaporation

The evaporation calculation details are presented in **Appendix H**.

10.1 Evaporation Findings

The main findings of the solar radiation and dew point temperature analysis were:

- Evaporation records could not be found within the area of interest of the project. Open water evaporation was calculated with commonly used empirical methods using the previously developed climatic timeseries as inputs.
- All four tested methods yielded similar results:
  - Hargreaves-Samani (Hargreaves 1985),
  - Morton CRWE (Morton 1983),
  - Penman-Monteith (FAO 1998),
  - Penman (Penman 1948).

  The daily average of the four methods was compiled as the project timeseries for evaporation.

10.2 Evaporation Results

Mean monthly and annual values were calculated from the synthetic time series. Values are presented for each reporting period in **Table 10-1**.

Table 10-1: Total Monthly and Annual Open Water Evaporation for the Project [mm]

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1994 – 2023	9	16	44	87	152	157	151	127	84	44	20	10	902
1985 – 2014	9	16	44	90	151	157	153	128	82	44	20	10	904

Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/06_Evaporation_v01.pdf

11 Summary

SRK completed a baseline meteorological study for the Matawinie site to support engineering design projects. The analysis was supported by site climate records complemented with data from regional stations and climatic gridded models (also called climate reanalysis).

For each parameter analyzed, SRK performed statistical and qualitative analyses to determine the most accurate source, or sources, to use for patching and extending the site stations time series. When possible or necessary, the data was adjusted and/or bias-corrected to available site data using regression analysis or quantile delta mapping. This resulted in synthetic long-term, gap-less timeseries representative of the site area for the following parameters: air temperature, wind speed, precipitation, relative humidity, dew point temperature, solar radiation. Open water evaporation was calculated from the previous parameters. Extreme events were also quantified for wind and precipitation (Intensity-Duration-Frequency curves and Probable Maximum Precipitation) based on available data.

This report and appendices detail the methods applied for the data evaluation and timeseries generation and contains summary results derived from the extended synthetic records. Resulting climate normals for the project based on synthetic data from the 1994 to 2023 period are presented in **Table 11-1**. This corresponds to the most recent 30 years-period, suitable for establishing up to date climate normals in accordance with the World Meteorological Organization guidelines (WMO, 2017).

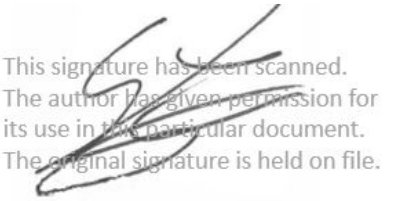
Table 11-1: Summary of Climate Normals for the Project (1994–2023)

Parameter	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Tmax	[°C]	-7.7	-5.4	0.6	7.6	16.4	21.4	23.5	22.4	18	10.2	2.2	-4.5	8.7
Tavg	[°C]	-13.8	-12.4	-6	1.6	9.5	14.9	17.3	16.2	12	5.2	-2.1	-9.3	2.7
Tmin	[°C]	-19.9	-19.3	-12.6	-4.5	2.6	8.3	11	10	5.9	0.3	-6.4	-14.2	-3.2
Wind Speed	[m/s]	1.5	1.6	1.7	1.8	1.6	1.4	1.4	1.3	1.5	1.7	1.7	1.5	1.6
Precipitation	[mm]	73	59	72	84	93	121	114	104	111	107	82	87	1106
Rain	[mm]	9	4	20	63	92	121	114	104	111	99	41	17	794
Snow	[mm]	64	55	52	21	1	0	0	0	0	8	41	70	312
RH	[%]	80	79	75	70	66	69	70	72	77	81	85	88	76
SSRD	[MJ/m^2]	169	271	473	641	793	677	613	534	386	240	151	129	5078
Evaporation	[mm]	9	16	44	87	152	157	151	127	84	44	20	10	902

Sources: NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Meteorology/03_Reports/06_Evaporation_v01.pdf

Closure

This report, Baseline Climate Analysis, was prepared by



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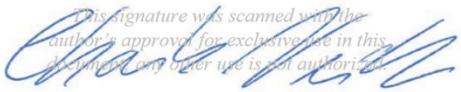

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

References

Allen, Pereira, R. G. 1998. Crop Evapotranspiration - Guidelines for Computing Crop Water Requirements - FAO Irrigation and Drainage Paper 56. Rome: FAO.

Cannon, A. (2023). MBC: Multivariate Bias Correction of Climate Model Output. Accessed: CRAN - Package MBC (r-project.org).

Cannon, A. S. (2015). Bias Correction of GCM Precipitation by Quantile Mapping: How Well Do Methods Preserve Changes in Quantile and Extremes. Journal of Climate. 6938–6959. https://doi.org/10.1175/JCLI-D-14-00754.1.

Freitas, A. L. (2021). Evaluation of Quantile Delta Mapping as a bias-correction method in maximum rainfall dataset from downscaled models in São Paulo state (Brazil). https://doi.org/10.1002/joc.7238

Gelaro, Ronald, Will McCarty, Max J. Suárez, Ricardo Todling, Andrea Molod, Lawrence Takacs, Cynthia A. Randles, et al. 2017. "The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2)." Journal of Climate 30 (14): 5419–54. https://doi.org/10.1175/jcli-d-16-0758.1.

George H. Hargreaves, and Zohrab A. Samani. 1985. "Reference Crop Evapotranspiration from Temperature." Applied Engineering in Agriculture 1 (2): 96–99. https://doi.org/10.13031/2013.26773.

Hersbach, Hans, Bill Bell, Paul Berrisford, Shoji Hirahara, András Horányi, Joaquín Muñoz-Sabater, Julien Nicolas, et al. 2020. "The ERA5 Global Reanalysis." Quarterly Journal of the Royal Meteorological Society 146 (730): 1999–2049. https://doi.org/10.1002/qj.3803.

Hosking, J. R. M., and James R. Wallis. 1997. "Regional Frequency Analysis," April 1997. https://doi.org/10.1017/cbo9780511529443.

Laio, F. (2009). Model selection techniques for the frequency analysis of hydrological extremes. Water Resources Research. https://doi.org/10.1029/2007WR006666

Morton, F. I. 1983. "Operational Estimates of Lake Evaporation." Journal of Hydrology 66 (1-4): 77–100. https://doi.org/10.1016/0022-1694(83)90178-6.

Penman, H. L. 1948. "Natural Evaporation from Open Water, Bare Soil and Grass." Proceedings of the Royal Society of London. Series A. Mathematical and Physical Sciences 193 (1032): 120–45. https://doi.org/10.1098/rspa.1948.0037.

NASA Shuttle Radar Topography Mission (SRTM)(2013). Shuttle Radar Topography Mission (SRTM) Global. Distributed by OpenTopography. https://doi.org/10.5069/G9445JDF. Accessed: 2025-02-10

Muñoz-Sabater, Joaquín, Emanuel Dutra, Anna Agustí-Panareda, Clément Albergel, Gabriele Arduini, Gianpaolo Balsamo, Souhail Boussetta, et al. 2021. "ERA5-Land: A State-of-the-Art Global Reanalysis Dataset for Land Applications." Earth System Science Data 13 (9): 4349–83. https://doi.org/10.5194/essd-13-4349-2021.

SRK Consulting Canada Inc. (2023) Precipitation parameters correction due to orographic effect. Memo prepared for NMG. October 24, 2023.

SRK Consulting Canada Inc. (2025) NMG Matawinie Climate Change Analysis. Report prepared for NMG. February 17, 2025.

Thornton, M. M., R. Shrestha, Y. Wei, P. E. Thornton, and S-C. Kao. 2022. “Daymet: Daily Surface Weather Data on a 1-Km Grid for North America, Version 4 R1,” November. https: //doi.org/10.3334/ORNLDAAC/2129.

Vionnet, Vincent, Colleen Mortimer, Mike Brady, Louise Arnal, and Ross Brown. 2024. “CanadianHistorical Snow Water Equivalent Dataset (CanSWE, 1928-2023).” Zenodo. https://doi.org/10.5281/ZENODO.10835278.

WMO. (2009). WMO-No. 1045. Manual on estimation of probable maximum precipitation. Geneva 2009. ISBN 978-92-63-11045-9

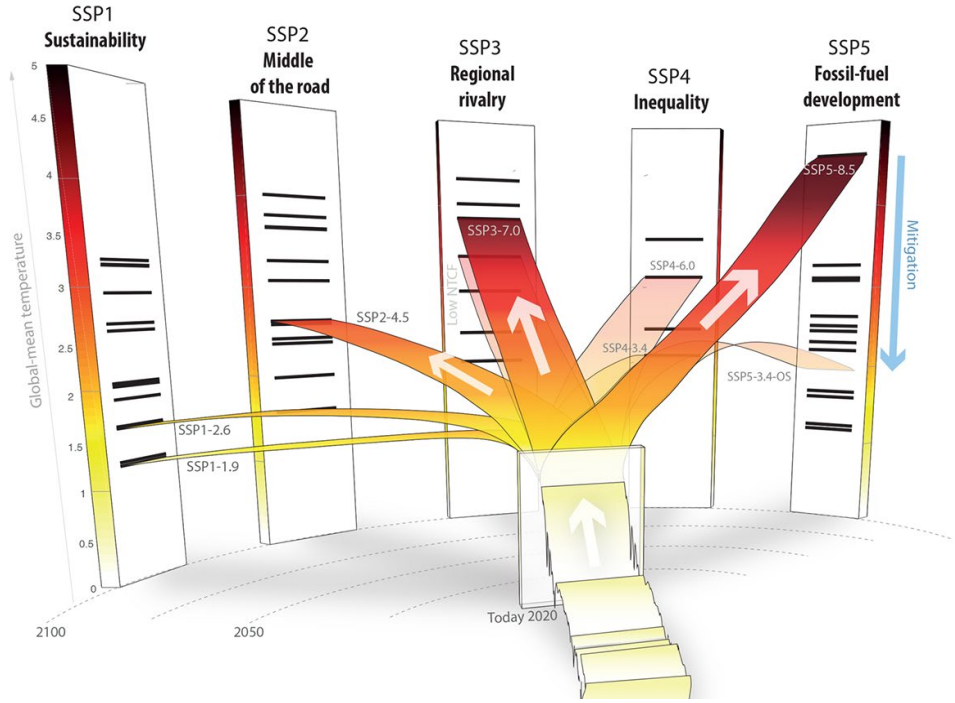
WMO. (2017). WMO-No. 1203. Guidelines on the Calculation of Climate Normals. Geneva 2017. ISBN 978-92-63-11203-3

FINAL

Climate Change Analysis

Matawinie, Quebec, Canada

Nouveau Monde Graphite



SRK Consulting (Canada) Inc. ▪ CAPR0033306 ▪ April 7, 2025

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FINAL

Climate Change Analysis

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Shared Socioeconomic Pathways (SSPs) and Scenarios (Meinshausen, et al., 2020)

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Appendix B Climate Change Analysis Code Output

Useful Definitions

This list contains definitions of symbols, units, abbreviations, and terminology that may be unfamiliar to the reader.

AR6	Assessment Report 6
CGM	Climatic Gridded Model
CMIP5	Coupled Model Intercomparison Project 5
CMIP6	Coupled Model Intercomparison Project 6
GCM	Global Circulation Model
GEV	Generalized Extreme Value
GHG	Greenhouse Gasses
GWL	Global Warming Level
HDI	Highest Density Interval
IPCC	Intergovernmental Panel on Climate Change
MAAT	Mean Annual Air Temperature
MAET	Mean Annual Potential Evapotranspiration
MAP	Mean Annual Precipitation
MAPE	Mean Annual Potential Evaporation
MASL	Meters above sea level
Max	Maximum
Min	Minimum
NEX-GDDP	NASA Earth Exchange Global Daily Downscaled Projection (dataset)
PCIC	Pacific Climate Impact Consortium
PMP	Probable Maximum Precipitation
QM	Quantile Mapping
QDM	Quantile Delta Mapping
R	The R programming Language
RCP	Representative Concentration Pathway
SSP	Shared Socioeconomic Pathway
WCRP	World Climate Research Programme
WMO	World Meteorological Organization

Executive Summary

Nouveau Monde Graphite Inc. (NMG) (the Client) has contracted SRK Consulting (Canada) Inc. (SRK) to perform a climate change analysis for the Matawinie Mine (the Site) to support their engineering design, water management strategy and water balance as a part of the Surface Water Management, Overburden Stockpile and Co-disposal Facility Engineering project initiated in 2023.

This report comprises a general climate change assessment for Matawinie based on global circulation models (GCMs or climate change models) provided in the Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report (AR6) (2021). These 35 models, in the downscaled ensemble used here and in AR6, are available to the global scientific community. Each model was run through four different emission or warming scenarios, known as socio-economic pathways (SSP). These are, in order of increasing projected warming: SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5. The results are climate projections that are reported for three different overlapping 30-year time slices reaching to Year 2100.

SSP5-8.5 assumes no change in emissions (business as usual) and is predicted to result in the highest degree of warming. At the other end of the spectrum, SSP1-2.6 assumes that global CO_2eq emissions declining to net zero around 2070. Because the future is uncertain, there is no consensus in the literature on the criteria for the selection of a specific emission scenario or a specific GCM. For this reason, all the emission scenarios and available GCM models were considered. To help interpret the variability and distribution of the data, a statistical tool called Highest Density Intervals (HDI) was used to present the results; bands of highest probability were identified as well as median and mode values.

Historical baseline conditions were defined from observations and synthetic regional datasets with records spanning from 1985 to 2014; this work is summarized in SRK's Climate Baseline Analysis (SRK, 2025). The projected values are compared to these baseline historical conditions, with the differences (or anomalies) presented as a rate of change (as percent difference) relative to baseline conditions. These projections were "adjusted" with respect to historical conditions.

The model results were grouped into three overlapping time series: 1) from 2015 to 2040; 2) from 2041 to 2070; and 3) from 2071 to 2100; these periods are referred to as the 2030s, 2060s, and 2090s, respectively.

The complete analysis for all scenarios is presented in **Appendix B**.

The projected median values in the 2030s (up to Year 2040) for meteorological parameters of models assessed for the site under all SSPs are as follows:

- **Mean annual values**:
  - The mean annual precipitation is expected to increase by up to 9% by 2040.
  - The mean annual air temperature is expected to increase by up to +2.5°C by 2040.
  - The mean annual potential evaporation is expected to increase by up to 14% by 2040.
- **Precipitation Intensity-Duration-Frequency**: the rate of change varies; however, an overall increase up to 9% is expected by 2040 for all durations and return periods.

- **Probable maximum precipitation**: two methodologies were presented: Hershfield and moisture maximization. The moisture maximization method is considered the most reliable one. It suggests an increase of 13% over baseline probable maximum precipitation by 2040.

Relevant GCMs results were benchmarked on a local bibliographical review, most of the sources were extended to different assessment reports, selected periods and GCMs; yet similar values and trends are observed when these are compared with this work's results.

These projected values are based on the most recent models provided in the IPCC's AR6. It is recommended to update this report every five to ten years as new information and new global climate models become available.

1 Introduction

Nouveau Monde Graphite Inc. (NMG) (the Client) has contracted SRK Consulting (Canada) Inc. (SRK) to support their engineering design, water management strategy and water balance for the Matawinie Mine (the Site) as a part of the Surface Water Management, Overburden Stockpile and Co-disposal Facility Engineering project initiated in 2023. As a part of its preliminary works, SRK performed a review of the existing hydrology analysis for the Site with a focus on orographic effects (SRK, 2023). As a part of this study, SRK recommended the development of a site-specific climate change analysis for the Matawinie Site to better quantify risks associated with water management and inform future engineering projects.

In 2024, SRK completed a thorough analysis of climate change effects on the Site location based on global circulation models (GCMs or climate change models) provided in the Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report (AR6) (2021) and the defined baseline conditions for the project (SRK 2025). The datasets compilation and subsequent analysis was conducted in the R Software environment.

This report describes the scientific background behind climate change datasets, procedures and analysis. It then outlines the main scientific methods applied to study climatic data and estimate rates of change for critical climatic parameters for the Site. Finally, the main results of this analysis are presented to characterize climate change conditions at the Matawinie site for multiple climatic parameters.

2 Climate Change Background

Climate change is considered one of human civilization's many challenges as it has the potential to impact current social and ecological systems. Estimating potential variation in future climate conditions to identify vulnerability, assess risk and develop adaptive management strategies is in the best interest of mine developers and operators.

This memo documents an analysis of climate change effects on the probable maximum precipitation (PMP) to reduce the mines exposure to legal, financial, environmental, and social risk caused by climate change.

2.1 Contextual Framework

While observed historical datasets have traditionally been used to investigate climate patterns and trends, global circulation models (GCMs, aka climate change models) are better suited to generate synthetic datasets with which to investigate the potential range of impacts of climate change into the future on a global or continental scale. GCM results can be scaled to local weather station datasets or gridded climate datasets to provide localized, site-specific projections.

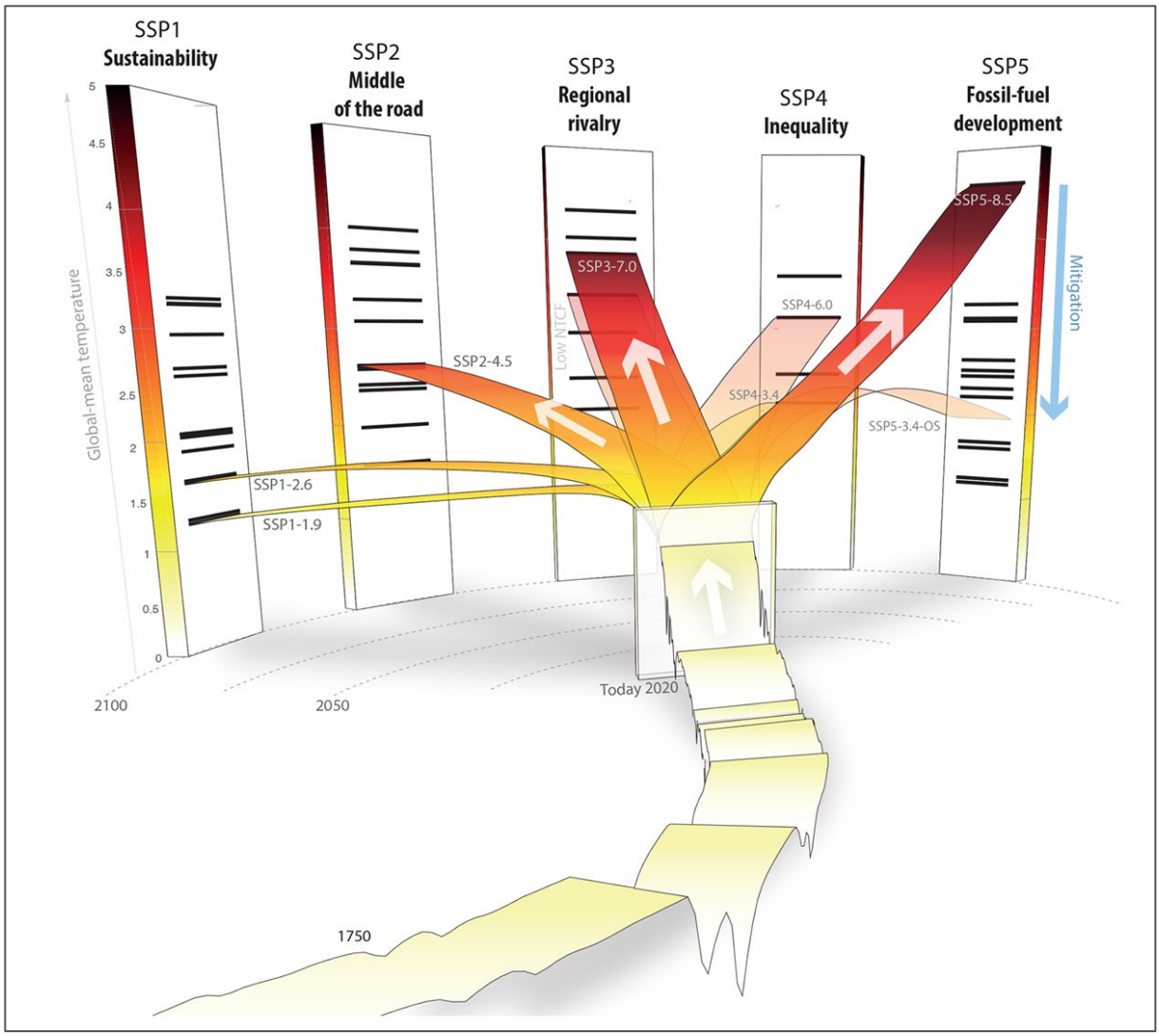
The Coupled Model Intercomparison Project (CMIP) is organized under the support of the World Climate Research Program's (WCRP) working group on coupled modelling. It coordinates experiments on coupling computer-based models of the Earth's climate such as GCMs. The objective of CMIP is to better understand past, present, and future climate change arising from natural unforced variability or in response to changes in radiative forcing in a multi-model context (Eyring, 2016). The CMIP is currently in its sixth phase (CMIP6) and its outcomes contribute to the most recent assessments and reports from the International Panel on Climate Change (IPCC).

CMIP6 includes the most up to date and peer-reviewed models for the simulation and projection of various aspects of climate change. The CMIP6 models include new and better representations of physical, chemical, and biological processes at higher resolution than its previous phases. This has improved the simulation of the recent mean state of most large-scale indicators of climate change and many other aspects across the climate system.

CMIP6 models were run for four different scenarios corresponding to future Shared Socio-economic Pathways (SSP), each associated with different levels of GHG emissions. The SSPs are derived from five different narratives (SSP1 to SSP5) that describe alternative potential socioeconomic paths of development. The four scenarios run for this project are, in order of increasing projected radiative forcing: SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5 (O'Neill 2016). SSPs and scenarios are summarized schematically in **Figure 2.1** and are described and discussed in detail in other works (O'Neill 2016, Riahi 2017, Meinshausen et. al. 2020).

This climate change assessment was based on results from GCMs included in CMIP6 and the corresponding IPCC Sixth Assessment Report (AR6) (Masson-Delmotte, 2021), including the four scenarios (SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5). GCMs included in CMIP6 are listed in **Appendix A**. The data compilation and subsequent analysis was conducted in the R Software (R Core Team, 2023) environment.

Figure 2.1: Shared Socioeconomic Pathways (SSPs) and Scenarios



Sources: (Meinshausen, et al., 2020)

Notes: There are eight main scenarios represented in this figure (SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP4-3.4, SSP4-6.0, SSP5-3.4, and SSP5-8.5). These scenarios were classified in priority tiers (O'Neill, 2016). Only the top priority scenarios were selected for modelling within the CMIP6 project (SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5).

2.2 GCM Variability

Uncertainty refers to epistemic situations in which information is incomplete or unknown, such as predictions of future events, existing physical measurements, and the unknown. Uncertainty arises in partially observable or stochastic environments, and in cases where knowledge is incomplete, such as the global scale climate projections provided by GCMs.

Uncertainty is inherent in the data, ranging from assessment report (AR) AR1 to the IPCC's latest AR6 (Masson-Delmotte, 2021). GCMs included in the ARs present the historical and projected climatic worldwide conditions until 2100 using meteorological parameters such as precipitation and air temperature.

The climate system is a coupled non-linear chaotic system. Therefore, long-term prediction of future climate states is not possible. Rather, the focus must be the prediction of the probability distribution of the system′s future possible states by the generation of ensembles of model solutions. Adequately addressing the statistical nature of climate is essential.

One of the biggest challenges to climate change projections is to explain the inherent variations in possible scenarios. Fixed-value definition as mean annual precipitation loses significance in the context of climate change projections, where most of the parameter definitions are in fact ranges defined by every GCM and every scenario.

Figure 2.2 presents some alternatives about how a singular meteorological parameter, such as probable maximum precipitation, can be presented. In this example, this one-parameter graph displays variability that is represented by approximately 140 valid data points.

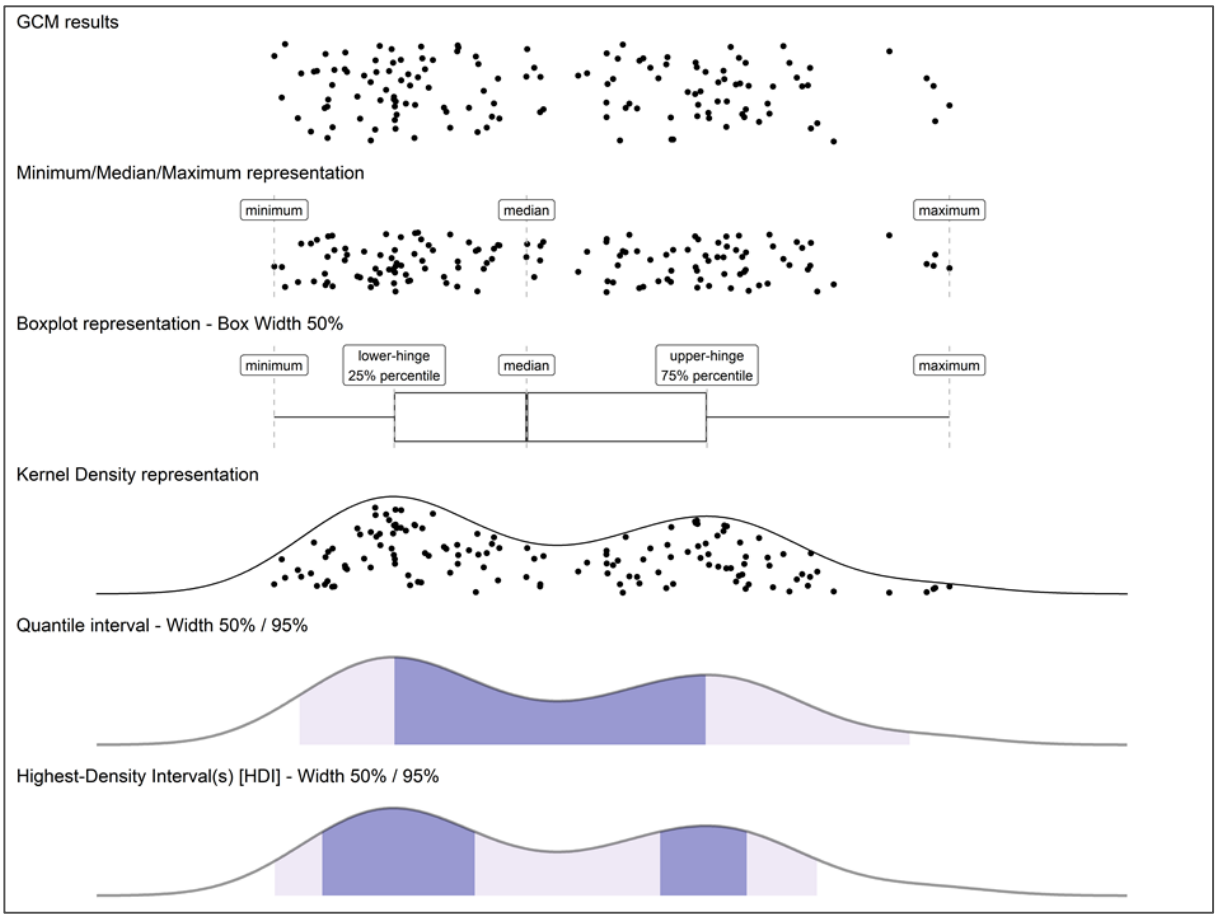
To simplify the point cloud, frequently used approaches (although not necessarily the most appropriate) consider only the point-cloud median (one data point), or display maximum, median, and minimum values (three data points), or illustrate the variation using a boxplot representation (as five points). These simplifications may not always be representative of the parameter's variability.

In this example of a multimodal distribution (more than one peak), most of the points are aligned around the boxplot box extreme values, which differ significantly from the point-cloud median (**Figure 2.2**).

Other approaches are based on Kernel density distributions, where values are represented by a single smooth density estimation. Quantile intervals are identified (as with the boxplot), and the highest-density intervals (HDI) highlight the most credible values (even in multimodal distributions).

SRK suggests that the reader selects the rate of change to be used for a particular design or to inform a decision based on risk tolerance.

Figure 2.2: Representations of GCM Values



Sources: SRK

2.3 GCM Evaluation Principles

Climate change analyses underlie the following principles:

- There are risks associated with the selection of one or several models due to the limited information they provide on the variability of meteorological parameters.
- The ability of a model to predict current conditions is loosely related, if at all, to its ability to predict future conditions (Knutti, 2010), (Reifen, 2009).
- Combining results of multiple GCMs and scenarios to represent meteorological conditions under climate change is considered best practise (Najafi & Moradkhani, 2015).

Informed by these principles, all climate change models used in this analysis are weighted equally, i.e., one-model-one-vote. With this assumption, every climate change model/scenario is considered equally likely to occur as the others. A list of the GCMs used in the analysis is presented in **Appendix A**.

The body of this report presents rate of change results as an average of scenarios SSP2-4.5 and SSP5-8.5 to provide a concise report. These values were chosen as they are likely to represents a conservative future climate, but it is not as critical as the SSP5-8.5 scenario. The average of scenarios SSP2-4.5 and SSP5-8.5 was used to summarize the results providing a consistent “middle-upper” pathway. Depending on risk tolerance associated to each particular project or decision, it is recommended for NMG to consider all the results presented in **Appendix B**.

3 Data Sources

Data used in this study include the GCMs introduced in **Section 2**, and local climatic gridded models from which to perform bias correction for the site. These data are discussed in the sub-sections below.

Site weather data analysis and baseline climate characterization was out of the scope of this study.

3.1 Global Circulation Models (GCM)

The following two sources were considered to evaluate climate change GCMs.

- Pacific Climatic Impact Consortium (PCIC): Canadian Downscaled Climate Scenarios – Univariated (CMIP6) at a 10 km by 10 km resolution. These records include 26 GCMs for three SSP-RCP schemes: SSP1-2.6, SSP2-4.5 and SSP5-8.5. Variables included are daily total precipitation, and maximum and minimum temperature.
- CMIP6 NASA Earth Exchange Global Daily Downscaled projections (NEX-GDDP) (Thrasher 2021, 2022): this dataset includes downscaled worldwide GCM records at a lower resolution than PCIC, with a grid size of 25 km by 25 km. These records include 35 GCMs for four SSP-RCP schemes: SSP1-2.6, SSP2 4.5, SSP3-7.0 and SSP5-8.5. In addition to total precipitation, maximum/minimum temperature, NEX-GDDP also includes daily mean temperature, relative/absolute humidity, wind speed, and short- and long-wave solar radiation. This dataset has been used to obtain these additional inputs for the site.

All datasets described above extend from 1950 – 2100, with daily historical records ranging from 1950 to 2014 and daily projections from 2015 to 2100.

The GCMs within CMIP6 consulted for this project, are listed in **Appendix A**.

3.2 Baseline Data

A meteorological baseline has been prepared by SRK (SRK 2025) to serve as reference for the climate change analysis. Daily timeseries for precipitation, temperature (Tavg, Tmax, Tmin), evaporation and other parameters were used to quantify baseline conditions and bias correct GCM outputs.

3.3 Climatic Gridded Models

Long-term records are required for an accurate representation of a site's climate and hydrology. The World Meteorological Organization (WMO) recommends a minimum of 30 years of meteorological data for climatological studies (WMO, 2017).

Reanalysis datasets are a subset of climatic gridded models, which are generated by a scientific method that develops a comprehensive record of historical climate. This method uses a collection of algorithms to interpolate and extrapolate from observations to generate a gridded estimate of meteorological parameters. This combination of observations and numerical or statistical modelling based on earth system characteristics, is used to generate a synthetic data series over instrumented and

un-instrumented regions. Climate reanalysis typically extends over several decades or longer and covers the entire globe from the Earth's surface to well above the stratosphere for historical, and current conditions.

Hourly dew-point temperature was derived from ERA5 (Hersbach, 2020), a climatic reanalysis dataset that provides a consistent view of the evolution of atmospheric variables over several decades at a resolution of 0.25°. This dataset was assumed representative of baseline climate conditions at the Site based on the baseline analysis (SRK 2025).

3.4 Ouranos

Ouranos is a Canadian consortium dedicated to advancing climate change research and adaptation. It specializes in providing high-quality climate data and projections to support informed decision-making. Ouranos offers a range of data products, including regional climate simulations, climate scenarios, and impact assessments that help support climate change analysis studies within the Quebec province.

The Ouranos Portraits service (Ouranos 2025) is designed to offer localized snapshots of climate change effects. It offers localized estimations of climatic parameters affected by climate change under multiple scenarios. This service was used as a benchmarking tool to evaluate the analysis results.

4 Methodology

4.1 General Approach

The Matawinie climate change analysis looked to quantify the effects of climate change over critical climatic parameters for the project. GCM data was bias corrected to baseline data based on the overlapping historical period to calculate rates of change.

Rates of change (ROC) were computed using the bias corrected GCM historical values against forecast values, and should be applied to baseline results as defined in the Matawinie Baseline Climate Analysis (SRK, 2025). Rates of change can be applied to the baseline to calculate an "expected value" as defined in the following equation:

$$Parameter^{fut} = Parameter^{hist} * (1 + \frac{ROC}{100})$$

A different approach is adopted for temperature, where the rate of change is expressed as a difference in temperature (Delta) in degrees Celius:

$$Parameter^{fut} = Parameter^{hist} + ROC)$$

Only rates of change are presented within this report to offer NMG and the design teams flexibility in decision-making around design criteria and risk.

The analysis was completed by categorizing results with four climate change scenarios (SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5), and for three projected time frames: 2030s (2015–2040), 2060s (2041–2070), and 2090s (2071 – 2100).

To illustrate the outcomes variability, the results were transformed into a Kernel density distribution to report the High Density Intervals (HDI). Intervals can be continuous or non continuous allowing for the classification of multi-modal distributions. The following parameters will be used to express the uncertainty in the results:

- HDI 90%L: The ROC value for the lower range of the 90% mass interval.
- HDI 75%L: The ROC value for the lower range of the 75% mass interval.
- HDI Median: The ROC value for which 50% of points are higher and 50% of points are lower.
- HDI 75%H: The ROC value for the higher range of the 75% mass interval.
- HDI 90%H: The ROC value for the higher range of the 90% mass interval.

4.2 Bias Correction

Quantile Delta Mapping (QDM) bias correction is an algorithm commonly used to correct systematic distributional biases in outputs from climate models. The purpose is that the distributional properties would more closely match those of historical observations (Cannon, 2015).

QDM adjusts the empirical cumulative distribution of climate change projections through removing the systematic error of raw data. The algorithm combines two steps in sequence:

1. GCM model outputs for baseline conditions are sorted into quantiles and bias corrected to match observations in the historical baseline period using quantile mapping.
2. Relative change in GCM model projections, in terms of quantiles, are superimposed on the bias-corrected model outputs (Cannon, 2015).

This method preserves relative changes in simulated quantiles from climate. QDM multiplies observed values by the ratio of the modelled values (period of interest divided by calibration period) at the same quantiles (Freitas, 2021).

This methodology was performed with the R library “MBC” (Cannon A., 2016).

4.3 Precipitation Intensity-Duration-Frequency

The Baseline Climate Analysis report (SRK, 2025) addresses the site conditions at Matawinie associated with the Intensity-Duration-Frequency (IDF) values of storms ranging from 1 in 2 to 10,000 years and duration from 5 minutes to 72 hours.

The results from the IDF_CC Tool v7.5 (Simonovic et al. 2015) were selected to project IDF values under climate change. This tool provides IDF data based on observed data either from a grid covering Canada or at meteorological stations. In this case, IDF projections for the nearby station Saint Michel des Saints were used. IDF-CC tool typically produces better results at meteorological stations compared to gridded evaluations. It's important to note that this tool only provides IDF estimations limited up to 24 hours and 100 years.

The gap associated with IDF projections under climate change for durations beyond those presented on IDF-CC Tool, including 48 and 72 hours, and return periods ranging from 200 to 10,000 years were addressed as described below.

The IDF (Intensity Duration Frequency) for the site under climate change was defined as follows:

- For durations between 2 to 100 years, and durations from 5 minutes to 24 hours, the median of the rate of change obtained from IDF-CC tool results at Saint Michel des Saints was used.
- For durations between 200 years to 10,000 years, and durations from 5 minutes to 24 hours, the rate of change corresponding to the 100 years return period was selected.
- For durations of 48 and 72 hours, the rate of change corresponding to the 24 hour events was selected.

4.4 Probable Maximum Precipitation

The probable maximum precipitation (PMP) is an estimation of the maximum amount of rainfall that could occur within a specific geographic area over a given duration, typically ranging from a few hours to a few days. It is an important parameter for designing infrastructure and determining the capacity of hydraulic structures such as dams and reservoirs.

Two commonly used methodologies for estimating the PMP are the statistical approach developed by Hershfield and the meteorological approach known as moisture maximization.

Both methodologies have their strengths and limitations. While the statistical approach relies on historical data and is simpler to apply, the meteorological approach takes into account the physical processes driving extreme precipitation events.

In this evaluation, the PMP values obtained from different GCMs were analyzed to assess the rate of change in precipitation over time and should be calculated in relation to the baseline findings (SRK 2025).

4.4.1 Statistical Method

The statistical approach, developed by engineer Louis C. Hershfield in the 1960s, relies on historical precipitation data to estimate the PMP. This method involves analyzing long-term precipitation records from a specific region and identifying the most extreme storms that have occurred in the past. By applying statistical techniques, such as probability distributions and frequency analysis, the PMP is estimated based on the assumption that extreme events in the future will resemble those observed in the past. The statistical approach considers factors such as the maximum rainfall intensities, the duration of the storm event, and the size of the watershed under consideration. It provides a practical and relatively straightforward way of estimating the PMP, especially in regions where limited meteorological data is available. However, it does not explicitly consider the underlying meteorological mechanisms responsible for extreme precipitation events.

The Hershfield method was conducted by implementing the following steps using the information from NASA Earth Exchange Global Daily Downscaled Projection (NEX-GDDP) project dataset:

1. Bias correction of data from global climate models outputs for every 30-year period.
2. A rate of change over baseline (rate of change) was calculated for each 30-year period, for each model and SSP as shown by the following equation:

$$PMP^{fut} = PMP^{hist}\left(1 + \frac{PMP^{fut}_{Hershfield} - PMP^{base}_{Hershfield}}{PMP^{base}_{Hershfield}}\right) = PMP^{hist}(1 + ROC)$$

4.4.2 Meteorological Method

The meteorological approach to estimating the PMP, often referred to as moisture maximization, takes into account the atmospheric conditions that could potentially lead to extreme precipitation events. This method is based on the understanding that the maximum possible rainfall is primarily determined by the availability of moisture in the atmosphere and the mechanisms that can cause it to be released. In the moisture maximization approach, meteorological models are used to simulate hypothetical extreme weather scenarios. These models incorporate various atmospheric variables such as temperature, humidity, wind patterns, and atmospheric stability. By maximizing the available moisture and assuming favorable atmospheric conditions for precipitation, the models estimate the upper limit of precipitation that could occur.

The moisture maximization approach provides a more physically based estimation of the PMP by considering the underlying meteorological processes. It is particularly useful in regions where detailed meteorological data and sophisticated modeling techniques are available. However, it requires more expertise and resources compared to the statistical approach.

The moisture maximization method estimates the PMP according to the following equation:

$$PMP = P_s \frac{W_{max}}{W_{storm}}$$

Where P_s is the observed precipitation for a large storm, W_{max} is the maximum precipitation water at that same time of year and location, and W_{storm} is the precipitable water of the observed storm. As W_{max} is the maximum precipitable water, it can be estimated as the 12-hour persistent dew-point temperature at 1000-hPa (WMO, 2009).

Rouhani and Leconte (Rouhani, 2016) as well as WMO (WMO, 2009), suggest using the 1:100 years 12-hour persistent dew-point temperature at 1000-hPa as representative for the maximum amount of water, instead of the maximum 12-hour persistent dew-point temperature at 1000-hPa. Variations in PMP for climate change analysis can then be explained as changes associated to W_{max}, based on the different GCMs and scenarios, as presented in the following equation:

$$PMP^{fut} = PMP^{hist} \frac{W_{max}^{fut}}{W_{max}^{base}} = PMP^{hist} \left(1 + \frac{W_{1:100yr}^{fut} - W_{1:100yr}^{base}}{W_{1:100yr}^{base}}\right) = PMP^{hist}(1 + ROC)$$

The following steps were conducted using the information from NEX-GDDP project dataset:

1. All available NEX-GDDP records for relative humidity and daily mean temperature were collected at the site grid.
2. From these two meteorological parameters, the Clausius-Clapeyron equation was used to estimate daily dew-point temperature for each GCM and SSP scenario.
3. All dew-point temperature records were bias-corrected using quantile delta mapping, considering the hourly/daily dew-point temperature synthetic timeseries from the baseline study (SRK, 2025) for the Site.

4. Using ERA5 data as representative of the site and mentioned is this report as observed data", the maximum-per-year persistent 12-hour dew-point temperature was estimated and related with every GCM and future periods, following an equidistance quantile matching method as described by Shardong et al. (Shardong A, 2022). The 12 hour-persistent dew-point temperature for 1:100 years was used instead of the total precipitation for different return periods. This procedure was implemented with a GEV probability distribution using L-moment methodology (Shardong A, 2022).
5. For every GCM and every future/baseline period, the maximum 1:100 years 12-hour dew point was transformed into maximum precipitable water, based on Annex I from WMO (WMO, 2009); this evaluation was done applying a quadratic polynomial expression considering site elevation as a proxy for atmospheric pressure.
6. Overall maximum precipitable water (W_{max}) estimations were presented for all periods and SSPs as "rates of change."

5 Climate Change Analysis Results

5.1 Mean Annual Air Temperature

Mean annual air temperature (MAAT) is presented as anomaly (change) in degrees (°C) from baseline. This variable increases for all the scenarios evaluated. **Table 5.1** presents the MAAT HDI and median ROC values per period (average between SSP2-4.5 and SSP5-8.5 results). By 2040 HDI values range from 0.4°C to 2.5°C increase for all scenarios.

Table 5.1: Delta Mean Annual Air Temperature (MAAT) HDI Values [°C]

Period	Highest Density Interval (HDI)				
	90%L	75%L	Median	75%H	90%H
2015-2040	0.6	0.9	1.4	1.9	2.4
2041-2070	2.1	2.3	3.0	3.7	4.6
2071-2100	3.5	4.2	4.9	6.7	7.5

Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Climate_Change/03_Reports/climate_change_rev4.qmd

Notes: The deltas presented in this table are the average of the results obtained for GCMs within the SSP2-4.5 and SSP5-8.5 scenarios.

Ouranos portraits (Ouranos 2025) were consulted to benchmark these forecasts. The obtained values are presented in **Table 5.2**. These results were found generally similar to the SRK analysis, considering the differences in approach between the two (different baseline period and percentiles versus HDI).

Table 5.2: Delta Mean Annual Air Temperature (MAAT) Percentiles from Ouranos [°C]

Period	Percentiles		
	10%	50%	90%
2011-2040	0.6	1.1	1.5
2041-2070	2.0	2.7	3.5
2071-2100	3.8	4.4	5.8

Sources: https://portraits.ouranos.ca/

Notes: The deltas presented in this table are the average of the results presented for the moderate (SSP2-4.5) and very high (SSP5-8.5) scenarios, compared to a 1990-2020 baseline.

Based on this review, the climate change MAAT delta results developed by SRK and presented in **Table 5.1** are considered validated for this area of Canada.

5.2 Mean Annual Precipitation

Mean annual total precipitation for future periods is presented as rate of change. **Table 5.3** presents the annual precipitation HDI and median ROC values per period (average between SSP2-4.5 and SSP5-8.5 results). The rates of change for each SSP display similar trends.

HDI rates of change for all SSPs tend to display increases in mean annual precipitation, except for lower HDI boundaries in the short term (2030s) where MAP remains constant. By 2040, the mean annual precipitation would be increasing of around 5% according to the median of all SSP scenarios.

Table 5.3: ROC Mean Annual Precipitation (MAP) HDI Values [%]

Period	Highest Density Interval (HDI)				
	90%L	75%L	Median	75%H	90%H
2015-2040	-1%	0%	5%	7%	9%
2041-2070	5%	7%	9%	14%	15%
2071-2100	7%	9%	13%	18%	21%

Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Climate_Change/03_Reports/climate_change_rev4.qmd

Notes: The ROC presented in this table are the average of the results obtained for GCMs within the SSP2-4.5 and SSP5-8.5 scenarios.

Ouranos portraits (Ouranos 2025) were consulted to benchmark these forecasts. The obtained values are presented in **Table 5.4**. These results were found to match the SRK analysis, considering the differences in approach between the two (different baseline period and percentiles versus HDI).

Table 5.4: ROC Mean Annual Precipitation (MAP) Percentiles from Ouranos [%]

Period	Percentiles		
	10%	50%	90%
2011-2040	0%	3%	7%
2041-2070	5%	9%	13%
2071-2100	7%	11%	19%

Sources: https://portraits.ouranos.ca/

Notes: The deltas presented in this table are the average of the results presented for the moderate (SSP2-4.5) and very high (SSP5-8.5) scenarios, compared to a 1990-2020 baseline.

Based on this review, the climate change MAP rate of change results developed by SRK and presented in **Table 5.3** are considered validated for this area of Canada.

5.3 Mean Annual Potential Evaporation

The Hargreaves equation (Hargreaves, 1985) was selected to calculate potential evaporation under climate change due to its simplicity, as it requires only minimum, maximum, and mean air temperatures, as well as extraterrestrial radiation. Furthermore, the Food and Agriculture Organization (Allen, 1998) suggests that the Hargreaves method is appropriate for the determination of potential evaporation. This formulation was originally conceived to calculate potential evapotranspiration, but potential evapotranspiration and potential evaporation are often comparable. This method was one of the methods used to determine baseline evaporation and performed similarly to evaporation calculation methods (SRK, 2025). Potential evaporation is reported in this section, but these results would also apply to potential evapotranspiration.

The mean annual potential evaporation HDI and median ROC values per period (average between SSP2-4.5 and SSP5-8.5 results) are presented in **Table 5.5**.

Table 5.5: ROC Mean Annual Potential Evaporation (MAPE) HDI Values [%]

Period	Highest Density Interval (HDI)				
	90%L	75%L	Median	75%H	90%H
2015-2040	-1%	1%	5%	10%	13%
2041-2070	5%	7%	12%	21%	22%
2071-2100	9%	9%	19%	32%	38%

Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Climate_Change/03_Reports/climate_change_rev4.qmd

Notes: The ROC presented in this table are the average of the results obtained for GCMs within the SSP2-4.5 and SSP5-8.5 scenarios.

5.4 Precipitation Intensity-Duration-Frequency

The expanded IDF tables under climate change shows the rate of change when compared with historical conditions (SRK, 2025). The rate of change median and HDI values were calculated for SSP1-2.6, SSP2-4.5 and SSP 5-8.5 climate scenarios. **Table 5.6**, **Table 5.7**, and **Table 5.8** present the average of SSP2-4.5 and SSP5-8.5 respective median IDF rates of change for the 2015-2040 period, 2041-2070 period, and 2071-2100 period respectively.

Table 5.6: Expanded IDF and PDF Median Rates of Change [%] for the 2015-2040 Period

Duration	Return Period [years]											
	2	5	10	20	25	50	100	200	500	1000	2000	10000
5min	7%	8%	9%	9%	9%	7%	6%	6%	6%	6%	6%	6%
10min	7%	8%	9%	9%	8%	6%	5%	5%	5%	5%	5%	5%
15min	7%	8%	9%	9%	8%	6%	5%	5%	5%	5%	5%	5%
30min	7%	8%	8%	7%	7%	6%	5%	5%	5%	5%	5%	5%
1hr	8%	7%	7%	6%	6%	5%	3%	3%	3%	3%	3%	3%
2hr	8%	7%	7%	6%	6%	4%	2%	2%	2%	2%	2%	2%
3hr	8%	8%	7%	7%	6%	5%	3%	3%	3%	3%	3%	3%
6hr	7%	8%	8%	8%	7%	6%	5%	5%	5%	5%	5%	5%
12hr	7%	8%	9%	9%	8%	6%	5%	5%	5%	5%	5%	5%
24hr	7%	8%	9%	9%	9%	7%	6%	6%	6%	6%	6%	6%
48hr	7%	8%	9%	9%	9%	7%	6%	6%	6%	6%	6%	6%
72hr	7%	8%	9%	9%	9%	7%	6%	6%	6%	6%	6%	6%

Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Climate_Change/03_Reports/climate_change_rev4.qmd

Table 5.7: Expanded IDF and PDF Median Rates of Change [%]for the 2041-2070 Period

Duration	Return Period [years]											
	2	5	10	20	25	50	100	200	500	1000	2000	10000
5min	14%	13%	14%	14%	14%	14%	15%	15%	15%	15%	15%	15%
10min	14%	12%	14%	13%	12%	12%	13%	13%	13%	13%	13%	13%
15min	14%	12%	13%	12%	12%	12%	13%	13%	13%	13%	13%	13%
30min	14%	12%	12%	11%	10%	10%	11%	11%	11%	11%	11%	11%
1hr	14%	11%	12%	11%	9%	8%	8%	8%	8%	8%	8%	8%
2hr	14%	11%	11%	10%	9%	8%	8%	8%	8%	8%	8%	8%
3hr	14%	11%	12%	11%	10%	9%	9%	9%	9%	9%	9%	9%
6hr	14%	12%	13%	12%	11%	11%	12%	12%	12%	12%	12%	12%
12hr	14%	12%	13%	12%	12%	12%	14%	14%	14%	14%	14%	14%
24hr	14%	13%	14%	14%	13%	13%	14%	14%	14%	14%	14%	14%
48hr	14%	13%	14%	14%	13%	13%	14%	14%	14%	14%	14%	14%
72hr	14%	13%	14%	14%	13%	13%	14%	14%	14%	14%	14%	14%

Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Climate_Change/03_Reports/climate_change_rev4.qmd

Table 5.8: Expanded IDF and PDF Median Rates of Change [%]for the 2071-2100 Period

Duration	Return Period [years]											
	2	5	10	20	25	50	100	200	500	1000	2000	10000
5min	20%	22%	23%	23%	23%	25%	26%	26%	26%	26%	26%	26%
10min	20%	22%	22%	22%	22%	22%	24%	24%	24%	24%	24%	24%
15min	21%	22%	21%	21%	21%	22%	23%	23%	23%	23%	23%	23%
30min	21%	21%	20%	20%	20%	19%	19%	19%	19%	19%	19%	19%
1hr	21%	21%	20%	19%	19%	18%	17%	17%	17%	17%	17%	17%
2hr	21%	21%	20%	19%	18%	17%	17%	17%	17%	17%	17%	17%
3hr	21%	21%	20%	19%	19%	18%	18%	18%	18%	18%	18%	18%
6hr	21%	21%	21%	21%	20%	21%	21%	21%	21%	21%	21%	21%
12hr	21%	22%	21%	21%	21%	22%	24%	24%	24%	24%	24%	24%
24hr	20%	22%	22%	22%	23%	24%	25%	25%	25%	25%	25%	25%
48hr	20%	22%	22%	22%	23%	24%	25%	25%	25%	25%	25%	25%
72hr	20%	22%	22%	22%	23%	24%	25%	25%	25%	25%	25%	25%

Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Climate_Change/03_Reports/climate_change_rev4.qmd

5.5 Probable Maximum Precipitation

Best practice recommends that the PMP estimates be adjusted based on climate change projections, however there is a lack of consensus on the specific methodology to use. As a reference two methodologies are implemented and presented in the next sub-sections.

5.5.1 Statistical Method Rates of change

The average rates of change resulting from the statistical Hershfield method for SSP2-4.5 and SSP5-8.5 are presented in **Table 5.9** for each projection period. All GCM rate of change results, including the median, are presented graphically in **Appendix B**. In most cases, the PMP is projected to increase, relative to current (baseline) conditions.

Table 5.9: ROC of the 24-hour PMP obtained via the Statistical Method [%]

Period	Highest Density Interval (HDI)				
	90%L	75%L	Median	75%H	90%H
2015-2040	-16%	1%	21%	75%	80%
2041-2070	6%	4%	41%	67%	98%
2071-2100	1%	-1%	47%	70%	93%

Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Climate_Change/03_Reports/climate_change_rev4.qmd

Notes: The ROC presented in this table are the average of the results obtained for GCMs within the SSP2-4.5 and SSP5-8.5 scenarios.

Outcomes from this method are very variable and suggest extreme precipitation events simulated with the available GCMs for the site location present inconsistent trends across models. Note that obtained rates of change show a substantial jump from baseline conditions to the 2015-2040 period, and then show little incremental progression between periods.

5.5.2 Meteorological Method Rates of change

The median rate of change results, using the meteorological moisture maximization method for SSP2-4.5 and SSP5-8.5 are presented in **Table 5.10** for each projection period. All GCM rate of change results, including the median, are presented graphically in **Appendix A**. Most GCM results predict an increase in the PMP over baseline conditions.

Table 5.10: ROC of the 24-hour PMP obtained via the Meteorological Method [%]

Period	Highest Density Interval (HDI)				
	90%L	75%L	Median	75%H	90%H
2015-2040	-2%	1%	13%	22%	23%
2041-2070	2%	8%	19%	30%	30%
2071-2100	6%	9%	27%	37%	51%

Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR003306/Internal/Task%20400-02%20Climate%20and%20Hydraulic%20Assessment/NAPR003306_NMG_Matawinie_Climate_Change/03_Reports/climate_change_rev4.qmd

Notes: The ROC presented in this table are the average of the results obtained for GCMs within the SSP2-4.5 and SSP5-8.5 scenarios.

Outcomes from this method showcase a better transition between baseline and forecast periods, and reduced ROC amplitude across models. SRK recommends using ROC obtained from the meteorological moisture maximization method presented in **Table 5.10** for PMP considerations under climate change.

5.5.3 Benchmarking

The results compiled in this memorandum for the Bouchard-Hébert mine site were compared to a study of probable maximum flood estimates and climate change completed in 2017 (Clavet-Gaumont et. al.) for multiple watersheds across Manitoba, Ontario, and Quebec. As part of this work, PMP depths were also estimated under climate change conditions, including two watersheds within 300 km of the site, Kenogami (Quebec) and Saguenay (Quebec).

The 2017 study utilized the CMIP3 climate change projections, which have since been superseded by CMIP6. However, the overall rate of change results presented in the 2017 study are similar to the findings from the analysis described above using CMIP6 for the meteorological method. **Table 5.11** presents a summary of these results, which shows that the range in PMP rates of change between the two nearby watersheds was 19% and 18%, while the median rate of change estimated by SRK for the site for the corresponding period is 19%.

Table 5.11: Benchmark of PMP results in the area

Watershed	24 hr - PMP (Clavet-Gaumont, 2017)[1]	24 hr - PMP (Current Analysis)[2]
Kenogami	19%	19%
Saguenay	18%	

Sources: Compiled from text.

Notes:

[1] Rate of change results reflect the median of all evaluated GCM results from CMIP3, with a baseline period from 1971 to 2000 and a projection period from 2041 to 2070.

[2] Rate of change results reflect the median of all evaluated GCM results from CMIP6 using the meteorological moisture maximization method, a baseline period of 1985 to 2014, a projection period from 2041 to 2070 and both the SSP2-4.5 and SSP5-8.5 emission scenarios.

Based on this review, the climate change PMP rate of change results developed by SRK and presented in **Table 5.10**, are considered to be within an acceptable range for this area of Canada.

6 Summary

This report documents the implementation of a general climate change assessment for Matawinie. The assessment was based on 35 global circulation models (GCMs, or climate change models) provided in the IPCC's Sixth Assessment Report (AR6) (2021). These GCMs models were combined with four emission (or warming) scenarios to produce climate projections until year 2100. The four emissions (or warming) scenarios considered are, in order of increasing projected warming: SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5. The models used in this assessment are listed in **Table A 2**.

Historical baseline conditions were defined from observations and synthetic regional datasets with records spanning from 1985 to 2014; this work is summarized in SRK's baseline climate analysis (SRK, 2025). The projected values are compared to these baseline historical conditions, with the differences (or anomalies) presented as rate of change (as percent difference) from baseline conditions. These projections were "adjusted" with respect to historical conditions.

The model results were grouped into three overlapping periods: 1) from 2015 to 2040; (2) from 2041 to 2070; and (3) from 2071 to 2100; these periods are referred to as the 2030s, 2060s, and 2090s, respectively.

This report presents rate of change results as an average of scenarios SSP2-4.5 and SSP5-8.5 for brevity. The average of scenarios SSP2-4.5 and SSP5-8.5 was used to summarize the results providing a consistent "middle-upper" pathway. Depending on risk tolerance associated to each particular project or decision, it is recommended for NMG to consider all the results presented in **Appendix B**.

The average of scenarios SSP2-4.5 and SSP5-8.5 medians for meteorological parameters for the 2030s (up to Year 2040) are as follows:

- **Mean annual values**:
  - The mean annual air temperature is expected to increase by +1.4°C by 2040.
  - The mean annual precipitation is expected to increase by up to 5% by 2040.
  - The mean annual potential evaporation is expected to increase by 5% by 2040.
- **Maximum precipitation 5min to 3 days**: the rate of change varies from 5 minutes to 3 days; however, an overall increase up to 9% is expected by 2040 for all durations and return periods.
- **Probable maximum precipitation**: two methodologies were presented: Hershfield and moisture maximization. The moisture maximization method is considered the most reliable one. It suggests an increase of 13% over baseline probable maximum precipitation by 2100.

All the site GCM records are available and can be used for other purposes such as local water balance estimations and for water management requirements.

These projected values are based on the most recent models provided in the IPCC's AR6; it is recommended to update this report every five to 10 years as new information becomes available.

Closure

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

References

Alain N. Rousseau, Iris M. Klein, Daphné Freudiger, Patrick Gagnon, Anne Frigon, Claudie Ratté-Fortin 2014, Development of a methodology to evaluate probable maximum precipitation (PMP) under changing climate conditions: Application to southern Quebec, Canada, Journal of Hydrology, Volume 519, Part D, Pages 3094-3109, ISSN 0022-1694, https://doi.org/10.1016/j.jhydrol.2014.10.053.

Bourdeau-Goulet, S.-C., & Hassanzadeh, E. (2021). Comparisons Between CMIP5 and CMIP6 Models: Simulations of Climate Indices Influencing Food Security, Infrastructure Resilience, and Human Health in Canada. *Earth's Future, 9*(5). doi:10.1029/2021EF001995

Eyring et al. (2016)*., Bony, S., Meehl, G. A., Senior, C. A., Stevens, B., Stouffer, R. J., and Taylor, K. E.Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization, Geosci. Model Dev., 9, 1937-1958, doi:10.5194/g.*

Hausfather, Z., & Peters, G. P. (2020). Emissions – the “business as usual” story is misleading. Nature, 577(7792), 618–620. https://doi.org/10.1038/d41586-020-00177-3

Hershfiel, D. (1965). *Method for estimating probable maximum precipitation.*

Jacinthe Clavet-Gaumont, David Huard, Anne Frigon, Kristina Koenig, Phillip Slota, Alain Rousseau, Iris Klein, Nathalie Thiémonge, Fanny Houdré, John Perdikaris, Richard Turcotte, Julie Lafleur, Bruno Larouche, 2017, Probable maximum flood in a changing climate: An overview for Canadian basins, Journal of Hydrology: Regional Studies, Volume 13, 2017,Pages 11-25, ISSN 2214-5818

Laio, F., Di Baldassarre, G., & Montanari, A. (2009). Model selection techniques for the frequency analysis of hydrological extremes. *Water Resources Research*.

Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S. L., Pean, C., Berger, S., Zhou, B. (. (2021). *Climate Change 2021: The Physical Science Basis Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press.

Meinshausen, M., Zebedee, N. R., Lewis, J., Gidden, M. J., Vogel, E., Freund, M., Wang, R. H. (2020). The shared socio-economic pathway (SSP) greenhouse gas concentrations and their extensions to 2500. *Geoscientific Model Development, 13*, 3571-3605. doi:10.5194/gmd-13-3571-2020

Ministère de l’Énergie et des Ressources naturelles, 2017, Guide De Préparation Du Plan De Réaménagement Et De Restauration Des Sites Miniers Au Québec

Muñoz Sabater, J. (2019). E*RA5-Land hourly data from 1981 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). (Accessed on 2022-September>), 10.24381/cds.e2161bac.*

R Core Team. (2022). *R: A language and environment for statistical computing.* Vienna, Austria: R Foundation for Statistical Computing.

Rouhani & Leconte. (2016). *A novel method to estimate the maximization ratio of the Probable Maximum Precipitation (PMP) using regional climate model output.*

Sarkar, S., & Maity, R. (2020). Increase in probable maximum precipitation in a changing climate over India. *Journal of Hydrology*.

SRK Consulting Canada Inc. (2023) Precipitation parameters correction due to orographic effect. Memo prepared for NMG. October 24, 2023.

SRK Consulting Canada Inc. (2025) NMG Matawinie Baseline Climate Analysis. Report prepared for NMG. February 17, 2025.

WMO. (2009). *(World Meteorological Organization). Manual on Estimation of Probable Maximum Precipitation (PMP). 3rd ed. WMO-No. 1045. Geneva, Switzerland: WMO.*

Appendix A Detailed Description of the SSPs and GCMs

Enclosed:

- Table A 1: Summary of SSP narratives.
- Table A 2: Global Climate Models (GCM) considered within Coupled Model Intercomparison Project Phase 6 (CMIP6)

Table A 1: Summary of SSP Narratives

SSP scenario	Description
SSP1	**Sustainability – Taking the Green Road** (Low challenges to mitigation and adaptation) *The world shifts gradually, but pervasively, toward a more sustainable path, emphasising more inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves, educational and health investments accelerate the demographic transition, and the emphasis on economic growth shifts toward a broader emphasis on human well-being. Driven by an increasing commitment to achieving development goals, inequality is reduced both across and within countries. Consumption is oriented toward low material growth and lower resource and energy intensity.*
SSP2	**Middle of the Road** (Medium challenges to mitigation and adaptation) *The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns. Development and income growth proceeds unevenly, with some countries making relatively good progress while others fall short of expectations. Global and national institutions work toward but make slow progress in achieving sustainable development goals. Environmental systems experience degradation, although there are some improvements and overall the intensity of resource and energy use declines. Global population growth is moderate and levels off in the second half of the century. Income inequality persists or improves only slowly and challenges to reducing vulnerability to societal and environmental changes remain.*
SSP3	**Regional Rivalry** – A Rocky Road (High challenges to mitigation and adaptation) *A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues. Policies shift over time to become increasingly oriented toward national and regional security issues. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time. Population growth is low in industrialised and high in developing countries. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions.*
SSP4	**Inequality – A Road Divided** (Low challenges to mitigation, high challenges to adaptation) *Highly unequal investments in human capital, combined with increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries. Over time, a gap widens between an internationally-connected society that contributes to knowledge- and capital-intensive sectors of the global economy, and a fragmented collection of lower-income, poorly educated societies that work in a labor intensive, low-tech economy. Social cohesion degrades and conflict and unrest become increasingly common. Technology development is high in the high-tech economy and sectors. The globally connected energy sector diversifies, with investments in both carbon-intensive fuels like coal and unconventional oil, but also low-carbon energy sources. Environmental policies focus on local issues around middle- and high-income areas.*
SSP5	**Fossil-fuelled Development** – Taking the Highway (High challenges to mitigation, low challenges to adaptation) *This world places increasing faith in competitive markets, innovation and participatory societies to produce rapid technological progress and development of human capital as the path to sustainable development. Global markets are increasingly integrated. There are also strong investments in health, education, and institutions to enhance human and social capital. At the same time, the push for economic and social development is coupled with the exploitation of abundant fossil fuel resources and the adoption of resource and energy intensive lifestyles around the world. All these factors lead to rapid growth of the global economy, while global population peaks and declines in the 21st century. Local environmental problems like air pollution are successfully managed. There is faith in the ability to effectively manage social and ecological systems, including by geo-engineering if necessary.*

Table A 2: Global Climate Models (GCM) considered within Coupled Model Intercomparison Project Phase 6 (CMIP6)

Climate Institute/Centre	Country	GMC Model Name
Beijing Climate Centre	China	BCC-CSM2-MR
Canadian Centre for Climate Modelling and Analysis	Canada	CanESM2
Centre National de Recherches Météorologiques, Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique	France	CNRM-CM6-1
		CNRM-ESM2-1
Commonwealth Scientific and Industrial Research Organization/Bureau of Meteorology	Australia	ACCESS-CM2
		ACCESS-ESM1.5
Institute Pierre Simon Laplace	France	IPSL-CM6A-LR
Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology	Japan	MIROC-ES2L
		MIROC6
Max Planck Institute for Meteorology	Germany	MPI-ESM1-2-HR
		MPI-ESM1-2-LR
National Centre for Atmospheric Research	USA	CCSM2
		CESM2-WACCM
Geophysical Fluid Dynamics Laboratory	USA	GFDL-ESM4
		GFDL-CM4 (gr1)
		GFDL-CM4 (gr2)
EC-Earth consortium	European Union	EC-Earth3
		EC-Earth3-Veg-LR
Chinese Academy of Sciences	China	FGOALS-g3
The UK Earth System Modelling Project	UK	HadGEM3-GC31-LL
		HadGEM3-GC31-MM
		UKESM1-0-LL
Russian Academy of Sciences, Institute of Numerical Mathematics	Russia	INM-CM4-8
		INM-CM5-0
National Institute of Meteorological Sciences	Republic of Korea	KACE-1-0-G
Korea Institute of Ocean Science and Technology	Republic of Korea	KIOST-ESM
Meteorological Research Institute of the Japan Meteorological Agency	Japan	MRI-ESM2-0
Norwegian Climate Centre	Norway	NorESM2-LM
		NorESM2-MM
Research Center for Environmental Changes	Taiwan	TaiESM1
Euro-Mediterranean Center on Climate Change	Italy	CMCC-CM2-SR5
		CMCC-ESM2
NASA Goddard Institute for Space Studies	USA	GISS-E2-1-G
Nanjing University of Information Science and Technology	China	NESM3
Indian Institute of Tropical Meteorology	India	IITM-ESM

Appendix B Climate Change Analysis Code Output

Climate Change Assessment for NMG

CAPR003306 - NMG Matawinie Engineering Support 2024

Camilo Gallard Júlio Lôbo

February 28, 2025

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Chapter 1

Glossary

- **ECCC**: Environment and Climate Change Canada
- **ERA5**: Reanalysis tool developed by the European Centre for Medium-Range Weather Forecasts (**hersbach2020?**)
- **ERA5-Land**: Reanalysis tool based on ERA5 but for Land surfaces and a smaller grid, and developed by the European Centre for Medium-Range Weather Forecasts (**muñoz-sabater2021?**)
- **ET**: Evapotranspiration
- **MAAT**: Mean Annual Air Temperature
- **MAP**: Mean Annual Precipitation
- **NASA**: U.S. National Aeronautics and Space Administration
- **NMG**: Nouveau Monde Graphite
- **PCC**: Pearson Correlation Coefficient
- **PMP**: Probable Maximum Precipitation.
- **SRK**: SRK Consulting (Canada) Inc.
- **Tavg**: Mean or Average Air Temperature over a given temporal unit (day, month, year…)
- **Tmax**: Maximum Air Temperature over a given temporal unit (day, month, year…)
- **Tmin**: Minimum Air Temperature over a given temporal unit (day, month, year…)

Chapter 2

Site Location

The NMG Matawinie site is located in southern Quebec, 125 km north of Montreal. Site latitude is 46.63 degrees, and longitude is -73.97 degrees, at an elevation of 562 masl. These coordinates were selected to match the location of the meteorological station on site.

Chapter 3

Data

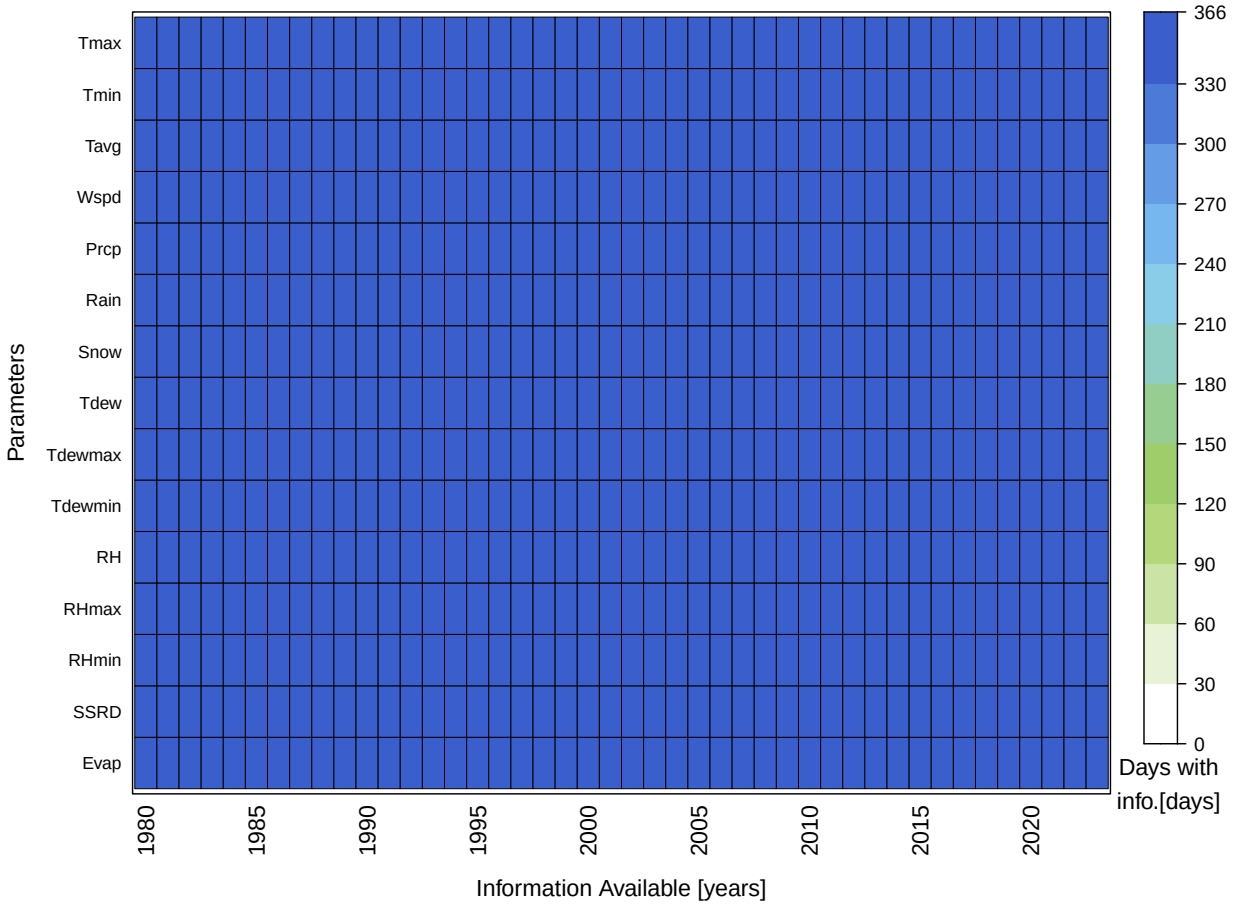
3.1 Site data

The baseline meteo has 9 variables:

- Precipitation [mm]
- Minimum, Average and Maximum daily Air temperature [DegC]
- Shortwave solar radiation [W/m2]
- Minimum, Minimum, Maximum daily relative humidity and Dew Point Temperature [%]
- Wind speed [m/s]
- (calculated) Average daily dewpoint temperature [DegC]
- (calculated) Monthly lake potential evaporation [mm]

The baseline period covers 1980 - 2023 for most variables, as shown below.

Gaps (last day of the year) in the baseline period were gap filled with the antecedent day, except for precipitation which was assumed to be 0.



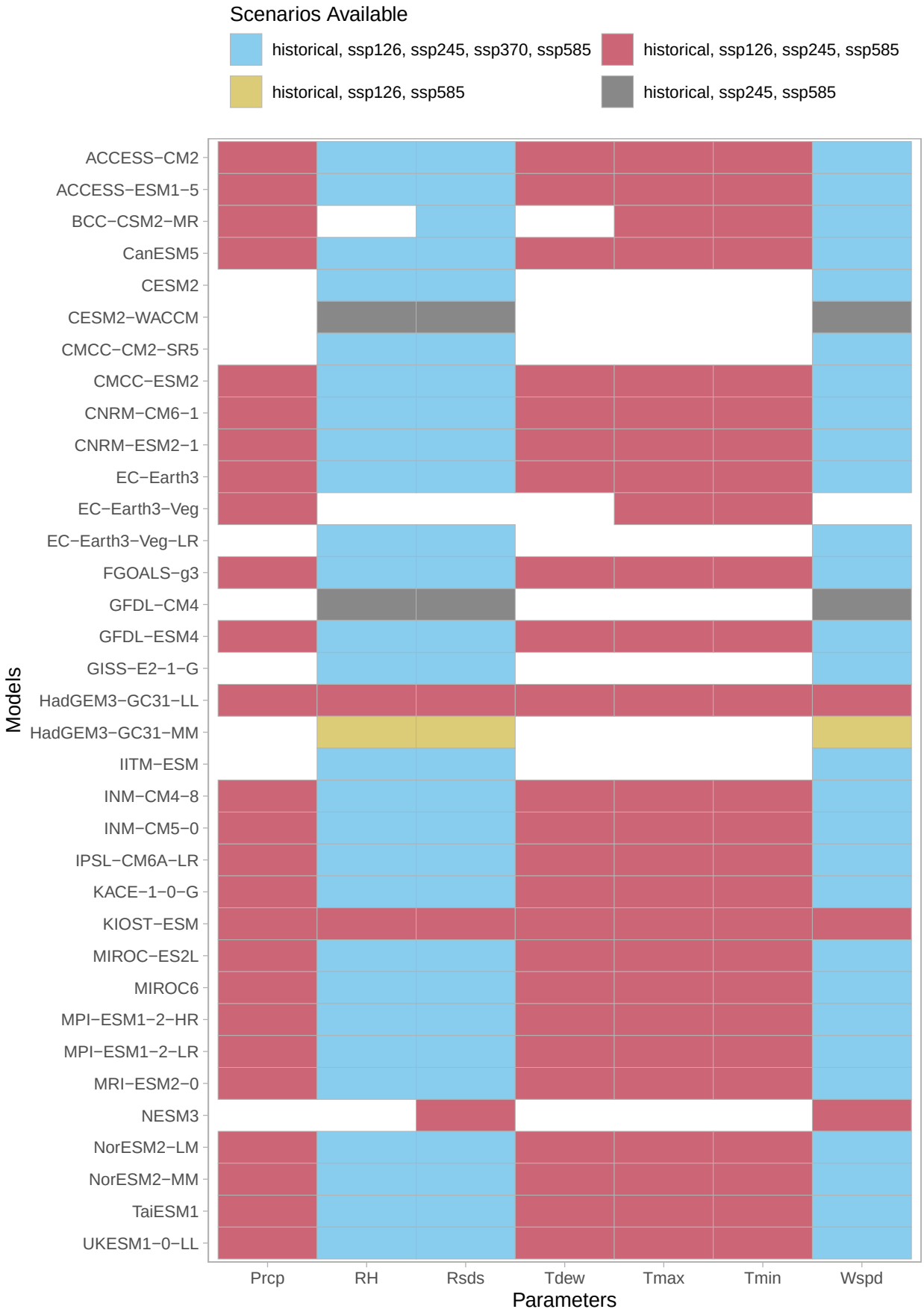
3.2 Climate change data

The code below reads the climate change projections for each parameter.

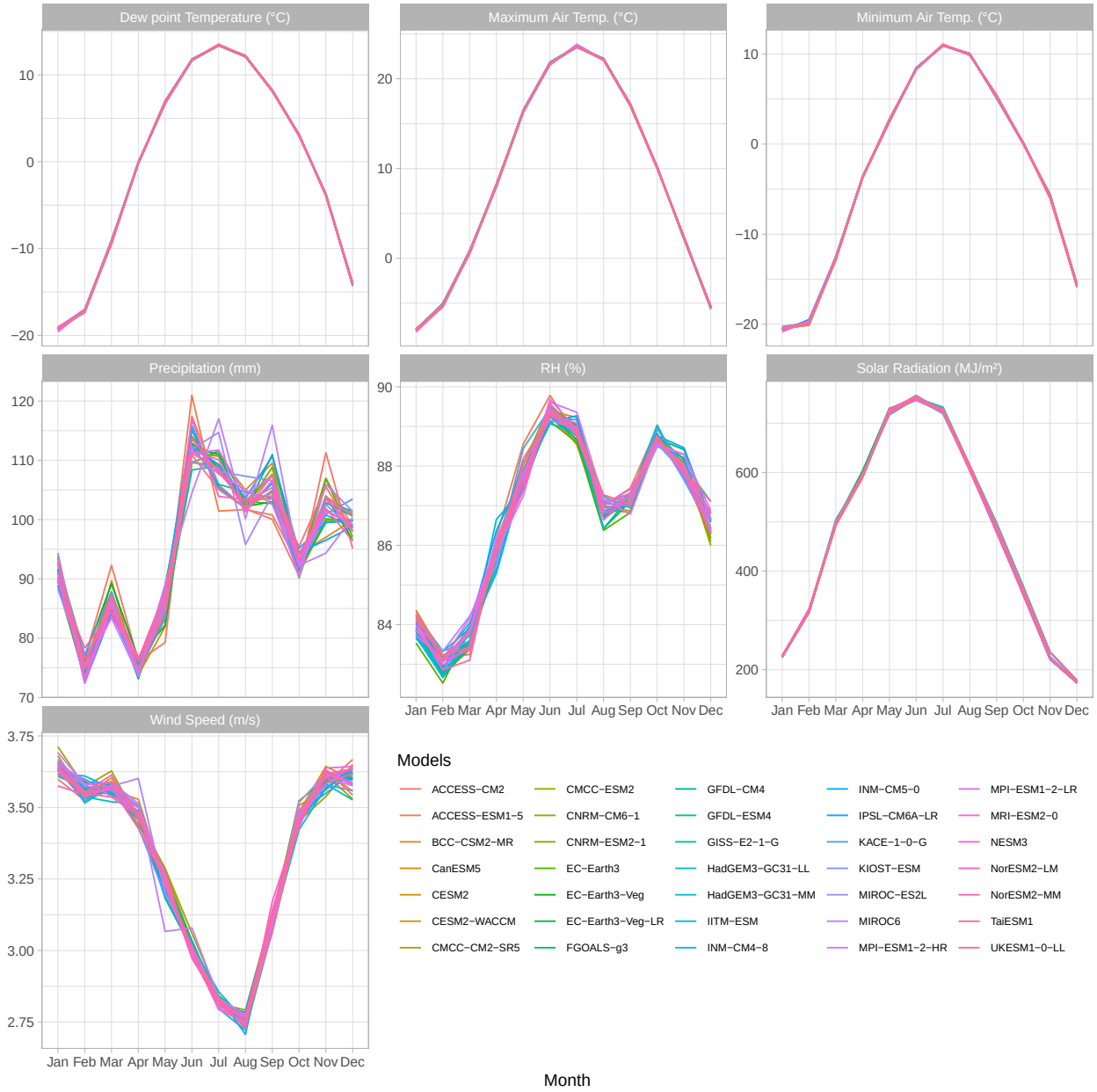
Missing data was observed in the climate change projections. This happens due to leap years, and in case of model HadGEM3-GC31-MM, it only has 360 days per year.

For gap filling (before any bias correction), the following procedure was followed:

- For precipitation, gaps were filled with 0.
- For other variables, gaps were filled with last non-missing record. This relies on the autocorrelation of time series (generally high for climate variables).
- Gaps were only filled in years with at least 350 days with information
- Tavg in the Baseline is the average between Tmax and Tmin. Since the GCMs do not have Tavg estimates, we first bias correct Tmax and Tmin to later calculate Tavg.


Scenarios Available
historical, ssp126, ssp245, ssp370, ssp585
historical, ssp126, ssp245, ssp585
historical, ssp126, ssp585
historical, ssp245, ssp585
Models
ACCESS−CM2
ACCESS−ESM1−5
BCC−CSM2−MR
CanESM5
CESM2
CESM2−WACCM
CMCC−CM2−SR5
CMCC−ESM2
CNRM−CM6−1
CNRM−ESM2−1
EC−Earth3
EC−Earth3−Veg
EC−Earth3−Veg−LR
FGOALS−g3
GFDL−CM4
GFDL−ESM4
GISS−E2−1−G
HadGEM3−GC31−LL
HadGEM3−GC31−MM
IITM−ESM
INM−CM4−8
INM−CM5−0
IPSL−CM6A−LR
KACE−1−0−G
KIOST−ESM
MIROC−ES2L
MIROC6
MPI−ESM1−2−HR
MPI−ESM1−2−LR
MRI−ESM2−0
NESM3
NorESM2−LM
NorESM2−MM
TaiESM1
UKESM1−0−LL
Prcp
RH
Rsds
Tdew
Tmax
Tmin
Wspd
Parameters

A total of 35 Climate Change models from CMIP6 were retrieved for this analysis. The climate change models have historical estimates in 1950 - 2014, and forecast estimates from 2015 - 2100. The figure below shows the monthly averages over the historical period.



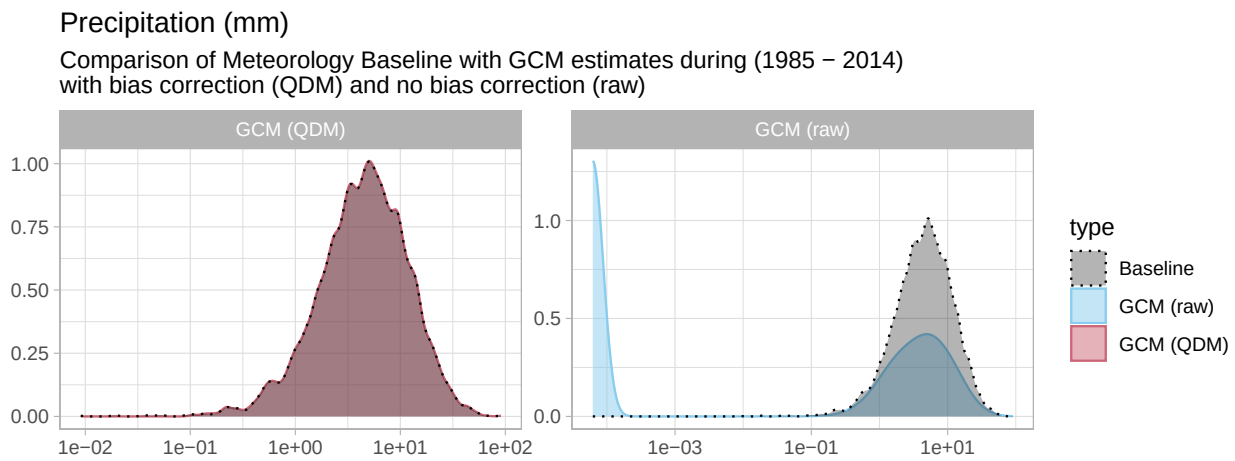
Chapter 4

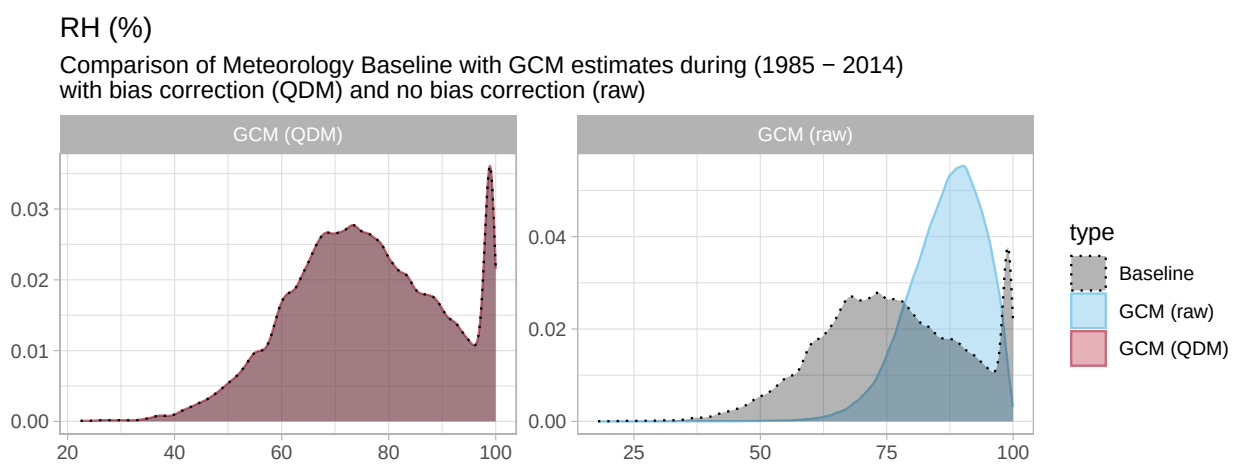
Bias correction

Bias correction is performed on a monthly basis using Quantile Delta Mapping.

Quantile Delta Mapping (QDM) was used to bias correct the climate change scenarios for each variable. QDM was applied per month due to seasonality effect among climate variables.

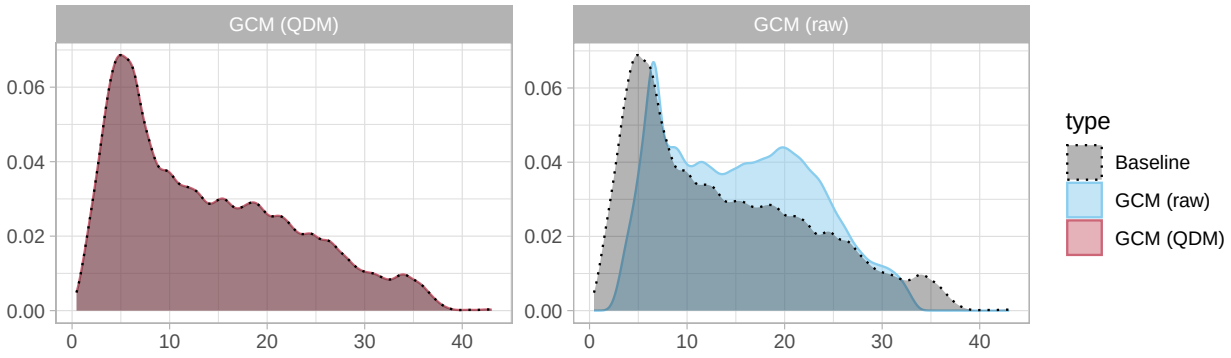
The bias correction period used was 1985-01-01, 2014-12-31.





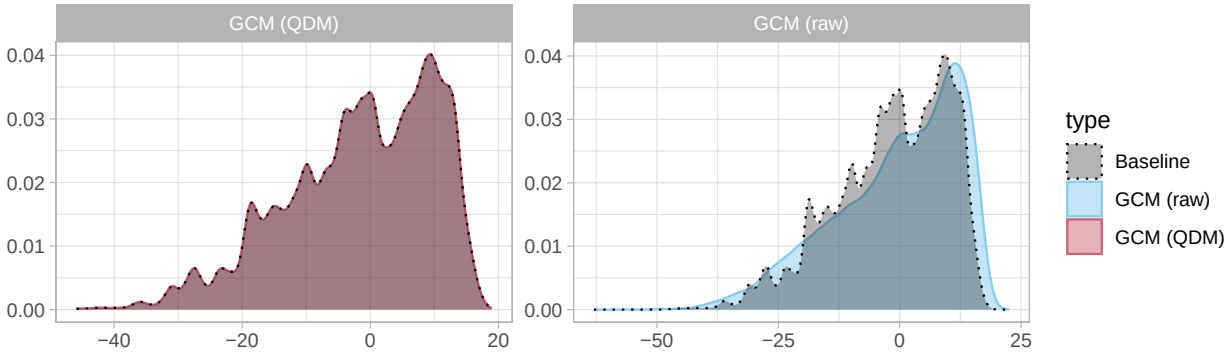
Solar Radiation (MJ/m²)

Comparison of Meteorology Baseline with GCM estimates during (1985 − 2014)
with bias correction (QDM) and no bias correction (raw)



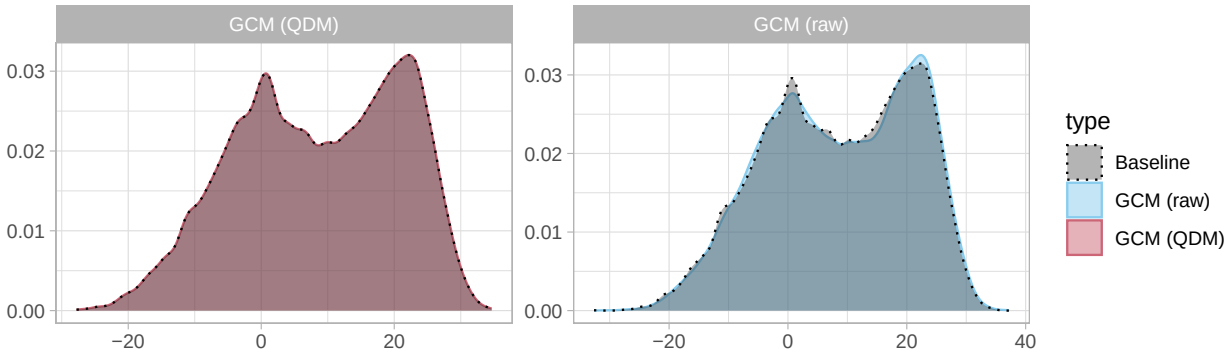
Dew point Temperature (°C)

Comparison of Meteorology Baseline with GCM estimates during (1985 − 2014)
with bias correction (QDM) and no bias correction (raw)



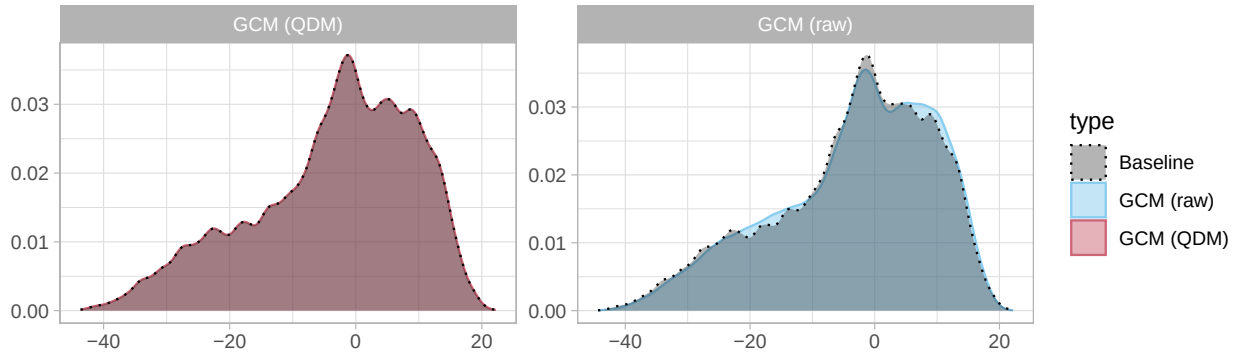
Maximum Air Temp. (°C)

Comparison of Meteorology Baseline with GCM estimates during (1985 − 2014)
with bias correction (QDM) and no bias correction (raw)



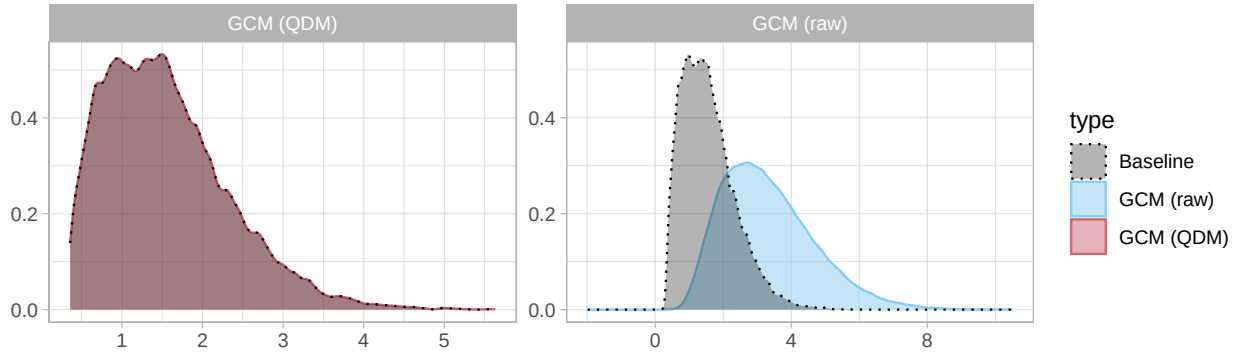
Minimum Air Temp. (°C)

Comparison of Meteorology Baseline with GCM estimates during (1985 − 2014)
with bias correction (QDM) and no bias correction (raw)



Wind Speed (m/s)

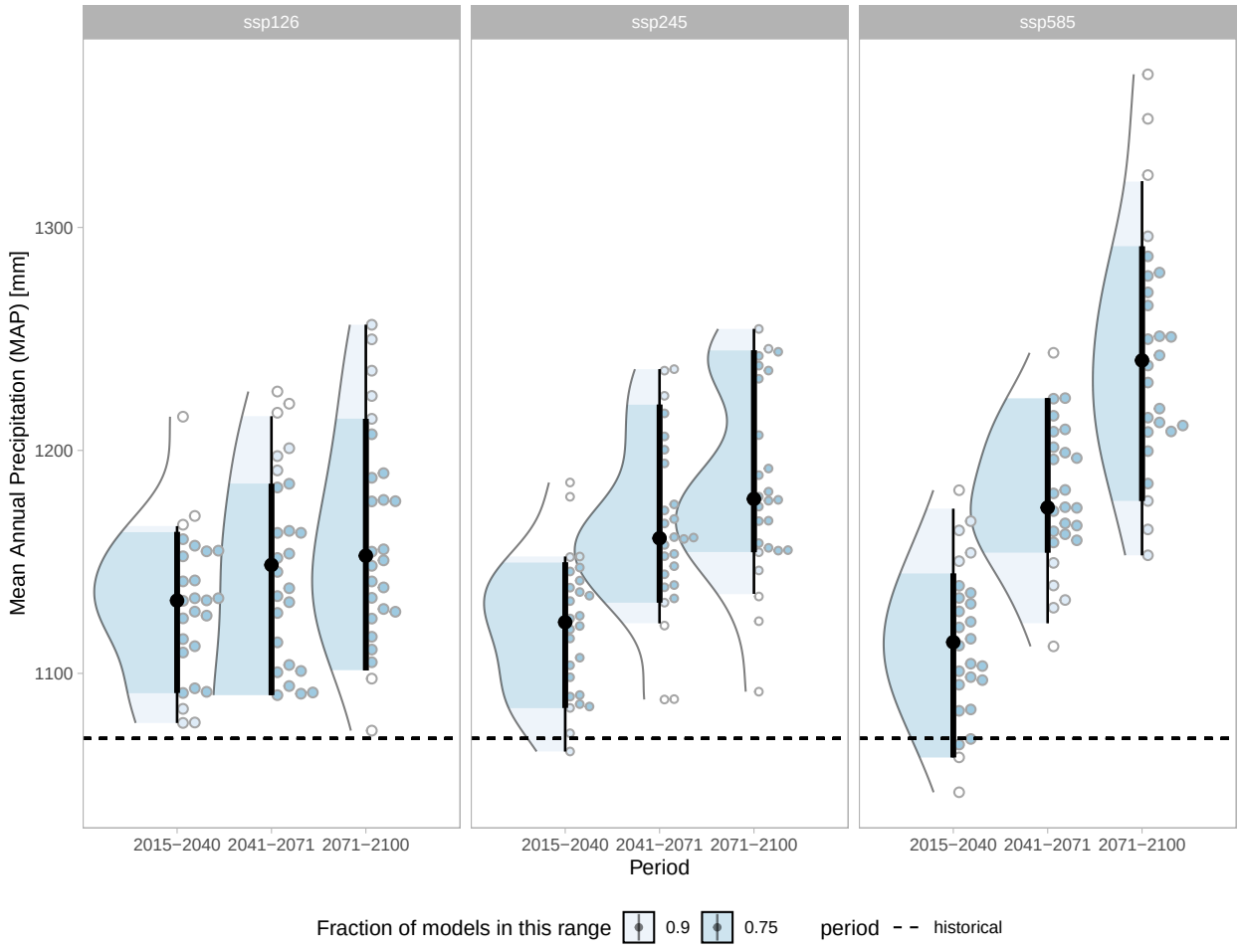
Comparison of Meteorology Baseline with GCM estimates during (1985 − 2014)
with bias correction (QDM) and no bias correction (raw)



Chapter 5

Mean Annual Values

5.1 MAP



Mean Annual Precipitation (MAP) [mm]

	HDI - Highest Density Interval				
period	90%L	75%L	median	75%H	90%H
ssp126					
2015-2040	1,078	1,091	1,133	1,160	1,167
2041-2071	1,090	1,090	1,149	1,185	1,217
2071-2100	1,105	1,105	1,153	1,214	1,256
ssp245					
2015-2040	1,065	1,085	1,123	1,147	1,152
2041-2071	1,121	1,121	1,161	1,206	1,236
2071-2100	1,134	1,154	1,178	1,244	1,254
ssp585					
2015-2040	1,062	1,062	1,114	1,139	1,168
2041-2071	1,129	1,159	1,174	1,223	1,223
2071-2100	1,153	1,177	1,240	1,287	1,323

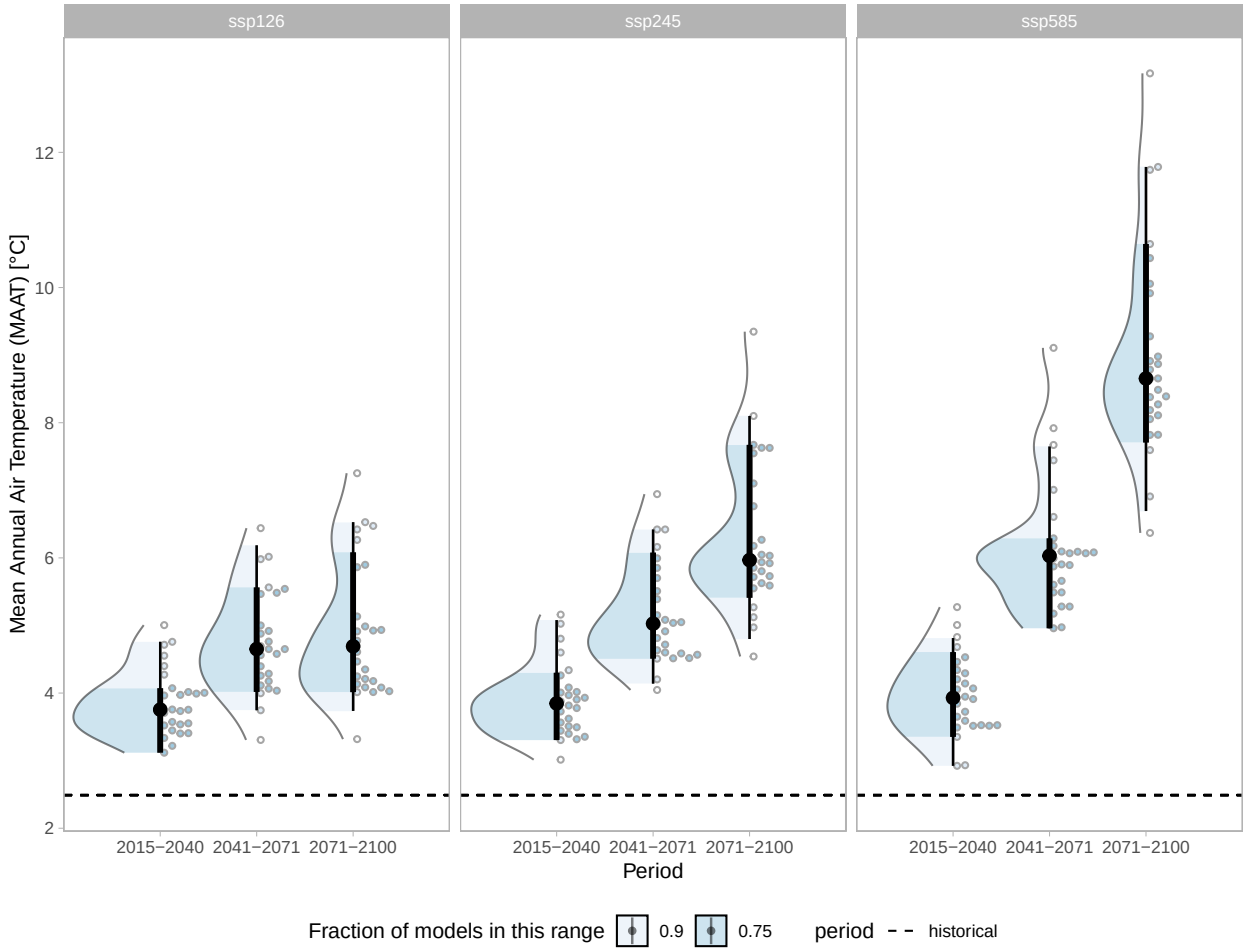
Historical value: 1071 mm

ROC Mean Annual Precipitation (MAP) [%]

	HDI - Highest Density Interval				
period	90%L	75%L	median	75%H	90%H
ssp126					
2015-2040	1%	2%	6%	8%	9%
2041-2071	2%	2%	7%	11%	14%
2071-2100	3%	3%	8%	13%	17%
ssp245					
2015-2040	-1%	1%	5%	7%	8%
2041-2071	5%	5%	8%	13%	15%
2071-2100	6%	8%	10%	16%	17%
ssp585					
2015-2040	-1%	-1%	4%	6%	9%
2041-2071	5%	8%	10%	14%	14%
2071-2100	8%	10%	16%	20%	24%

ROC[MAP] = MAP[projected] / MAP[historical] - 1

5.2 MAAT



5.3 MAE

The Hargreaves method (Hargreaves and Samani, 1985) is a temperature-based evapotranspiration method. The method is based on an empirical relationship where reference evapotranspiration was regressed with solar radiation and air temperature data. The regression was based on eight years of precision lysimeter observations for a grass reference crop in Davis, CA. The method has been validated for sites around the world (Hargreaves and Allen, 2003). The method is capable of capturing diurnal variation in potential evapotranspiration for simulation time steps less than 24 hours.

Potential evapotranspiration ETo is computed as (Hargreaves and Samani, 1985):

$$ETo = K * RS * (T + 17.8)$$

where K is a coefficient, RS is solar radiation, and T is mean daily temperature.

Mean Annual Air Temperature (MAAT) [°C]

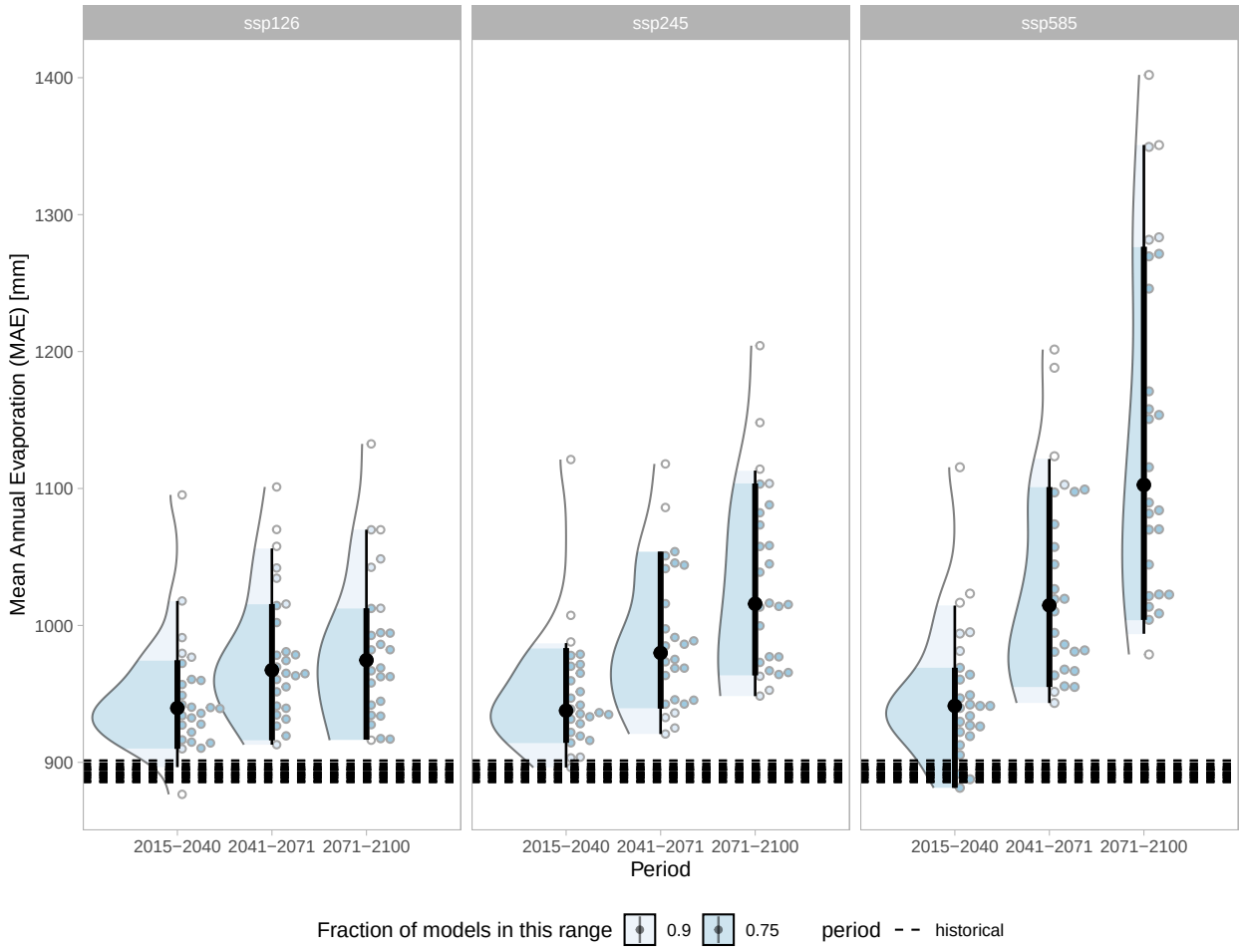
period	HDI - Highest Density Interval				
	90%L	75%L	median	75%H	90%H
ssp126					
2015-2040	3.2	3.1	3.8	4.1	4.8
2041-2071	3.7	4.0	4.7	5.6	6.0
2071-2100	4.0	4.0	4.7	5.9	6.5
ssp245					
2015-2040	3.3	3.3	3.8	4.3	5.0
2041-2071	4.2	4.5	5.0	6.0	6.4
2071-2100	5.0	5.6	6.0	7.7	8.1
ssp585					
2015-2040	2.9	3.4	3.9	4.5	4.8
2041-2071	5.0	5.0	6.0	6.3	7.7
2071-2100	6.9	7.8	8.7	10.6	11.8

Historical value: 2.5 °C

Delta Mean Annual Air Temperature (MAAT) [°C]

period	HDI - Highest Density Interval				
	90%L	75%L	median	75%H	90%H
ssp126					
2015-2040	0.7	0.6	1.3	1.6	2.3
2041-2071	1.3	1.5	2.2	3.1	3.5
2071-2100	1.5	1.5	2.2	3.4	4.0
ssp245					
2015-2040	0.8	0.8	1.4	1.8	2.5
2041-2071	1.7	2.0	2.5	3.5	3.9
2071-2100	2.5	3.1	3.5	5.2	5.6
ssp585					
2015-2040	0.4	0.9	1.4	2.0	2.3
2041-2071	2.5	2.5	3.5	3.8	5.2
2071-2100	4.4	5.3	6.2	8.2	9.3

ROC[MAAT] = MAAT[projected] - MAAT[historical]


ssp126
ssp245
ssp585
Mean Annual Evaporation (MAE) [mm]
1400
1300
1200
1100
1000
900
2015−2040
2041−2071
2071−2100
Period
Fraction of models in this range
0.9
0.75
period
historical

Mean Annual Evaporation (MAE) [mm]

	HDI - Highest Density Interval				
period	90%L	75%L	median	75%H	90%H
ssp126					
2015-2040	910	910	940	972	1,018
2041-2071	913	919	967	1,016	1,058
2071-2100	917	917	975	1,013	1,070
ssp245					
2015-2040	896	914	938	979	988
2041-2071	921	942	980	1,054	1,054
2071-2100	948	948	1,016	1,082	1,114
ssp585					
2015-2040	881	881	941	969	1,017
2041-2071	943	955	1,015	1,099	1,124
2071-2100	1,004	1,004	1,103	1,271	1,351

Historical value: 893 mm

ROC Mean Annual Evaporation (MAE) [%]

	HDI - Highest Density Interval				
period	90%L	75%L	median	75%H	90%H
ssp126					
2015-2040	2%	2%	5%	9%	14%
2041-2071	2%	3%	8%	14%	19%
2071-2100	3%	3%	9%	13%	20%
ssp245					
2015-2040	0%	2%	5%	10%	11%
2041-2071	3%	6%	10%	18%	18%
2071-2100	6%	6%	14%	21%	25%
ssp585					
2015-2040	-1%	-1%	5%	9%	14%
2041-2071	6%	7%	14%	23%	26%
2071-2100	12%	12%	24%	42%	51%

ROC[MAE] = MAE[projected] / MAE[historical] - 1

Chapter 6

Preciptation IDF under climate change

The results from the IDF_CC Tool v7.5 (Simonovic et al. 2015) were selected to project IDF values under climate change. This tool provides IDF data based on observed data either from a grid covering Canada or at meteorological stations. In this case, IDF projections for the nearby station Saint Michel des Saints were used. IDF-CC tool typically produces better results at meteorological stations compared to gridded evaluations. It's important to note that this tool only provides IDF estimations limited up to 24 hours and 100 years.

Chapter 7

PMP

The probable maximum precipitation (PMP) is an estimation of the maximum amount of rainfall that could occur within a specific geographic area over a given duration, typically ranging from a few hours to a few days. It is an important parameter for designing infrastructure and determining the capacity of hydraulic structures such as dams and reservoirs.

Two commonly used methodologies for estimating the PMP are the statistical approach developed by Hershfield and the meteorological approach known as moisture maximization.

Statistical Approach (Hershfield Method): The statistical approach, developed by engineer Louis C. Hershfield in the 1960s, relies on historical precipitation data to estimate the PMP. This method involves analyzing long-term precipitation records from a specific region and identifying the most extreme storms that have occurred in the past. By applying statistical techniques, such as probability distributions and frequency analysis, the PMP is estimated based on the assumption that extreme events in the future will resemble those observed in the past. The statistical approach considers factors such as the maximum rainfall intensities, the duration of the storm event, and the size of the watershed under consideration. It provides a practical and relatively straightforward way of estimating the PMP, especially in regions where limited meteorological data is available. However, it does not explicitly consider the underlying meteorological mechanisms responsible for extreme precipitation events.

Meteorological Approach (Moisture Maximization): The meteorological approach to estimating the PMP, often referred to as moisture maximization, takes into account the atmospheric conditions that could potentially lead to extreme precipitation events. This method is based on the understanding that the maximum possible rainfall is primarily determined by the availability of moisture in the atmosphere and the mechanisms that can cause it to be released. In the moisture maximization approach, meteorological models are used to simulate hypothetical extreme weather scenarios. These models incorporate various atmospheric variables such as temperature, humidity, wind patterns, and atmospheric stability. By maximizing the available moisture and assuming favorable atmospheric conditions for precipitation, the models estimate the upper limit of precipitation that could occur.

The moisture maximization approach provides a more physically based estimation of the PMP by considering the underlying meteorological processes. It is particularly useful in regions where detailed meteorological data and sophisticated modeling techniques are available. However, it requires more expertise and resources compared to the statistical approach.

Both methodologies have their strengths and limitations. While the statistical approach relies on

historical data and is simpler to apply, the meteorological approach takes into account the physical processes driving extreme precipitation events. Depending on the available data and resources, either method may be used to estimate the probable maximum precipitation, providing engineers and planners with essential information for designing resilient infrastructure.

In this evaluation, the PMP values obtained from different GCMs were analyzed to assess the rate of change in precipitation over time.

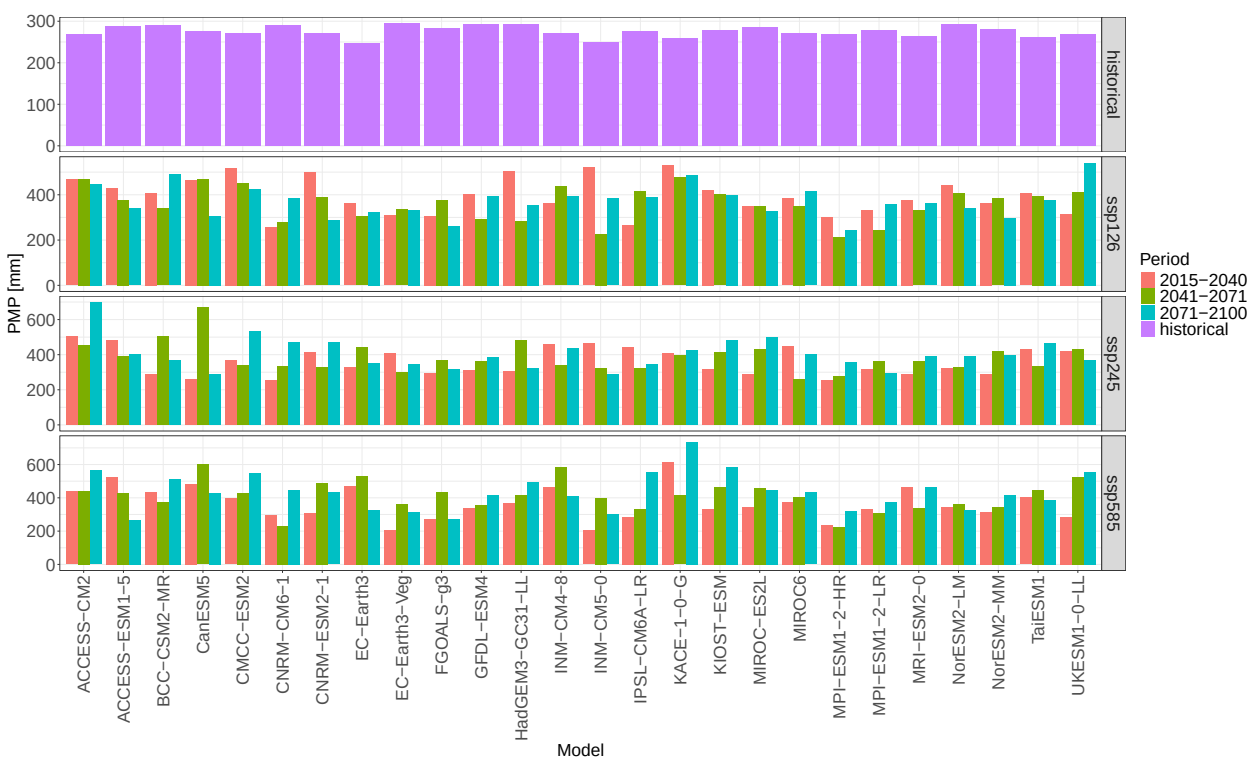
Additionally, to ensure the analysis focuses on the most relevant and extreme values, thresholds were set to filter out extreme outliers. Typically, values that exceed a certain number of standard deviations from the mean are considered extreme. In this case, PMP values beyond -4 to 4 times the standard deviation were removed from the analysis. By applying this threshold, the analysis can concentrate on the range of values that are most representative of extreme precipitation events while excluding highly anomalous data points.

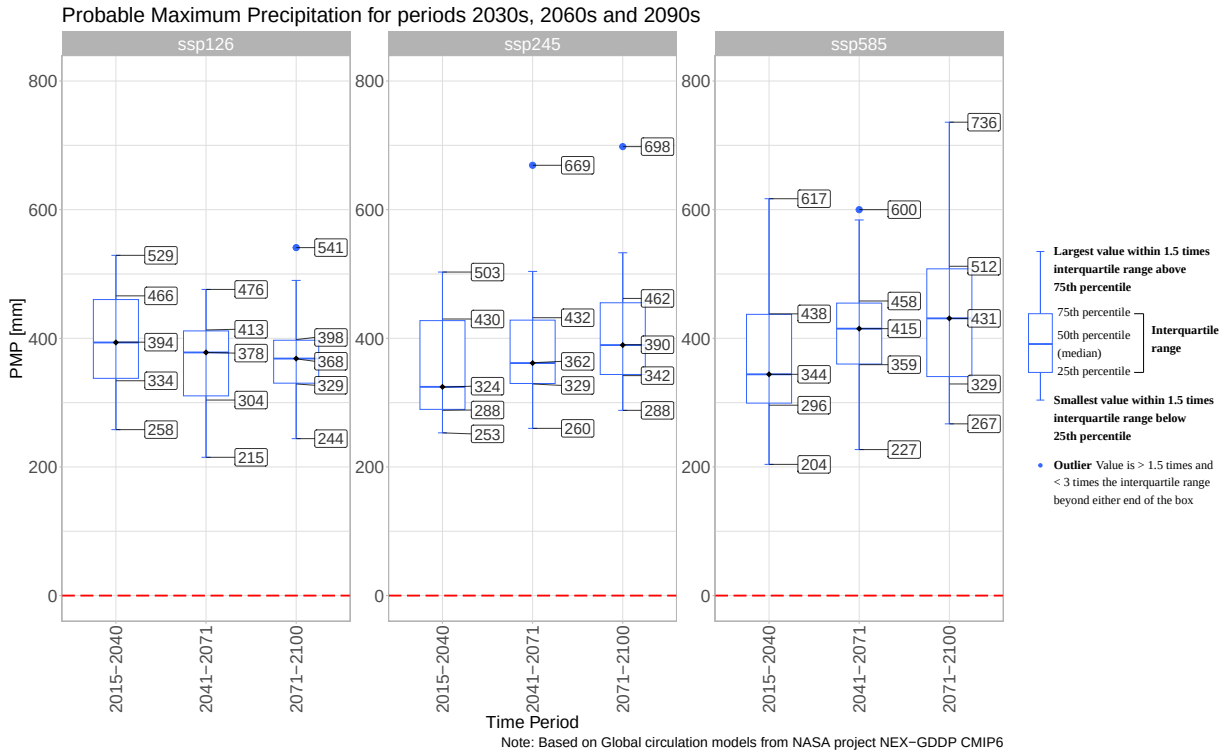
By evaluating the PMP values as a rate of change and considering multiple GCMs, researchers can assess the potential changes in extreme precipitation patterns under different climate scenarios. This information is crucial for understanding the potential impacts of climate change on water resources, infrastructure design, and risk management strategies.

7.1 Hershfield Approach

7.1.1 Resulting PMP values

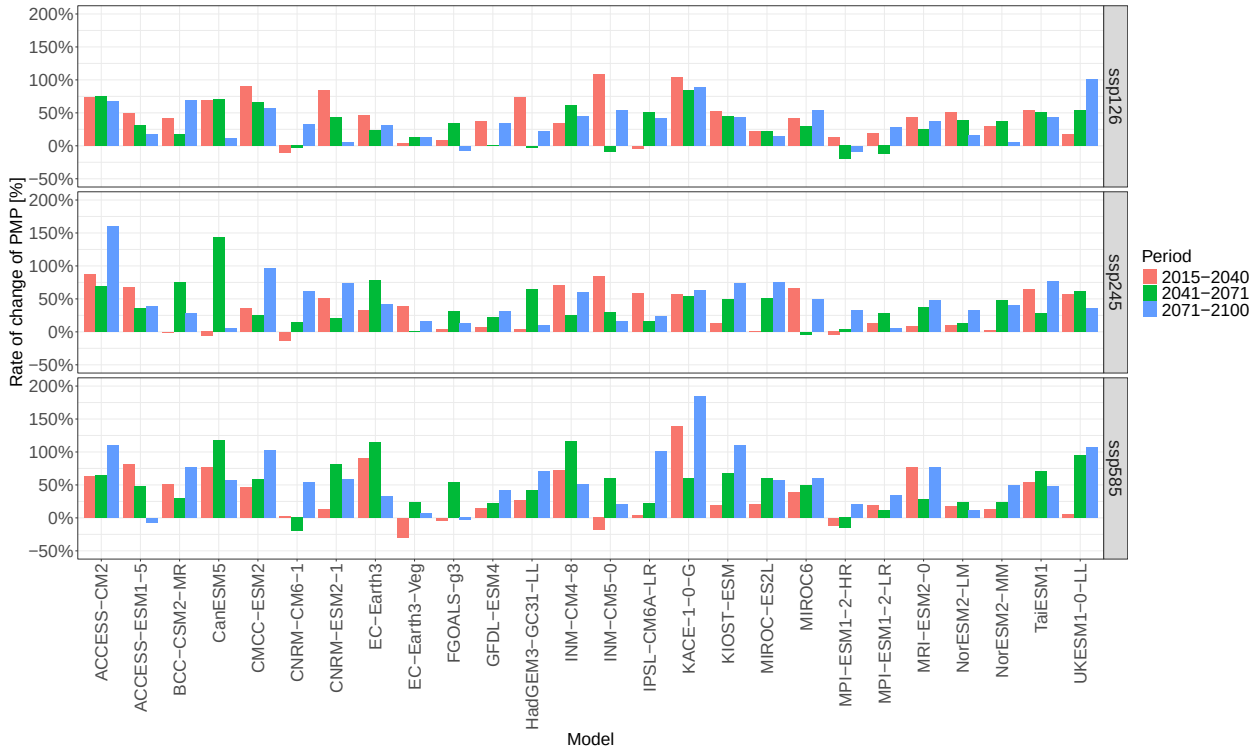
The PMP values in mm obtained with the Hershfield method are presented in the following plots and tables.

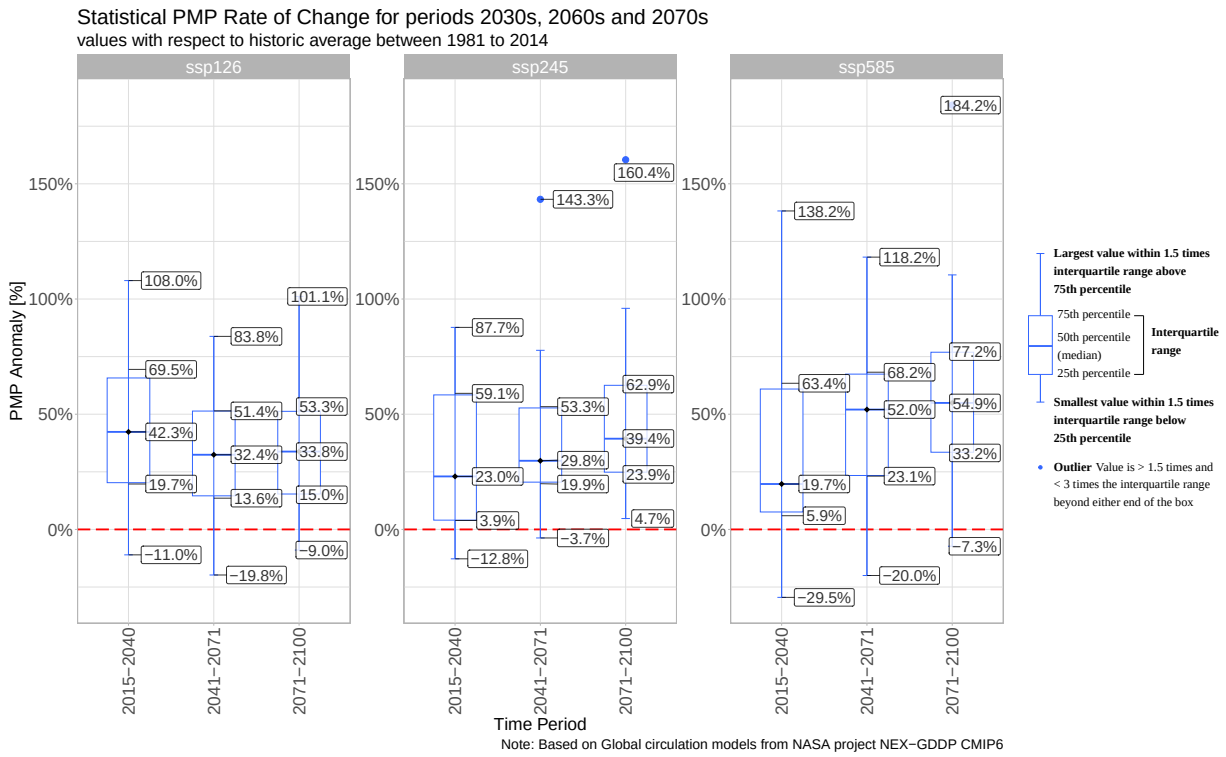




7.1.2 Statistical Method Results

The PMP values rates of change obtained with the Hershfield method are presented in the following plots and tables.

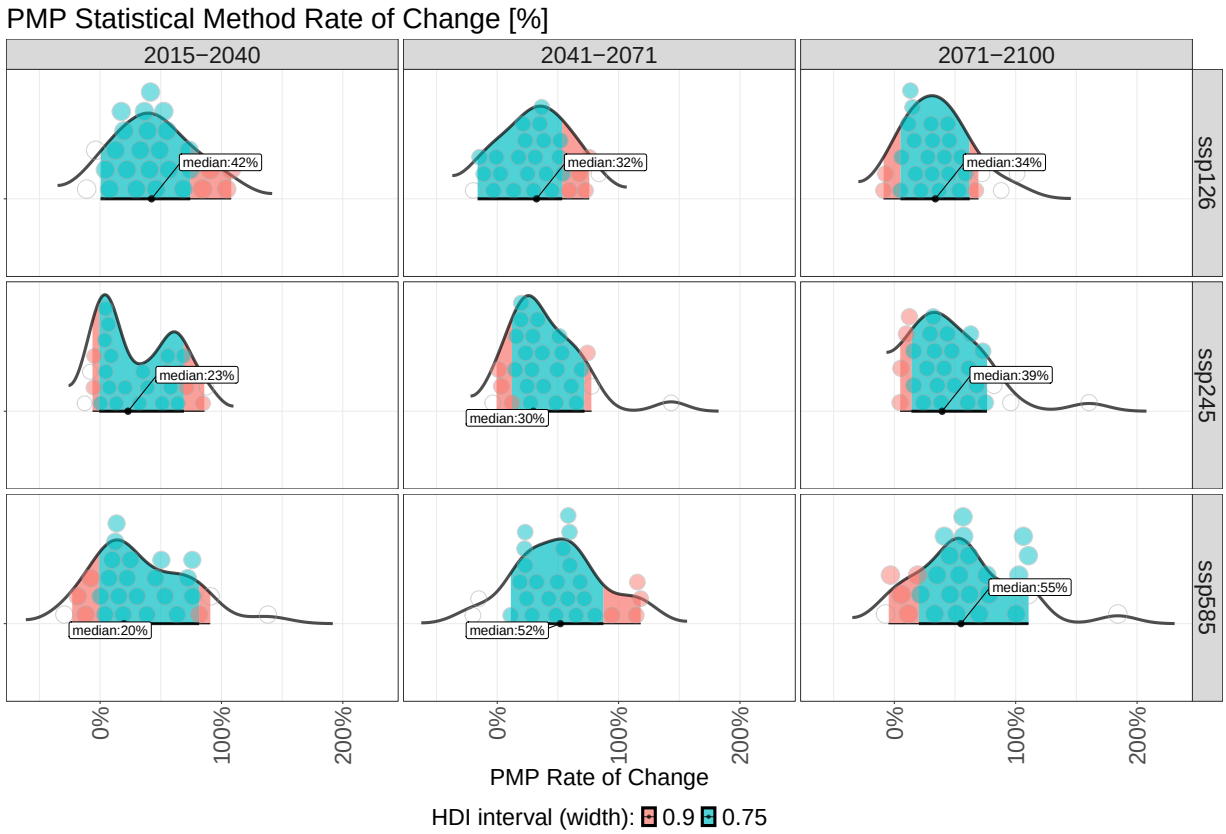




The HDI results are presented in the following table and plot.

Table 7.1: Statistical PMP Rate of Change HDI [%]

period	scenario	90%L	75%L	median	75%H	95%H
2015-2040	ssp126	-11	4.4	42.3	74.3	90.8
2015-2040	ssp245	-12.8	-0.7	23	68.1	70.1
2015-2040	ssp585	-18.4	2.1	19.7	81.6	90.7
2041-2071	ssp126	-12.5	-12.5	32.4	53.5	75.7
2041-2071	ssp245	1.4	-3.7	29.8	53.3	77.7
2041-2071	ssp585	11.1	11.1	52	80.5	118.2
2071-2100	ssp126	-9	5.1	33.8	57	69.6
2071-2100	ssp245	4.7	4.7	39.4	62.9	76.3
2071-2100	ssp585	-3.2	-7.3	54.9	77.2	110.5



7.2 Moisture Maximization Approach

As a alternative way to understand the PMP, this methodology is based on maximum precipitable water (Meteorological PMP).

In this case:

$$PMP = P_s \frac{W_{max}}{W_{storm}}$$

where Ps is the observed precipitation from a large storm

W_{max} is the maximum precipitable water at the same time of year and location

W_{storm} is the precipitable water of the observed storm

The maximum precipitable water is associated to the 12-hr persisting dew point temperature at 1000-hPa, as presented by Annex I Table A.1.1 from WMO (2009).

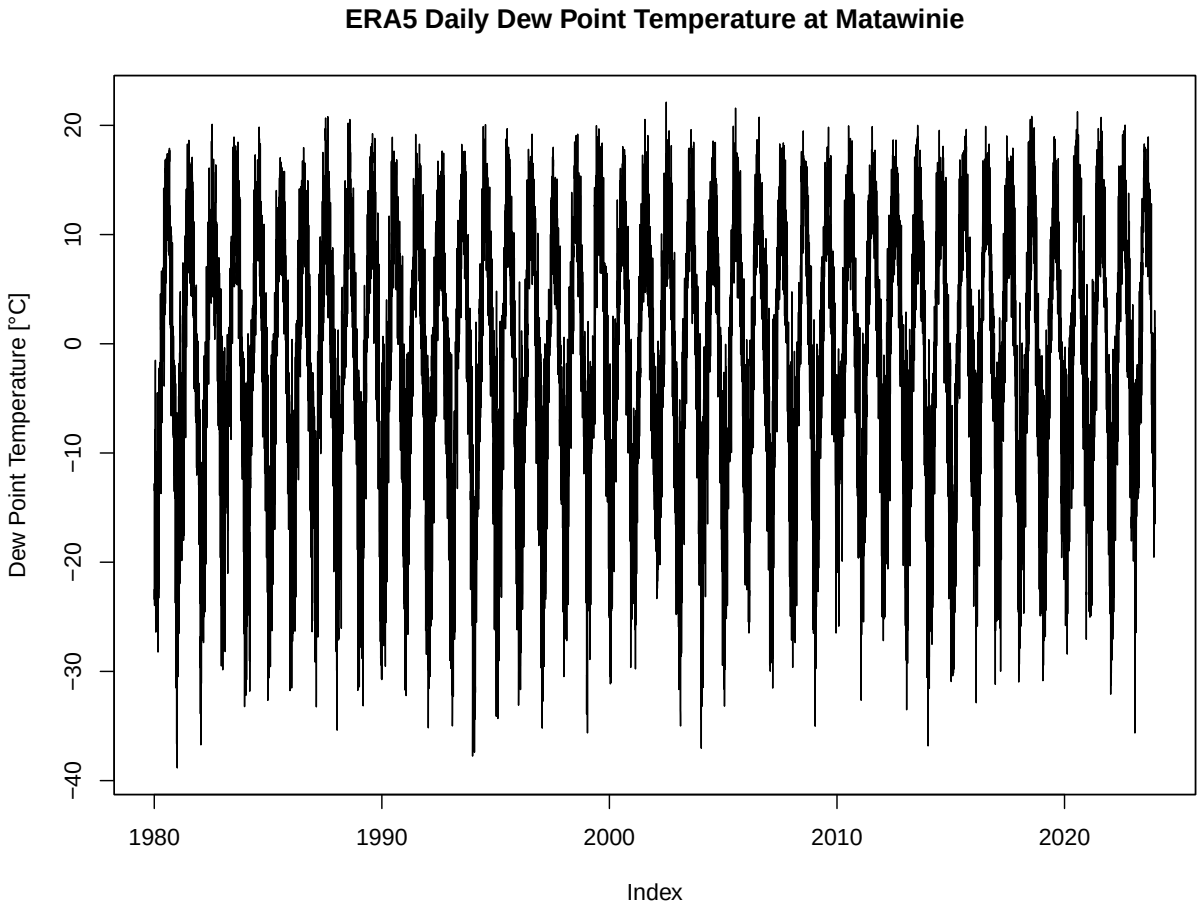
The 12-hrs persisting dew point temperature under climate change is used as a proxy to understand rate of change for the PMP.

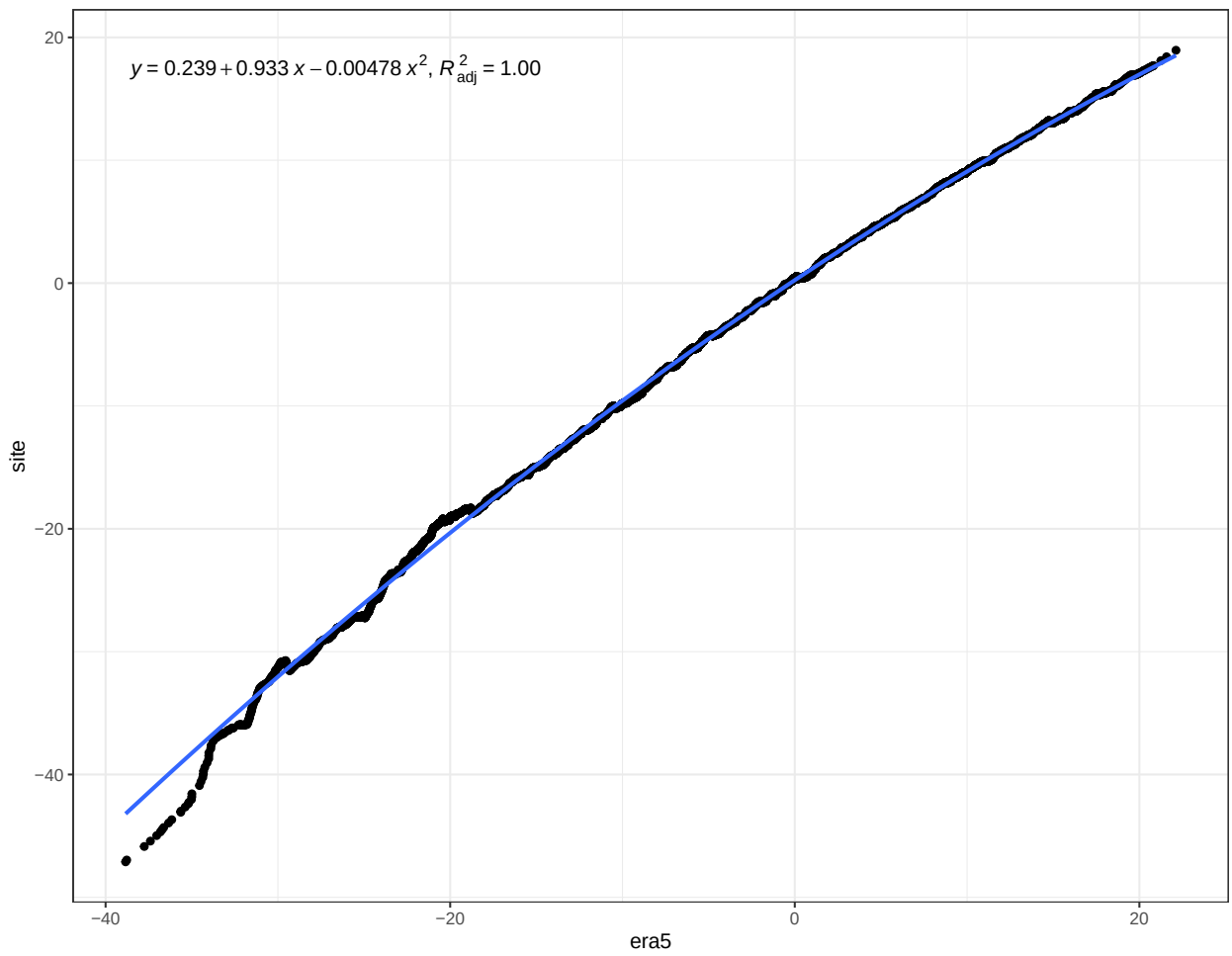
NEX-GDDP includes daily relative humidity and temperature, dew-point temperature can be estimated through the Clausius Clapeyron equation.

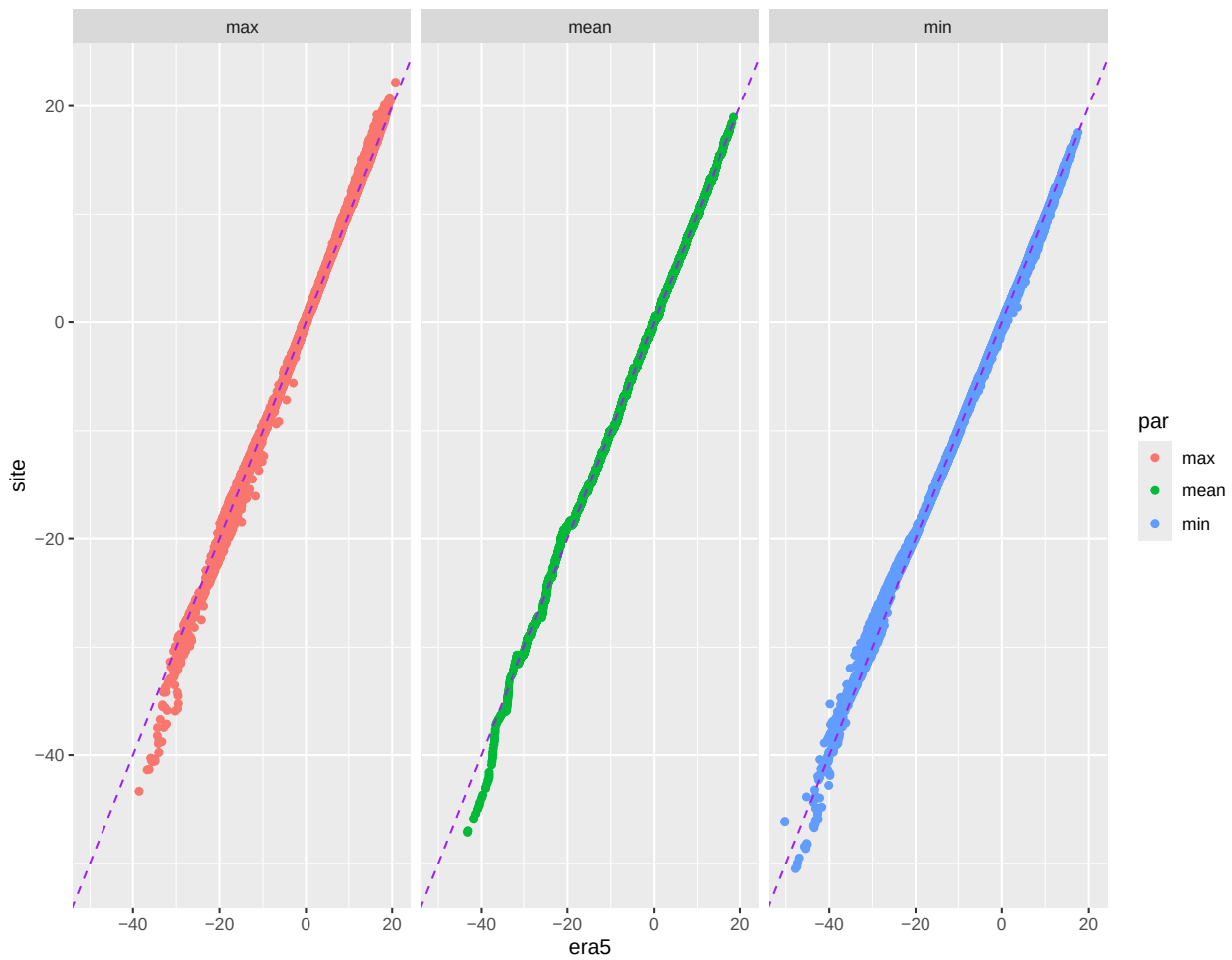
The maximum precipitation water is associated to the maximum 12-hr persistent dew point temperature as indicated by WMO (2009), the 1:100 yr return period of the precipitable water (Rouhani and Leconte, 2016) was used as reference for rate of change calculation.

7.2.1 Hourly ERA5 corrected for Site

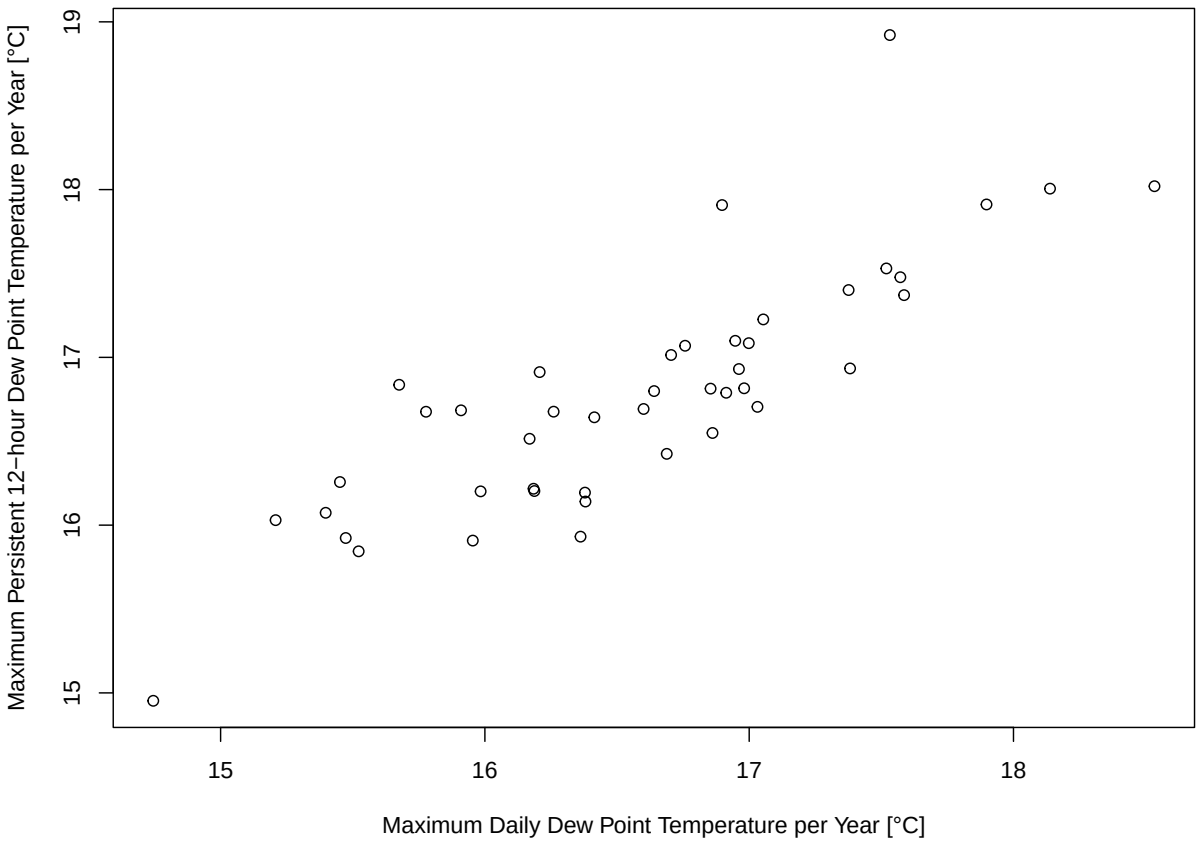
The information from ERA5 was obtained at the site from 1985 to 2014 for hourly dew point temperature. A polynomial model was then used correct hourly ERA5 to the project timeseries. This process allows to have hourly records for site.

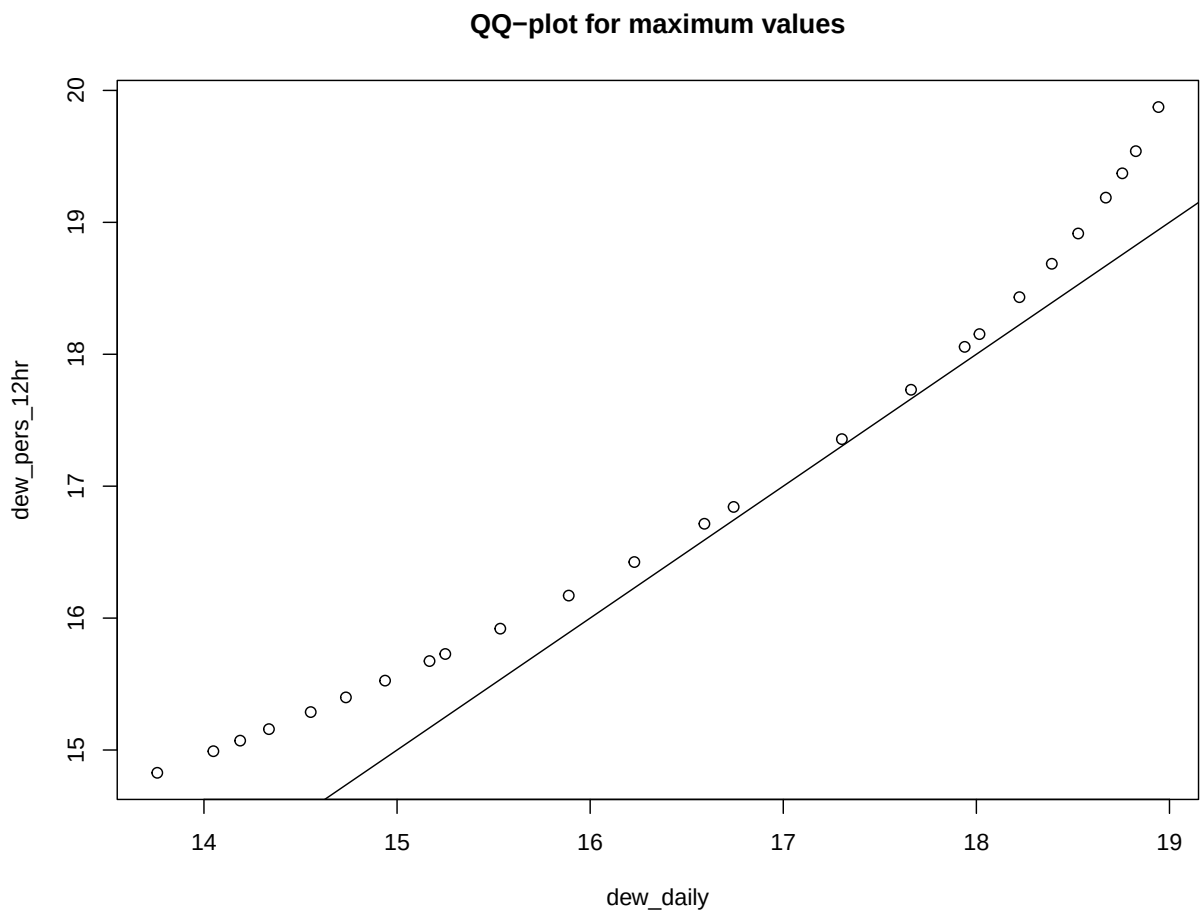



$y = 0.239 + 0.933\,x - 0.00478\,x^2$, $R^2_{adj} = 1.00$
site
era5
20
0
−20
−40
−40
−20
0
20



Two parameters are obtained from the corrected ERA5 dew point temperature timeseries: daily dew point temperature and persistent 12 hours dew point temperature.


Maximum Persistent 12−hour Dew Point Temperature per Year [°C]
15
16
17
18
19
15
16
17
18
Maximum Daily Dew Point Temperature per Year [°C]



7.2.2 12-hr Persistent Dew Point temperature for 1:100 yrs.

The 12 hours persistent temperature for 1:100 yrs was estimated following similar approach as the Simonovic presented for the IDF_CC tool in Canada; were relationships for daily values and hourly values are implemented for IDF.

In this case, similar procedures is done but for dew point temperature. As with IDF_CC tool GEV probabilistic distribution was used for this analysis.

The complete analysis was implemented with Kelvin degrees.

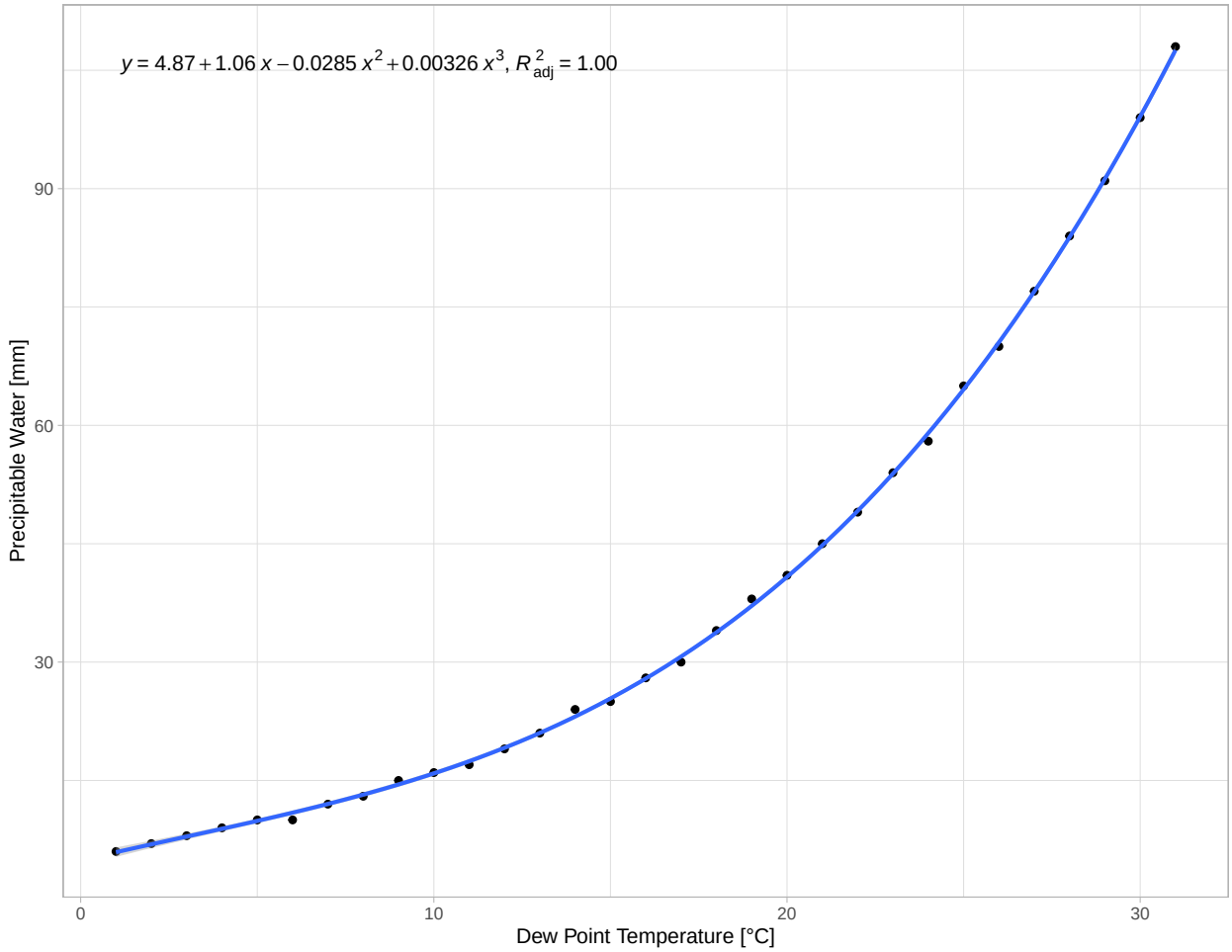
7.2.3 WMO - Precipitable water at site

WMO (2009) provides in Table A.1.1 the maximum PW assuming that the atmosphere contains the same amount of water vapour as saturated air with saturation pseudoadiabatic temperature lapse rate. The values reported in this table are shown in the chart below for dew point temperatures between 0 °C and 30 °C.

Maximum precipitable water between the 1000 hPa surface and various pressure levels were extracted from Table A.1.1. from WMO (2009) - the data is shown in the table bellow.

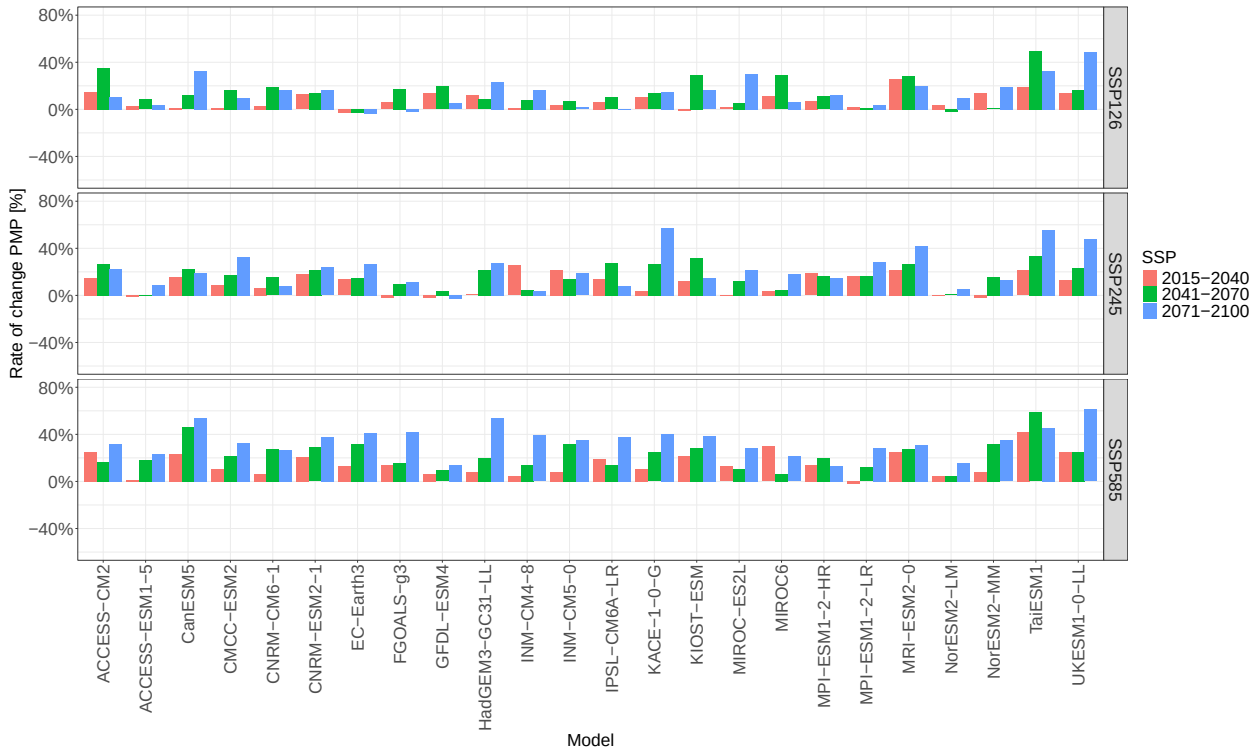
The storm deriving the PMP under the Moisture Maximization Method is assumed to be located between the site pressure level (950 hPa) and the 300 hPa level, assumed to be the top of the storm

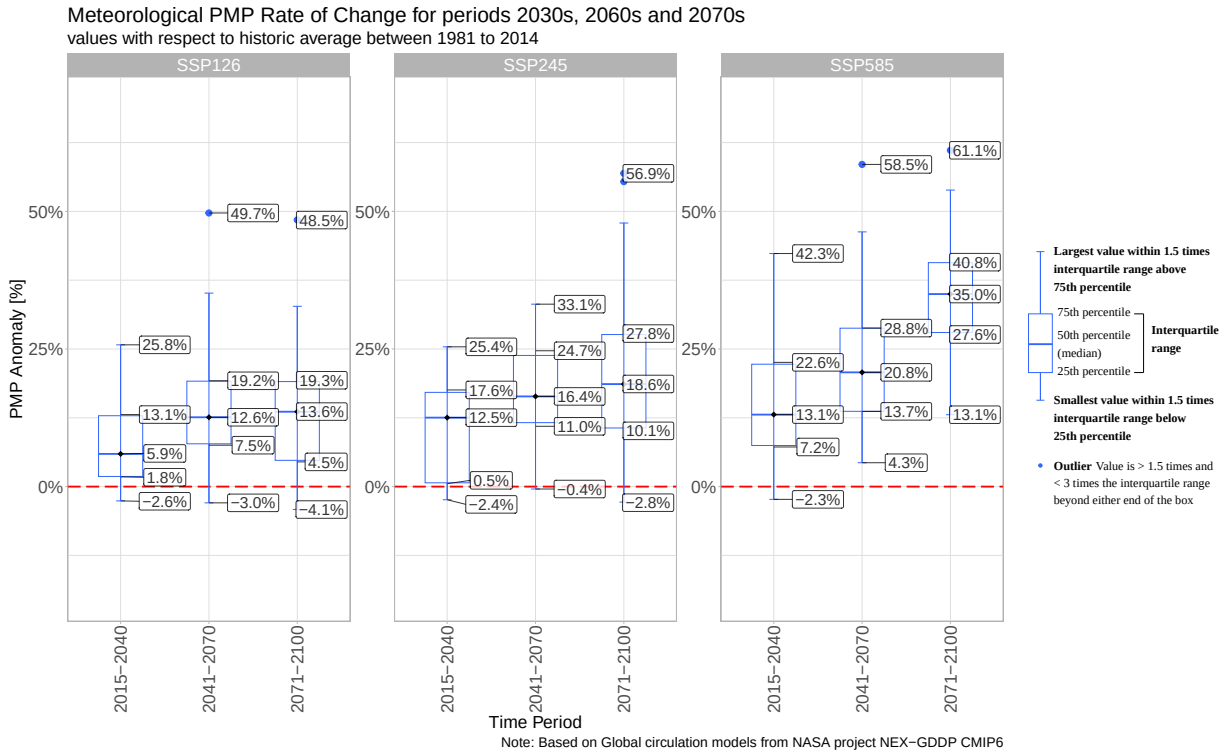
(WMO, 2009, p. 14). The maximum precipitable water for this air column is shown in the graph bellow, together with its polynomial approximation.



7.2.4 Meteorological Method Results

The PMP values rates of change obtained with the moisture maximization method are presented in the following plots and tables.



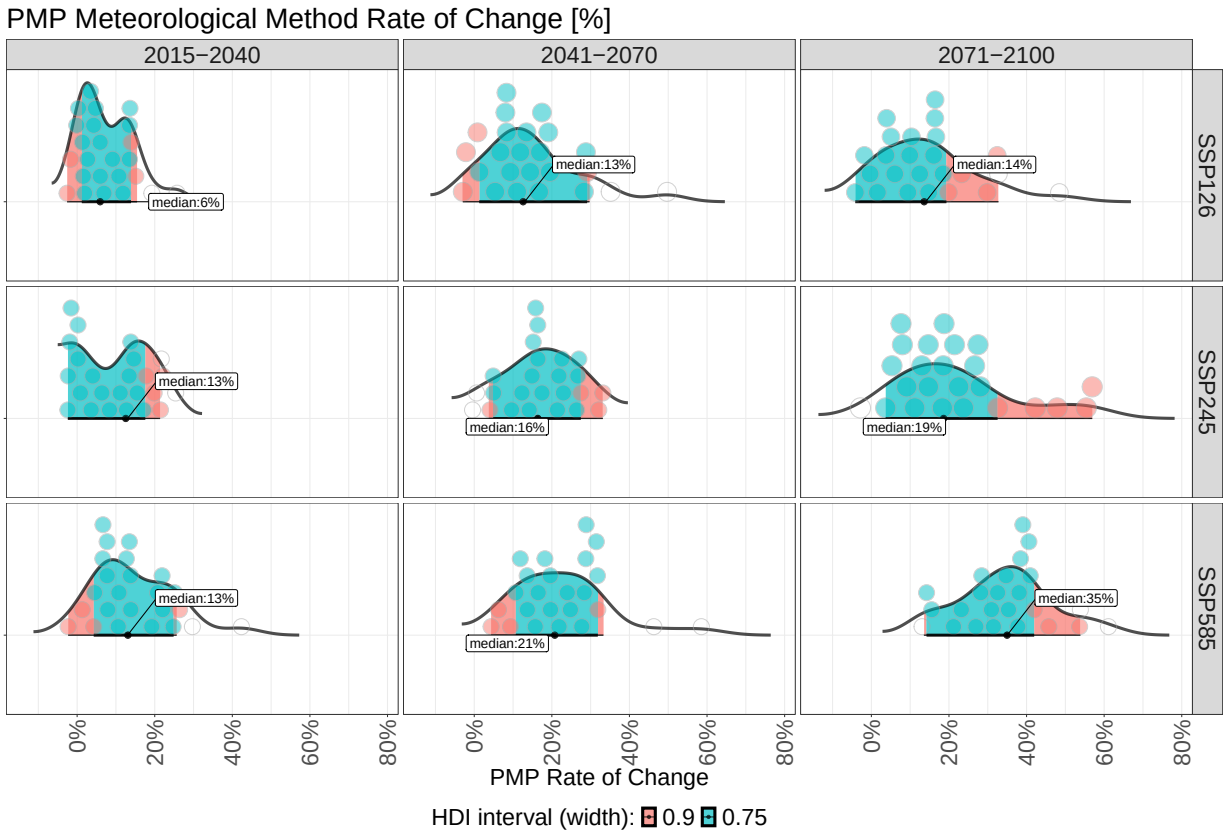


The HDI results are presented in the following table and plot.

Table 7.2: Meteorological PMP Rate of Change HDI [%]

period	scenario	90%L	75%L	median	75%H	90%H
2015-2040	SSP126	-0.03	0.01	0.06	0.14	0.15

period	scenario	90%L	75%L	median	75%H	90%H
2015-2040	SSP245	-0.02	-0.02	0.13	0.18	0.21
2015-2040	SSP585	-0.02	0.04	0.13	0.25	0.25
2041-2070	SSP126	-0.03	-0.03	0.13	0.19	0.29
2041-2070	SSP245	0	0.05	0.16	0.27	0.27
2041-2070	SSP585	0.04	0.11	0.21	0.32	0.32
2071-2100	SSP126	-0.02	-0.04	0.14	0.2	0.33
2071-2100	SSP245	-0.03	0.04	0.19	0.33	0.48
2071-2100	SSP585	0.14	0.14	0.35	0.42	0.54



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Final

Memo

To	Tony Fedec, Charles Veilleux	**Client**	Nouveau Monde Graphite Inc.
From	Camilo Gallard	**Project**	CAPR002717
Cc	Victor Munoz	**Date**	18 juillet 2024
Subject	Precipitation parameters correction due to orographic effect		

File name: CAPR002717_NMG_Matawinie_Orografic_Effect_Final_Memo_20240718.docx

1 Introduction

Nouveau Monde Graphite Inc. (NMG) (the Client) asked SRK Consulting (Canada) Inc. (SRK) to support their water management strategy and water balance for the Matawinie Mine (the Site) as a part of the Surface Water Management, Overburden Stockpile and Co-disposal Facility Engineering project initiated in 2023. As a part of its preliminary works, SRK performed a review of the existing hydrology analysis for the Site.

The Site is located at an elevation of around 550 meters above mean sea level (m amsl). Previous water balance (Wood, 2020) includes precipitation inputs developed for the site from the Environment and Climate Change Canada (ECCC) Saint Michel des Saints station as an analogous station (SNC-Lavalin, 2020). However, this station is located at an elevation of 370 m amsl. In meteorology, the orographic effect occurs when air masses are forced to flow over high topography resulting in rainfall increasing with elevation.

Due to the elevation difference (170 m) between the Site and the location of the analogous station at Saint Michel des Saints, SRK considered the orographic effect to be potentially significant. SRK completed a high-level regional precipitation analysis to assess the magnitude of the orographic effect around the site, and the results are presented in this memorandum.

2 Regional Orographic Effects Analysis for Precipitation

2.1 Available Information

The following meteorological datasets were consulted to perform the orographic effect analysis in the region around the Site for precipitation and snow cover:

- Site data: NMG operates a meteorological station at the Matawinie site. The records available for this analysis cover the June 2021 to November 2022 period.
- Environment and Climate Change Canada (ECCC) historical weather records: meteorological records from stations within 150 kilometers from Site.
- Daymet: reanalysis tool developed by the Oak Ridge National Laboratory and supported by NASA, Daymet provides long-term, continuous, gridded estimates of daily weather and climatology in North America (Daymet, 2023).
- Merra2: long-term global reanalysis tool developed by NASA (GMAO, 2015). Used to validate Daymet results.
- CanSWE5: Canadian historical water equivalent of snow cover (SWE) dataset version 5 (Vionnet, 2023)

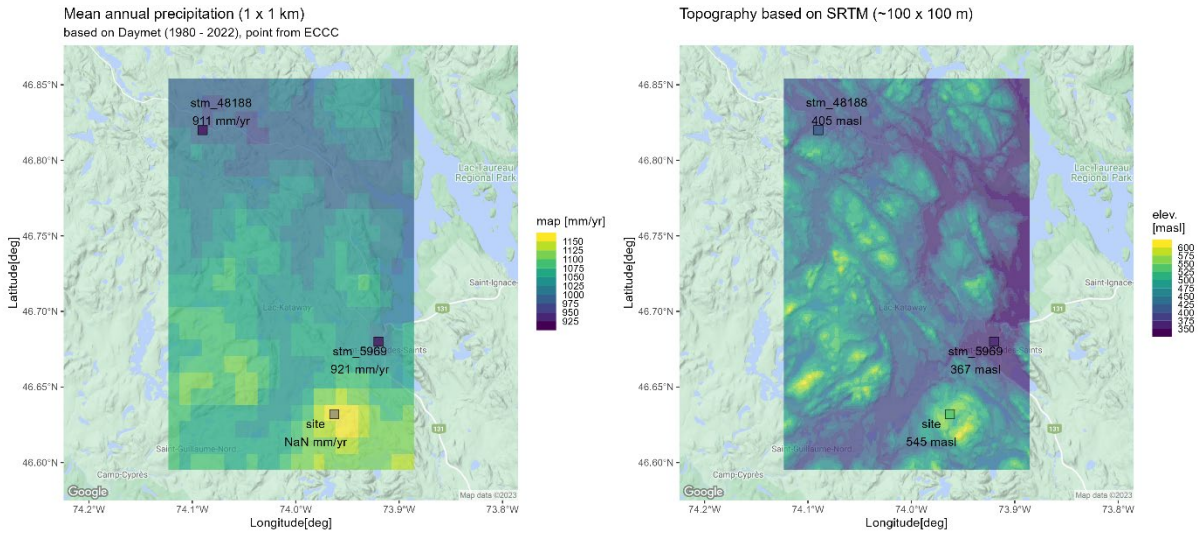
2.2 Maximum Annual Precipitation Regional Analysis

ECCC maintains records for two stations labeled as Saint Michel des Saints (id 5969 and id 48188). The previous hydrology analysis (SNC-Lavalin, 2020) results match the data from station 48188.

Site data was compared to Saint-Michel-des-Saints ECCC station 48188 data as a preliminary check for elevation influence in precipitation. During the June 2021 to November 2022 period, Site data recorded an additional 6% cumulative precipitation compared to Saint Michel des Saints ECCC station. Due to the short length of records of the site station, further analysis on a broader spatial and temporal scale was deemed necessary to validate this observation.

Figure 1 is a spatial representation of Daymet mean annual precipitation (MAP) between 1980 and 2022 compared to digital elevation model STRM (NASA, 2013) near Site. The Site, and the Saint Michel des Saints ECCC stations locations are also represented. In this figure, areas with higher MAP match higher elevation areas, like the site location.

Figure 1: Mean Annual Precipitation (Daymet, and ECCC) comparison to Topography (STRM) in the Project region



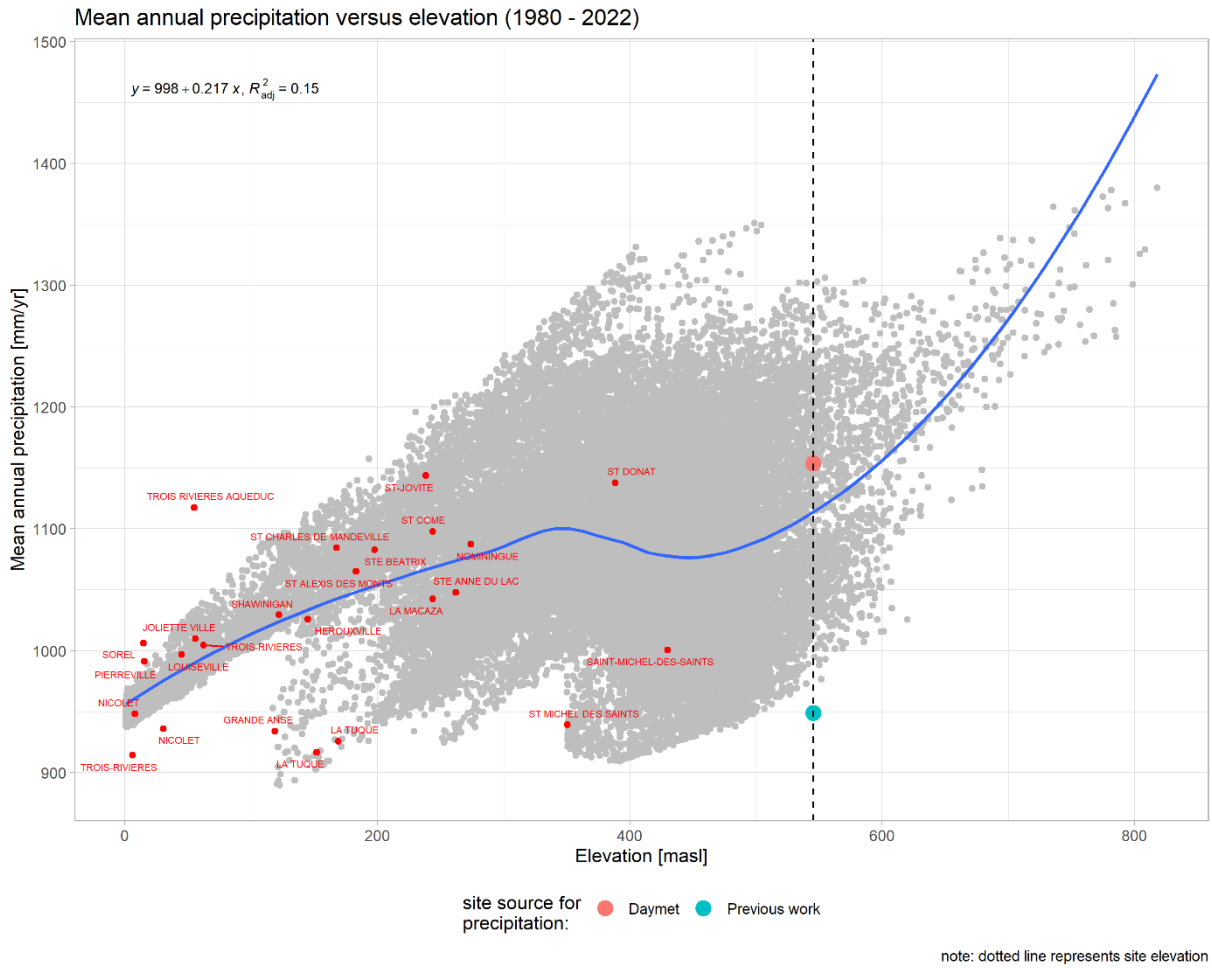
Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR002717/Internal/!020_Project_Data/010_SRK/Hydrologie/reports/meteo_review_rev3.Rmd

To confirm this on a broader regional scale, MAP from ECCC stations with records after 1980 and Daymet within 150 km from site were plotted against their corresponding elevations, and the results are presented in Figure 2.

In Figure 2, ECCC stations are represented as red dots, Daymet pixels are represented as grey dots. Site elevation is signaled by the dotted vertical line, with the corresponding MAP results from the previous analysis (teal) and Daymet (pink) as large points. An overall trendline is also presented in blue (locally estimated scatterplot smoothing method).

Based on this analysis, MAP tends to increase with elevation on a regional scale. Although there are no ECCC stations at a similar elevation to site, MAP estimated through previous is below the expected result range for site elevation.

Figure 2: Regional Mean Annual Precipitation versus Elevation Analysis



Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR002717/Internal/!020_Project_Data/010_SRK/Hydrologie/reports/meteo_review_rev3.Rmd

2.3 Seasonal Precipitation Analysis

To assess the relevance of seasonal variations in rainfall and snowfall between the Site location and previous analysis based on Saint-Michel-des-Saints data, the monthly distribution between rain and snow was developed for the Daymet dataset at the Site location. These values were normalized to their corresponding yearly totals and compared to the values presented in the previous analysis (SNC-Lavalin, 2020). The values are presented in Table 1.

The normalized difference columns show the change between precipitation, rainfall and, snowfall distributions between both analyses, relative to their corresponding yearly totals. All these values are below 1.4% showcasing little variation between the relative monthly distribution of precipitation, rainfall and snowfall between both analyses. This suggests that there are no major changes in seasonality between the previous analysis and Daymet for Site.

Table 1: Rainfall, Snowfall, and Precipitation distribution difference between the previous analysis and Daymet for Site

Month	Previous Analysis[1]			Daymet at Site[2]			Normalized Difference[3]		
	Total PP (mm)	Rain (mm)	Snow (mm)	Total PP (mm)	Rain (mm)	Snow (mm)			
Jan	59	6	53	78	8	70	-0.5%	-0.1%	0.3%
Feb	50	5	45	65	5	60	-0.3%	0.1%	0.2%
Mar	64	20	43	76	21	55	0.2%	0.3%	0.7%
Apr	65	51	14	86	63	24	-0.5%	-0.2%	-1.4%
May	87	86	1	101	99	2	0.6%	0.5%	-0.1%
Jun	105	105	0	123	123	0	0.5%	0.3%	0.0%
Jul	99	99	0	119	119	0	0.2%	-0.1%	0.0%
Aug	92	92	0	115	115	0	-0.1%	-0.6%	0.0%
Sep	101	101	0	117	117	0	0.6%	0.5%	-0.1%
Oct	87	81	6	106	98	9	0.1%	-0.1%	-0.1%
Nov	71	37	34	91	44	47	-0.3%	0.0%	-0.5%
Dec	69	8	61	92	13	78	-0.5%	-0.5%	1.0%

Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR002717/Internal/!020_Project_Data/010_SRK/Hydrologie/reports/meteo_review_rev3.Rmd

Notes:

[1] SNC-Lavalin, 2020

[2] For reference only

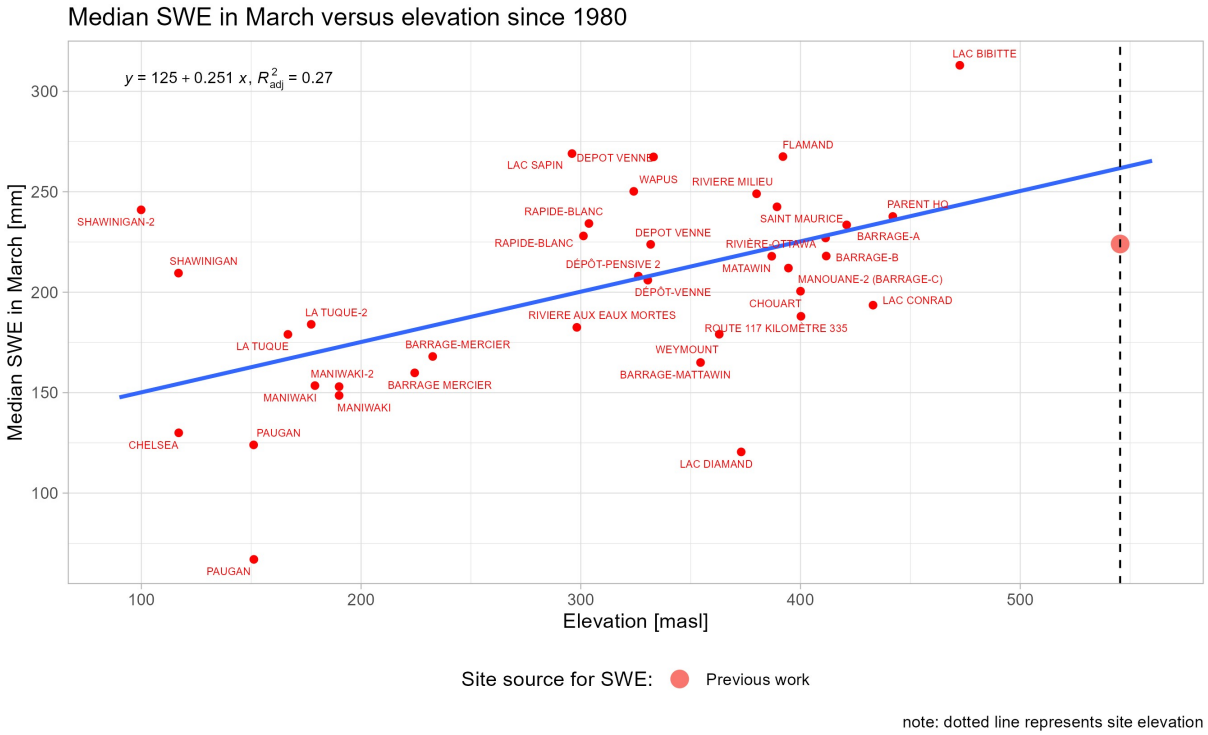
[3] Difference in percentage of the corresponding yearly total between the Previous Analysis and Daymet values.

2.4 Regional Snowpack Verification

In addition, a regional verification was performed on snowpack records using the Canadian historical water equivalent of snow cover dataset version 5 (CanSWE5) (Vionnet, 2023). For each station within 200 km of Site, median SWE surveyed during the month of March was plotted against elevation obtaining Figure 3. Median SWE for Site based on the previous analysis is also represented by a pink dot, and a linear approximation of the median SWE/elevation relationship is shown by the blue line.

The month of March was picked for consistency of measurements. The selected CanSWE5 results might be an underestimation of the SWE observed due to further accumulation during the spring. Despite this, the previous analysis median SWE of 224 mm (SNC-Lavalin, 2020) is under the corresponding linear regression for Site based on CanSWE median March SWE data by a about 16% of its value. This seems consistent with the regional precipitation and seasonality analysis findings.

Figure 3: Median equivalent of snow cover (SWE) in March since 1980 versus Elevation



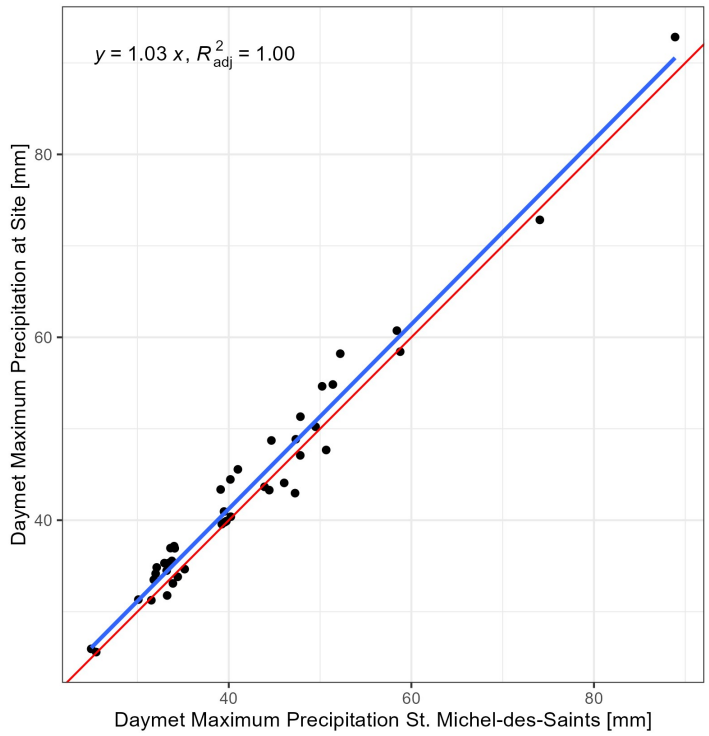
Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR002717/Internal/!020_Project_Data/010_SRK/Hydrologie/reports/meteo_review_rev3.Rmd

2.5 Extreme Precipitation Events Verification

Extreme events increase in intensity could also be expected due to orographic effects. The daily maximum precipitation every year between 1980 and 2022 from the Daymet dataset at the Site location was compared to the corresponding values at the Saint-Michel-des-Saints station location. The results are presented in Figure 4.

An average 3% increase in this parameter is also observed within the Daymet dataset with the change in elevation between both locations. Frequency analyses were not included as a part of this scope, however an increase in extreme events resulting from these values could also be inferred.

Figure 4: Daymet Maximum Daily Precipitation every year between 1980 and 2022 comparison between Site and Saint-Michel-des-Saints



Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR002717/Internal/!020_Project_Data/010_SRK/Hydrologie/reports/meteo_review_rev3.Rmd

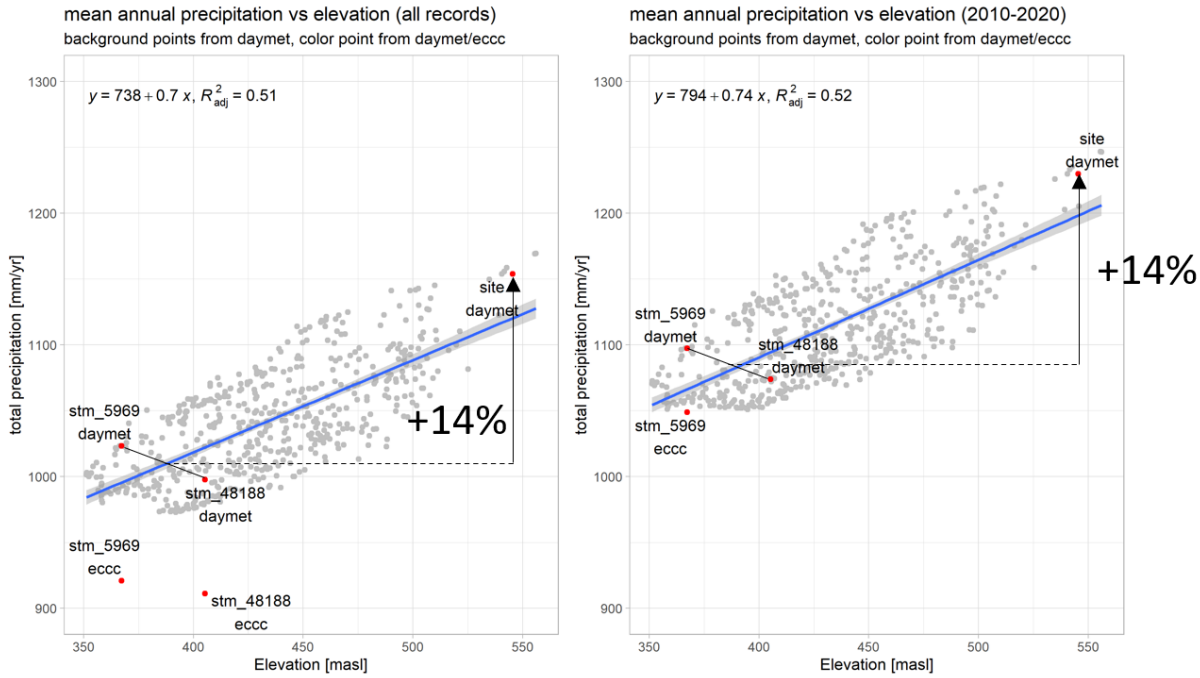
2.6 Conclusion

The prevalence of an orographic effect for all precipitation parameters in the Site region can be inferred from the previous analysis, however no major seasonal distribution of rain and snow changes are expected between site location and the previous analysis analogous station.

Based on the Daymet dataset, mean annual precipitation is expected to be 14% higher at the Site location compared to the Saint-Michel-des-Saints stations as shown in Figure 5. A similar magnitude increase is expected when comparing regional SWE between the elevations of these two locations. An increase in the intensity of extreme precipitation events can also be inferred due to orographic effects but remains uncertain.

Therefore, a single correction factor of 14% is proposed as an interim measure to be applied to all precipitation related design criteria to advance design and water management planning for Site. It is important to note that Daymet values were compared against each other to obtain this correction factor to try to reduce the effects of any dataset bias that might be intrinsically present within the Daymet reanalysis tool or within these specific Saint-Michel-des-Saints ECCC data processing methods, like undercatch consideration. The average Daymet MAP of both Saint-Michel-des-Saints stations locations was used to calculate the correction factor.

Figure 5: Precipitation Increase Estimation for Site due to Orographic Effect



Sources: https://srk.sharepoint.com/:u:/r/sites/NACAPR002717/Internal/!020_Project_Data/010_SRK/Hydrologie/reports/meteo_review_rev3.Rmd

3 Recommendations

SRK recommends developing a site-specific hydrology study for the Matawinie Site, accounting for the orographic effect as well as including climate change considerations.

Based on the previous orographic effects analysis, a safety increase of 14% magnitude is proposed for all previously developed precipitation parameters, including:

- Extreme events (IDF),
- Daily, Monthly and Annual Precipitation values.

Note that SRK considers the application of this factor is an interim measure. All designs and models having used this factor must be verified when the next hydrology analysis is completed.

This factor doesn't account for climate change effects that might alter weather patterns at the site location.

Regards,

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References

Daymet: Daily Surface Weather Data on a 1-km Grid for North America, Version 4 R1 https://doi.org/10.3334/ORNLDAAC/2129

Global Modeling and Assimilation Office (GMAO) (2015), inst3_3d_asm_Cp: MERRA-2 3D IAU State, Meteorology Instantaneous 3-hourly (p-coord, 0.625x0.5L42), version 5.12.4, Greenbelt, MD, USA: Goddard Space Flight Center Distributed Active Archive Center (GSFC DAAC), Accessed Enter User Data Access Date at doi: 10.5067/VJAFPLI1CSIV.

NASA Shuttle Radar Topography Mission (SRTM)(2013). Shuttle Radar Topography Mission (SRTM) Global. Distributed by OpenTopography. https://doi.org/10.5069/G9445JDF. Accessed: 2023-10-04

SNC-Lavalin, 2020 Rapport 654068-4000-40 ER-0001 (SNC-Lavalin, 2020), Rapport de faisabilité sur la gestion de l'eau, des résidus et stériles miniers.

Vionnet, Vincent, Mortimer, Colleen, Brady, Mike, Arnal, Louise, & Brown, Ross. (2023). Canadian historical Snow Water Equivalent dataset (CanSWE, 1928-2022) (Version v5) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.7734616

Wood, 2020. Nouveau Monde Graphite – Projet Matawinie. Ingénierie détaillée - Données de base et critères de conception. TX20035103-02000-NGE-0001-B. 2020-11-25. Wood – Solutions en environnement & infrastructure, une division de Wood Canada limitée.

Performance du système de traitement des eaux
Projet minier de graphite Matawinie

Description de la filière de traitement

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2024-12-16

Notre référence N° 6535

RÉVISION 04

Le 16 décembre 2024

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ANNEXES

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1. INTRODUCTION

Le projet minier Matawinie est une mine à ciel ouvert de graphite géré par Nouveau Monde Graphite (NMG). NMG prévoit d'étendre sa capacité d'exploitation, en deux phases (A, B1) sur une période de 28 ans. À travers ces années d'opération, les eaux de la fosse de ruissellement et de procédé seront acheminées vers les bassins collecteurs (BC-1, BC-2 et BS). Depuis le bassin BC-2, l'eau sera pompée vers l'usine de traitement d'eau (UTE). Les eaux traitées seront en partie réutilisées pour les besoins de l'usine de production et la balance des eaux traitées rejoindra par gravité le ruisseau à L'Eau Morte.

NMG a sollicité Mabarex en demandant une proposition pour la conception, la fabrication, l'installation de l'UTE ainsi que pour la formation des opérateurs, non seulement pour répondre aux exigences de la qualité de l'effluent final selon la Directive 019 mais également pour se rapprocher et respecter le plus possible les OER du milieu récepteur (ruisseau à L'Eau Morte). Après caractérisation, les boues pourraient être disposées sur la halde de co-disposition.

Dans ce contexte, Mabarex, spécialisée dans le traitement des eaux, propose une filière de traitement physico-chimique sur deux trains, couvrant les phases A et B1 de développement de la mine au cours des 28 prochaines années. Les débits ayant servi à la conception de l'UTE proviennent du document "CAPR002717 Water Balance Model" reçu de NMG le 12 janvier 2024.

Le système proposé permet un service continu avec un minimum de surveillance et est dimensionné pour répondre aux performances du devis. L'usine de traitement aura pour fonction d'enlever des matières en suspension et des métaux présents dans les eaux de ruissellement, les eaux d'infiltration et les eaux de procédé de la mine pour permettre un rejet au milieu récepteur. L'usine sera installée sous un dôme, permettant le traitement des eaux à l'année longue. Les eaux traitées durant la période hivernale serviront essentiellement à générer des eaux pour les besoins de l'usine de production.

Les caractéristiques des eaux à traiter pour la conception du système de traitement sont basées sur la qualité de l'eau indiquée au Tableau 1 du Mémo Technique de NMG "NMG-ENV-024" daté du 13 novembre 2024. Cette caractéristique des eaux est identique à celle qui avait été considérée en 2021 lors de l'étape de soumission budgétaire. En juin 2021, nous avions reçu un échantillon d'un mètre cube provenant de la cellule de terrain représentative de la gestion des résidus miniers (courriel de Mme Martine Paradis du 10 juin 2021) sur lequel nous avons réalisé des tests afin de déterminer les consommations en produits chimiques. Ces mêmes données de consommation ont été considérées pour la présente révision de soumission qui comprend essentiellement une augmentation substantielle des débits comparés à ceux transmis en 2021.

Le système proposé consiste en un procédé de neutralisation, coagulation, floculation et clarification avec décanteurs lamellaires/épaississeurs. Afin de réduire l'empreinte au sol

le plus possible, un filtre-presse est proposé pour la déshydratation des boues. Le panneau de contrôle pour l'ensemble de la chaîne de traitement est inclus dans notre offre.

Le présent document vise à décrire le système proposé plus en détails et compile en annexe les résultats des essais, les dessins, ainsi que les fiches techniques des principaux équipements.

2. PARAMÈTRES DE CONCEPTION

Pour accommoder les deux phases (A et B1) d'exploitation produisant des volumes d'eaux usées variables, Mabarex a planifié le dimensionnement de cette usine en considérant deux trains de traitement d'une capacité de 900 m³/h chacun, prévoyant une pompe d'alimentation dédiée par train, ce qui permet une grande flexibilité d'opération, surtout en considérant les variations importantes du débit de conception.

Les débits de conception de la filière de traitement des eaux, qui combinent le ruissellement, les eaux d'infiltration et les eaux de procédé, sont décrits dans le document "CAPR002717 Water Balance Model" reçu de NMG le 12 janvier 2024 et sont compilés au tableau 1.

Tableau 1 : Débits de conception

Paramètre	Unité	UTE	
Phase		**A**	**B1**
Débits maximaux	m³/h	1000	1800
Débits moyens annuels	m³/h	395	395-**500**

À noter que, pour garantir l'efficacité du traitement, un débit minimum de 350 m³/h doit être maintenu sur un train de traitement. Pour la conception de l'usine de traitement, les concentrations dans l'eau en matières en suspension (MES) et en métaux à traiter sont résumées dans le Mémo Technique "NMG-ENV-024" cité plus haut. Nous avons également considéré les concentrations mesurées dans l'échantillon reçu le 10 juin 2021 lors de la réalisation des essais. L'annexe 4 présente un sommaire de ces résultats. Notons que selon NMG la concentration en métaux présente dans l'échantillon fourni est possiblement supérieure à celle qui sera à traiter réellement.

Les étapes de traitement de cette filière sont : augmentation du pH pour favoriser la formation d'hydroxydes insolubles, ajout d'un coagulant, d'un chélatant et d'un floculant, décantation et ajustement du pH en amont d'une étape de filtration tertiaire avant le rejet au milieu récepteur. La filière de traitement comprend également un filtre-presse automatique pour la déshydratation des boues.

C'est l'ajout du chélatant organique, à base de polythiocarbonates, qui permet l'atteinte des concentrations finales très faibles en métaux. L'utilisation de ce type de produit offre l'avantage de capter les métaux qui pourraient être complexés avec des produits organiques ou inorganiques.

Les quantités de produits chimiques présentées dans ce document reflètent la consommation aux débits de 1800 m^3/h.

Afin de bien comprendre la filière de traitement des eaux minières proposée, nous vous invitons à vous référer au diagramme de procédé et d'instrumentation 6535-DI-A01-A07_RA (annexe 2) et au plan préliminaire d'aménagement 6535-DP-P11-RA (annexe 3).

2.1 Alimentation de la filière

Tel que demandé au devis, nous avons considéré pouvoir alimenter l'usine à partir du bassin BC-2. Deux pompes submersibles d'alimentation seront fournies par d'autres. Chaque pompe alimentera un train. Nous avons prévu que le puits de pompage dans lequel les pompes submersibles seront installées sera construit en même temps que les bassins et réalisé par d'autres.

Pour les deux pompes en opération, les variateurs de fréquence qui commanderont chacune des pompes seront installés à proximité de celles-ci.

2.2 Prétraitement

Nous considérons qu'aucune étape de prétraitement (d'enlèvement des solides grossiers) n'est nécessaire puisque les eaux ont cheminé par des bassins de sédimentation avant de se rendre à la station.

2.3 Traitement physico-chimique

Le traitement physico-chimique de la station comprend deux trains de traitement identiques, chacun avec une étape de neutralisation, coagulation et floculation en amont d'un décanteur/épaississeur lamellaire.

2.3.1 Ajustement du pH et coagulation

Le mélange requis pour l'ajustement du pH et la coagulation sera effectué par un mélangeur dynamique en ligne. Chaque train aura son propre mélangeur. Le mélangeur est configuré pour fournir un mélange efficace tout en réduisant les temps de contact.

Le coagulant (en l'occurrence le sulfate ferrique), sera dosé proportionnellement au débit.

Le pH y sera mesuré en continu. Au besoin, de la soude caustique ("Cal-Artic") pourra être dosée pour maintenir un pH stable et ajouter de l'alcalinité aux eaux à traiter.

Les quantités de produits chimiques consommées, inscrites au tableau 6, proviennent des résultats des essais réalisés sur l'échantillon transmis par NMG. Ces quantités pourraient varier en fonction des variations de la composition réelle de l'eau à traiter et des résultats obtenus lors de l'opération de la filière de traitement.

Pour les calculs de consommation des produits chimiques, basé sur les tests effectués, nous avons considéré une augmentation du pH jusqu'à 10,5 et un ajustement de l'effluent final à un pH de 8,5. L'alcalinité finale des eaux traitées devra être vérifiée, une alcalinité trop basse pourrait engendrer des problèmes de toxicité de l'effluent final.

2.3.2 Coprécipitation avec le chélatant spécialisé

Le mélange du chélatant spécialisé sera effectué par un mélangeur dynamique en ligne. Le mélangeur est configuré pour fournir un mélange efficace tout en réduisant les temps de contact.

2.3.3 Réservoir de floculation

Le mélange lent dans les réservoirs de floculation permettra un brassage optimal du polymère afin de favoriser l'agglomération des flocs. La vitesse variable du mélangeur permettra d'avoir un contrôle optimal sur cette étape de floculation.

Tableau 2 : Réservoir de floculation

Paramètre	Unité	Valeur
Débit nominal de conception par train	m³/h	900
Débit minimal de conception par train	m³/h	350
Nombre de trains	--	2
Dimensions de chaque réservoir		
Volume	m³	45
Temps de résidence hydraulique (@ Q nom)	min	3,0
Mélange		
Puissance mélangeur mécanique	HP	2,0

2.3.4 Décanteurs lamellaires à fond raclé

Les décanteurs lamellaires recevront par gravité les eaux des réservoirs de floculation pour la séparation des matières solides. Les décanteurs lamellaires comprennent les éléments suivants :

- Structure autoportante préassemblée en usine;
- Une chambre d'admission de l'affluent qui sert à briser l'écoulement et à répartir uniformément le débit dans la section de séparation des solides;

- Une section de séparation des solides avec des lamelles en acier inoxydable inclinées à 55°;
- Un épaississeur de fond pour le stockage et l'épaississement des boues comprenant un système de raclage avec son entrainement à vitesse fixe, un interrupteur de torque et des racleurs de fond qui entrainent la boue vers le système de collecte central. Ce système permet non seulement de retenir les matières en suspension mais également de concentrer les boues afin que le volume de boues à pomper au système de déshydratation soit minimal;
- Des goulottes de reprise des eaux traitées et une chambre d'effluent.

Les caractéristiques des décanteurs/épaississeurs lamellaires proposés sont répertoriées au tableau 3.

Tableau 3 : Décanteurs/épaississeurs lamellaires

Paramètre	Unité	Valeur
Débit nominal de conception par train	m³/h	900
Nombre de trains	--	2
Dimensions		
Largeur	m	4,80
Hauteur	m	7,32
Longueur	m	8,23
Surface effective de décantation/décanteur	m²	362
Vitesse de décantation (@ Q nom)	m/h	2,5
Inclinaison des lamelles	°	55
Matériau des lamelles		Thermoplastique
Matériau du décanteur		Acier peint époxy

Les décanteurs ont été sélectionnés avec un système de raclage dans le fond afin de favoriser l'épaississement des boues et afin d'éviter le phénomène de « rathole » dans le fond du décanteur lors du pompage des boues. De cette façon, les risques d'accumulation des boues dans le décanteur sont minimisés. En effet, les caractéristiques des boues démontrent que cette boue forme une pâte qui a tendance à s'accumuler sur les parois, et toutes les précautions permettant d'éviter ce problème doivent être considérées.

Des pompes d'extraction des boues décantées sont prévues. Un débitmètre est prévu au refoulement des pompes afin de quantifier le volume des boues et contrôler le dosage de polymère en amont de la déshydratation.

Les différentes applications similaires ont permis d'estimer que les concentrations en matières en suspension de l'effluent pourront être réduites à moins de 15 mg/L. L'atteinte de cet objectif est garantie avec l'utilisation de la filtration tertiaire.

Une vanne automatique à la sortie de chaque décanteur pourra dévier les eaux traitées vers le bassin BC-2A le temps de stabiliser la filière de traitement ou si celles-ci ne respectent pas les critères de rejet.

2.3.5 Ajustement de pH

À l'effluent du décanteur lamellaire, un ajustement de pH en réservoir a lieu. L'acide sulfurique sera dosé pour atteindre un pH final de 8,5 ou moins avant que l'effluent ne soit rejeté à l'émissaire. Le mélange requis pour l'ajustement du pH sera effectué par un mélangeur pendulaire.

2.4 Filtration tertiaire

Le filtre à disques proposé est constitué de 18 disques de 2,2 m de diamètre, alignés sur un même axe et totalement submergés; ils sont munis d'une toile de 10 microns. Ce filtre offre une surface effective de filtration de 108 m^2, ce qui résulte en un taux de charge hydraulique de 8,33 m/h au débit maximum de la chaine de traitement soit 900 m^3/h par train. Les taux de charge hydrauliques reconnus sur les filtres à disques au débit de pointe doivent se situer entre 8 et 16 m/h avec des toiles de 10 microns.

Le filtre tertiaire a été dimensionné en considérant des concentrations en MES de l'ordre de 30 à 35 mg/L qui sont des valeurs supérieures à ce que les décanteurs lamellaires sont capables d'atteindre, ceci pour tenir compte des baisses de performances éventuelles lorsque les décanteurs seront opérés à leur capacité hydraulique maximale de 900 m^3/h.

L'utilisation du chélatant spécialisé combinée à la filtration tertiaire permettra de rencontrer l'OER de la majorité, voire de la totalité des composés à la sortie de l'UTE.

2.5 Gestion des boues

Les boues sédimentées dans les décanteurs seront pompées, à l'aide de la pompe de recirculation dédiée à chaque décanteur en déviant périodiquement ce flux vers le réservoir d'homogénéisation des boues situé en amont du filtre-presse.

Un filtre-presse automatique, d'une capacité de 0,55 m^3, sera utilisé. L'unité de déshydratation est munie d'un système de collecte des filtrats. La fermeture des plaques du filtre-presse se fera à l'aide d'une unité hydraulique.

Les paramètres de conception du filtre-presse figurent au tableau 4.

Tableau 4 : Filtre-presse automatique

Paramètres	Unité	Valeur
Nombre de filtre-presse	--	1
Capacité	m³	0,55
Dimension des plaques	mm	800 x 800
Dimensions approximatives		
Largeur	m	1,5
Longueur	m	5,8
Poids à vide	kg	5500

Les boues seront pompées du réservoir d'homogénéisation des boues vers le filtre-presse par une pompe centrifuge. La fin d'un cycle de filtre-presse se terminera par l'atteinte de la pression de consigne par la pompe d'alimentation.

L'ensemble des toiles du filtre-presse seront lavées automatiquement au besoin. Le filtre-presse comprend un système de surpression d'eau de service et de nettoyage des toiles qui, pour être plus efficace, est fait à contre-courant entre les plaques et les toiles.

Aux conditions de débit et de charge, nous estimons une moyenne de 36 cycles d'opération du filtre-presse par jour. Le filtrat de déshydratation du filtre-presse sera collecté et s'écoulera par gravité vers le bassin BC-2.

L'expérience du manufacturier du filtre-presse sur des boues similaires ne préconise pas l'utilisation de floculant pour atteindre de bonnes performances de déshydratation. Le système de préparation de solution de polymère n'est donc pas considéré.

La production horaire de boues est estimée à environ 20 m^3/h basé sur un débit de pointe d'eau maximum de 1800 m^3/h. Les boues déshydratées auront une siccité supérieure à 50%. Il n'est pas rare, surtout aux pressions élevées atteintes par le filtre-presse que nous avons considéré, que les boues atteignent des siccités proches de 80%. À 50% de siccité, la production de boues déshydratées correspondrait à environ 2 m^3/h.

2.6 Préparation et dosage des produits chimiques

Les consommations de produits chimiques proviennent essentiellement des tests réalisés sur l'échantillon reçu en juin 2021 (voir item 3). Les réservoirs de stockage sont sélectionnés pour offrir une autonomie de stockage de 7 jours en fonction du débit de pointe possible de la crue de 1800 m^3/h. En opération annuelle normale de l'UTE, l'autonomie de stockage sera supérieure à 21 jours.

2.6.1 Soude caustique hivernale ("Cal-Artic")

La consommation de produit chimique pour l'augmentation du pH de l'affluent afin de l'amener dans des zones permettant la précipitation des métaux constitue la principale source de dépense en produits chimiques.

La soude caustique hivernale "Cal-Artic" à 50 % de concentration est considérée pour son pouvoir alcalin et son efficacité de dissolution à une basse température jusqu'à -20°C.

Deux réservoirs à double paroi d'une capacité de 33 m^3 chaque, pour stocker en vrac ce produit chimique et assurer une autonomie de 7 jours, sont prévus.

Le système de dosage du "Cal-Artic" est livré préassemblé sur skid duplex.

Même si l'utilisation de chaux hydratée peut, à première vue, s'avérer plus économique contrairement à de la soude caustique nordique, cette dernière offre des avantages indéniables. Par exemple elle nécessite beaucoup moins d'entretien qu'un système de dissolution de lait de chaux et de sa boucle de dosage. En effet, la soude caustique nordique est facile à doser, ne nécessitant aucun entretien particulier des lignes de dosage, et constitue un excellent choix compte-tenu du fait que le traitement devra être parfois interrompu lorsque le débit du ruisseau récepteur sera trop faible. Par rapport à de la soude caustique traditionnelle à la concentration de 50 %, la soude caustique nordique ("Cal-Artic") possède les mêmes caractéristiques de neutralisation mais supporte des températures bien inférieures sans cristalliser, éliminant ainsi les périodes, parfois longues, requises pour déboucher les conduites de dosage obstruées par la cristallisation de la soude caustique à 50 %. Un skid duplex a été prévu sur chaque train.

2.6.2 Coagulant

Le coagulant choisi est le sulfate ferrique. Ce coagulant est communément utilisé dans ce genre d'application. Nous avons prévu un réservoir double-parois de 24 m^3 en polyéthylène pour stocker en vrac ce produit chimique.

Le système de dosage du coagulant est livré préassemblé sur skid duplex. Un skid duplex a été prévu sur chaque train.

2.6.3 Chélatant spécialisé

Pour permettre l'atteinte des OER, des chélatants spécialisés doivent être considérés. Ces chélatants, à base de soufre, permettent d'atteindre les concentrations listées dans les OER (voir section 3 concernant les essais en laboratoire).

Ce chélatant spécialisé sera injecté en ligne en amont du réservoir de floculation.

Le stockage du chélatant spécialisé est prévu dans un réservoir à double-parois d'environ 2 m^3.

Le système de dosage du chélatant spécialisé est livré préassemblé sur skid duplex. Un skid duplex a été prévu sur chaque train.

2.6.4 Polymère

Du polymère en poudre a été considéré pour cette application. Une unité automatique de préparation de la solution de polymère est prévue. Cette unité sera munie d'un aspirateur de polymère sec, d'une trémie, d'une vis doseuse de polymère sec, d'un système de transport pneumatique du polymère vers le cône mouilleur, d'un cône mouilleur, d'un réservoir de préparation avec mélangeur mécanique, et d'un réservoir de stockage. La préparation de la solution de polymère sera automatisée, mais l'opérateur devra s'assurer qu'il y ait suffisamment de polymère dans la trémie.

Le système de polymère est conçu pour une préparation d'une solution à 0,2 %. Le système de dosage du polymère est livré préassemblé sur skid duplex. Le dosage de polymère se fera dans chacun des réservoirs de floculation.

2.6.5 Acide sulfurique

L'acide sulfurique est retenu comme produit pour l'ajustement du pH à la baisse avant le rejet à l'environnement.

Le stockage d'acide sulfurique est prévu dans un réservoir de 13 m^3.

Le système de dosage d'acide sulfurique est livré préassemblé sur skid duplex.

3. ESSAIS EN LABORATOIRE

Sur réception de l'échantillon en provenance de NMG, reçu en juin 2021, un échantillon a été prélevé et envoyé au laboratoire accrédité. Le résultat de ces analyses figure à l'annexe 6 et est comparé aux valeurs transmises dans l'appel d'offres ainsi qu'aux valeurs obtenues lors des essais.

Les essais en laboratoire ont débuté avec l'étape d'augmentation du pH à différentes valeurs en utilisant soit de la soude caustique, soit du "Cal-Artic". Les essais ont démontré une consommation identique, pour atteindre un pH en particulier, entre la soude caustique et le "Cal-Artic". Nous recommandons d'utiliser le "Cal-Artic" dans le cas présent puisque ce produit est beaucoup moins susceptible à la cristallisation à températures froides. Le but de ces essais était de déterminer la consommation de produit alcalin en fonction du pH final atteint et des dosages de coagulant utilisés. La quantité et l'aspect des boues générées dans chacun des essais, ainsi que la clarté du surnageant permet de faire une première sélection des pH à atteindre et des dosages de coagulant à cibler.

Les photos des essais avec le "Cal-Artic" à différents pH, tels que résumés à l'annexe 4, sont visibles dans le Tableau 5.

Tableau 5 : Augmentation du pH avec le "Cal-Artic"

pH initial	9,5	10,0	10,2	10,5
pH final [(A)]	8,7	9,1	9,5	9,9

Note (A) : après injection sulfate ferrique

Les surnageants des essais à pH 10,0; 10,2 et 10,5 ont été transmis au laboratoire accrédité pour analyse. Les résultats de ces analyses figurent dans les colonnes pour la date du 17 juin 2021 (annexe 6). La décantation du floc est rapide, quelques secondes pour 80 % des flocs et ± 2 minutes pour l'ensemble des flocs formés.

Une deuxième série d'essais a été réalisée pour déterminer l'effet de l'ajout d'un chélatant, en plus du coagulant, sur l'atteinte des OER, en particulier sur le nickel, car c'était le seul élément qui ne respectait pas l'OER dans les essais réalisés avec le coagulant uniquement. Un pH initial de 10,5 a été retenu pour ces essais. À la suite d'échanges avec le fournisseur des produits chimiques, la nature et le dosage du floculant ont également été changés pour ces essais pour accroitre l'efficacité du traitement.

Les résultats des analyses externes (annexe 6, essais du 25 juin 2021) montrent que les OER sont respectés. Le nickel demeure l'élément le plus sensible. Les concentrations sont inférieures à l'OER mais s'approchent de celui-ci. Dans ces conditions, une étape de filtration tertiaire ajoute une sécurité supplémentaire afin d'atteindre les OER.

Finalement, un dernier essai pour générer un échantillon suffisamment volumineux pour permettre de réaliser des essais de toxicité sur des *Daphnia magna*, a été réalisé en date du 6 juillet 2021. Le résultat de cet essai démontre une absence de toxicité vis-à-vis de *Daphnia magna*. Cependant, la concentration en nickel a été légèrement supérieure à l'OER (0,033 mg/L comparée à 0,029 mg/L pour l'OER). L'atteinte de l'OER au niveau du nickel fera partie d'ajustements au niveau de l'opération. Le fait d'avoir considéré :

1. Une boucle de recirculation pour opérer la filière de traitement en mode HDS (High Density Sludge);
2. La possibilité de pouvoir augmenter le pH au-delà des pH testés lors des essais de laboratoire au niveau de la première étape d'ajustement du pH;
3. la possibilité de pouvoir retourner l'eau traitée en tête de traitement si elle ne respecte pas les concentrations souhaitées;

sont des aspects qui démontrent la flexibilité de la filière tant au niveau des performances de procédé qu'au niveau de l'optimisation de la consommation en produits chimiques.

4. IMPLANTATION DES ÉQUIPEMENTS

L'implantation des équipements est présentée au plan préliminaire 6535-DP-P11_RA. La surface au sol requise est de 20 m x 37 m pour tous les équipements de la chaîne de traitement et une dalle en béton est requise pour assurer une bonne répartition du poids des différentes unités. Le bâtiment mécanique sera de type dôme hybride à fournir par le client similaire à celui présenté à la figure 1. Les décanteurs, filtres tertiaires, filtre presse ainsi que les réservoirs de stockage de produits chimiques seront installés à l'intérieur du dôme tel que présenté au plan d'implantation préliminaire.

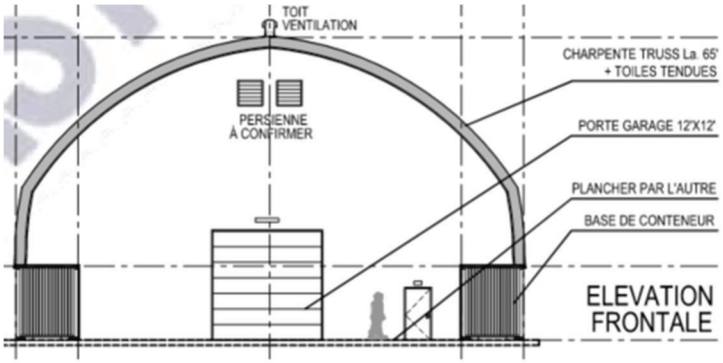


Figure 1: Coupe transversale d'un dôme hybride typique

Six (6) conteneurs de 40' serviront de structure au dôme et en même temps ils contiendront les équipements de préparation et dosage de produits chimiques, l'entrée électrique, ainsi que les équipements complémentaires.

L'accès aux décanteurs et aux réservoirs de floculation et ajustement de pH est réalisé par des plateformes structurales.

5. AVANTAGES DU SYSTÈME PROPOSÉ

Voici les principaux avantages du procédé proposé:

- Traitement éprouvé, requérant un minimum d'opération et d'entretien;
- Traitement peu énergivore, la principale dépense énergétique provenant des pompes d'alimentation;
- Volumes de boues à disposer minimisés.

6. CONSOMMATION DES PRODUITS CHIMIQUES

Les consommations de produits chimiques ont été estimées à partir des dosages moyens utilisés au débit d'opération annuel nominaux pour les phases A et B1 (voir Tableau 1).

Tableau 6 : Consommation estimée en produits chimiques

Produit chimique	Consommation journalière	
	Phase A (kg/d)	Phase B1 (kg/d)
"Cal-Artic" 50% (pH 10,5)	2 648	3 352
Sulfate ferrique	735	930
Chélatant spécialisé	71	90
Polymère (floculant)	28	36
Acide sulfurique 93% (pH 8,5)	526	666

Annexe 1
Diagramme de procédé et d'instrumentation
Envoi séparé

Annexe 2
Plan d'implantation
Envoi séparé

Annexe 3
Fiches techniques

MONROE ENVIRONMENTAL
Water & Wastewater Treatment | Air Pollution Control

Vertical Plate Clarifiers

The **Monroe Environmental**® Vertical Clarifier is designed to provide low cost, efficient solids removal from a wide range of waste and process liquids. The inclined plate design allows the total gravity settling area to be as much as ten times more than the actual floor space occupied by the clarifier. Integral chemical mixing and flocculation tanks are available, as well as options for enhanced sludge thickening.

This unit is typically used to remove solids from industrial waste and process waters. For municipal treatment plants, they are often used to clarify and remove solids from sand filter backwash water and other filtration processes.

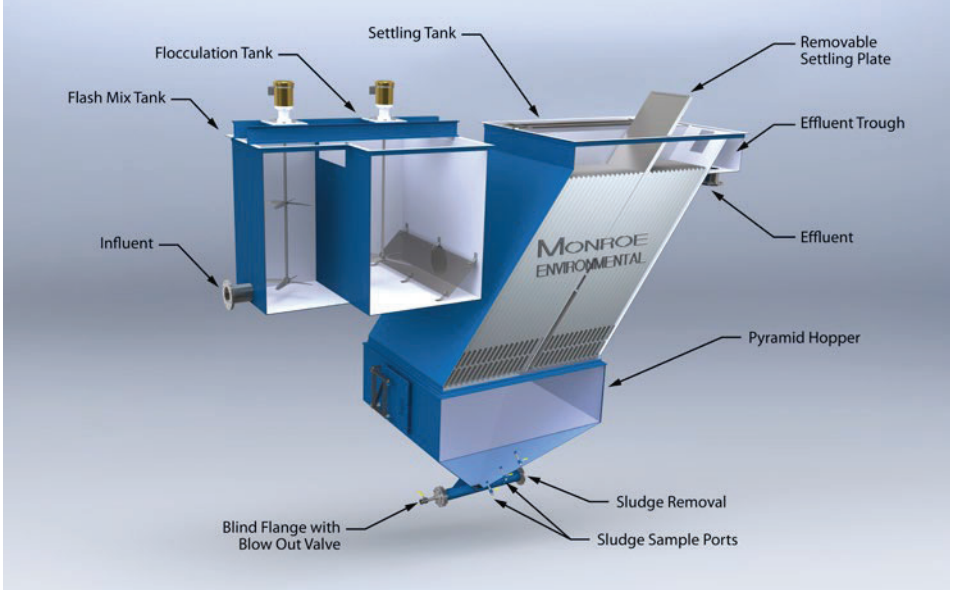
Optional equipment includes skimmer, drag conveyors, chemical treatment, flocculator, thickener, and control panel.

- Inclined plate separator
- Efficient removal of solids (TSS, TDS, metals, etc.) from liquids
- Extremely low space requirements
- Minimum maintenance
- Low installed costs
- No moving parts in settling area
- Capacities from 1 to 2,000 GPM

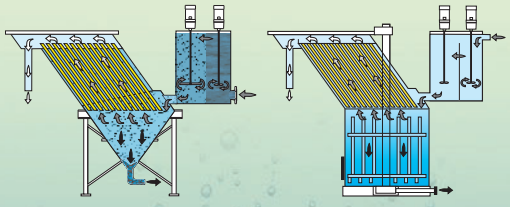
The unique, modular design of the Monroe Vertical Plate Clarifier allows for easy removal of individual laminar plate modules from the clarifier for inspection.

Monroe also offers versatile Horizontal Plate Clarifiers which utilize cross flow parallel plate technology capable of removing floating contaminants as well as settle–able materials.

1,000 GPM Vertical Plate Clarifier used to clarify filter backwash water



Sludge Removal Designs



Pyramid Hopper Sludge Thickener

Applications

- Chemical processing
- Coolant systems
- Filter backwash clarification
- Food processing
- Foundry operations
- Glass plant operations
- Industrial waste management
- Metal working
- Oil refining
- Paper making
- Plastic manufacturing
- Plating and coating processes
- Process water treatment
- Steel processing
- Storm water systems

70 GPM Vertical Clarifier with flash and flocculation tanks, thickener, and FRP cover for landfill leachate treatment

Installation of Vertical Clarifier for disc filter backwash with chemical mix tanks, access platform, ladder, and support structure

60 GPM Vertical Clarifier to treat surface/process water at chemical plant

Inclined Plate Clarifier Design

The Monroe Vertical Clarifier is designed to remove solids from wastewater and other process liquids. The flash mix and flocculation tanks (optional) allow for the addition of chemicals and polymers that will aid the settling process — adjusting pH to precipitate dissolved solids and/or enhancing the agglomeration of suspended particles into heavier, more settle-able floc. The liquid is fed from these tanks into the clarifier through the inlet chamber, which directs flow into the separation section.

The liquid then enters the lower area of the laminar plates through side slots which distribute it across the entire width of the plates. Particulate settles onto the face of the plates and slides down to the clarifier bottom. The clarified liquid exits the plate sections through launders at the top of the unit which are designed to develop and control adequate pressure drop, maintaining laminar flow through the plates.

The clarified liquid then flows into the effluent chamber and out of the clarifier.

Settled solids collect at the bottom of the pyramid sludge hopper and are removed from the clarifier. A Sludge Thickener (optional) with rake mechanism may be utilized in place of the pyramid hopper when applicable.

The unique, modular design of the Monroe Parallel Plate Vertical Clarifier allows for easy removal of individual laminar plate modules from the clarifier for inspection.

Designed For Your Specific Clarifier Application

While many installations provide adequate solids removal without influent pre-treatment, optional mixers and flocculator tanks are available to enhance efficiency when required. Some solids must be flocculated to achieve adequate mass to be effectively removed.

Special Features

Customized covers, access ladders, and platforms are available in a variety of materials including stainless steel, FRP, aluminum, and many others.

Wide range of construction materials. Mild steel, special coatings, stainless steel, fiberglass, plastics, and other materials are available to meet specific needs.

The unique, modular design of the Monroe Vertical Clarifier allows easy removal of individual laminar plate modules from the clarifier for inspection.

A flash mixer and flocculator tank are available pretreatment options.

A rake thickener with geared drive is available for the bottom of the separator tank to increase solids concentration.

Complete electrical controls are available to meet customer requirements.

Customized covers, access ladders, and platforms are available in a variety of materials including stainless steel, FRP, aluminum, and many others.

Pilot & Testing Programs

Monroe Environmental pilot systems are an excellent option for testing your application. This is a cost-effective way to evaluate an environmental solution before making a capital investment in a full scale system. Monroe has several pilot systems available for rent as well as the support services required to install, operate, and evaluate the system's performance.

MONROE ENVIRONMENTAL
Water & Wastewater Treatment | Air Pollution Control

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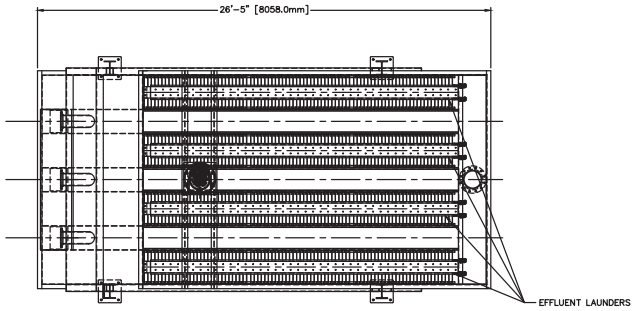
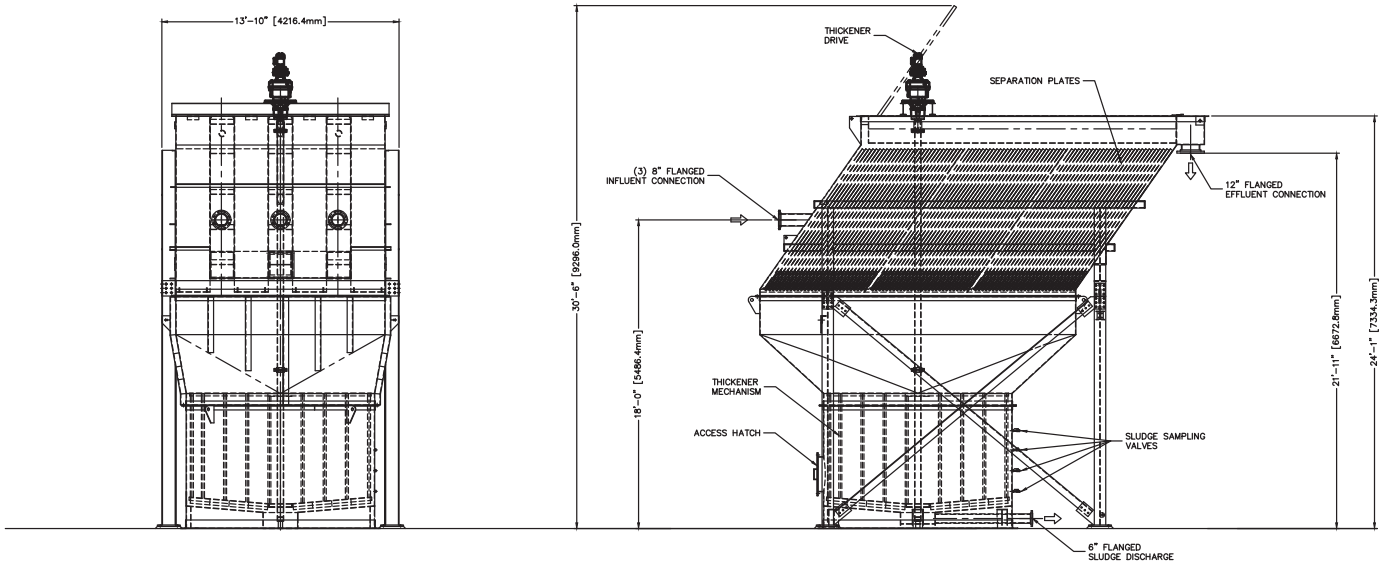
RSP = RECOMMENDED SPARE PARTS

RSP	No.	QTY	DESCRIPTION	PART NUMBER





ELEVATION VIEW

PRELIMINARY

-SUBJECT TO CHANGE -
- DIMENSIONS ARE APPROXIMATE -
- NOT TO SCALE -
- FOR REFERENCE ONLY -

FABRICATION TOLERANCES
UNLESS OTHERWISE SPECIFIED
0 FT ≤ 10 FT ±1/4 | 0 mm ≤ 3000 mm ±1.5 mm
10 FT ≤ 20 FT ±1/8 | 3000 mm ≤ 6000 mm ±3 mm
> 20 FT ±3/16 | > 6000 mm ±4.5 mm
STRUCTURAL STEEL TOLERANCES PER AISC

MACHINING TOLERANCES
UNLESS OTHERWISE SPECIFIED
ANGULAR ±1 DEGREE | 1 PLACE DECIMAL INCHES ±0.1 INCHES (±2.5 mm)
SURFACE FINISH 125 MICROINCHES | 2 PLACE DECIMAL INCHES ±0.01 INCHES (±0.25 mm)
3 PLACE DECIMAL INCHES ±0.005 INCHES (±0.005 mm)

CAUTION
WHEN INSTALLING OR OPERATING OUR MACHINING EQUIPMENT, ALWAYS REFER TO INSTALLATION, OPERATING AND MAINTENANCE MANUAL FOR SAFETY PRECAUTIONS.

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DO NOT SCALE USE DIMENSIONS ONLY
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REV	CHANGE	DRW	DATE	CKD	DATE	APP	DATE

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MONROE ENVIRONMENTAL
MONROE, MICHIGAN

TITLE
VCT-3900
GENERAL ARRANGEMENT

MABAREX

SCALE: NTS
PROJECT NO.: 12496
DRAWING NO.: 12496-MABAREX

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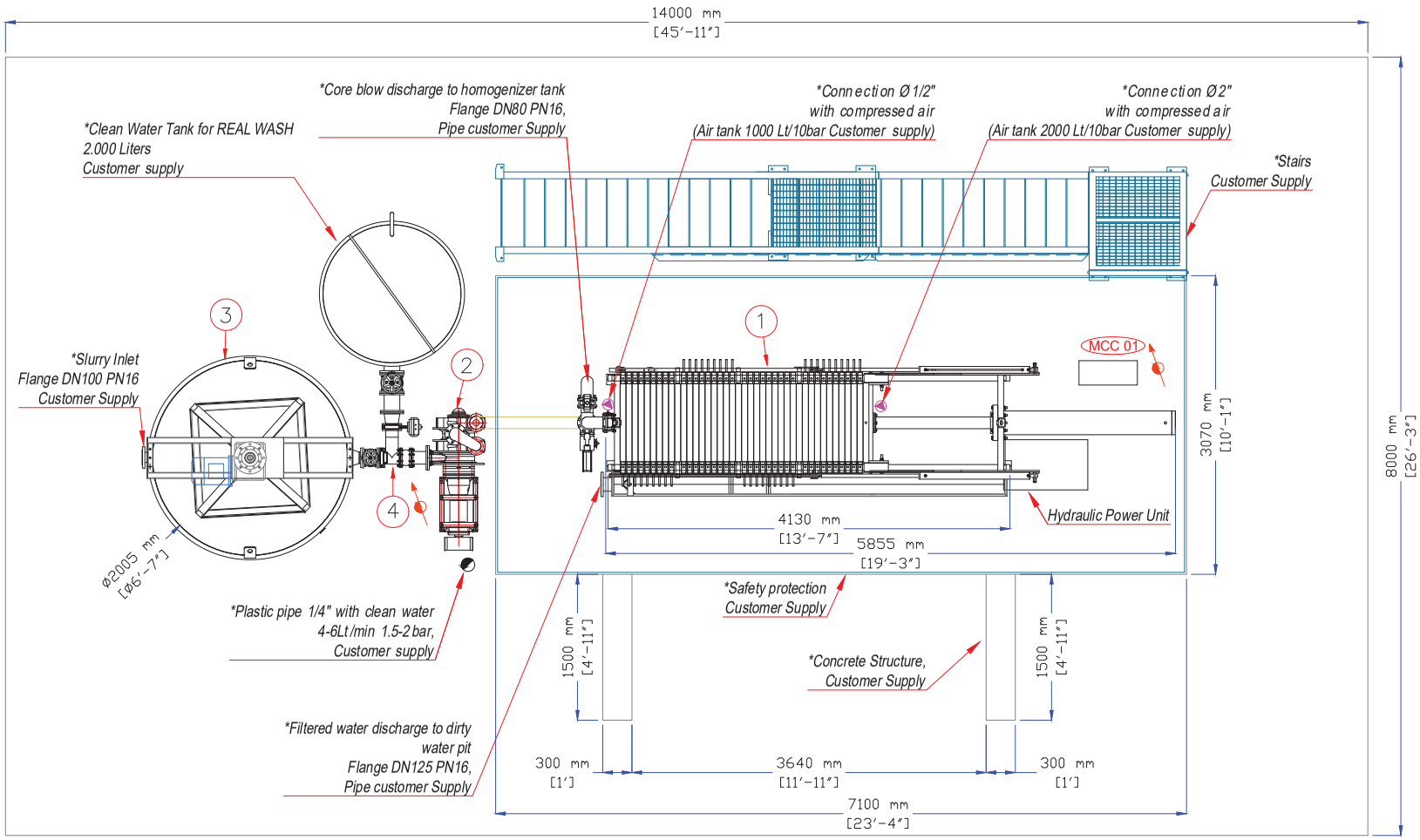

***	Considering a material weight of 1.85 g/cm³				
**	Considering a material weight of 1.8 g/cm³				
*	Supplied by Customer				
4	Manual and automatic valve				
3	Slurry homogeniser tank inox	BIFANG 10.000	2.2	1.000	***19.500
2	Filter feeding centrifugal pump	Delta 550-2H (305)	37		
1	Filter Press	FP800_40P	4	5.500	***7.300
POS.	DESCRIPTION	MODEL	power kW	empty weight kg	working weight kg

LEGEND

electrical connection point | potable water connection | air connection pipe

Customer: Mabarex

Drawing code: B02_20210726_00_01

ELECTRICAL PANEL LEGEND

N° Panel	DESCRIPTION	Power kW	TO BE SUPPLIED BY
MCC 01	FILTERPRESS ELECTRICAL PANEL, supplies and distributes power to hydraulic power unit, feeding pump and homogenizer tank	43.7	575 V 60 Hz

Carefully verify the Layout proposal in every detail and kindly submit a confirmation or a request for modification
Customer signature:_____

All electrical cables and general electrical panel are excluded from Matec supply unless otherwise specified in the contract.

Impianti di depurazione e filtrazione acque
Depuration plants and water filtration
MATEC ENGINEERING
via Aurelia Ovest, 383 54100 Massa (MS)
tel. +39.0585.831034 fax. +39.0585.835918
info@matecitalia.com www.matecitalia.com

Plan View _Depuration plants/filtration | Rev. 00

design by	Ostrogovich Luca	date 19.05.21	pg. 1/3
checked by	Giovanelli Davide	date 19.05.21	format A1

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Dimensions are given in millimeters

0 500 1000 2000mm

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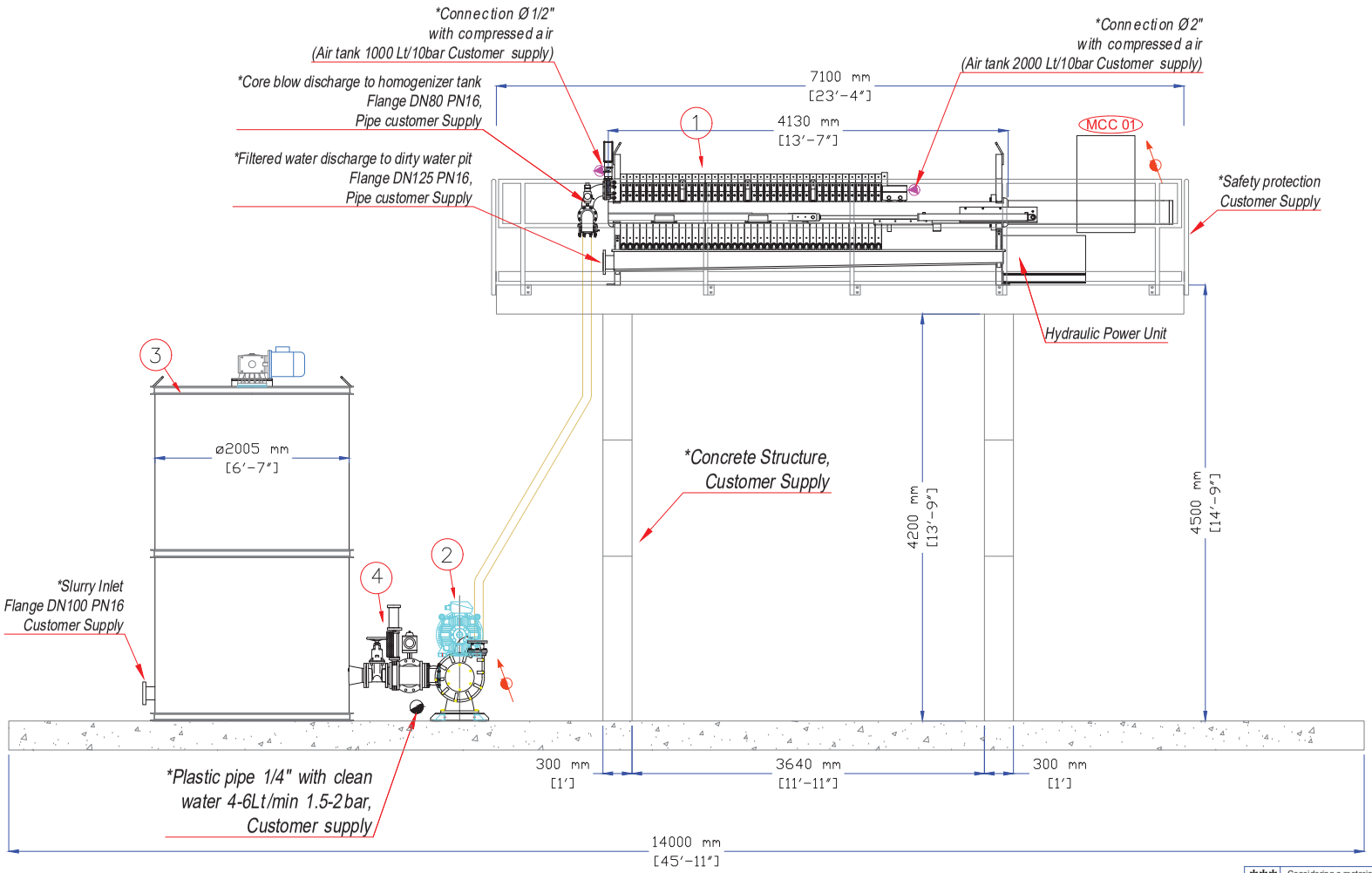

***	Considering a material weight of 1.85 g/cm³				
**	Considering a material weight of 1.8 g/cm³				
*	Supplied by Customer				
4	Manual and automatic valve				
3	Slurry homogeniser tank inox	BIFANG 10.000	2.2	1.000	***19.500
2	Filter feeding centrifugal pump	Delta 550-2H (305)	37		
1	Filter Press	FP800_40P	4	5.500	***7.300
POS.	DESCRIPTION	MODEL	power kW	empty weight kg	working weight kg

LEGEND

electrical connection point | potable water connection | air connection pipe

ELECTRICAL PANEL LEGEND

MCC 01	FILTERPRESS ELECTRICAL PANEL, supplies and distributes power to hydraulic power unit, feeding pump and homogenizer tank	43.7	575 V 60 Hz
N° Panel	DESCRIPTION	Power kW	TO BE SUPPLIED BY

Carefully verify the Layout proposal in every detail and kindly submit a confirmation or a request for modification
Customer signature:_____

All electrical cables and general electrical panel are excluded from Matec supply unless otherwise specified in the contract.

Customer: Mabarex

Drawing code: B02_20210726_00_02

Impianti di depurazione e filtrazione acque
Depuration plants and water filtration

MATEC ENGINEERING

via Aurelia Ovest, 383 54100 Massa (MS)
tel. +39.0585.831034 fax. +39.0585.835918
info@matecitalia.com www.matecitalia.com

Frontal View_Depuration plants/filtration | Rev. 00

design by	Ostrogovich Luca	date 19.05.21	pg. 2/3
checked by	Giovanelli Davide	date 19.05.21	format A1

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Dimensions are given in millimeters

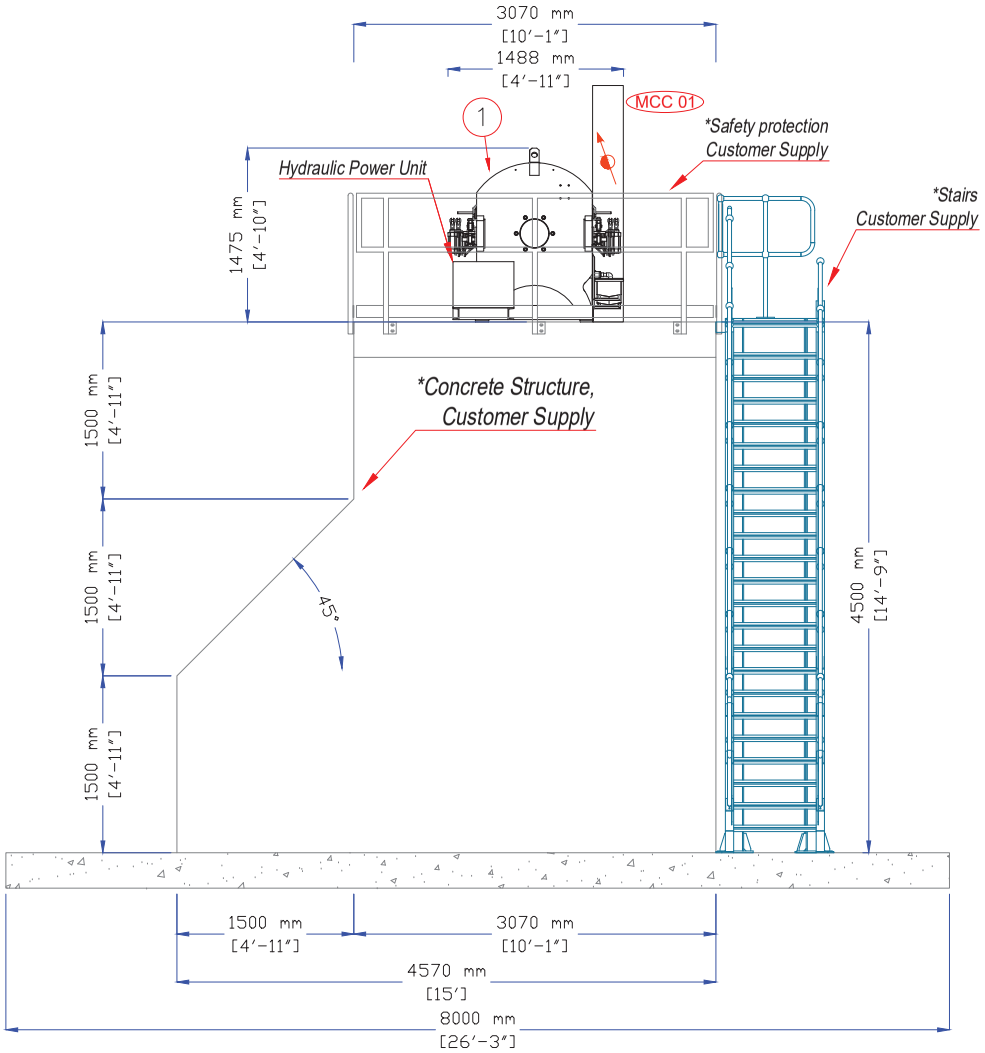
0 500 1000 2000mm

PRELIMINARY LAYOUT

We recommend to NOT use this dwg for construction purpose.
It is PRELIMINARY.

DIMENSIONS OF CONCRETE WORKS ARE NOT BINDING. CHECK WITH YOUR TECHNICIAN IN EXECUTIVE PROJECT.

SIZES: in the drawing refer to standard components. Therefore, they will have to be checked with components delivered by supplier.



Dimensions are given in millimeters

0 500 1000 2000mm

ELECTRICAL PANEL LEGEND

N° Panel	DESCRIPTION	Power kW	TO BE SUPPLIED BY
MCC 01	FILTERPRESS ELECTRICAL PANEL, supplies and distributes power to hydraulic power unit, feeding pump and homogenizer tank	43.2	575 V 60 Hz

Carefully verify the Layout proposal in every detail and kindly submit a confirmation or a request for modification
Customer signature:_____

All electrical cables and general electrical panel are excluded from Matec supply unless otherwise specified in the contract.

***	Considering a material weight of 1.85 g/cm³				
**	Considering a material weight of 1.8 g/cm³				
*	Supplied by Customer				
4	Manual and automatic valve				
3	Slurry homogeniser tank inox	BIFANG 10.000	2.2	1.000	***19.500
2	Filter feeding centrifugal pump	Delta 550-2H (305)	37		
1	Filter Press	FP800_40P	4	5.500	***7.300
POS.	DESCRIPTION	MODEL	power kW	empty weight kg	working weight kg

LEGEND

electrical connection point | potable water connection | air connection pipe

Customer: Mabarex

Drawing code: B02_20210726_00_03

Impianti di depurazione e filtrazione acque
Depuration plants and water filtration

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Lateral View_Depuration plants/filtration | Rev. 00

design by	Ostrogovich Luca	date 19.05.21	pg. 3/3
checked by	Giovanelli Davide	date 19.05.21	format A1

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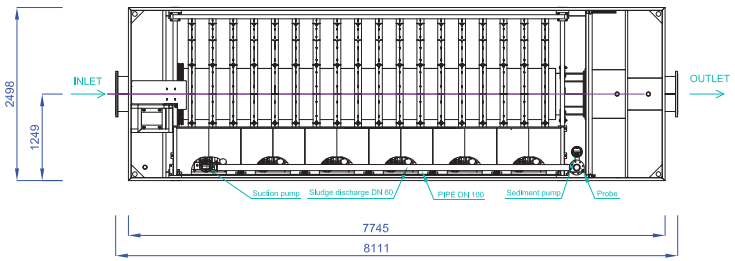
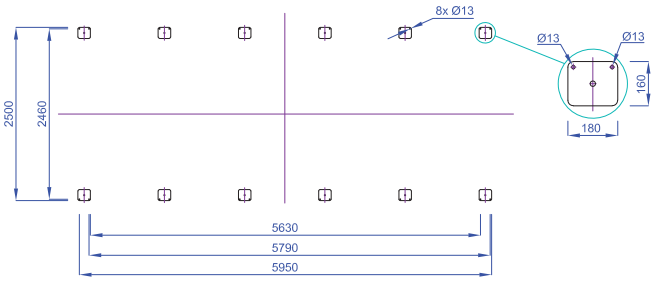
DISC FILTER
M 1:50

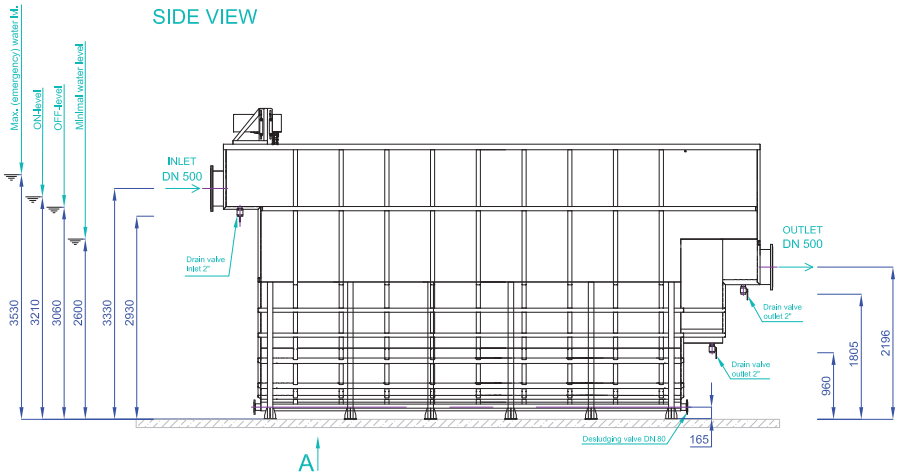
FLOOR PLAN



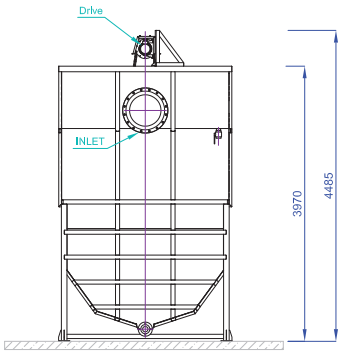
SECTION A - ANCHORING



SIDE VIEW



INLET VIEW



www.in-eko.com Projection	ALL FOR WATER	IN-EKO TEAM	Trnec 1734 Tišnov 66603 Czech Republic
Weight without water 6600kg	Name **Disc filter**		
Weight with water 52600kg	Type 18FC2_O_R		

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V20230424

Annexe 4
Résultats des essais en laboratoire

date d'impression : 20/08/2021

IDENTIFICATION DU PROJET

Numéro du projet: 6535

Seuils de toxicité et normes

			Directive 019 (moyenne mensuelle)	Directive 019 (conc. maximale acceptable)	OER	devis tableau 3 moyenne	devis tableau 3 moyenne	Analyse tote	précipitation hydroxydes			essais chélatant spécialisé		essai 20 L
									pH initial : 10,0 pH coag.: 9,1	pH initial : 10,2 pH coag.: 9,6	pH initial : 10,5 pH coag.: 9,9	pH initial : 10,5 pH coag.: 9,10 chélatant av. coag.	pH initial : 10,5 pH coag.: 9,8 chélatant ap. coag.	pH initial : 10,5 pH coag.: 9,9 chélatant ap. coag.
									17/06/2021			25/06/2021		06/07/2021
Alcalinité totale	*général*	mg/L				*16*	*32*				32			
Azote ammoniacal ($N\text{-}NH_3/NH_4^+$)	*général*	mg-N/L			4,2/6,6	*< 12*		< 0,020						
Matières en suspension	*général*	mg/L	15	30	15	*70*	*519*	6	110	120	170			
Chlorures	*ions*	mg/L						5,5						
Nitrates	*ions*	mg-N/L			10,3			0,62						
Nitrites	*ions*	mg-N/L			0,069									
Sulfates	*ions*	mg-SO_4/L					*1 600*	2 100						
Aluminium	*soluble*	mg/L				*0,2*	*0,3*	0,024						< 0,030
Aluminium	*total*	mg/L			*1,36*			0,040	0,010	< 0,010	0,018	< 0,010	< 0,010	0,029
Argent	*soluble*	mg/L					*0,02*	< 0,0010						< 0,00030
Argent	*total*	mg/L			0,00034			< 0,0010	< 0,0010	< 0,0010	< 0,0010	< 0,0010	< 0,0010	< 0,010
Arsenic	*soluble*	mg/L					*0,05*	0,032						0,030
Arsenic	*total*	mg/L	0,2	0,4	0,074			0,033	0,030	0,029	0,030	0,029	0,028	0,030
Baryum	*soluble*	mg/L				*0,03*	*0,3*	0,045						0,077
Baryum	*total*	mg/L			0,14			0,040	0,038	0,037	0,039	0,034	0,032	0,037
Béryllium	*soluble*	mg/L					*0,00002*	< 0,0020						< 0,0020
Béryllium	*total*	mg/L			0,000027			< 0,0020	< 0,0020	< 0,0020	< 0,0020	< 0,0020	< 0,0020	< 0,0020
Cadmium	*soluble*	mg/L				*< 0,0003*	*0,005*	0,00087						< 0,0010
Cadmium	*total*	mg/L			0,000187			**0,00076**	< 0,00020	< 0,00020	< 0,00020	< 0,00020	< 0,00020	< 0,00020
Calcium	*soluble*	mg/L						550						540
Calcium	*total*	mg/L						550	520	520	520	540	510	530
Chrome	*soluble*	mg/L					*6,31*	0,0070						< 0,0050
Chrome	*total*	mg/L			0,038			< 0,0050	< 0,0050	< 0,0050	< 0,0050	< 0,0050	< 0,0050	< 0,0050
Cobalt	*soluble*	mg/L				*0,003*	*0,28*	0,011						< 0,020
Cobalt	*total*	mg/L			0,35			0,011	< 0,0010	< 0,0010	< 0,0010	< 0,0010	< 0,0010	< 0,0010
Cuivre	*soluble*	mg/L				*0,015*	*5,0*	0,0099						< 0,0030
Cuivre	*total*	mg/L	0,3	0,6	0,0046			0,0027	0,001	< 0,0010	< 0,0010	< 0,0010	< 0,0010	< 0,0010
Fer	*soluble*	mg/L				*6,8*	*25,1*	< 0,060						< 0,10
Fer	*total*	mg/L	3	6	4,3			< 0,060	0,53	0,21	0,29	0,14	0,19	0,14
Magnésium	*soluble*	mg/L						200						180
Magnésium	*total*	mg/L						200	180	170	170	170	160	170
Manganèse	*soluble*	mg/L				*7,2*	*10,6*	18						0,091
Manganèse	*total*	mg/L			1,00			**19**	**4,00**	0,65	0,32	0,15	0,14	0,32
Mercure	*soluble*	mg/L					*0,0005*	< 0,00010						< 0,00010
Mercure	*total*	mg/L			0,0000013			< 0,00010	< 0,00010	< 0,00010	< 0,00010	< 0,00010	< 0,00010	< 0,00010
Nickel	*soluble*	mg/L				*0,073*	*2,8*	2,7						< 0,010
Nickel	*total*	mg/L	0,5	1,0	0,029			**2,8**	**0,20**	**0,047**	**0,055**	0,021	0,020	**0,033**
Phosphore	*soluble*	mg/L						0,042						0,026
Phosphore	*total*	mg/L						< 0,010	0,011	< 0,010	< 0,010	< 0,010	< 0,010	< 0,010
Plomb	*soluble*	mg/L					*0,08*	< 0,00050						< 0,0010
Plomb	*total*	mg/L	0,2	0,4	0,00065			< 0,00050	< 0,00050	< 0,00050	< 0,00050	< 0,00050	< 0,00050	< 0,00050
Potassium	*soluble*	mg/L						72						120
Potassium	*total*	mg/L						72	100	110	120	130	130	120
Sodium	*soluble*	mg/L						41						70
Sodium	*total*	mg/L						23	51	62	72	81	77	67
Zinc	*soluble*	mg/L				*0,106*	*12,6*	0,065						0,0086
Zinc	*total*	mg/L	0,5	1,0	0,066			0,017	< 0,0070	< 0,0070	< 0,0070	< 0,0070	< 0,0070	< 0,0070

AtkinsRéalis	AVIS TECHNIQUE Revue de la mise à jour de la chaine de traitement des eaux de contact		
	No de document :	**Rév.**	**Date :**
	701617-0001-4KER-0001	00	13 mai 2025

Titre du document : Revue de la mise à jour de la chaine de traitement des eaux de contact

Client : **NOUVEAU MONDE GRAPHITE**

Projet : **Mine Matawinie**

Préparé par : Anh-Long Nguyen, ing.,
#OIQ : 122858

Note au lecteur

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Liste des révisions

#	Prép.	Rév.	App.	Date	Pages	Remarques
PA	ALN	PDB		2025-05-08		Pour commentaire interne
00	ALN	PDB	KD	2025-05-13		Final

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1. Introduction 1

2. Limitations 1

3. Documents référence 1

4. Avis Technique 1

5. Conclusions 2

6. Références 2

1. Introduction

Les services professionnels d'AtkinsRéalis Canada inc. (AtkinsRéalis) ont été retenus par Nouveau Monde Graphite (NMG) pour fournir un avis technique sur la mise à jour de la chaine de traitement des eaux de contact provenant du site qui diffère de celle présentée originalement dans l'Étude d'Impact Environnemental et Social (EIES) pour ce projet (SNC-Lavalin, 2019). Le changement principal est l'élimination du bassin de polissage en aval de l'usine de traitement des eaux (UTE).

2. Limitations

Le présent avis technique se limite sur l'enlèvement du bassin de polissage de la chaine de traitement et la revue des unités de procédé prévues pour l'UTE.

Cet avis technique ne couvre pas les éléments suivants :

- Revue de l'hydrologie de base, calcul de laminage de crue et le débit de conception de l'UTE;
- Dimensionnement des bassins de collecte;
- Dimensionnement des équipements de procédé.

3. Documents référence

Les documents techniques suivants ont été consultés pour cet avis technique :

- Description de la filière de traitement rédigé par Mabarex (Mabarex, 2024);
- Rapport d'ingénierie des ouvrages de gestion des eaux de surface du projet minier Matawinie par SRK Consulting (SRK Consulting, 2025);
- Diagramme de procédé des bassins et usine de traitement des eaux (AtkinsRéalis, 2025).

4. Avis Technique

Originalement, tel que décrit dans l'EIES (SNC-Lavalin, 2019), un bassin de polissage était prévu en aval de l'UTE afin de (1) agir comme un bassin pour décanter les matières en suspension (MES) résiduelles provenant de l'UTE; et (2) fournir une réserve d'eau pour alimenter le procédé.

Avec la nouvelle mise à jour du plan de gestion des eaux, le bassin de polissage a été retiré de la chaine de traitement (SRK Consulting, 2025). Ce bassin a été remplacé par une filtration tertiaire.

La chaine de traitement prévue pour l'UTE consiste d'un traitement physico-chimique conçu pour enlever les métaux lourds ainsi que les MES. Les MES et les métaux précipités sont décantés dans des décanteurs lamellaires. Ensuite, l'eau clarifiée est acheminée vers une filtration tertiaire pour assurer une filtration des MES résiduelles. L'eau filtrée est ensuite acheminée au point de décharge de l'effluent final (Mabarex, 2024).

La technologie proposée par Mabarex pour l'étape de la filtration tertiaire est des filtres à disques. Chaque unité est constituée de 18 disques de 2,2 m de diamètre, alignée sur un même axe et totalement submergée et chaque disque est muni d'une toile de 10 microns nominal. De plus, l'unité proposée est conçue pour filtrer une eau clarifiée ayant une concentration de MES entre 30 à 35 mg/L (Mabarex, 2024).

L'utilisation des filtres à disques avec une toile de 10 microns nominal assure une séparation des MES résiduelles dans l'eau clarifiée et une protection en cas de problème de traitement au niveau des décanteurs. Sa performance de traitement sera mieux qu'un bassin de polissage étant donné que le mécanisme de séparation des MES est par une filtration au lieu d'une décantation. Avec une toile de 10 microns, ceci permet une filtration des particules silteuses.

Pour le stockage de l'eau traitée pour alimenter le procédé, une partie de l'eau de l'UTE sera pompée vers un réservoir de stockage d'eau pour être réutilisée comme source d'eau fraiche (AtkinsRéalis, 2025).

5. Conclusions

La mise à jour de la chaine de traitement inclut maintenant une étape de filtration tertiaire de l'eau clarifiée en utilisant des filtres à disques munis d'une toile de 10 microns nominal. Cette étape de filtration tertiaire remplit la même fonction prévue originalement par le bassin de polissage. De plus, sa performance de traitement devrait être supérieure à celle du bassin.

Pour favoriser la réutilisation de l'eau traitée dans le procédé de minerai, une réserve d'eau fraiche est prévue pour stocker cette eau.

6. Références

AtkinsRéalis. (2025). Process Flow Diagram, Ponds and Water Treatment Plant, 669469-0505-49DG02-0004_02.

Mabarex. (2024, décembre 16). Performance du système de traitement des eaux, Projet minier graphite de Matawinie, Description de la filière de traitement.

SNC-Lavalin. (2019, décembre). Projet Matawinie – Étude d'impact environnemental et social.

SRK Consulting. (2025, janvier 31). Rapport d'ingénierie des ouvrages de gestion des eaux de surface du projet minier Matawinie.

AtkinsRéalis

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Minéraux et Métaux

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ATKINSRÉALIS - Sensible

NOTE TECHNIQUE

Détermination des OER et des impacts sur la qualité des eaux de surface

SUJET
Modification du décret de NMG

NO DE PROJET
701617

DATE
05-09-2025

AUTEUR
Claude Côté

DISTRIBUTION
Kevin Ducharme, NMG

RÉFÉRENCE DE DOCUMENT
701617-0001-4EER-0001-00

Historique du document

Révision	Description de l'objectif	Origine	Vérifié	Révisé	Autorisé	Date
PA	Révision par client	Claude Côté	Pierre-David Beaudry	CC	PDB	22-07-2025
00	Version finale	Claude Côté	Pierre-David Beaudry	CC	PDB	04-09-2025

Les OER actuels du projet ont été déterminés par le MELCCFP (ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs) et transmis à Nouveau Monde Graphite (NMG) en novembre 2020. Ils sont basés sur un débit moyen de 3 204 m^3/j à la Phase B2 du projet avec un arrêt du rejet lorsque le débit du ruisseau à l'Eau Morte est inférieur à 182 L/s (correspondant au débit d'étiage Q_{10-7} pour la période hivernale). Cependant, les nouveaux résultats du modèle hydrologique [1]obtenus à la suite d'une mise à jour des effets des changements climatiques et tenant compte maintenant de l'effet orographique démontrent que les volumes d'eaux traitées à rejeter dans l'environnement seront plus élevés que ceux prévus initialement, tel qu'indiqué dans le tableau 1 ci-dessous.

Tableau 1 Volume annuels d'eaux usées traitées pour les trois phases du projet

Phase	Années	Volume annuel (m^3)		
		Moyen	Minimum	Maximum
A	2028 – 2032	400 000	300 000	530 000
B1	2033 – 2035	720 000	630 000	940 000
B2	2036 – 2056	1 340 000	1 180 000	1 560 000

En raison des débits plus importants, une révision des objectifs environnementaux de rejet (OER) pour l'effluent final s'avère nécessaire. Les nouveaux OER présentés dans cette note technique sont préliminaires puisque les OER officiels devront être évalués par le MELCCFP. Les OER sont maintenant spécifiques à chacune des phases afin de considérer l'importante différence des débits d'une phase à l'autre. Les impacts sur la qualité des eaux du milieu récepteur sont également réévalués dans cette note technique à la suite de ces changements aux débits de l'effluent final.

Phase A

Pour la première phase du projet, les OER sont évalués comme dans l'EIE, c'est-à-dire basé sur le débit moyen de l'effluent et en fixant un débit minimum dans le ruisseau à l'Eau Morte pour qu'il y ait rejet. En fonction des équipements de pompage qui seront en place, il est maintenant établi que le débit minimal de l'effluent sera de 116 m^3/h. Pour ce dernier débit de l'effluent, un débit minimal de 176 L/s (634 m^3/h) dans le ruisseau à l'Eau Morte est nécessaire pour faire en sorte que tous les critères de la qualité de l'eau ne soient pas dépassés, et ce sur la base d'un calcul de dilution qui prend en compte les concentrations déjà présentes dans le ruisseau.

Pour les nouveaux OER, l'effluent sera donc arrêté lorsque le débit du ruisseau à l'Eau Morte sera inférieur à 176 L/s, soit un débit un peu plus bas que le débit précédent de 182 L/s qui était basé au débit d'étiage Q_{10-7} pour la période hivernale. Selon les mesures disponibles des débits du ruisseau à l'Eau Morte, un débit supérieur à 176 L/s est rencontré en moyenne 329 jours par année. Avec un volume annuel maximal de 530 000 m^3, le débit annuel maximal de l'effluent est de 1 611 m^3/jour.

Les OER déterminés pour la Phase A sont résumés dans le tableau 2. Comme indiqué dans le tableau 3, toutes les concentrations prévues dans l'effluent final sont en deçà des OER.

[1] SRK Consulting 2025. GoldSim Model Built: Water Balance Model – Matawinie Site, Saint-Michel-des-Saints, Québec, Canada.

Tableau 2 Objectifs environnementaux de rejet de l'effluent final dans le ruisseau à l'Eau Morte Phase A (effluent avec un débit moyen de 1 611 m³/jour ; pas de rejet lorsque le débit du ruisseau est inférieur à 176 L/s)

Contaminants	Critères de qualité des eaux de surface		Concentrations amont dans le ruisseau (mg/L)	OER	
	Usages *	(mg/L)		Concentrations dans l'effluent (mg/L)	Charges dans l'effluent (kg/jour)
Matières en suspension	CVAC	5,8	0,8	Directive 019	-
Aluminium	CVAC	0,43	0,05	2,2	3,6
Argent	CVAC	0,0001	0,000002	0,00056	0,00091
Arsenic	CPC(O)	0,021	0,0001	0,12	0,19
Baryum	CVAC	0,046	0,0076	0,23	0,37
Béryllium	CVAC	0,000188	0,000005	0,0011	0,0017
Cadmium	CVAC	0,000056	0,000003	0,00031	0,00049
Chrome	CVAC	0,011	0,00009	0,062	0,10
Cobalt	CVAC	0,10	0,000065	0,57	0,92
Cuivre	CVAC	0,0015	0,00028	0,0073	0,012
Fer	CVAC	1,3	0,09	7,0	11
Manganèse	CVAC	0,30	0,013	1,7	2,7
Mercure	CFTP	0,0000013	0	0,0000013	0,0000021
Nickel	CVAC	0,0087	0,00027	0,048	0,078
Plomb	CVAC	0,00021	0,000035	0,0011	0,0017
Zinc	CVAC	0,020	0,00097	0,11	0,18
Azote ammoniacal (hiver)	CVAC	1,9	0,01	11	17
Azote ammoniacal (été)	CVAC	1,2	0,01	6,8	11
Diésel	CVAC	0,2	0	1,2	1,8
Fluorures	CVAC	0,2	0,03	1,0	1,6
Nitrates	CVAC	3	0,01	17	28
Nitrites	CVAC	0,02	0	0,12	0,18
pH		-	-	6,0 à 9,5	-
Toxicité aigue	VaFe (Uta)	1	-	1,0	-
Toxicité chronique	CVAC (Utc)	1	-	5,7	-

* CVAC : protection de la vie aquatique (effet chronique) ; CPC(O) : prévention de la contamination (organismes aquatiques seulement) ; CFTP : protection de la faune terrestre piscivore ; VaFe : valeur aigue finale à l'effluent

Tableau 3 Comparaison des objectifs environnementaux de rejet aux concentrations prévues de l'effluent final – Phase A

Contaminants	OER - Concentrations allouées (mg/L)	Concentrations prévues dans l'effluent final (mg/L)
Matières en suspension	Directive 019	nd
Aluminium	2,2	0,01
Argent	0,00056	< 0,001
Arsenic	0,12	0,028
Baryum	0,23	0,032
Béryllium	0,0011	< 0,002
Cadmium	0,00031	0,0002
Chrome	0,062	0,005
Cobalt	0,57	0,001
Cuivre	0,0073	0,001
Fer	7,0	0,19
Manganèse	1,7	0,14
Mercure	0,0000013	< 0,0001
Nickel	0,048	0,02
Plomb	0,0011	0,0005
Zinc	0,11	0,007
Azote ammoniacal (hiver)	11	0,02
Azote ammoniacal (été)	6,8	0,02
Diésel	1,2	nd
Fluorures	1,0	nd
Nitrates	17	0,6
Nitrites	0,12	nd

Phase B1

Pour la phase B du projet, les OER sont évalués comme dans la phase A. En considérant un débit de 176 L/s rencontré en moyenne 329 jours par année ainsi qu'un volume annuel maximal de 940 000 m^3, le débit annuel maximal de l'effluent est de 2 857 m^3/jour.

Les OER déterminés pour la Phase B1 sont résumés dans le tableau 4. Comme indiqué dans le tableau 5, toutes les concentrations prévues dans l'effluent final sont en deçà des OER.

Tableau 4 Objectifs environnementaux de rejet de l'effluent final dans le ruisseau à l'Eau Morte – Phase B1 (effluent avec un débit moyen de 2 857 m³/jour ; pas de rejet lorsque le débit du ruisseau est inférieur à 176 L/s)

Contaminants	Critères de qualité des eaux de surface		Concentrations amont dans le ruisseau (mg/L)	OER	
	Usages *	(mg/L)		Concentrations dans l'effluent (mg/L)	Charges dans l'effluent (kg/jour)
Matières en suspension	CVAC	5,8	0,8	Directive 019	-
Aluminium	CVAC	0,43	0,05	1,5	4,1
Argent	CVAC	0,0001	0,000002	0,00036	0,0010
Arsenic	CPC(O)	0,021	0,0001	0,077	0,22
Baryum	CVAC	0,046	0,0076	0,15	0,42
Béryllium	CVAC	0,000188	0,000005	0,00068	0,0019
Cadmium	CVAC	0,000056	0,000003	0,00020	0,00056
Chrome	CVAC	0,011	0,00009	0,040	0,11
Cobalt	CVAC	0,10	0,000065	0,37	1,0
Cuivre	CVAC	0,0015	0,00028	0,0047	0,014
Fer	CVAC	1,3	0,09	4,5	13
Manganèse	CVAC	0,30	0,013	1,1	3,0
Mercure	CFTP	0,0000013	0	0,0000013	0,0000037
Nickel	CVAC	0,0087	0,00027	0,031	0,089
Plomb	CVAC	0,00021	0,000035	0,00068	0,0019
Zinc	CVAC	0,020	0,00097	0,071	0,20
Azote ammoniacal (hiver)	CVAC	1,9	0,01	6,9	20
Azote ammoniacal (été)	CVAC	1,2	0,01	4,4	12
Diésel	CVAC	0,2	0	0,73	2,1
Fluorures	CVAC	0,2	0,03	0,65	1,9
Nitrates	CVAC	3	0,01	11	31
Nitrites	CVAC	0,02	0	0,073	0,21
pH		-	-	6,0 à 9,5	-
Toxicité aigue	VaFe (Uta)	1	-	1,0	-
Toxicité chronique	CVAC (Utc)	1	-	3,7	-

* CVAC : protection de la vie aquatique (effet chronique) ; CPC(O) : prévention de la contamination (organismes aquatiques seulement) ; CFTP : protection de la faune terrestre piscivore ; VaFe : valeur aigue finale à l'effluent

Tableau 5 Comparaison des objectifs environnementaux de rejet aux concentrations prévues de l'effluent final – Phase B1

Contaminants	OER - Concentrations allouées (mg/L)	Concentrations prévues dans l'effluent final (mg/L)
Matières en suspension	Directive 019	nd
Aluminium	1,5	0,01
Argent	0,00036	< 0,001
Arsenic	0,077	0,028
Baryum	0,15	0,032
Béryllium	0,00068	< 0,002
Cadmium	0,00020	0,0002
Chrome	0,040	0,005
Cobalt	0,37	0,001
Cuivre	0,0047	0,001
Fer	4,5	0,19
Manganèse	1,1	0,14
Mercure	0,0000013	< 0,0001
Nickel	0,031	0,02
Plomb	0,00068	0,0005
Zinc	0,071	0,007
Azote ammoniacal (hiver)	6,9	0,02
Azote ammoniacal (été)	4,4	0,02
Diésel	0,73	nd
Fluorures	0,65	nd
Nitrates	11	0,6
Nitrites	0,073	nd

Phase B2

Avec l'augmentation du taux de production à la phase B2, NMG prévoit de modifier la gestion de l'effluent final afin de gérer le volume d'eaux usées beaucoup plus élevé. Afin d'augmenter le volume rejeté sans compromettre le milieu récepteur, le débit de l'effluent sera modulé en fonction du débit du ruisseau à l'Eau Morte. Plus le débit du ruisseau sera élevé et permettra une meilleure dilution, plus le débit de l'effluent sera élevé. Le système de mesure en continu du débit du ruisseau permettra cette gestion active du débit de l'effluent final.

Afin de moduler le débit de l'effluent final en fonction du débit du ruisseau à l'Eau Morte, sept (7) classes ont été établies pour le débit du ruisseau à l'Eau Morte. Pour chacune des classes, un débit maximal de l'effluent a été déterminé afin de toujours respecter la capacité de support du ruisseau à l'Eau Morte.

Les classes et les débits maximums sont listés dans le tableau 6. Comme c'est le cas pour la gestion actuellement prévue, il n'y a pas de rejet lorsque le débit du ruisseau à l'Eau Morte est inférieur à 176 L/s. lorsque le débit du ruisseau est supérieur à 176 L/s, l'effluent est selon les débits maximums indiqués dans le tableau. Par exemple, le débit maximal de l'effluent est fixé à 2 750 m^3/jour lorsque le débit du ruisseau se situe entre 176 et 499 L/s, 7 500 m^3/jour lorsqu'il est entre 500 et 999 m^3/jour, et ainsi de suite.

Tableau 6 Débit maximal de l'effluent en fonction de sept classes du débit du ruisseau à l'Eau Morte

Ruisseau à l'Eau Morte		Débit maximal de l'effluent		
Débit (L/s)	**Nombre de jours par année**	**(m^3/jour)**	**m^3/h**	**L/s**
< 176	36	Aucun rejet		
176 – 499	151	2 785	116 *	32,2
500 – 999	103	7 500	312	86,8
1 000 – 1499	24	15 500	646	179
1 500 – 1999	11	23 500	979	272
2 000 – 2750	11	31 500	1 312	365
> 2 750	29	43 200	1 800 *	500

* Débits minimal et maximal de pompage respectivement

L'augmentation du taux de production à la phase B2 implique que les concentrations attendues dans l'effluent demeurent les mêmes puisque la performance du système de traitement des eaux ne change pas. Toutefois, les charges augmentent en raison l'augmentation du débit rejeté.

Dans les faits, les débits de rejet 1800 m^3/jr sont prévus pour la gestion de pluie abondante ou de la fonte rapide du couvert nival, il est donc attendu qu'en raison du temps de résidence moins important de ces eaux, leurs concentrations soient moins élevées. NMG ajoute donc un facteur de sécurité à la gestion de leur effluent en considérant des concentrations constantes dans le calcul des OER.

Pour chacune des six classes précédentes où un débit est permis, des OER ont été déterminés. Ceux-ci sont résumés dans le tableau 7.

Comme indiqué dans le tableau 8, toutes les concentrations prévues dans l'effluent final sont en deçà des OER.

Pour la phase B2 dont les impacts seront les plus importants, les figures 1 à 4 montrent les concentrations maximales qui seraient observées dans le milieu récepteur en fonction des débits maximums de l'effluent spécifiés au tableau 6 (applicables pour les six classes de OER établies en fonction du débit du ruisseau à l'Eau Morte). Ces concentrations maximales sont montrées pour le nickel, le cuivre, le fer et le zinc, soit les métaux les plus présents dans la composition géologique du site.

Dans tous les cas, les concentrations sont en deçà des critères de qualité des eaux de surface.

Les figures 5 à 8 montrent plutôt les concentrations maximales qui seront observées dans le milieu récepteur compte tenu des concentrations prévues dans l'effluent final (applicables pour les six classes de OER établies en fonction du débit du ruisseau à l'Eau Morte). Dans tous les cas, les concentrations sont nettement en deçà des critères de qualité des eaux de surface.

Avec la nouvelle gestion de l'effluent final, l'évaluation des impacts pour la qualité des eaux de surface telle que présentée dans l'étude d'impact ne change pas. Celle-ci est rappelée dans le tableau 9.

Tableau 7 Objectifs environnementaux de rejet de l'effluent final dans le ruisseau à l'Eau Morte – Phase B2

Contaminants	Critères de qualité des eaux de surface		Concentrations amont (mg/L)	Objectifs environnementaux de rejet						
	Usages *	Critères (mg/L)		Concentrations allouées (mg/L)	Charges allouées (kg/jour)					
					Note 1	Note 2	Note 3	Note 4	Note 5	Note 6
Matières en suspension	CVAC	5,8	0,8	Directive 019	-	-	-	-	-	-
Aluminium	CVAC	0,43	0,05	1,5	4,1	11,4	23	35	46	64
Argent	CVAC	0,0001	0,000002	0,00037	0,0010	0,0029	0,0058	0,0087	0,012	0,016
Arsenic	CPC(O)	0,021	0,0001	0,079	0,22	0,61	1,2	1,8	2,5	3,4
Baryum	CVAC	0,046	0,0076	0,15	06,42	1,17	2,4	3,6	4,8	6,5
Béryllium	CVAC	0,000188	0,000005	0,00069	0,0019	0,0054	0,011	0,016	0,022	0,030
Cadmium	CVAC	0,000056	0,000003	0,00020	0,00056	0,0016	0,0032	0,0048	0,0063	0,0087
Chrome	CVAC	0,011	0,00009	0,041	0,11	0,32	0,64	1,0	1,3	1,8
Cobalt	CVAC	0,10	0,000065	0,38	1,0	2,9	5,9	8,8	12	16
Cuivre	CVAC	0,0015	0,00028	0,0049	0,014	0,038	0,076	0,11	0,15	0,21
Fer	CVAC	1,3	0,09	4,6	13	36	72	109	145	200
Manganèse	CVAC	0,30	0,013	1,1	3,0	8,4	17	26	34	47
Mercure	CFTP	0,0000013	0	0,0000013	-	-	-	-	-	-
Nickel	CVAC	0,0087	0,00027	0,032	0,089	0,25	0,50	0,75	1,0	1,4
Plomb	CVAC	0,00021	0,000035	0,00069	0,0019	0,0054	0,011	0,016	0,022	0,030
Zinc	CVAC	0,020	0,00097	0,073	0,20	0,56	1,1	1,7	2,3	3,1
Azote ammoniacal (hiver)	CVAC	1,9	0,01	7,1	20	55	111	167	223	307
Azote ammoniacal (été)	CVAC	1,2	0,01	4,5	13	35	70	105	141	193
Diésel	CVAC	0,2	0	0,75	2,1	5,8	12	18	24	32
Fluorures	CVAC	0,2	0,03	0,67	1,9	5,2	10	16	21	29
Nitrates	CVAC	3	0,01	11	31	87	176	264	353	485
Nitrites	CVAC	0,02	0	0,075	0,21	0,58	1,2	1,8	2,4	3,2
pH		-	-	6,0 à 9,5	-	-	-	-	-	-
Toxicité aigue	VaFe (Uta)	1	-	1,0	-	-	-	-	-	-
Toxicité chronique	CVAC (Utc)	1	-	3,8	-	-	-	-	-	-

Note 1 - Débit du ruisseau à l'Eau Morte : 176 - 499 L/s ; Débit maximal de l'effluent : 2 750 m^3/jour
Note 2 - Débit du ruisseau à l'Eau Morte : 500 - 999 L/s ; Débit maximal de l'effluent : 7 500 m^3/jour
Note 3 - Débit du ruisseau à l'Eau Morte : 1 000 – 1 499 L/s ; Débit maximal de l'effluent : 15 500 m^3/jour
Note 4 - Débit du ruisseau à l'Eau Morte : 1 500 – 1 999 L/s ; Débit maximal de l'effluent : 23 500 m^3/jour
Note 5 - Débit du ruisseau à l'Eau Morte : 2 000 - 2749 L/s ; Débit maximal de l'effluent : 31 500 m^3/jour
Note 6 - Débit du ruisseau à l'Eau Morte : >2 750 L/s ; Débit maximal de l'effluent : 43 200 m^3/jour

* CVAC : protection de la vie aquatique (effet chronique) ; CPC(O) : prévention de la contamination (organismes aquatiques seulement) ; CFTP : protection de la faune terrestre piscivore ; VaFe : valeur aigue finale à l'effluent

Tableau 8 Comparaison des objectifs environnementaux de rejet aux concentrations prévues de l'effluent final – Phase B2

Contaminants	OER - Concentrations allouées (mg/L)	Concentrations prévues dans l'effluent final (mg/L)
Matières en suspension	Directive 019	nd
Aluminium	1,5	0,01
Argent	0,00037	< 0,001
Arsenic	0,079	0,028
Baryum	0,15	0,032
Béryllium	0,00069	< 0,002
Cadmium	0,00020	0,0002
Chrome	0,041	0,005
Cobalt	0,38	0,001
Cuivre	0,0049	0,001
Fer	4,6	0,19
Manganèse	1,1	0,14
Mercure	0,0000013	< 0,0001
Nickel	0,032	0,02
Plomb	0,00069	0,0005
Zinc	0,073	0,007
Azote ammoniacal (hiver)	7,1	0,02
Azote ammoniacal (été)	4,5	0,02
Diésel	0,75	nd
Fluorures	0,67	nd
Nitrates	11	0,6
Nitrites	0,075	nd

Figure 1 **Concentrations en nickel en mg/l attendues dans le milieu récepteur si la concentration dans l'effluent est égale à l'OER – Phase B2**

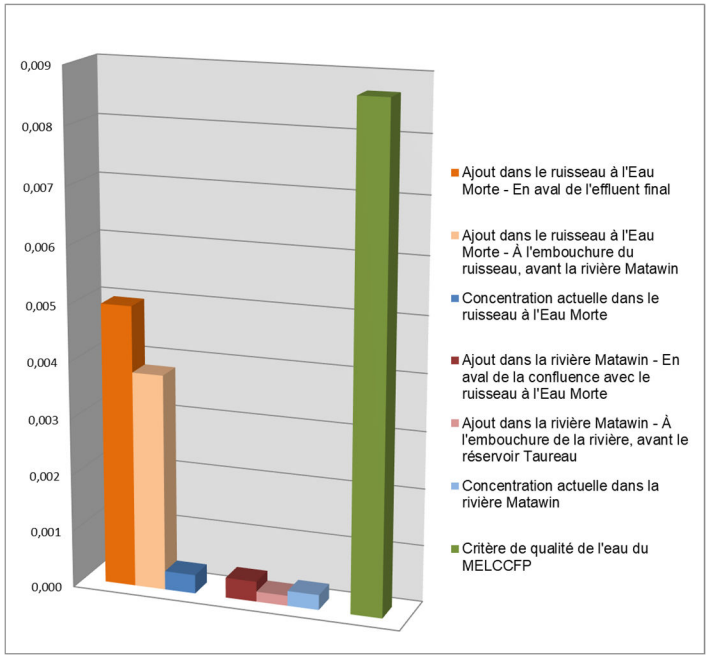

Figure 2 **Concentrations en cuivre en mg/l attendues dans le milieu récepteur si la concentration dans l'effluent est égale à l'OER – Phase B2**

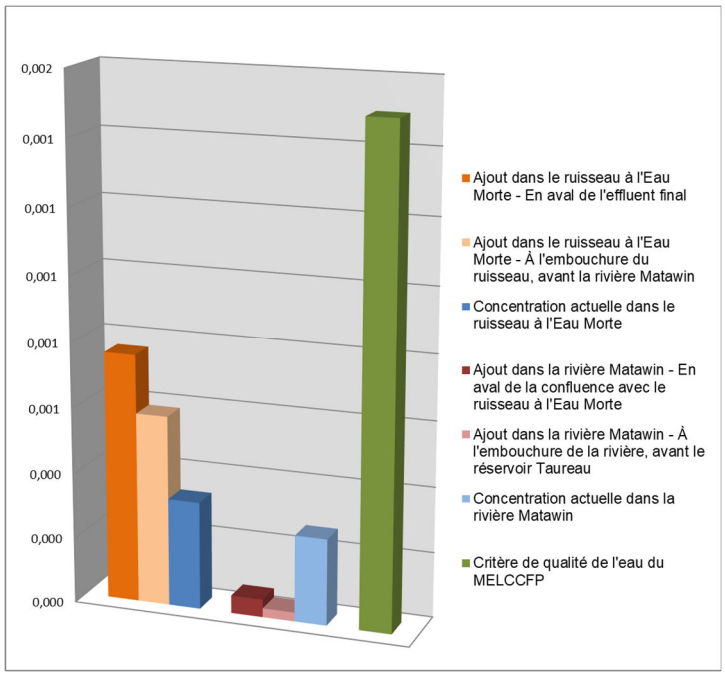

Figure 3 **Concentrations en fer en mg/l attendues dans le milieu récepteur si la concentration dans l'effluent est égale à l'OER – Phase B2**

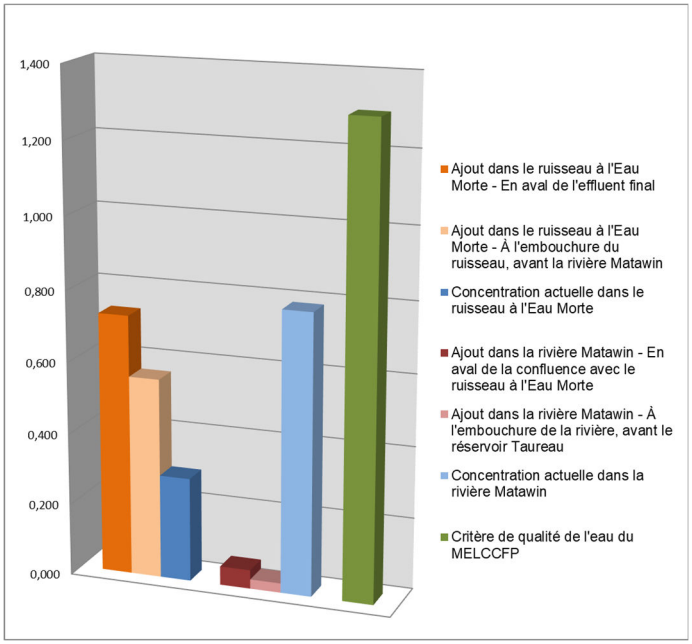

Figure 4 **Concentrations en zinc en mg/l attendues dans le milieu récepteur si la concentration dans l'effluent est égale à l'OER – Phase B2**

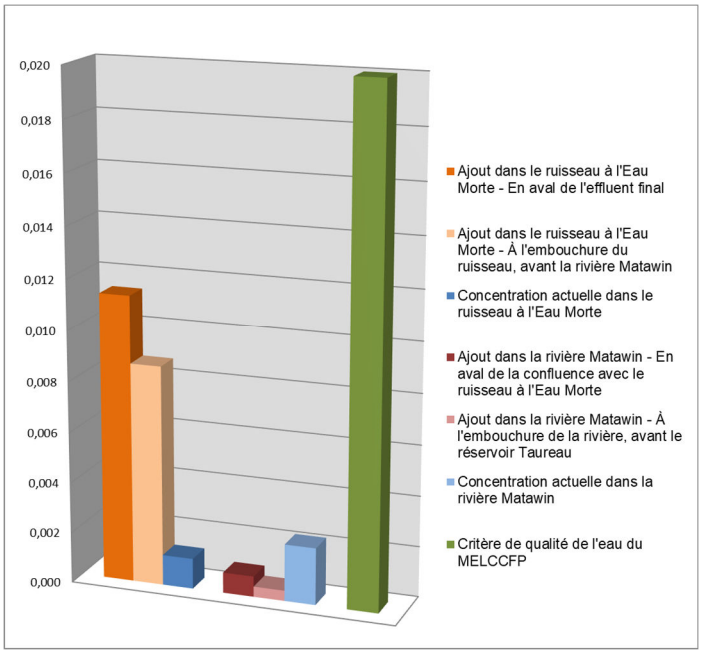

Figure 5 **Concentrations en nickel en mg/l attendues dans le milieu récepteur si la concentration dans l'effluent est égale à la concentration prévue – Phase B2**

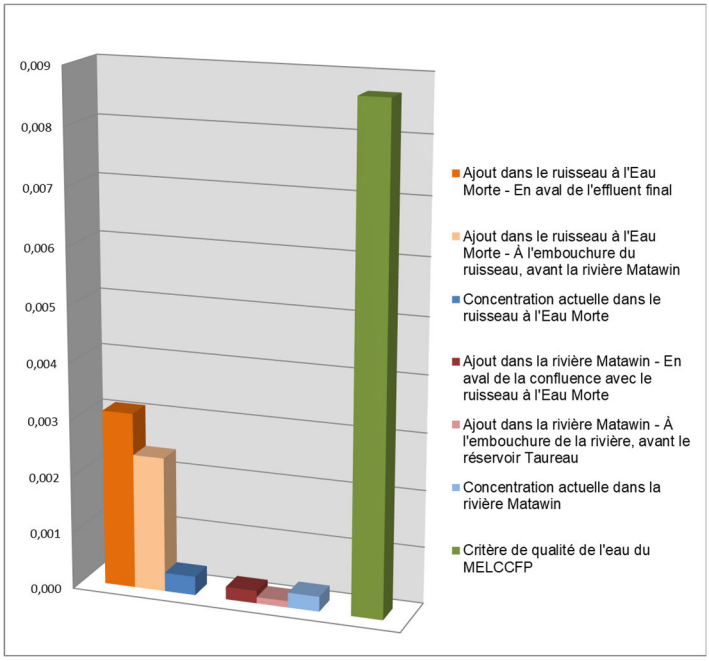

Figure 6 **Concentrations en cuivre en mg/l attendues dans le milieu récepteur si la concentration dans l'effluent est égale à la concentration prévue – Phase B2**

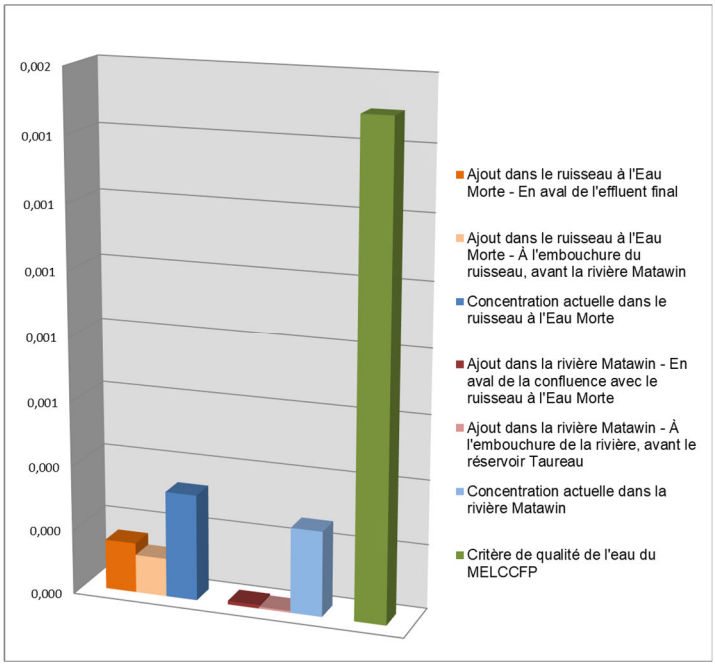

Figure 7 **Concentrations en fer en mg/l attendues dans le milieu récepteur si la concentration dans l'effluent est égale à la concentration prévue – Phase B2**

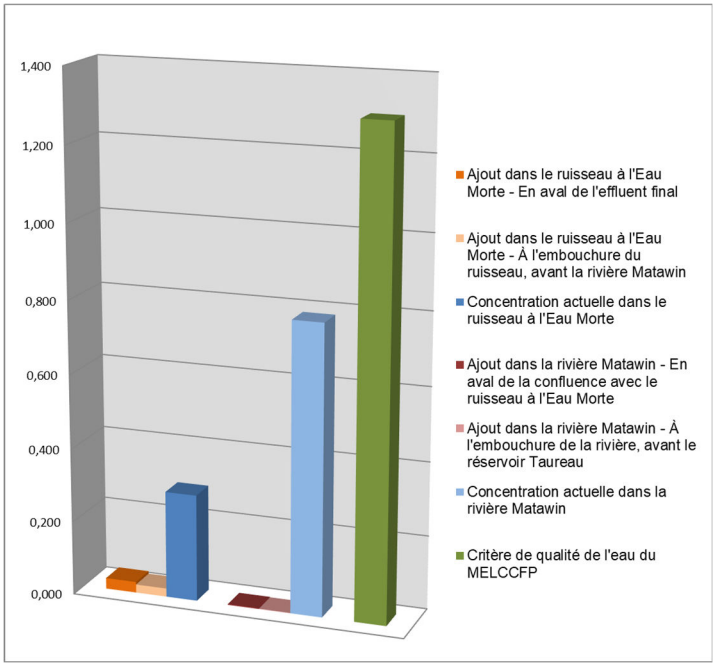

Figure 8 **Concentrations en zinc en mg/l attendues dans le milieu récepteur si la concentration dans l'effluent est égale à la concentration prévue – Phase B2**

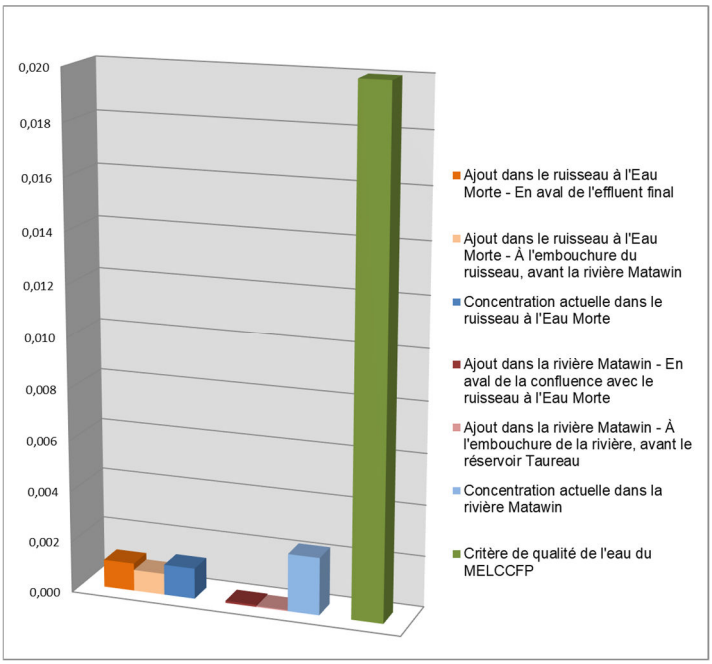

Tableau 9 Bilan des impacts du projet Matawinie sur la qualité des eaux de surface et des sédiments

Période	Importance des impacts (sans mesures d'atténuation spécifiques)	Importance des impacts résiduels (avec mesures d'atténuation spécifiques)
Exploitation	Type : Négatif	Type : Négatif
	Intensité : Moyenne pour les eaux de surface et faible pour les sédiments	Intensité : Faible pour les eaux de surface et les sédiments
	Étendue : Ponctuelle	Étendue : Ponctuelle
	Durée : Longue	Durée : Longue
	Importance : Moyenne (6) pour les eaux de surface et faible (3) pour les sédiments	Importance : Faible (3) pour les eaux de surface et les sédiments
	Probabilité : Élevée	Probabilité : Élevée

Conception chemin et émissaire

Note technique

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1. Mise en contexte

Nouveau Monde Graphite (NMG) a confié à GHD le mandat de concevoir un chemin d'accès reliant le bassin BC-2 au point de rejet final des effluents dans le cadre du projet minier Matawinie. Ce projet, une mine de graphite à ciel ouvert exploitée par NMG, se situe à environ 5 km au sud-ouest de la municipalité de Saint-Michel-des-Saints et à 150 km au nord de Montréal. La mine devrait être opérationnelle pendant une durée de 26 ans, avec une production annuelle prévue de 100 000 tonnes de concentré de graphite.

Durant la période d'exploitation, les eaux provenant de la fosse, du ruissellement et les eaux recirculées pour le procédé seront dirigées vers trois bassins principaux : BC-1, BC-2 et BS. Les eaux des bassins BC-1 et BS seront transférées par pompage vers le bassin BC-2, puis acheminées vers l'usine de traitement des eaux (UTE). Après traitement, les eaux s'écouleront seront retournées vers le concentrateur, ou lorsque nécessaire, pompées vers l'émissaire.

Afin de permettre l'installation des conduites de pompage reliant l'UTE au point de rejet final, la construction d'un chemin d'accès est requise.

Une portion de ce chemin, dont l'alignement est illustré dans le plan TX20035103-15000-DGE-série 100 (WSP, 2022a), a déjà été soumise pour autorisation auprès du ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs. NMG a retenu les services de GHD Consultants Ltd. (ci-après « GHD ») pour concevoir la dernière portion du chemin permettant d'accéder à l'effluent final. Cette conception inclut également l'installation d'un ponceau traversant le chemin au niveau du ruisseau CE36, ainsi qu'un bassin de dissipation à la sortie de l'émissaire.

La présente note technique vise à détailler la conception de ces infrastructures afin de soutenir la demande des permis nécessaires avant le début des travaux de construction.

1.1 Portée et limitations

Ce rapport a été préparé pour Nouveau Monde Graphite et peut être utilisé uniquement par Nouveau Monde Graphite aux fins convenues entre GHD et Nouveau Monde Graphite lesquelles sont décrites à la section 1.1.

GHD décline toute autre responsabilité envers toute autre personne que Nouveau Monde Graphite découlant du présent rapport. GHD exclut aussi les garanties et conditions implicites, dans la mesure permise par la loi.

Les services rendus par GHD dans le cadre de la préparation du présent rapport se limitent à ceux qui y sont précisément décrits et sont assujettis aux limitations de la portée établie dans le rapport.

Les opinions, conclusions et recommandations fournies dans ce rapport sont basées sur les conditions rencontrées et sur les informations examinées à la date de la préparation du rapport. GHD n'a aucune responsabilité ni obligation de mettre à jour ce rapport pour tenir compte d'événements ou de changements survenant après la date à laquelle le rapport a été préparé.

Les opinions, conclusions et recommandations fournies dans le présent rapport sont basées sur les hypothèses formulées par GHD et décrites dans ce dernier (voir la section 1.1 du rapport). GHD décline toute responsabilité découlant de l'inexactitude de l'une ou l'autre de ces hypothèses.

Accessibilité des documents

Si ce rapport doit être accessible dans un autre format, celui-ci peut être fourni par GHD sur demande et moyennant un coût supplémentaire si nécessaire.

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Avis de non-responsabilité

GHD a préparé le présent rapport en se basant sur les informations fournies par Nouveau Monde Graphite et par d'autres parties (y compris des autorités gouvernementales), que GHD n'a pas vérifiées de manière indépendante au-delà de la portée convenue des travaux. GHD n'accepte aucune responsabilité en lien avec ces informations non vérifiées, y compris toutes erreurs et omissions dans le présent rapport ayant été causées par des erreurs ou omissions dans ces informations.

2. Données de base et provenance

Cette section présente les données utilisées pour la conception des fossés collecteurs et les bassins de rétention :

- Les données climatiques de la station St-Michel des Saints (7077571) localisée à proximité du site minier et fournies par Environnement Canada ;
- Analyse IDF de la hauteur de pluie présentée dans le Tableau 2 fournie par Environnement Canada ;
- Mémo technique CAPR002717_NMG_Matawinie_Orografic_Effect_Final_Memo_20240718 (SRK, 2024), « Precipitation parameters correction due to orographic effect » ;
- Note de calculs 701617_3000_4H_0001 Rev E00 - Note ponceau CE36_2024-09-03 (AtkinsRéalis, 2024), « Évaluation des débits au ponceau CE36 » ;
- La topographie de la zone d'étude fournie par NMG (Shapefile : Lidar_1m_Contour_20160525.shp) ;
- Les empreintes des bassins et infrastructures fournie par NMG (Shapefile : NMG_EMPREINTE_ModifSNC_20230601.shp) ;
- Localisation des cours d'eau intermittents, permanents ainsi que les milieux humides (Fichiers CAD : snc653897_phy_hydro_l_240813.dxf et snc653897_veg_milhumide_s_240812.dxf) ;
- Localisation de la ligne de haute tension de HQ effectuée en 2020 (Shapefile : LIGNES_HQ [25012020]) ;
- Étude d'impact environnemental et social fournie par NMG ;
- Rapport P2403041 (Technosub, 2024) « Rapport et recommandations » ;
- Plans pour permis TX20035103-15000-DGE-série 100 (WSP, 2022a) « Chemin d'accès reliant le bassin BC-2 et l'effluent final » ;
- Note technique TX20035103-15000-NGE-001-0 (WSP, 2022b), « Conception du chemin d'accès reliant le bassin BC-2 à l'effluent final » ;
- Note technique TX20035103-16000-AGE-001-2 (WSP, 2023), « Quantités d'excavation chemin d'accès et bassins BC-2 et BS ».

3. Guides, critères et hypothèses de conception

3.1 Guides

Les principaux guides consultés et utilisés pour la conception des fossés collecteurs et des bassins d'eau sont les suivants :

- Règlement sur l'aménagement durable des forêts du domaine de l'état (RADF) ;
- La loi sur la qualité de l'environnement (MELCCFP).

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- Lignes directrices pour les traversées de cours d'eau du Québec, édition 2016 du MPO ;
- Le guide de gestion des eaux pluviales (MDDEFP et MAMROT, 2012) ;
- Le manuel de calcul et de conception des ouvrages municipaux de gestion des eaux pluviales (MDDELCC, 2017) ;
- Manuel de conception des ponceaux (MTMD, 2024) ;
- HEC-14 Hydraulic Design of Energy Dissipators for Culverts and Channels (FHA, 2006).

3.2 Critères de conception

3.2.1 Conception du chemin

Les critères et contraintes suivants ont été considérés pour la géométrie du chemin :

- Le chemin sera utilisé uniquement pour le passage des pick-up de type F-150 et comme assise pour les tuyaux de pompage ;
- Une largeur de 7 mètres pour permettre le passage des pick-up ;
- Une tablette de 1 mètre devra être aménagée pour permettre l'installation sécuritaire du tuyau de pompage entre le bassin BC-2 et l'effluent. Le tuyau sera de type PEHD DR17 de 350 mm de diamètre tel que spécifié dans le rapport technique de Technosub (2024) ;
- Un alignement du chemin de telle sorte à éviter les milieux humides existants ;
- Une pente longitudinale descendante en continu pour permettre la vidange par gravité des tuyaux lors de l'arrêt des systèmes de pompage ;
- Une pente longitudinale maximale de 15 % pour faciliter la circulation des véhicules ;
- Des pentes latérales minimales de 2H : 1V ;
- Des barrières de sécurité faites de blocs de roc de ± 1 m de diamètre devront être aménagées où requis selon les règles de SST en vigueur ;
- Une épaisseur minimale de 0.5 m pour la fondation de chemin ;
- Un alignement de chemin de telle sorte à relier l'effluent final au chemin menant vers le bassin BC-2, dont le tracé est défini dans le plan TX20035103-15000-DGE-série100 ;
- Une conception des ponceaux, selon les règles d'art et la réglementation en vigueur, pour assurer le libre passage des poissons.

3.2.2 Conception du ponceau

Les critères ci-dessous ont été retenus pour la conception des ponceaux dans l'alignement du chemin :

- Le ponceau a été conçu pour gérer adéquatement un débit d'une récurrence de 1 : 100 ans plus une majoration de 18% pour tenir compte des changements climatiques ;
- Lignes directrices pour la conception d'un ponceau à déversoir selon les lignes directrices pour traversées de cours d'eau du Québec ;
- Des ponceaux de type TTOG avec un coefficient de Manning de 0,028 ont été considérés.

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3.2.3 Conception des fossés

Les hypothèses émises pour la conception des fossés collecteurs le long du chemin sont les suivantes :

- Le fossé a été conçu afin d'être capable d'évacuer adéquatement une crue estivale ayant une récurrence de 1 : 10 ans, une majoration respective de 14% et 18% a été considérée pour tenir compte des effets orographiques et du changement climatique ;
- L'écoulement dans le fossé est considéré comme étant uniforme et en régime permanant ;
- Un coefficient de Manning de 0,035 a été utilisé pour les fossés en supposant que ceux-ci seront excavés dans le sol naturel et protégés avec de l'enrochement (Chow, 1959) ;
- Le sol du bassin versant contribuant au fossé est considéré comme étant saturé en eau ;
- Les fossés auront :
    - Une section de forme trapézoïdale ;
    - Une largeur minimale à la base de 1,0 m ;
    - Une profondeur minimale de 1,0 m ;
    - Une pente minimale de 0,1 % ;
    - Le fossé sera protégé avec de l'enrochement sur les tronçons où la vitesse est importante.
    - Des pentes latérales minimales de 2H : 1V ;
    - Une revanche minimale de 0,30 m.

3.2.4 Conception du bassin de dissipation

Les éléments ci-dessous ont été retenus pour la conception du bassin de dissipation :

- Le débit maximum pompé est de 1800 m^3/h (Technosub, 2024) ;
- A la sortie de l'émissaire, la vitesse maximum attendue est de 5.8 m/s (Technosub, 2024) ;
- Une dissipation d'énergie d'au moins 50% doit être atteinte.

4. Conception hydrotechnique

La conception du chemin de l'émissaire comprend deux fossés et un ponceau afin de permettre le drainage des eaux de surface considérées propres vers l'environnement. Le système de drainage du chemin a été optimisé afin de favoriser l'écoulement gravitaire en considérant la topographie et développement du site. Puisque le système draine uniquement des eaux propres vers l'environnement, le critère de conception considéré dans le dimensionnement de ces ouvrages est une pluie de récurrence de 1 : 10 ans tel que recommandé dans le guide de préparation des projets routiers (MTQ, 2018).

Les sections suivantes présentent les données utilisées pour le dimensionnement des ouvrages ainsi que les principaux résultats obtenus à l'issue de l'étude.

4.1 Données climatiques

Le projet minier Matawinie est situé à environ 5 km au sud-ouest de la municipalité de Saint-Michel-des-Saints et à 150 km au nord de Montréal. La station climatique la plus proche du site est celle St Michel des Saints (7077570-7077571) aux coordonnées Lat: 46°48'56,010" N; Long: 74°05'38,050" O et à l'élévation 429.9 m.

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Les données pluviométriques de la station climatiques sont présentées dans le Tableau 4-1 et le Tableau 4-2.

Les débits du ruisseau CE36 pour chaque période de retour ont été tirées de la note te calcul préparée par AtkinsRéalis (2024) et sont présentées dans le Tableau 4-3 ci-dessous.

Tableau 4-1 Quantité de pluie (mm) à la station St Michel des Saints (7077570 - 7077571)

Période de retour (ans)	Pluie 24h (mm)
2	41,9
5	59,8
10	71,7
25	86,7
50	97,8
100	108,9

Tableau 4-2 Intensité de pluie (mm/h), pour une récurrence de 10 ans à la station St Michel des Saints

Durée	Intensité de pluie Printemps (mm/h)	Intensité de pluie Été-Automne (mm/h)
5 min	8.2	10,8
10min	12.0	15,8
15 min	15.0	19,8
30 min	20.5	27,0
1h	29.1	38,3
2h	38.6	50,8
6h	46.4	61,1
12h	50.8	66,9
24h	54.5	71,7

Tableau 4-3 Débits au ruisseau CE36 par période de retour (AtkinsRéalis, 2024)

Période de retour (ans)	Débit (m^3/s)
2	0,45
5	0,55
10	0,64
20	0,72
25	0,74
50	0,84
100	0,91

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4.2 Délimitation des bassins versant

La zone se drainant vers les fossés du chemin de l'émissaire a été divisée en deux bassins versants, soient le BV16 et le BV17, tels que présentés dans la Figure 4-1. Entre les chainages approximatifs 0+086 et 0+393 le terrain se draine naturellement loin du chemin. La superficie des deux bassins versants est montrée dans le Tableau 4-4 ci-dessous. Le bassin versant BV16 a une superficie cumulative de 0,8 hectares puisqu'il draine également le bassin versant BV15B (WSP, 2022).

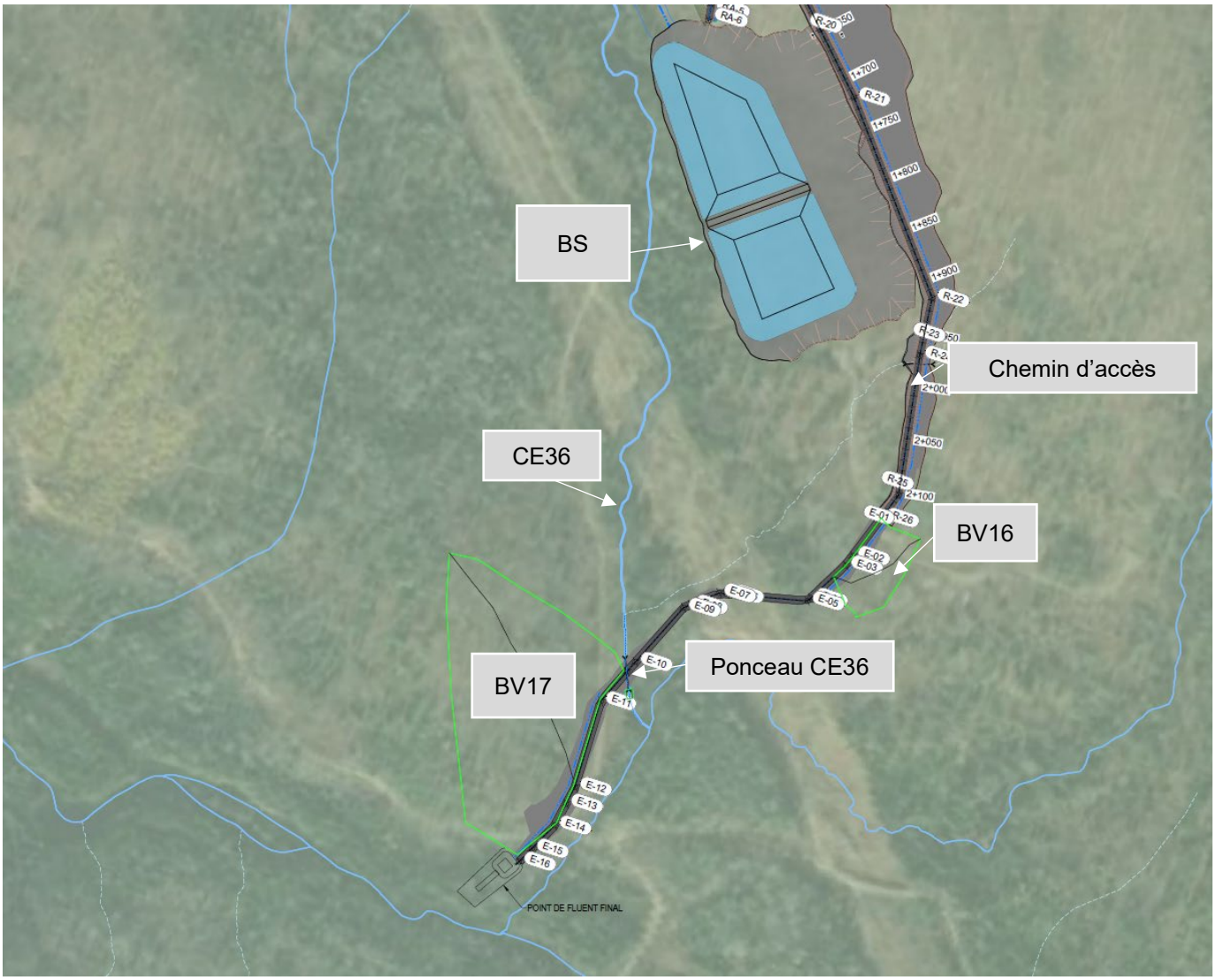

Figure 4-1 Délimitation des bassins versants

4.3 Coefficient de ruissellement

Le choix d'un critère de ruissellement dépend de l'utilisation du territoire, du type de sol et de la topographie. Étant donné la nature similaire des bassins versants du chemin de l'émissaire, le même critère de ruissellement a été appliqué. Ce coefficient de ruissellement a été estimé basé sur le guide d'application du règlement sur l'aménagement durable des forêts du domaine de l'État. Dans le cadre de la présente étude, un coefficient de 0,26 a été adopté pour les deux bassins versants du chemin de l'émissaire.

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4.4 Estimation des débits de pointe

Afin d'estimer les débits de pointes de ruissellement pour la conception des fossés du chemin, la méthode rationnelle présentée dans le manuel de calcul et de conception des ouvrages municipaux de gestion des eaux pluviales (MELCC, 2017) a été retenue.

Ainsi, l'équation utilisée pour calculer le temps de concentration de chaque bassin versant est la suivante :

$$T_c = (3{,}26\left(1{,}1 - C_p\right) L_c^{0,5})/S_C^{0,33}$$

Où les paramètres sont :

- T_c temps de concentration (min);
- C_p coefficient de ruissellement (-);
- L_c longueur d'écoulement (m);
- S_c pente moyenne (%).

L'intensité de pluie choisie correspond au temps de concentration du bassin versant considéré. Le Tableau 4-4 présente les paramètres utilisés pour estimer le débit de pointe pour l'évènement de conception.

Tableau 4-4 Paramètres des bassin versants et débit de pointe calculés

Nom du bassin versant	Superficie (ha)	Superficie cumulée (ha)	Coefficient de ruissèlement	Temps de concentration (min)	Intensité de pluie (mm/h)	Débit de pointe (m3/s)	Pente moyenne (%)
BV16	0,39	0,80	0,26	60	52	0,03	12
BV17	2,88	2,88	0,26	90	60	0,12	11

4.5 Conception du réseau de drainage

Le réseau de drainage comprend deux fossés conçus pour intercepter les eaux de ruissellement provenant du terrain naturel avant qu'elles n'entrent en contact avec la surface du chemin. Le premier fossé débutera au chainage 0+000 et s'écoulera directement sur le terrain naturel à son extrémité, située au chainage approximatif 0+086.

Entre les chainages approximatifs 0+086 et 0+393, aucune excavation de fossé n'est nécessaire, car les eaux de ruissellement s'écoulent naturellement loin du chemin. Le deuxième fossé sera aménagé le long de la section du chemin comprise entre les chainages approximatifs 0+393 et 0+499. Ce fossé s'écoulera directement dans le bassin de dissipation situé à l'extrémité du chemin.

Le bassin de dissipation, équipé d'un déversoir et d'un canal de sortie, sera aménagé à la fin du chemin pour dissiper l'énergie des eaux à la sortie du tuyau de pompage de l'émissaire, assurant ainsi un écoulement contrôlé jusqu'au ruisseau à l'Eau Morte.

Pour traverser le ruisseau CE36 et garantir le libre passage des poissons, un ponceau sera installé dans l'alignement du ruisseau, au chainage approximatif 0+300.

Compte tenu de la topographie du terrain naturel et de l'emplacement du chemin, les fossés de drainage du chemin ne recevront aucune eau contaminée.

4.5.1 Conception des fossés

Le dimensionnement hydraulique des fossés a été réalisé en utilisant l'équation de Manning pour un régime d'écoulement permanent. Le diamètre D50 de l'enrochement a été déterminé en utilisant la méthodologie proposée dans le manuel d'ingénierie « *Hydraulic Design of Flood Control Channels* » (*US Army Corps of Engineers*, 1994).

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À la suite des calculs hydrauliques, une section optimale a été retenue pour les fossés situés au pied du chemin d'accès. Les fossés recommandés auront une section de forme trapézoïdale avec une largeur à la base de 1 m et des pentes latérales de 2H : 1V. Une revanche de 0,3 m doit être ajoutée aux profondeurs d'écoulement.

Le Tableau 4-5 présente les débits de conception, les profondeurs d'eau maximales et minimales, les vitesses maximales atteintes ainsi que le diamètre D50 de l'enrochement de protection contre l'érosion pour le fossé 17.

Compte tenu du faible débit de pointe du BV16 et de la faible vitesse d'écoulement associée dans le fossé 16, aucun enrochement de protection n'est nécessaire. Cependant, il est recommandé de procéder à l'hydroensemencement de ce dernier.

Tableau 4-5 Dimensionnement hydraulique des fossés collecteurs du chemin de l'émissaire

	Débit de conception (m3/s)	Pente min. (%)	Pente max. (%)	Profondeur d'écoulement (m)	Vitesse moyenne d'écoulement (m/s)	Enrochement D50 requis (mm)
Fossé 17	0,12	0,35	13,26	0,19	0,46	100

4.5.2 Conception ponceau

Le Tableau 4-6 résume les dimensions du ponceau à déversoirs CE36 ainsi que les vérifications effectuées pour assurer le libre passage des poissons selon les lignes directrices pour les traversées de cours d'eau au Québec et pour assurer la capacité du ponceau à passer d'un débit d'une récurrence de 1 :100 ans avec une majoration de 18% pour tenir compte des changement climatiques.

Tableau 4-6 Dimensionnement du ponceau CE36

Élément	Unités	Valeur	Critères & contraintes
Propriétés du ponceau proposé et du cours d'eau CE36			
Pente cours d'eau	%	3,7	NA
Pente amont ponceau	%	4	NA
Pente ponceau	%	5	NA
Diamètre ponceau	mm	2000	MIN. 1500 mm et réduction LDPB ≤ 20%
LDPB (largeur au débit plein bord)	m	3,2	NA
Longueur ponceau	m	26,2	NA
Vérification selon les contraintes des lignes directrices			
Réduction LDPB	%	12,5	Réduction LDPB ≤ 20%
Ratio de pentes (RP)	-	1,35	≥ 1.25
Élévation crête du 1er déversoir	m	433,12	Même élévation que le point bas du premier seuil en aval du ponceau
Élévation radier amont	m	432,53	NA
Élévation radier aval	m	430,98	NA
Dimensionnement des déversoirs			
Dénivelé	mm	40	NA
Ennoiement	mm	50	NA
Espacement entre les déversoirs	m	1,8	MIN. 1.8

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Élément	Unités	Valeur	Critères & contraintes
Hauteur de l'encoche	mm	90	Hauteur minimale encoche = dénivelé + hauteur ennoiement
Largeur de l'encoche	mm	160	Largeur minimale de l'encoche est de 150 mm
Débit de l'encoche coulant pleine	m^3/s	0,006	Calcul débit encoche coulant pleine selon équation : Formule tirée de Larinier (2003)
Dimensionnement du bassin de dissipation			
Largeur du bassin	m	4	MIN. 2 fois Diamètre ponceau
Longueur du bassin	m	6	MIN. 3 fois Diamètre ponceau
Profondeur bassin	m	1	MIN. 1m (profondeur mesurée à partir de la crête du 1er déversoir)

4.5.3 Conception bassin de dissipation

La conception d'un dissipateur d'énergie à la sortie de l'émissaire est nécessaire pour réduire la vitesse élevée et prévenir l'érosion en aval. La vitesse d'écoulement à la sortie de l'émissaire sera significativement élevée lors de la dernière phase (5,8 m/s). Le manuel de conception des ponceaux (MTDT,2024) et HEC-14 présente les éléments de conception d'ouvrage de dissipation d'énergie. Un bassin de dissipation d'énergie avec un déversoir suivi d'un canal de dissipation a été sélectionné pour contrôler le déversement vers l'environnement.

La vitesse d'écoulement à la sortie du bassin sélectionné est de 2,39 m/s.

Le Tableau 4-7 résume les dimensions retenues pour le bassin de dissipation

Tableau 4-7 Dimensionnement du bassin de dissipation

Élément	Unité	Valeur	Critères & contraintes
Dimension du bassin	m	10x10	
Pente latérale	H :1V	4	
Longueur totale	m	18	
Pente du bassin	%	1	
Profondeur	m	1,00	MIN. 1m
Enrochement D50	mm	1000	Masse équivalente (1300 kg)

4.5.4 Conception du déversoir et du canal de dissipation

Le déversoir retenu est de forme trapézoïdale, avec une base de 3 m de largeur, des pentes de talus 4H :1V et une profondeur de 1 m.

Le canal de dissipation a été conçu après le déversoir pour assurer une dissipation d'énergie contrôlée jusqu'au ruisseau à l'Eau Morte.

Le Tableau 4-8 ci-dessous résume les critères de conception utilisés et les dimensions du canal sélectionnées.

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Tableau 4-8 Dimensionnement du canal de dissipation

Élément	Unité	Valeur
Débits de conception		
Apport du bassin de dissipation	m^3/s	1,27
Apport du fossé 17	m^3/s	0,12
Dimensions		
Largeur de la base	m	2
Pente des talus	H :1V	2
Profondeur	m	1
Pente min.	%	2
Pente max.	%	4
Enrochement D50	mm	150

5. Quantités d'excavation

La présente section fournit une estimation des quantités d'excavation nécessaires pour l'exécution du chemin de l'émissaire, le bassin de dissipation et son déversoir. Les hypothèses utilisées pour effectuer les calculs des volumes des matériaux y sont également détaillées.

5.1 Information géotechnique

La stratigraphie des sols dans l'emprise du chemin de l'émissaire et le bassin de dissipation a été approximée selon la description des données géotechniques fournie dans la note technique présentant les quantités d'excavation pour le chemin d'accès et bassins BC-2 et BS (WSP, 2023).

D'après ces informations, la géologie de surface dans le secteur du chemin comprend une couche superficielle de sols organiques majoritairement sableux, d'une épaisseur variante entre 150 et 250 mm. Cette couche est suivie par une couche de sable et de silt, dont les proportions varient, avec une épaisseur comprise entre 1 et 5 mètres selon l'emplacement. Ces deux couches reposent sur le socle rocheux. Ces données proviennent des résultats de forages et/ou puits d'exploration réalisés sur le site de Matawinie, mais à l'extérieur de l'emprise projetée du chemin.

En 2024, NMG a réalisé 21 puits d'explorations dans les premiers 1200 m de l'alignement du chemin entre les bassins BC-2 et BS pour obtenir plus d'informations sur l'élévation du socle rocheux. Les données recueillies indiquent une profondeur moyenne de 2.8 mètres. Le mort-terrain par-dessus le roc est constitué majoritairement de sable silteux avec présence de gravier, cailloux et blocs. Aucun échantillon n'a été prélevé dans les puits d'exploration.

5.2 Hypothèses de calcul

GHD a pris en compte les hypothèses suivantes lors du calcul des quantités :

- Les travaux de décapage sont strictement limités à l'intérieur de l'emprise des infrastructures, sans inclure de surfaces situées en dehors des limites projetées dans les calculs.
- Une épaisseur de 500 mm a été adoptée pour la couche de sols organiques dans l'emprise des travaux.
- Le socle rocheux sous l'emprise du chemin d'accès se situe à une profondeur de 2,5 m sous la surface naturelle du terrain.
- L'ensemble du mort-terrain excavé dans l'emprise du chemin est présumé constitué de sable.

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5.3 Estimation des quantités

5.3.1 Surface de décapage

Le Tableau 5-1 présente une estimation des superficies à décaper pour les ouvrages

Tableau 5-1 Surface de décapage estimées

Ouvrage	Superficie (hectare)
Chemin de l'émissaire	0,85
Bassin de dissipation et déversoir	0,18

5.3.2 Excavation

Le Tableau 5-2 présente une estimation des quantités de matériaux à excaver pour la construction du chemin et du bassin de dissipation.

Tableau 5-2 Quantités d'excavation estimées

Matériau	Quantité	Unité
Chemin de l'émissaire		
Décapage	4150	m^3
Mort terrain	5075	m^3
Roc	830	m^3
Bassin de dissipation et déversoir		
Décapage	900	m^3
Mort terrain	960	m^3
Roc	-	m^3

Les matériaux de décapage en provenance des travaux d'excavation seront entreposés dans la halde de terre végétale.

Le mort-terrain excavé lors du déblai du chemin d'accès sera réutilisé pour la construction des sections du chemin en remblai. Tout matériau excédentaire ou ne répondant pas aux exigences des matériaux de remblai sera transporté vers la halde de mort-terrain.

La roc extrait lors des travaux de construction du chemin d'accès sera utilisé pour produire l'enrochement nécessaire à la protection contre l'érosion des sections du fossé, du bassin de dissipation et du ponceau. Les matériaux excédentaires seront stockés en attendant leur traitement au concasseur.

6. Conclusion et recommandations

Cette note technique présente la conception du chemin de l'émissaire, du ponceau qui traverse le chemin au niveau du ruisseau CE36 ainsi que du bassin de dissipation à la sortie de l'émissaire.

Cette note technique servira de base pour l'obtention de permis et l'autorisation du ministère avant de débuter la construction.

La construction des infrastructures devra tenir compte des recommandations suivantes :

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– Une révision de la conception pourrait être nécessaire dans le cas où des différences entre la surface du terrain, au moment de la construction, et la surface (topographie) considérée lors de la conception seraient constatées.
– Il est recommandé d'effectuer des inspections régulières – au minimum durant et après la fonte printanière et après tout événement de précipitation majeure. Ainsi, les travaux d'entretien et de nettoyage permettront d'assurer la pérennité de l'ouvrage et de conserver la capacité hydraulique des structures.
– Dans le cas où des problèmes/des dommages localisés tels que l'érosion du lit et des parois du canal ou encore le déplacement de l'enrochement de protection contre ces derniers seraient constatés pendant les inspections régulières, il est important de mettre en place des mesures correctives rapidement.
– Dans le cas où des accumulations excessives de sédiments seraient constatées pendant les inspections régulières dans les fossés ou dans le bassin existant, il est important de procéder à un nettoyage.

7. Références

Department of the Army U.S. Army Corps of Engineers (1994). *Hydraulic Design of Flood Control Channels.*

MDDEFP Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs, et MAMROT Ministère des Affaires municipales, des Régions et de l'Occupation du territoire (2014). *Guide de gestion des eaux pluviales.*

Ministère des Forêts, de la Faune et des Parcs. *Guide d'application du Règlement sur l'aménagement durable des forêts du domaine de l'état*, [En ligne], Gouvernement du Québec. [mffp.gouv.qc.ca/RADF/guide].

MTQ Ministère des Transports du Québec (2018). *Guide de préparation des projets routiers.*

Pêche et Océans Canada (2016). *Lignes directrices pour les traversées de cours d'eau au Québec.*

U.S. Department of Transportation, Federal Highway Administration (2006). *Hydraulic Design of Energy Dissipators for Culverts and Channels*, Hydraulic Engineering Circular No. 14.

Chow, V.T. (1959). *Open-Channel Hydraulics.*

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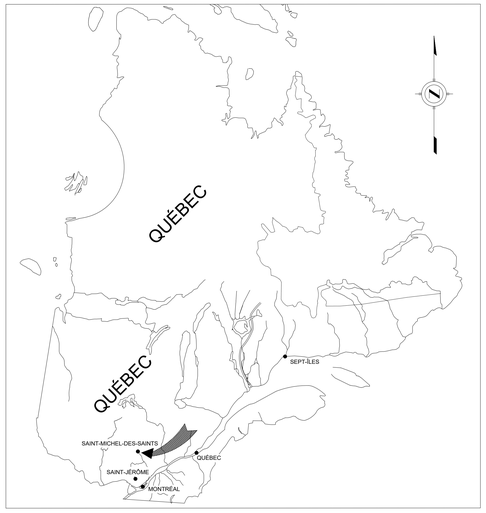

PROJET MATAWINIE
CHEMIN ET ÉMISSAIRE

POUR : NOUVEAU MONDE GRAPHITE

PAR : GHD

LISTE DES PLANS

DESSIN	DESCRIPTION	RÉVISION / DATE
G-001	FRONTISPICE	S / 2025-01-15
G-002	PLAN GÉNÉRAL DU SITE	S / 2025-01-15
G-003	PLAN, PROFIL LONGITUDINAL ET DÉTAILS DU BASSIN DESSIPATION	S / 2025-01-15
G-004	COUPES TYPES DU CHEMAIN	S / 2025-01-15
G-005	DÉTAILS DE PONCEAU ET TABLEAUX DES EXIGENCES DES MATÉRIAUX	S / 2025-01-15

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Code de statut
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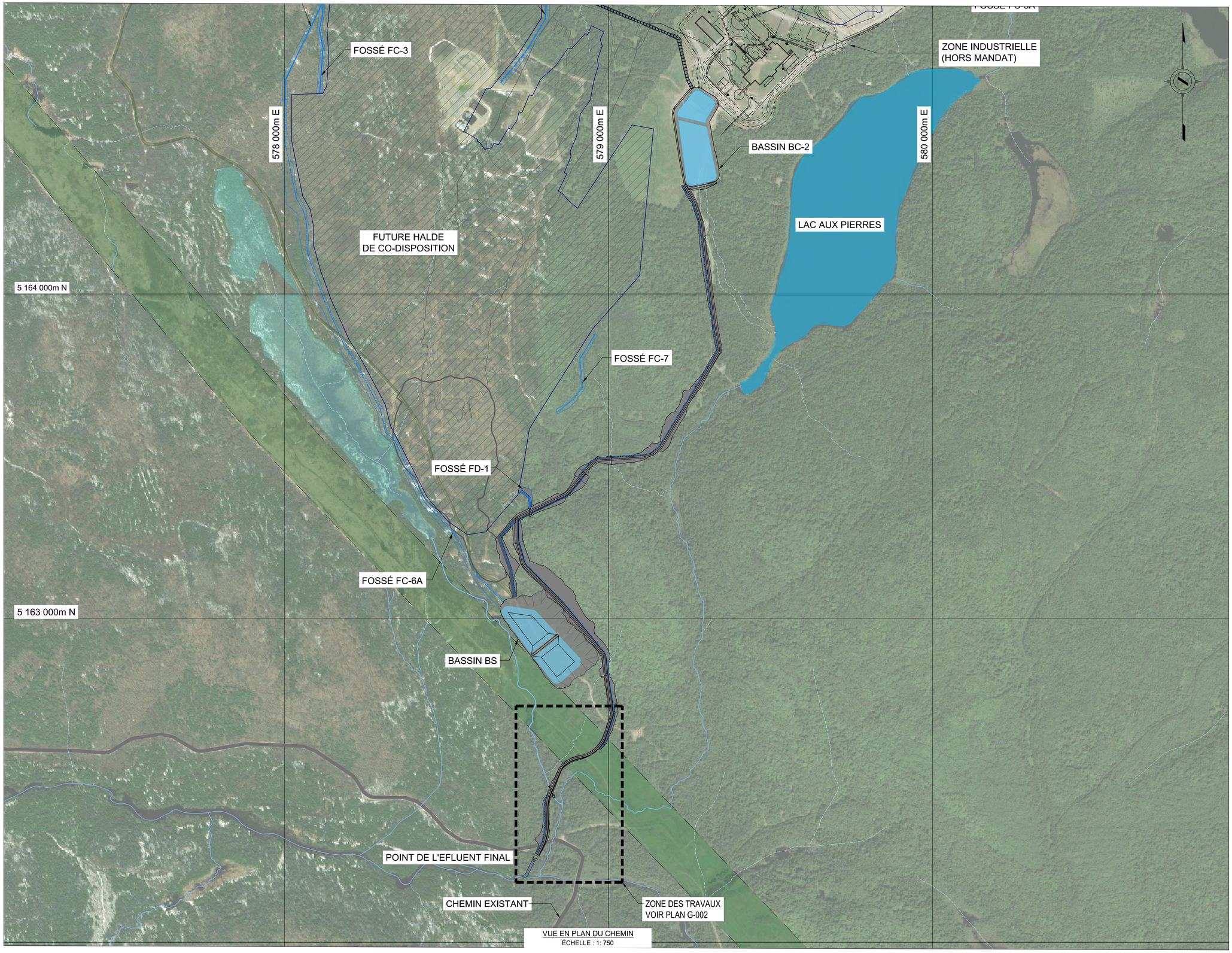

VUE EN PLAN DU CHEMIN
ÉCHELLE : 1: 750

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MILIEU_HUMIDE_SNC_20190605.shp

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LACS:

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FOSSE:

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FUTURE HALDE
DE CO-DISPOSITION
HALDE_MORT-TERRAIN
654068-Deposition_Y26_2019 (2019-09-30)
CHEMIN EXISTANT
BASSIN
CORRDIOR DE LA LIGNE H.Q.
FOSSÉ
CHEMIN PROPOSÉ
PONCEAU

NOTES:

1. PROJECTION: UTM NAD 83 FUSEAU 18 NORD.
2. ISOCONTOURS À INTERVALLES DE 1 m.
3. LES COORDONNÉES ET LES ÉLÉVATIONS ET LES CHÎNAGES SONT APROXIMATIFS ET SERONT AJUSTÉS SUR LE CHANTIER SELON LE PROFIL RÉEL DU TERRAIN.

ÉCHELLE: 1:4000
0 200 400m

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Titre **CHEMIN ÉMISSAIRE**
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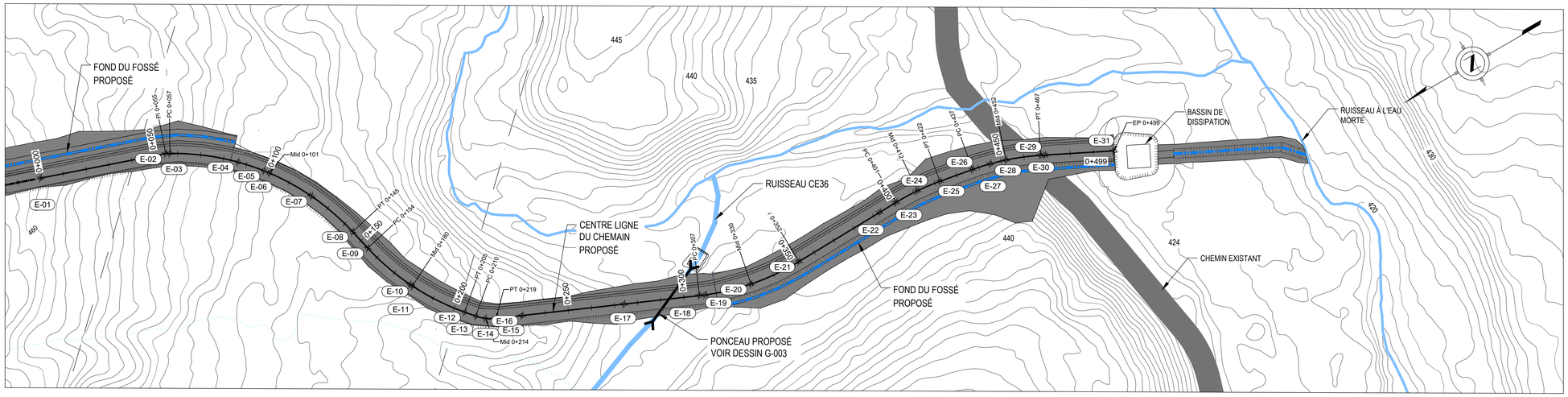
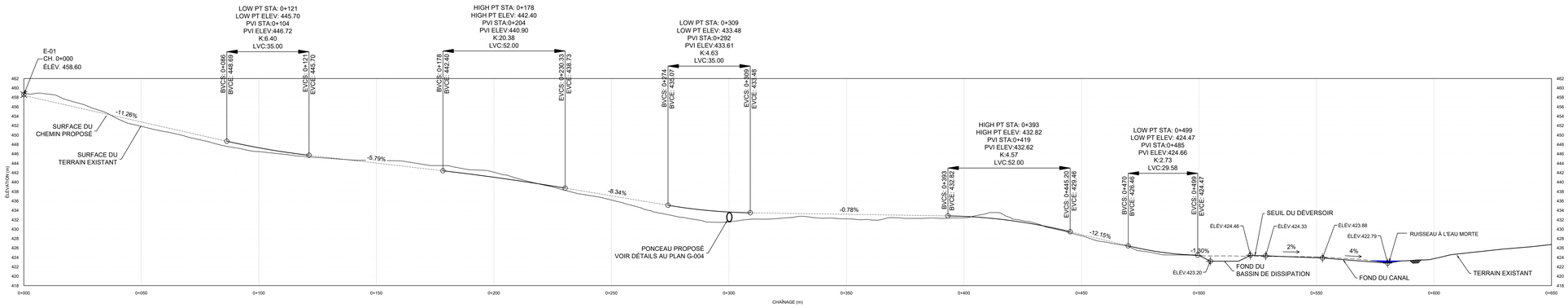


VUE EN PLAN DU CHEMIN
ÉCHELLE : 1: 750

COORDONNÉES DES POINTS DU CENTRE LIGNE DU CHEMIN UTM FUSEAU 18 NORD					
POINT	CHAINAGE (m)	EST (m)	NORD (m)	ELE. (m)	DÉSCRIPTION
E-01	0+000	579 002	5 162 677	458.60	DEBUT DE CHEMIN
E-02	0+055	578 985	5 162 626	451.94	PI
E-03	0+057	578 984	5 162 624	451.72	PC
E-04	0+086	578 966	5 162 600	448.69	BVC
E-05	0+098	578 957	5 162 593	447.04	PVI
E-06	0+101	578 955	5 162 591	446.81	MID : R=105m
E-07	0+121	578 937	5 162 580	445.70	EVC
E-08	0+145	578 915	5 162 573	444.37	PT
E-09	0+154	578 906	5 162 571	443.89	PC
E-10	0+178	578 882	5 162 562	442.63	MID : R=105m
E-11	0+188	578 883	5 162 563	442.40	BVC
E-12	0+205	578 861	5 162 548	441.20	PT
E-13	0+210	578 857	5 162 545	440.85	PC
E-14	0+214	578 854	5 162 542	440.53	MID : R=55m
E-15	0+219	578 852	5 162 538	440.16	PT
E-16	0+230	578 848	5 162 528	438.73	EVC
E-17	0+274	578 830	5 162 487	434.07	BVC
E-18	0+307	578 817	5 162 457	433.50	PC
E-19	0+309	578 816	5 162 455	433.48	EVC
E-20	0+330	578 810	5 162 436	433.28	MID : R=105m
E-21	0+352	578 808	5 162 413	433.11	PT
E-22	0+393	578 809	5 162 372	432.82	BVC
E-23	0+401	578 809	5 162 364	432.74	PC
E-24	0+412	578 809	5 162 353	432.50	MID : R=105m
E-25	0+422	578 808	5 162 343	431.94	PT
E-26	0+437	578 805	5 162 328	430.59	PC
E-27	0+445	578 803	5 162 321	429.46	EVC
E-28	0+452	578 801	5 162 314	428.81	MID : R=105M
E-29	0+467	578 796	5 162 300	426.98	PT
E-30	0+469	578 795	5 162 298	426.85	BVC
E-31	0+499	578 782	5 162 272	424.40	EVC -FIN DE CHEMIN

PC : POINT DE DEBUT DE LA COURBE HORIZONTALE
PT : POINT DE FIN DE LA COURBE HORIZONTALE
MID : LE POINT DE MILIEU DE LA COURBE HORIZONTALE

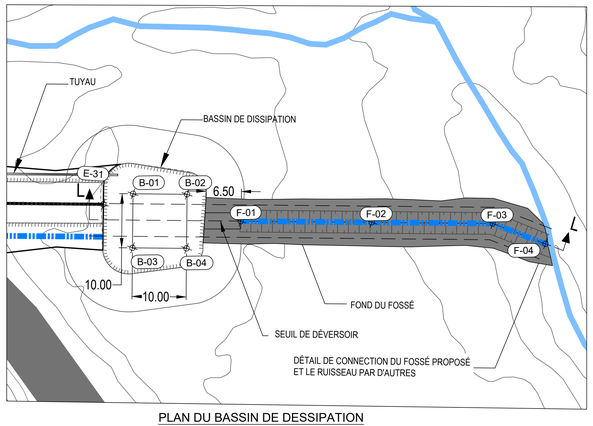
BVC : POINT DE DÉBUT DE LA COURBE VERTICALE
EVC : POINT DE FIN DE LA COURBE VERTICAL



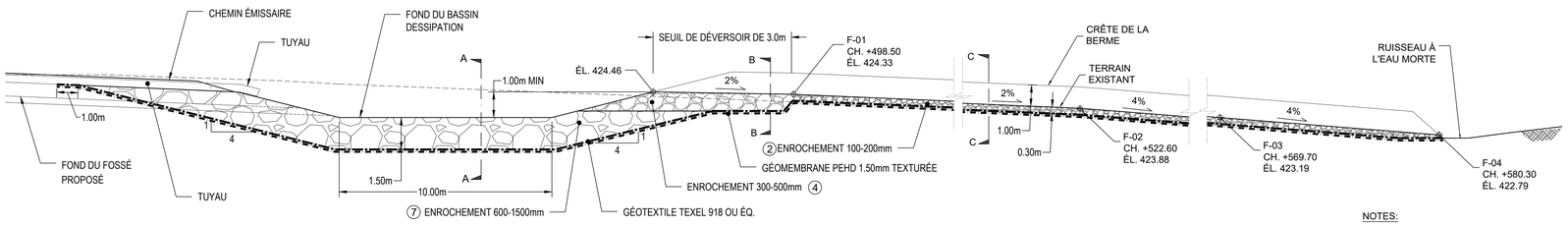
PROFIL LONGITUDINAL DU CH. 1+600 m AU CH. 2+132 m
ÉCHELLE HORIZONTALE: 1: 750
ÉCHELLE VERTICALE: 1: 375

COORDONNÉES DES POINTS DU CENTRE LIGNE DU FOSSÉ UTM FUSEAU 18 NORD			
POINT	EST (m)	NORD (m)	ÉLE. (m)
F-01	578 768	5 162 250	424.38
F-02	578 757	5 162 228	423.88
F-03	578 747	5 162 208	423.21
F-04	578 739	5 162 201	422.79

COORDONNÉES DES POINTS DU 4-COTÉS DU BASSIN DE DESSIPATION UTM FUSEAU 18 NORD			
POINT	EST (m)	NORD (m)	ELE. (m)
B-01	578 781	5 162 266	423.20
B-02	578 776	5 162 257	423.20
B-03	578 772	5 162 270	423.20
B-04	578 767	5 162 261	423.20



PLAN DU BASSIN DE DESSIPATION
ÉCHELLE : 1: 40



COUPE L- L
COUPE LONGITUDINALE DU BASSIN DE DISSIPATION
ÉCHELLE : 1: 100

LÉGENDE:

- ISOCONTOUR MAJEUR
- ISOCONTOUR MINEUR
- EMPRISE DU CHEMIN
- PROFIL DU CHEMIN PROPOSÉ
- FOSSÉ PROPOSÉ
- COURS D'EAU INTERMITTENT
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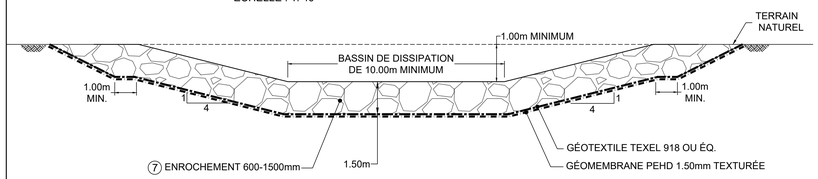
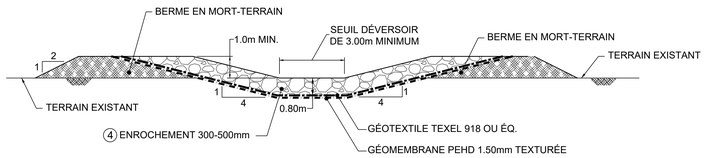
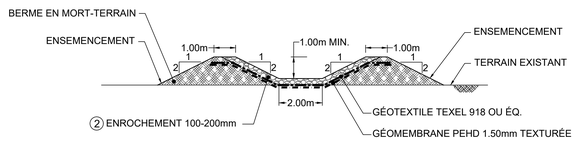
4. LE DÉTAIL ET LE MATÉRIAUX DE CONSTRUCTION DE LA BERME À L'APPRROCHE DU RUISSEAU À L'EAU MORTE DEVORNT ÉTRE CONFIRMÉS EN FONCTION DES SPÉCIFICATIONS DE CONNEXION AU RUISSEAU (PAR D'AUTRES).



COUPE A-A
ÉCHELLE : 1: 100



COUPE B-B
ÉCHELLE : 1: 100



COUPE TYPE DU FOSSÉ - COUPE C-C (VOIR NOTE 4)
ÉCHELLE : 1: 100

ÉCHELLE: 1:100
0 5 10m

ÉCHELLE: 1:750
0 25 50 75 100m

ÉCHELLE: 1:325
0 25 50m

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Échelle **N.A.**

Titre **CHEMIN ÉMISSAIRE PLAN, PROFIL LONGITUDINAL ET DÉTAILS DU BASSIN DESSIPATION**

Format **ISO A0**
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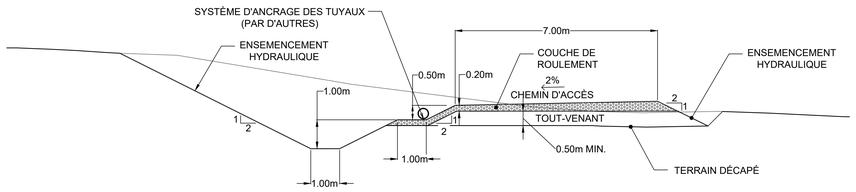
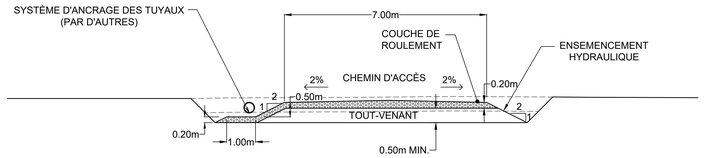


COUPE TYPE (LORSQU'EN DÉBLAI) DU CH. 0+000 m AU CH. 0+086 m
ÉCHELLE 1: 75



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ÉCHELLE 1: 75

LÉGENDE:

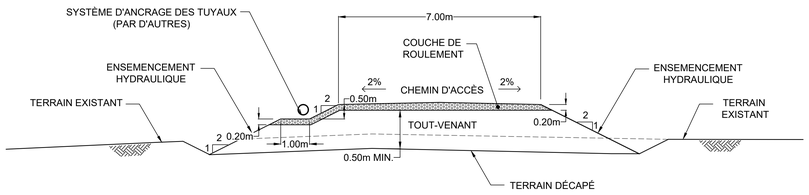
TERRAIN EXISTANT
GÉOTEXTILE
ENROCHEMENT
COUCHE DE ROULEMENT
TUYAU

NOTE:

1. LES COORDONNÉES ET LES ÉLÉVATIONS SONT APROXIMATIVES ET SERONT AJUSTÉES SUR LE CHANTIER SELON LE PROFIL RÉEL DU TERRAIN.

ÉCHELLE: 1:75

0 1 2 3 4 5m



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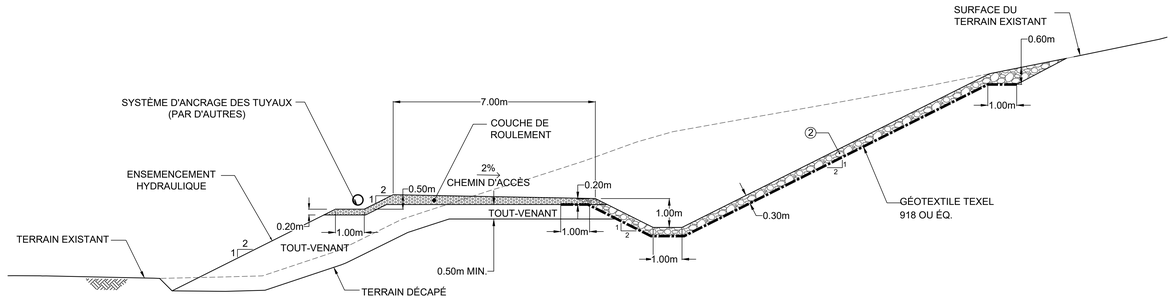
ÉCHELLE 1: 75



COUPE TYPE (LORSQU'EN DÉBLAI) DU CH. 0+393 m AU CH. 0+499m
ÉCHELLE 1: 75

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Projet CHEMIN ET ÉMISSAIRE

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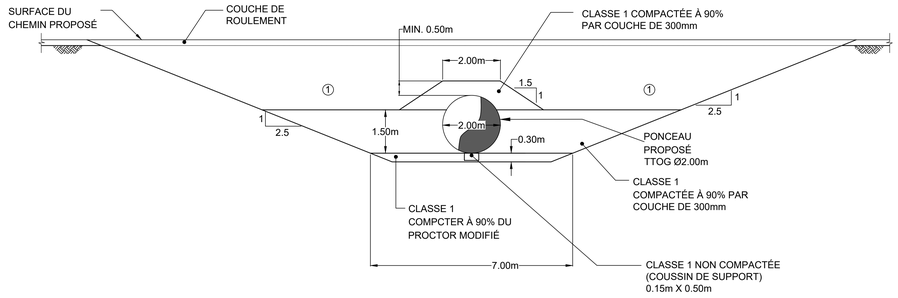
PAS POUR CONSTRUCTION

EXIGENCES DES MATÉRIAUX

CLASSE	DESCRIPTION	GRANULOMÉTRIE		TENEUR EN EAU À LA MISE EN PLACE	ÉPAISSEUR MAXIMALE DES COUCHES	DEGRÉ DE COMPACTAGE REQUIS
		TAMIS (mm)	PASSANT %			
1	SABLE ET GRAVIER	80.000	100	-2% À +1% DE L'OPTIMUM	300mm	≥95% DE LA DENSITÉ SÈCHE MAXIMALE PROCTOR STANDARD
		20.000	76-95			
		5.000	56-75			
		0.630	26-45			
		0.315	17-35			
		0.080	0-10			
2	ENROCHEMENT SÉLÉCTIONNÉ 100-200	-ETALÉ ENTRE 200 mm MAXIMUM ET 100 mm -MAXIMUM 5% PLUS PETIT QUE 100 mm -ROC MASSIF SAIN OU CAILLOUX SAINS		N/A	NA	N/A
3	ENROCHEMENT SÉLÉCTIONNÉ 100-300	-ETALÉ ENTRE 300 mm MAXIMUM ET 100 mm -MAXIMUM 5% PLUS PETIT QUE 100 mm -ROC MASSIF SAIN OU CAILLOUX SAINS		N/A	N/A	N/A
4	ENROCHEMENT SÉLÉCTIONNÉ 300-500	-ETALÉ ENTRE 500 mm MAXIMUM ET 300 mm -MAXIMUM 5% PLUS PETIT QUE 300 mm -ROC MASSIF SAIN OU CAILLOUX SAINS		N/A	N/A	N/A
5	ENROCHEMENT SÉLÉCTIONNÉ 100-300	- 50% PLUS GRAND QUE 200 mm - MAXIMUM 5% PLUS PETIT QUE 150 mm - ROC ARRONDI ET SAIN		N/A	N/A	N/A
6	ENROCHEMENT SÉLÉCTIONNÉ 100-500	- 50% PLUS GRAND QUE 300 mm - MAXIMUM 5% PLUS PETIT QUE 150 mm - ROC ARRONDI ET SAIN		N/A	N/A	N/A
7	ENROCHEMENT SÉLÉCTIONNÉ 600-1500	-ETALÉ ENTRE 1500 mm MAXIMUM ET 600 mm -BLOQUE DU ROC MASSIF SAIN		N/A	N/A	N/A



COUPE C-C
ÉCHELLE 1: 75

LÉGENDE:

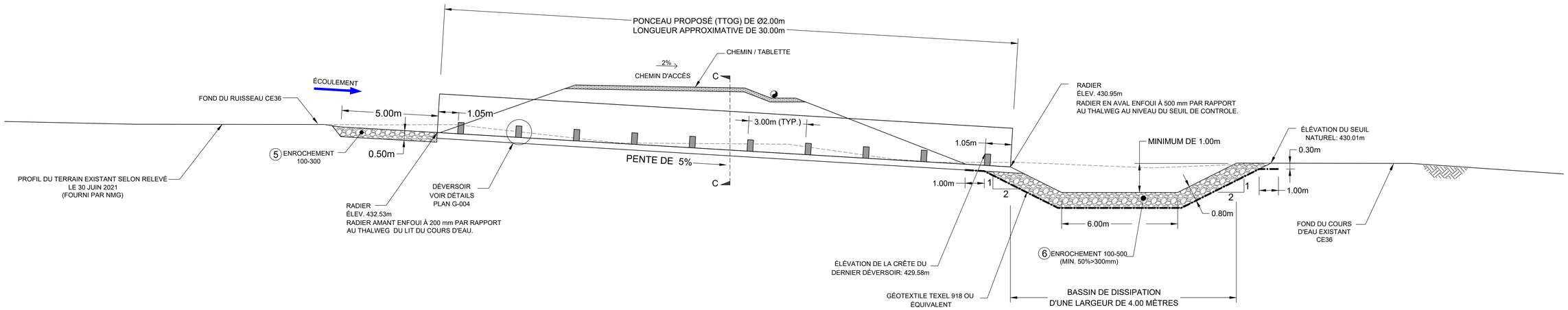
- TERRAIN EXISTANT
- GÉOTEXTILE
- ENROCHEMENT
- COUCHE DE ROULEMENT
- TUYAU

NOTE:

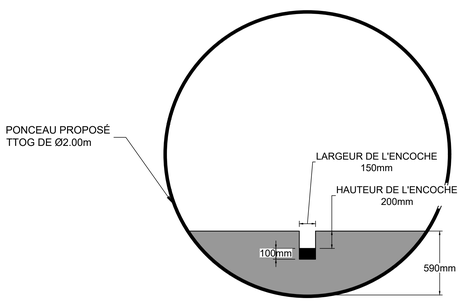
1. LES COORDONNÉES ET LES ÉLÉVATIONS SONT APROXIMATIVES ET SERONT AJUSTÉES SUR LE CHANTIER SELON LE PROFIL RÉEL DU TERRAIN.
2. LES PRATIQUES ÉNUMÉRÉES CI-DESSOUS SONT INTERDITES :
   LES SOUDURES EN CHANTIER.
   LA COUPE AU CHALUMEAU D'ÉLÉMENTS EN ACIER.
   LE PERÇAGE DE TROUS AU CHALUMEAU.

ÉCHELLE: 1:75
0 1 2 3 4 5m

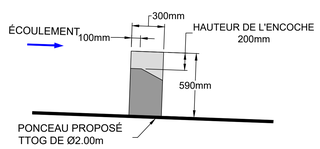
ÉCHELLE: 1:20
0 1 2m



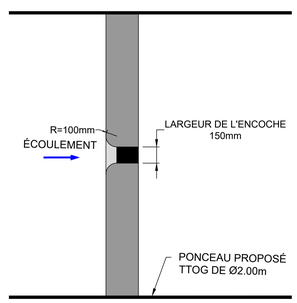
COUPE LONGITUDINALE DU PONCEAU PROPOSÉ
ÉCHELLE 1: 75



DÉVERSOIR - DÉTAIL
VUE EN COUPE
ÉCHELLE 1:20



DÉVERSOIR - DÉTAIL
VUE EN PROFIL
ÉCHELLE 1:20



DÉVERSOIR - DÉTAIL
VUE EN PLAN
ÉCHELLE 1:20

NOTE:
DÉVERSOIR EN ACIER GALVANISÉ FABRIQUÉE D'UNE BASE EN FORME DE DEMI-LUNE

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AtkinsRéalis

Rapport technique

Nouveau Monde Graphite

26 août 2025

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Rapport d'étude hydraulique
Révision de la conception du point de rejet de l'effluent

Page de signatures

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1. Introduction

1.1 Mise en contexte

Dans le cadre du projet minier Matawinie, Nouveau Monde Graphite (NMG) souhaite concevoir l'effluent final de la mine. Cet effluent est situé en aval de l'usine de traitement des eaux industrielles (UTEI). NMG avait produit des plans du bassin de dissipation et du canal de dissipation situés entre l'UTEI et le milieu récepteur, soit le ruisseau à l'Eau Morte. À la demande de NMG, cette note technique a pour but de réviser la conception du bassin de dissipation et du canal de dissipation et de proposer une nouvelle conception de ceux-ci.

1.2 Objectifs de l'étude

Les objectifs de l'étude hydraulique sont les suivants :

- Établir les critères de conception pour le dimensionnement du bassin de dissipation et du canal de dissipation ;
- Développer les modèles hydrauliques nécessaires ;
- Calculer les vitesses et les hauteurs d'eau dans le bassin de dissipation et le canal de dissipation ;
- Dimensionner le bassin de dissipation et le canal de dissipation afin de respecter les critères de conception ;
- Évaluer l'effet du ruisseau à l'Eau Morte sur la capacité d'évacuation des eaux du canal de dissipation ;
- Dimensionner l'enrochement du bassin de dissipation et du canal de dissipation en fonction des vitesses calculées ;
- Comparer le dimensionnement du bassin de dissipation et du canal de dissipation de cette étude avec celui proposé lors de la précédente conception ;
- Dimensionner le ponceau situé à la croisée du chemin d'accès et du chemin des véhicules hors-route ;
- Développer une protection contre le gel pour le tuyau se déversant dans le bassin de dissipation.

2. Localisation du site à l'étude

Le site à l'étude se situe dans la municipalité de Saint-Michel-des-Saints, dans la région administrative de Lanaudière. La **Figure 2-1** montre la localisation du projet minier Matawinie à l'étude. La **Figure 2-2** montre la localisation approximative du bassin de dissipation de la mine Matawinie, mais aussi celle du ruisseau CE09, du ruisseau à l'Eau Morte et du chemin d'accès aux véhicules hors-route. Le ruisseau CE09 est présenté considérant sa proximité avec le bassin de dissipation.

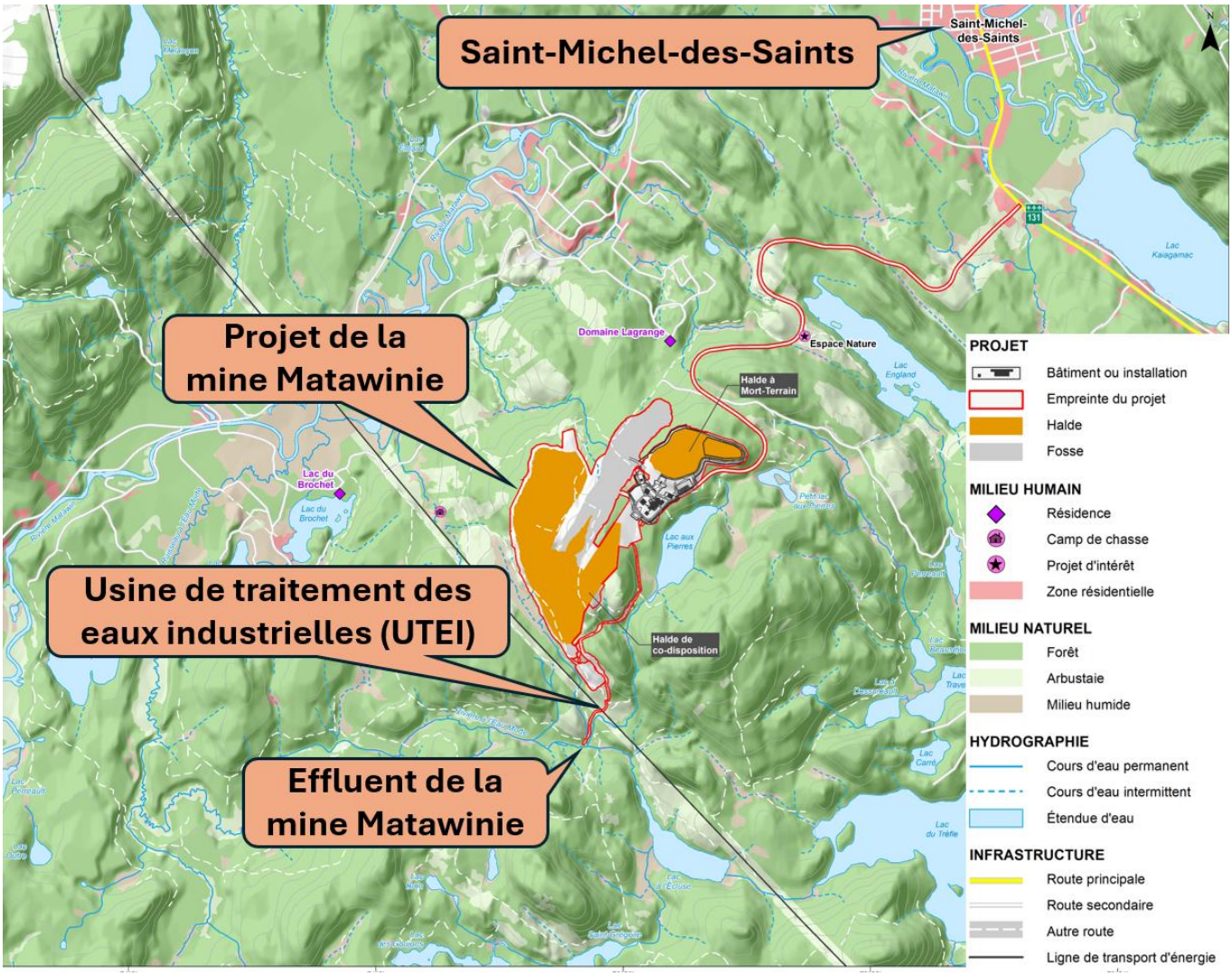


Figure 2-1 : **Localisation du site à l'étude**

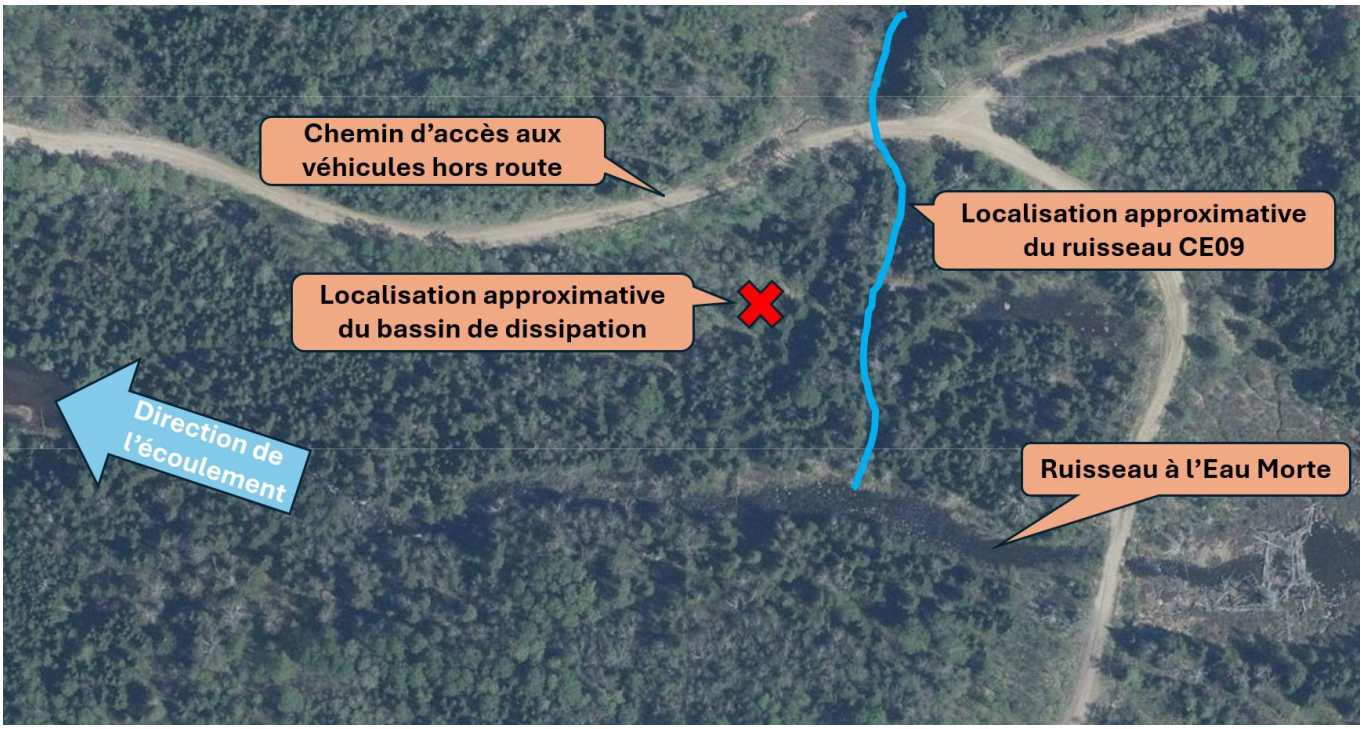


Figure 2-2 : Localisation approximative du bassin de dissipation de la mine Matawinie, du ruisseau CE09, du ruisseau à l'Eau Morte et du chemin d'accès aux véhicules hors-route

3. Intrant

3.1 Données hydrologiques

Les données hydrologiques présentées dans le cadre de cette étude sont tirées de la note technique « Site overall Water Balance for BC1 and BC2 Sizing » produite par SRK Consulting (SRK Consulting, 2024). La note technique de SRK Consulting se réfère à la note technique « Rapport de faisabilité sur la gestion de l'eau, des résidus et stériles miniers » de SNC-Lavalin (SNC-Lavalin, 2020), et cette dernière se réfère quant à elle à la note technique « Étude de préfaisabilité du projet Matawinie » de SNC-Lavalin (SNC-Lavalin, 2018).

La note technique « Étude de préfaisabilité du projet Matawinie » (SNC-Lavalin, 2018) mentionne que les trois stations météorologiques d'Environnement Canada les plus proches du site ont été considérées dans la réalisation de l'hydrologie de base. Les caractéristiques de ces stations météorologiques sont présentées au **Tableau 3-1.**

Tableau 3-1 : Caractéristiques des stations météorologiques considérées (SNC-Lavalin, 2018)

Station		Latitude Nord	Latitude Ouest	Altitude (m)	Distance (km)	Période disponible
Numéro	Nom					
7077570	St-Michel des Saints	46° 41'	73° 55'	351	6	1966 - 2017
7077571	St-Michel des Saints	46° 49'	73° 05'	430	23	2009 - 2017
7017080	St-Come	46° 17'	73° 45'	244	42	1950 - 2017

Cette hydrologie de base datant de 2018 est jugée encore valide pour cette étude.

Il est mentionné qu'étant donné la proximité du site avec la station St-Michel des Saints (7077570), les données qui y sont mesurées sont jugées représentatives du site. Les séries journalières de précipitation et de couvert de neige au sol reconstitué pour le site sont principalement basées sur les données de la station St-Michel des Saints (7077570). Les données des stations St-Michel des Saints (7077571) et St-Come (7017080) ont été utilisées lorsque nécessaire pour combler les périodes de données manquantes. Des données journalières sont disponibles à la station St-Michel des Saints (7077570) pour la période allant de 1966 à 2017. Cependant, seuls les mois de novembre et décembre sont disponibles en 1966. Cette année a été exclue des analyses qui suivent. (SNC-Lavalin, 2018).

Afin de prendre en compte l'augmentation possible des précipitations causée par la différence en élévation entre la mine Matawinie et les stations météorologiques, SRK considère une majoration de 14% (SRK Consulting, 2024). Ce phénomène est nommé l'effet orographique.

Cependant, ces données hydrologiques ne prennent pas en compte des effets possibles des changements climatiques. Afin de les prendre en compte, l'outil IDF_CC Tool a été utilisé (IDF_CC, 2015). Cet outil permet d'interpoler les données de précipitations entre différentes stations météorologiques. Cet outil donne l'option de considérer ou non l'effet possible des changements climatiques lors de l'interpolation des données de précipitations. En comparant les données de précipitation avec et sans les effets des changements climatiques, il est possible de déterminer le facteur de majoration associé aux changements climatiques.

Le **Tableau 3-2** présente les majorations appliquées aux données de précipitation pour un horizon de 100 ans.

Tableau 3-2 : Majorations des données de précipitation pour un horizon de 100 ans

	Effets possibles des changements climatiques	Effets possibles de l'orographie
Majoration	14,5%	14,0%

Il est à noter que l'hydrologie de base a été mise à jour en 2025 (SRK, 2025) après avoir complété les modélisations de cette étude. Cependant, les précipitations présentées dans l'hydrologie de base de 2025 (Tableau 2-11 de l'étude SRK, 2025) sont légèrement inférieures à celles considérées dans cette étude. Les résultats présentés dans cette étude sont donc jugés acceptables.

3.1.1 Précipitations

Le **Tableau 3-3** et le **Tableau 3-4** présentent les données de précipitation « Intensité-Durée-Fréquence » (IDF) retenues dans le cadre du projet pour les pluies de printemps et d'été-automne. Ces données ont été utilisées pour développer les hyétogrammes de fonte des neiges et de précipitation des scénarios météorologiques simulés dans le cadre des analyses.

Tableau 3-3 : Courbes IDF printanières majorées pour tenir compte des changements climatiques et de l'orographie

Durée	Période de récurrence					
	2 ans	5 ans	10 ans	25 ans	50 ans	100 ans
	Hauteur de précipitation (mm)					
5 min	5.4	8.6	10.6	13.4	15.5	17.5
10 min	7.6	12.4	15.7	19.8	23.0	26.1
15 min	9.0	15.2	19.6	25.1	29.2	33.3
30 min	11.3	20.5	26.8	34.8	40.9	46.8
1 h	15.6	28.9	38.0	49.8	58.7	67.7
2 h	19.4	37.6	50.4	66.9	79.1	91.5
6 h	27.1	46.9	60.6	78.0	91.0	103.9
12 h	31.5	52.2	66.3	84.2	97.7	111.1
24 h	35.4	56.8	71.1	89.3	102.8	116.4

Tableau 3-4 : Courbes IDF d'été-automne majorées pour tenir compte des changements climatiques et de l'orographie

Durée	Période de récurrence					
	2 ans	5 ans	10 ans	25 ans	50 ans	100 ans
	Hauteur de précipitation (mm)					
5 min	8.4	11.9	14.1	16.9	19.2	21.3
10 min	11.6	17.1	20.6	25.2	28.6	31.8
15 min	14.0	21.2	25.9	31.8	36.3	40.8
30 min	17.6	28.2	35.3	44.1	50.7	57.3
1 h	24.0	39.7	50.0	63.2	72.9	82.7
2 h	29.9	51.9	66.3	84.6	98.2	111.8
6 h	42.0	64.7	79.8	98.8	112.9	126.9
12 h	48.5	71.8	87.4	106.8	121.3	135.6
24 h	54.7	78.1	93.5	113.1	127.7	142.1

3.1.2 Couvert de neige

Le **Tableau 3-5** présente les épaisseurs du couvert de neige et les lames d'eau équivalentes avec et sans les majorations présentées au **Tableau 3-2**. Il a été assumé que de la teneur en eau de 1,0 cm de neige équivaut à une teneur en eau de 3,0 mm d'eau (Maidment, 1993).

Tableau 3-5 : Épaisseur du couvert de neige et lame d'eau équivalente (SNC-Lavalin, 2018)

Récurrence	Épaisseur du couvert de neige (cm)	Lame d'eau équivalente sans majoration (mm eq-eau)	Lame d'eau équivalente avec majoration (mm eq-eau)
2	75	224	292
5	93	279	364
10	105	315	411
20	117	351	458
50	132	396	517
100	143	429	560
EMP	200	600	783

3.1.3 Scénarios météorologiques

Au total, deux (2) scénarios météorologiques ont été simulés dans le cadre de cette étude. Les récurrences utilisées sont celles prescrites dans la Directive 019 (MELCCFP, 2012) pour le réseau de drainage d'une mine. Ces scénarios météorologiques sont présentés au **Tableau 3-6**.

Tableau 3-6 : Scénarios météorologiques

Scénario	Description
Scénario printanier - 100p 24h	Fonte rapide du couvert de neige d'une récurrence de 1 fois dans 100 ans (560,0 mm) en 13 jours, suivie d'une pluie printanière 24h d'une récurrence de 1 fois dans 100 ans (116,4 mm) le 13e jour
Scénario été-automne - 100ea 24h	Pluie d'été-automne 24h d'une récurrence de 1 fois dans 100 ans (142,1 mm)

3.1.4 Débit du ruisseau à l'Eau Morte

Deux évènements hydrologiques ont été considérés pour le ruissellement du ruisseau à l'Eau Morte. Le **Tableau 3-7** présente ces évènements.

Le 1er évènement est pour respecter les critères de dilution de la Directive 019 (MELCCFP, 2012) lorsque l'usine de traitement des eaux industrielles (UTEI) rejette un débit maximal de 1800 m^3/h. À noter que la note technique de SRK Consulting (SRK Consulting, 2024) mentionne que 234 m^3/h de ces eaux est recyclées dans les opérations de la mine. C'est pourquoi il est considéré que le débit maximal provenant de l'UTEI et se rejetant dans le bassin de dissipation est de 1566 m^3/h. Le débit de dilution de 9900 m^3/h provient de la note technique « Détermination des OER et des impacts sur la qualité des eaux de surface » (AtkinsRéalis, 2025).

Le 2e évènement est pour vérifier l'influence du ruisseau à l'Eau Morte lors de la crue centenaire sur la capacité d'évacuation du canal de dissipation. Ce niveau d'eau provient de la note technique « Remplacement du ponceau du ruisseau à l'Eau Morte » (AtkinsRéalis, 2024).

Tableau 3-7 : Scénarios hydrologiques du ruisseau à l'Eau Morte

1er évènement : Débit de dilution (m^3/h)	2e évènement : Niveau d'eau du ruisseau à l'Eau Morte durant la crue centenaire (m)
9900	423,28

3.2 Apport de l'usine de traitement des eaux industrielles (UTEI)

Les eaux provenant de l'UTEI se rejettent dans le bassin de dissipation. Comme présenté à la **Section 3.1.4**, l'UTEI rejette un débit maximal de 1800 m^3/h, mais considérant que 234 m^3/h de ces eaux sont recyclées dans les opérations de la mine, il est considéré que le débit maximal provenant de l'UTEI et se rejetant dans le bassin de dissipation est de 1566 m^3/h.

Il a aussi été considéré que le tuyau connectant l'UTEI au bassin de dissipation a un diamètre de 16 pouces tel qu'indiqué dans la note technique de Technosub (Technosub, 2025).

3.3 Modèle Numérique de Terrain

L'élévation du terrain naturel a été obtenu à partir du Modèle Numérique de Terrain (MNT) de *Forêt ouverte* (Forêt Ouverte, 2024). Le MNT utilisé a une résolution d'un mètre et provient de données LiDAR datant de 2024.

3.4 Ancienne conception

Les plans et la note technique de GHD présentant l'ancienne conception sont joints en annexes.

4. Critères de conception

4.1 Bassin de dissipation

Les critères de conception du bassin de dissipation sont les suivants :

- Les pentes transversales du bassin de dissipation se basent sur la section 8.4.2 du « Manuel de conception des ponceaux » (Manuel de conception des ponceaux, 2024). Il est indiqué que les pentes transversales minimales doivent être de 3H:1V tel que montré à la **Figure 4-1** ci-dessous. Cependant, il n'est pas possible de dimensionner la largeur, la longueur et la profondeur du bassin à l'étude selon les critères de conception présentés à la **Figure 4-1** puisque le bassin à l'étude reçoit aussi les eaux d'un fossé de drainage et le tuyau rejetant les eaux de l'UTEI est sous pression et surélevé. Tel que présenté à la **Section 5,** trois logiciels hydrauliques ont donc dû être utilisés pour dimensionner le bassin de dissipation.

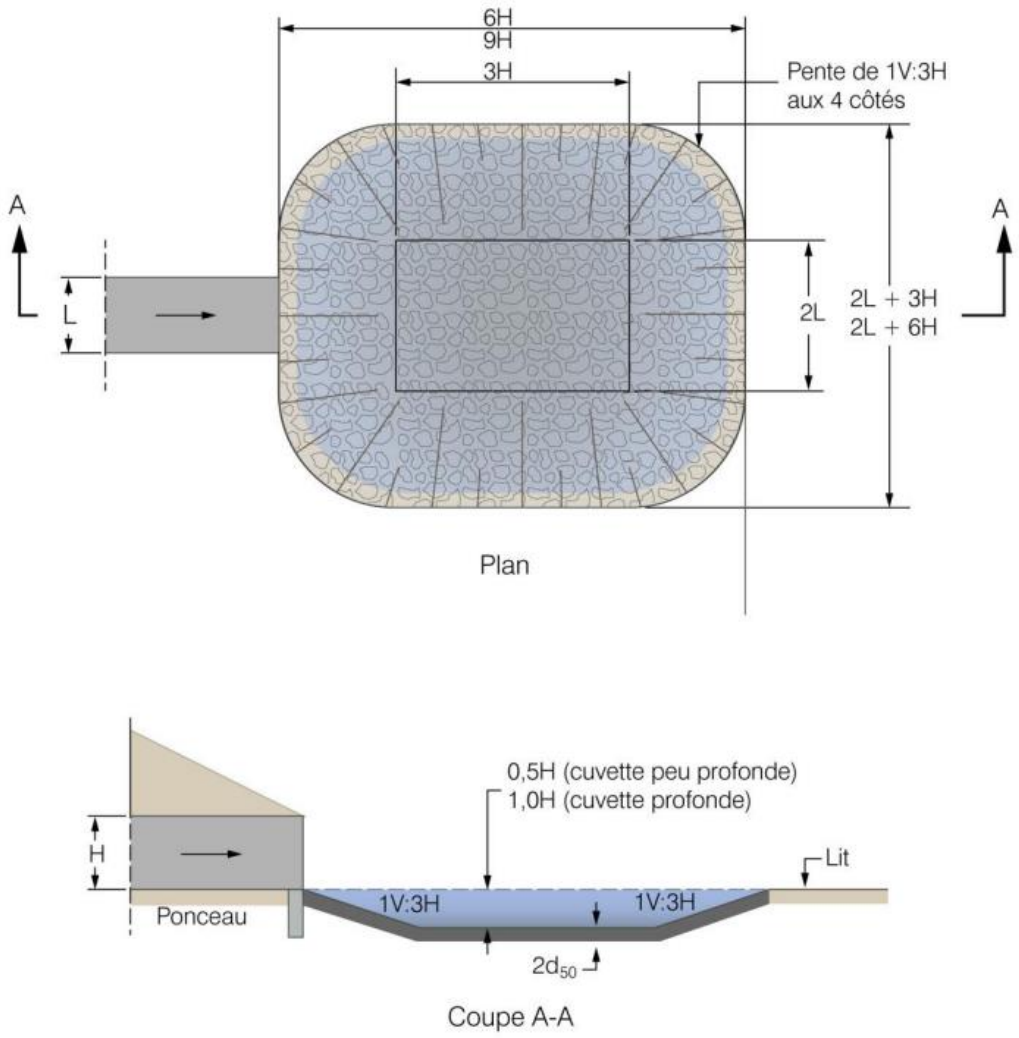


Figure 4-1 : Critère de conception du bassin de dissipation (Manuel de conception des ponceaux, 2024)

- Le bassin de dissipation doit être en mesure d'acheminer les eaux des scénarios météorologiques présentés à la **Section 3.1.3** tout en maintenant une revanche minimale de 0,3 m par rapport à la crête du bassin (Guide de gestion des eaux pluviales, 2024).

4.2 Canal de dissipation

Le canal de dissipation doit être en mesure d'acheminer les eaux des scénarios météorologiques présentés à la **Section 3.1.3** tout en maintenant une revanche minimale de 0,3 m par rapport aux hauts du talus. Le canal de dissipation achemine les eaux du bassin de dissipation vers le ruisseau à l'Eau Morte.

4.3 Ponceau

Les ponceaux ne doivent pas restreindre l'écoulement de manière à créer des débordements sur le chemin d'accès du bassin lors des scénarios météorologiques présentés à la **Section 3.1.3**.

5. Modélisation hydraulique

L'étude comprend trois modèles hydrauliques complémentaires. Le premier est un modèle hydraulique développé dans le logiciel PCSWMM afin d'évaluer les hauteurs d'eau dans le bassin de dissipation, ainsi que les hauteurs d'eau et les vitesses dans le canal de dissipation. Ce modèle a aussi été utilisé pour dimensionner le ponceau situé à la croisée du chemin d'accès et du chemin des véhicules hors-route.

Le deuxième est un modèle hydraulique 2D développé dans le logiciel HEC-RAS afin d'évaluer l'effet du ruisseau à l'Eau Morte sur la capacité d'évacuation des eaux du canal de dissipation lors de la crue 100 ans.

Le troisième est un modèle hydraulique 3D développé dans le logiciel FLOW-3D afin de calculer les vitesses dans le bassin de dissipation causées par le fossé de drainage et le tuyau. Il est aussi utilisé pour calculer les vitesses au niveau de la marche située dans le canal de dissipation.

La **Figure 5-1** présente une vue d'ensemble de la géométrie 3D utilisée pour ces modèles et la localisation du ponceau à concevoir.

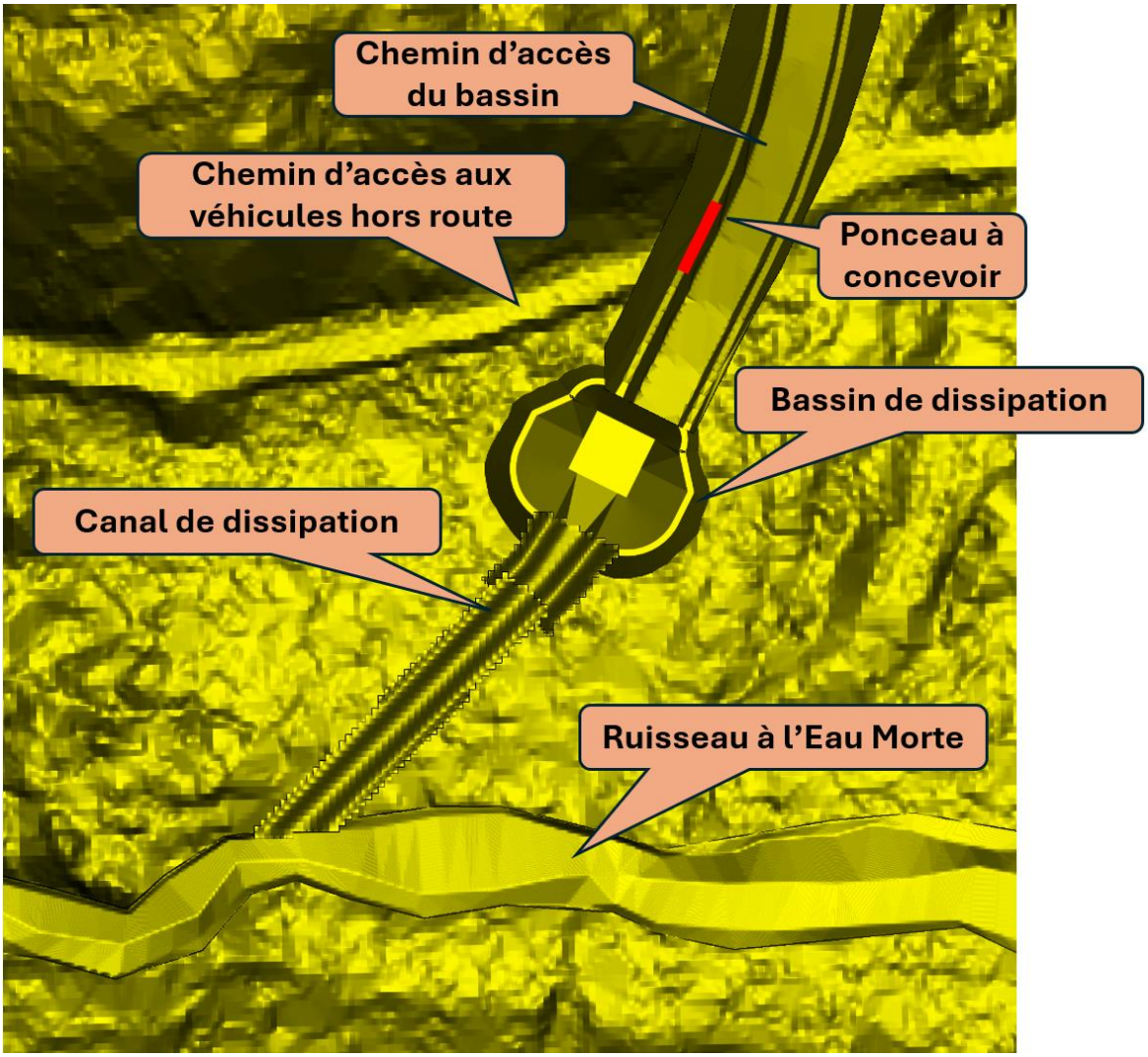


Figure 5-1 : Vue d'ensemble de la géométrie utilisée pour les modèles

La **Figure 5-2** présente une vue en coupe du chemin d'accès du bassin de dissipation. Cette coupe est localisée juste en amont du bassin. À noter qu'il est montré ici une coupe en considérant une vue du nord vers le sud. Cette coupe présente également le fossé de drainage et le tuyau. Cette coupe est tirée des plans de l'ancienne conception (GHD, 2025).

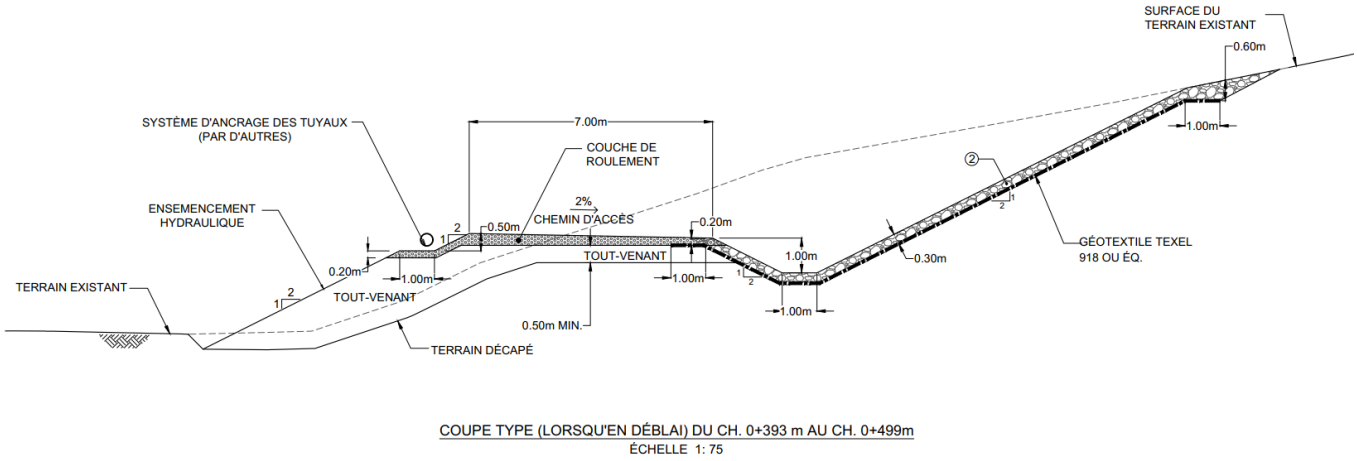


Figure 5-2 : Vue en coupe du chemin d'accès du bassin de dissipation (GHD, 2025)

5.1 Bassin de dissipation

La configuration du bassin de dissipation est présentée à la **Figure 5-3**. Les pentes transversales du bassin sont de 4:1 à l'exception du côté où le tuyau est placé. Pour ce côté, la pente transversale est de 2:1 afin de réduire la longueur du tuyau sortant à l'extérieur de la fondation de la route. Cette pente plus abrupte est jugée acceptable considérant les vitesses calculées et l'enrochement de protection qui y sera appliqué tel que présenté à la **Section 6.5.1**. Le positionnement du ponceau est aussi détaillé à la **Section 6.5.1**. Le seuil du déversoir doit être à l'élévation 425 m, soit à un mètre plus haut que le fond du bassin. Ceci permet de garder en permanence une profondeur d'eau minimale de 1 m dans le bassin et ainsi de dissiper l'énergie et de réduire les vitesses d'eau le long des parois du bassin de dissipation tel que présenté à la **Section 6.5.1**.

La localisation du tuyau est présentée à la **Section 5.5.1**.

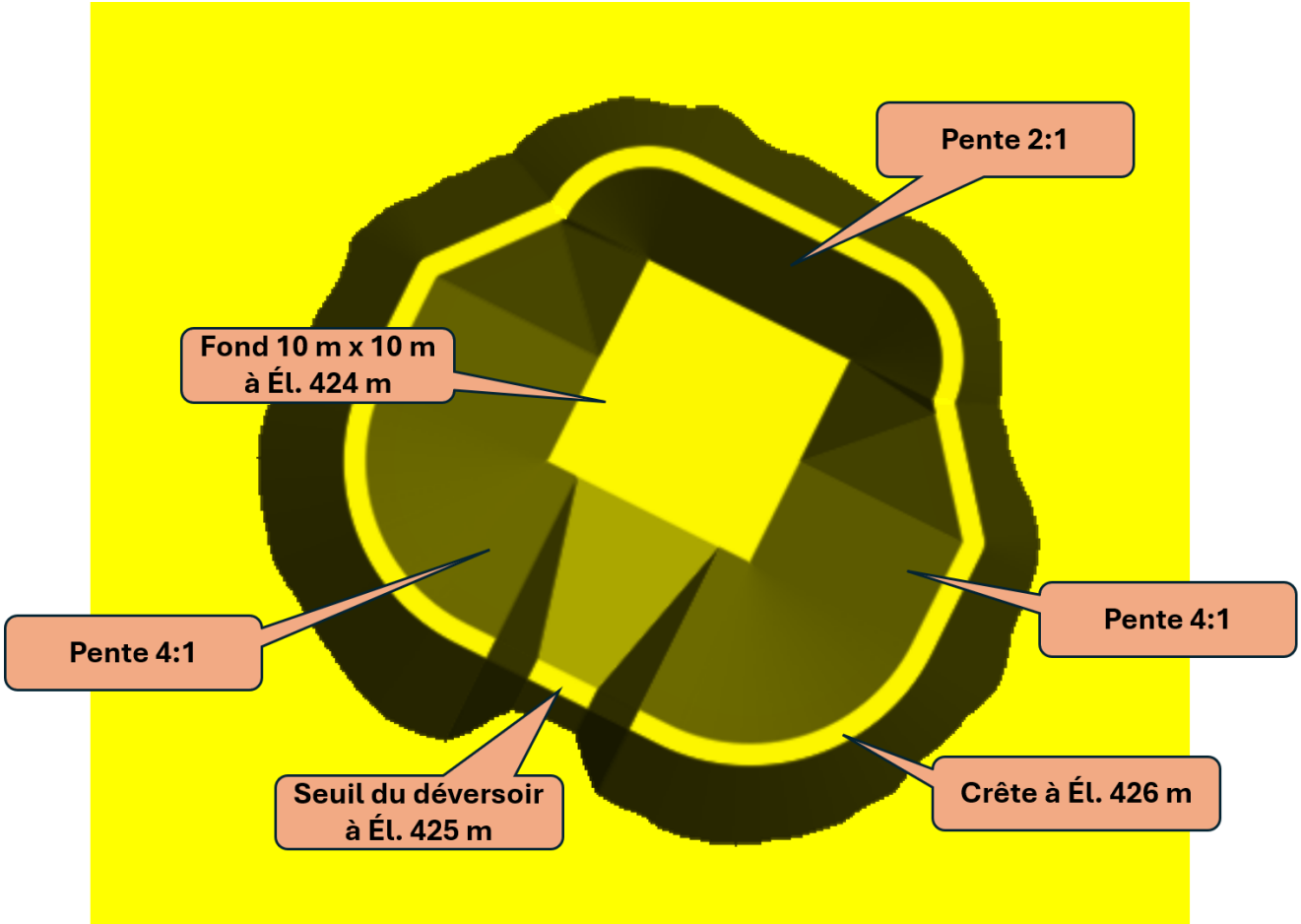


Figure 5-3 : Configuration du bassin de dissipation

La **Figure 5-4** présente la courbe d'emmagasinement du bassin de dissipation.

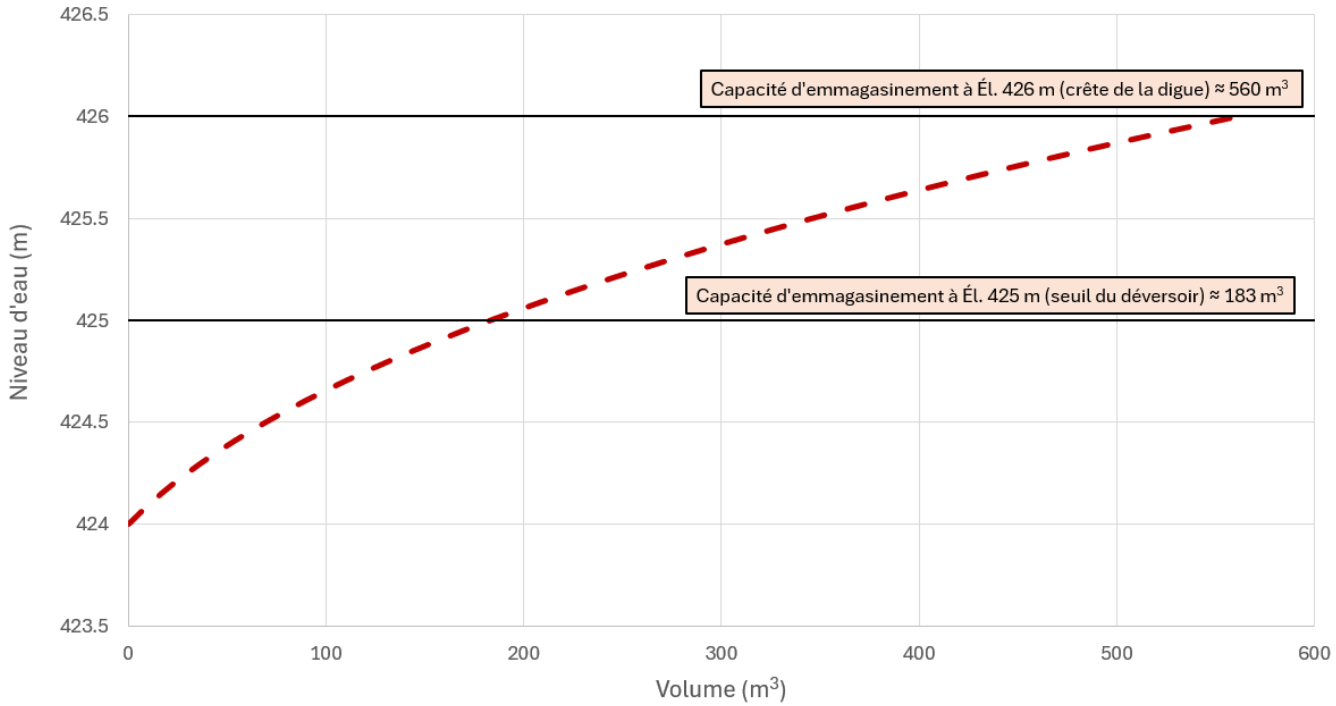


Figure 5-4 : Courbe d'emmagasinement du bassin de dissipation

5.2 Canal de dissipation

Le canal de dissipation permet de relier le bassin de dissipation au ruisseau à l'Eau Morte. La localisation de l'exutoire du canal de dissipation est présentée à la **Figure 5-1**. L'exutoire du canal est placé juste en amont d'une section du ruisseau à l'Eau Morte où la pente longitudinale est plus importante et est égale à environ 4 %. Cette augmentation de pente augmente localement la vitesse d'eau dans le ruisseau, et ainsi améliore la dilution.

La configuration du canal de dissipation est présentée à la **Figure 5-5**. Les pentes transversales du canal sont de 2H:1V et la largeur du fond est de 1,5 m. La pente longitudinale est entre 5 et 6 %. Il y a présence d'une marche de 0,6 m de hauteur à environ 12 m en aval du seuil du déversoir afin d'empêcher les poissons en provenance du ruisseau à l'Eau Morte de remonter le canal et d'atteindre le bassin de dissipation.

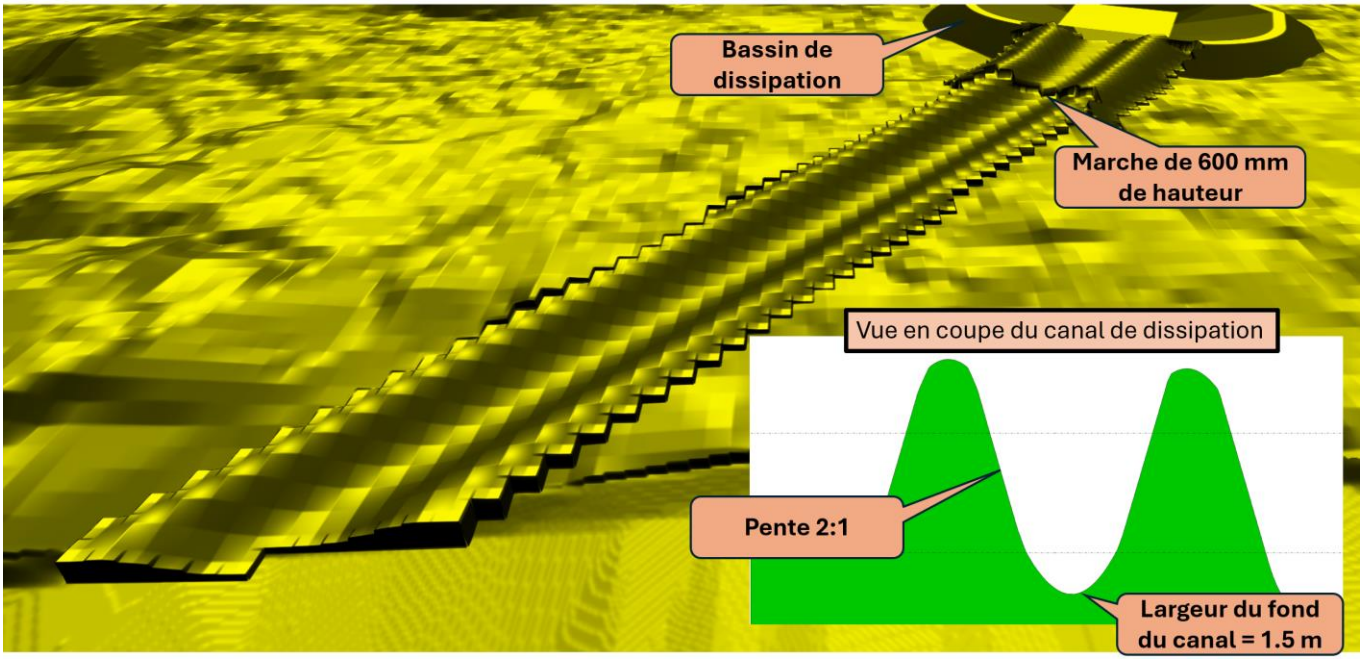


Figure 5-5 : Configuration du bassin de dissipation

5.3 Modèle PCSWMM

5.3.1 Géométrie du modèle PCSWMM

Le logiciel PCSWMM 2024 Professional 2D (SWMM v.5.1.15) a été utilisé afin de modéliser le système d'écoulement du site pour les différents scénarios météorologiques. La **Figure 5-6** présente une vue d'ensemble du modèle PCSWMM.

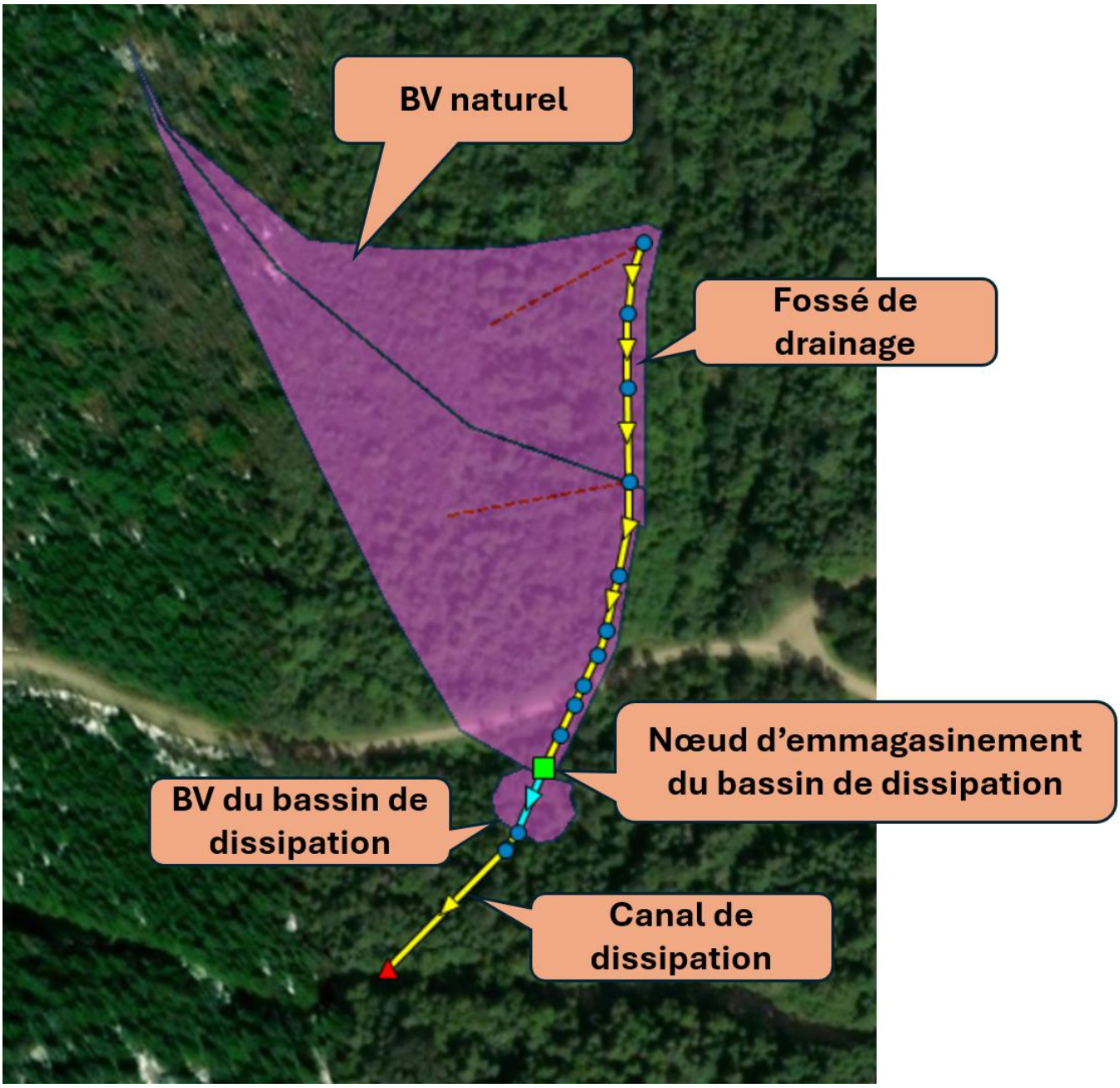


Figure 5-6 : Vue d'ensemble du modèle PCSWMM

5.3.2 Paramètres du modèle PCSWMM

Le **Tableau 5-1** présente la valeur de Manning N des différents éléments présentés à la **Figure 5-6**. Cette valeur représente la rugosité des surfaces et influence, entre autres, la vitesse et la hauteur d'eau.

Tableau 5-1 : Valeur de Manning N utilisés pour les calculs hydrologiques dans PCSWMM

	Manning N	Justification
BV naturel	0,60[1]	Forêt dense
Bassin dissipation	0,04[2]	Enrochement grossier (300 – 500 mm)
Fossé de drainage	0,03[3]	Enrochement de taille moyenne (200 – 300 mm)
Canal de dissipation	0,03[4]	Enrochement de taille moyenne (200 – 300 mm)
Notes :		
1 : Tableau A.6 : « Manning's n - Overland Flow » pour une Surface « Woods - Light/dense underbrush » (EPA, 2015).		
2 : Tableau A.8 : « Manning's n - Open Channels » pour une Surface « Excavated - Rock » (EPA, 2015).		
3 : Tableau A.8 : « Manning's n - Open Channels » pour une Surface « Excavated - Earth, straight and uniform » (EPA, 2015).		
4 : Tableau A.8 : « Manning's n - Open Channels » pour une Surface « Excavated - Earth, straight and uniform » (EPA, 2015).		

5.4 Modèle HEC-RAS 2D

5.4.1 Géométrie du modèle HEC-RAS 2D

Le logiciel HEC-RAS a été choisi pour sa capacité à simuler l'écoulement en deux dimensions (2D). La **Figure 5-7** présente la vue d'ensemble du modèle HEC-RAS 2D. Le modèle HEC-RAS 2D exécute un algorithme avec un schéma de solution à volumes finis. Il utilise un système interne de type maillage (composé de cellules) pour représenter les caractéristiques hydrauliques dans un modèle 2D. La résolution du modèle 2D dépend de la taille de ce système maillé.

Les tailles de maillages optimisées du modèle ont été obtenues par essais et erreurs jusqu'à ce que la taille minimale du maillage n'altère plus les résultats et n'engendre pas d'erreurs dans le modèle. Sur cette base, la taille du maillage utilisée pour ce modèle est présentée à la **Figure 5-8.** Dans ce modèle, un maillage plus petit a été utilisé le long du fossé de drainage et du canal de dissipation puisque les vitesses d'écoulement sont plus importantes.

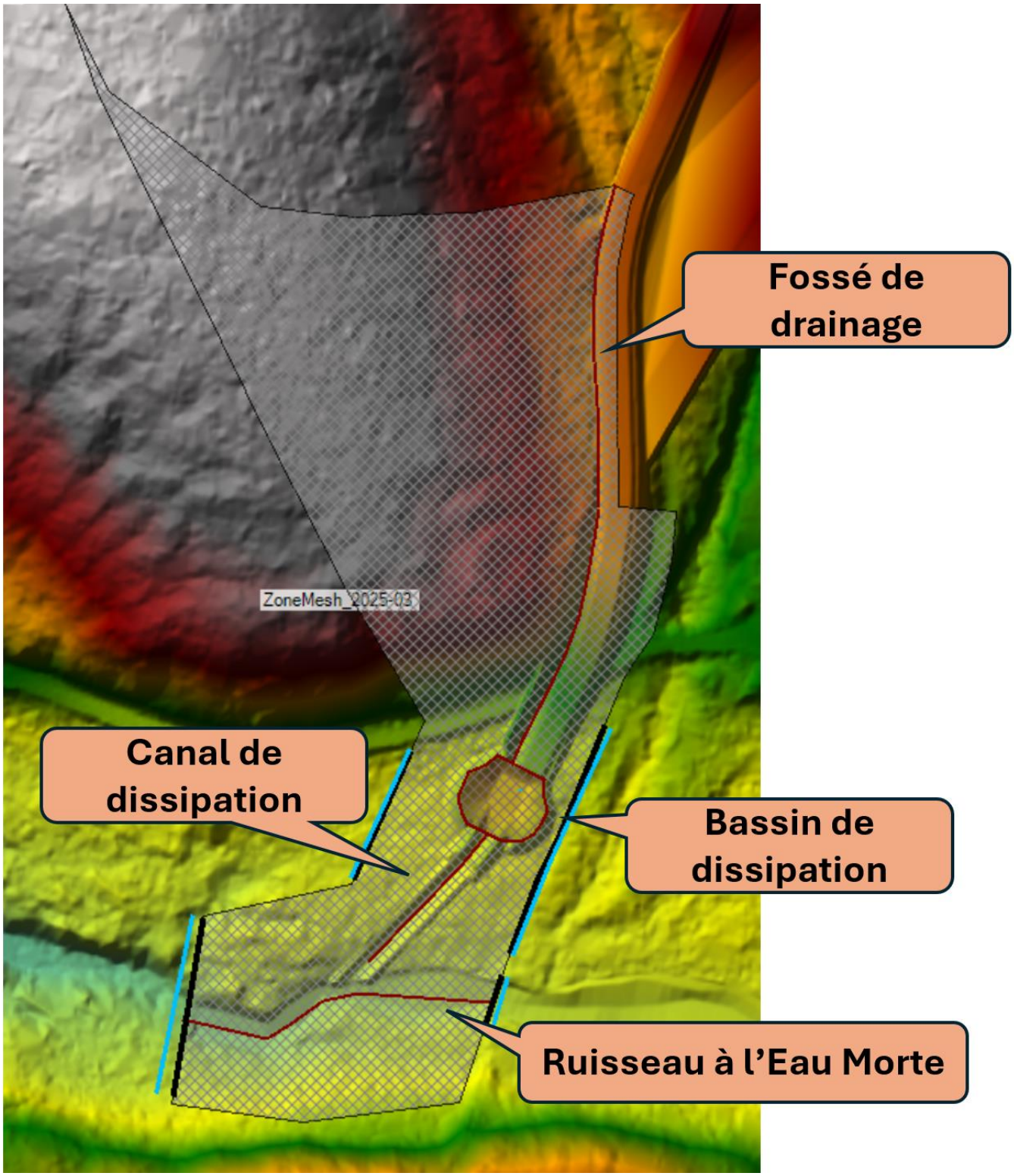


Figure 5-7 : Vue d'ensemble du modèle HEC-RAS 2D

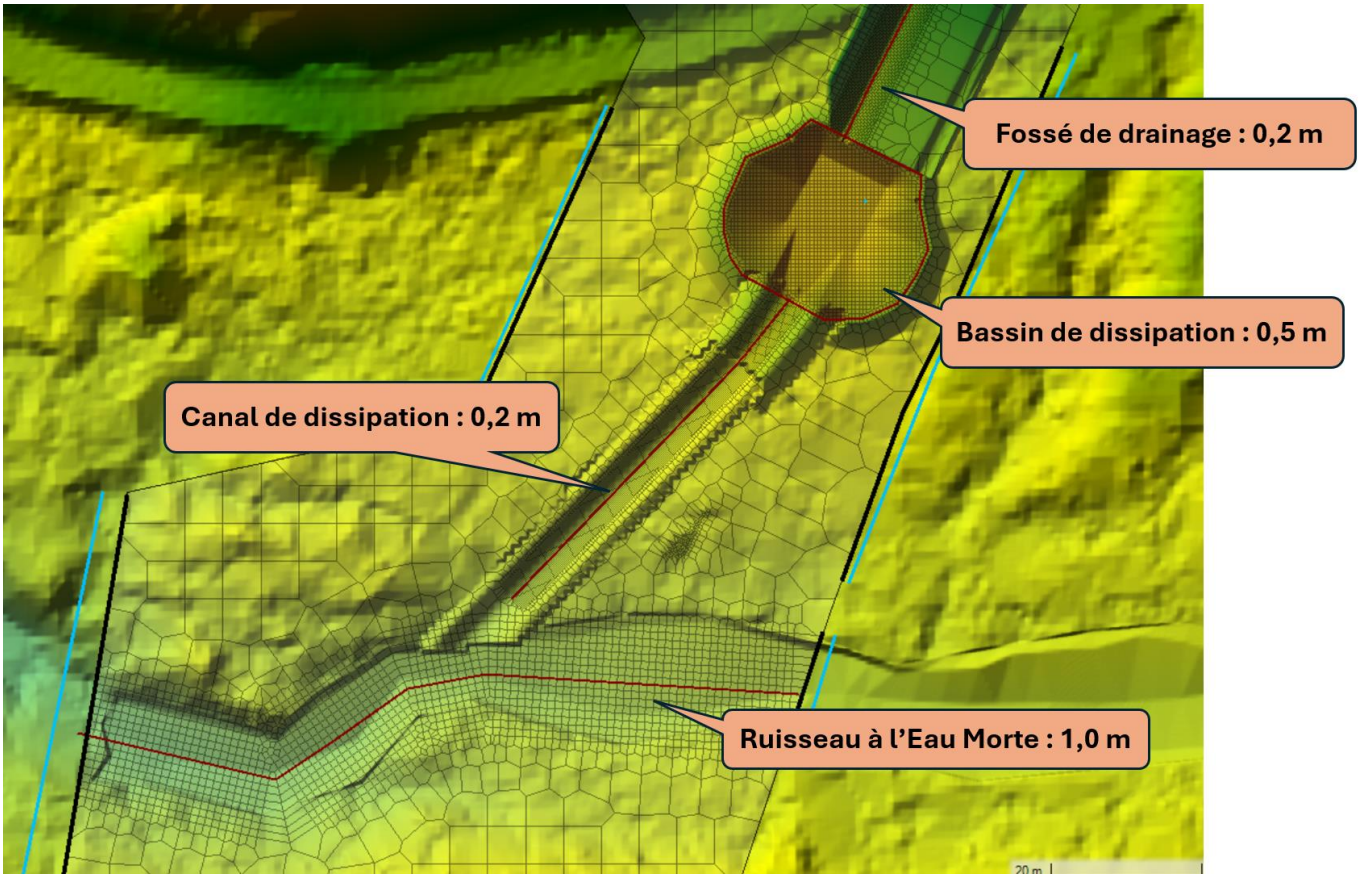


Figure 5-8 : Taille du maillage utilisée dans le modèle HEC-RAS 2D

5.4.2 Paramètres du modèle HEC-RAS 2D

Les valeurs de Manning N considérées dans le modèle HEC-RAS 2D sont les mêmes que celles utilisées dans le modèle PCSWMM présentées au **Tableau 5-1**.

5.5 Modèle FLOW-3D

5.5.1 Géométrie du modèle FLOW-3D

Le logiciel FLOW-3D a été choisi pour sa capacité à simuler l'écoulement en trois dimensions (3D). La **Figure 5-9** présente la géométrie utilisée pour le modèle FLOW-3D. Comme pour le modèle HEC-RAS 2D, celui de FLOW-3D exécute un algorithme avec un schéma de solution à volumes finis, mais cette fois-ci en trois dimensions. Il utilise aussi un système interne de type maillage, cette fois-ci pour représenter les caractéristiques hydrauliques dans un modèle 3D. La résolution du modèle 3D dépend de la taille de ce système maillé. La principale différence entre le logiciel HEC-RAS 2D et FLOW-3D est que ce dernier peut aussi calculer les caractéristiques hydrauliques en élévation, ce qui est nécessaire dans notre cas afin de simuler, entre autres, le rejet d'eau du tuyau dans le bassin de dissipation. La localisation du tuyau modélisé est présentée à la **Figure 5-10** et détaillée à la **Section 6.5.1**.

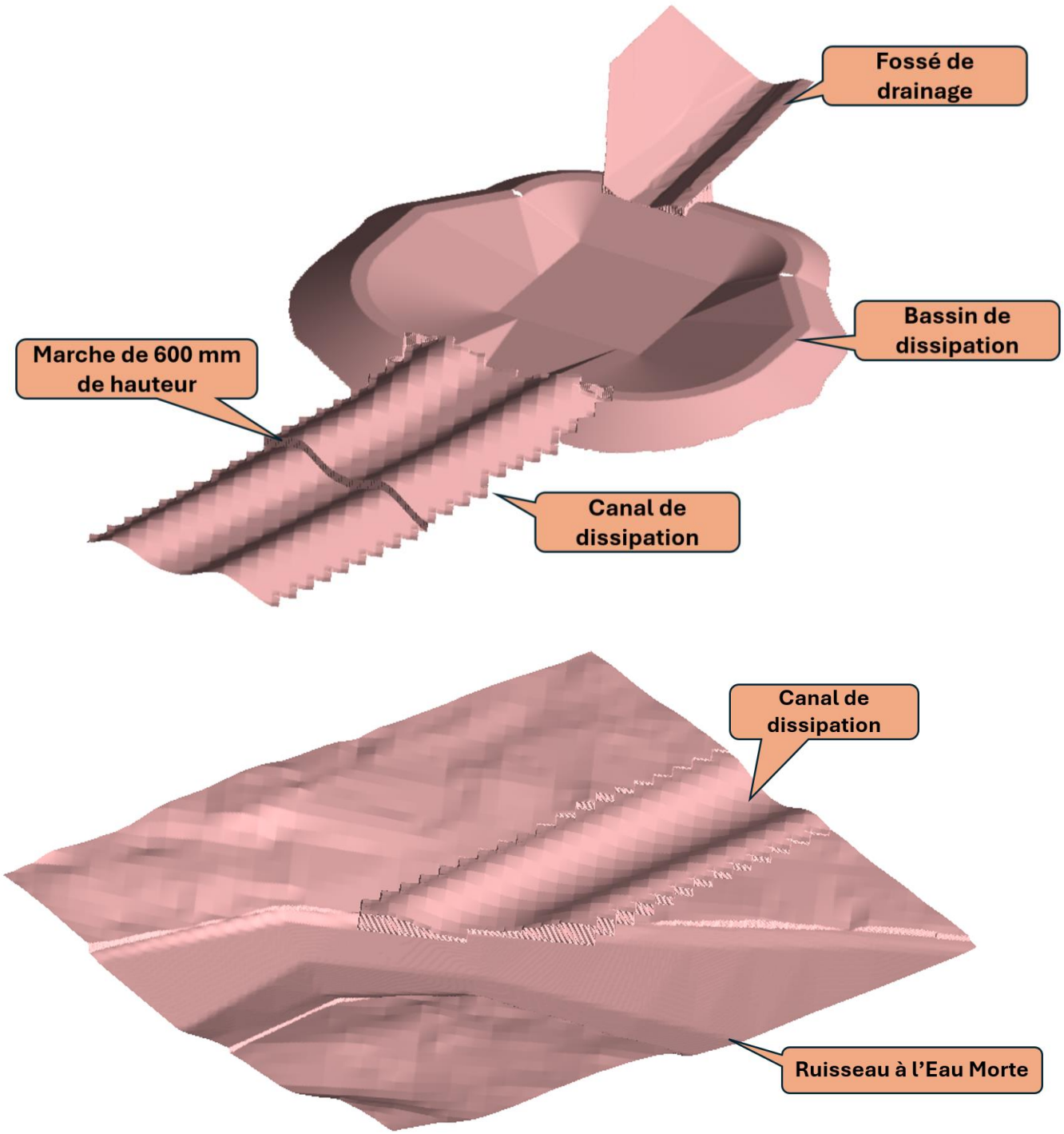


Figure 5-9 : Géométrie utilisée pour le modèle FLOW-3D

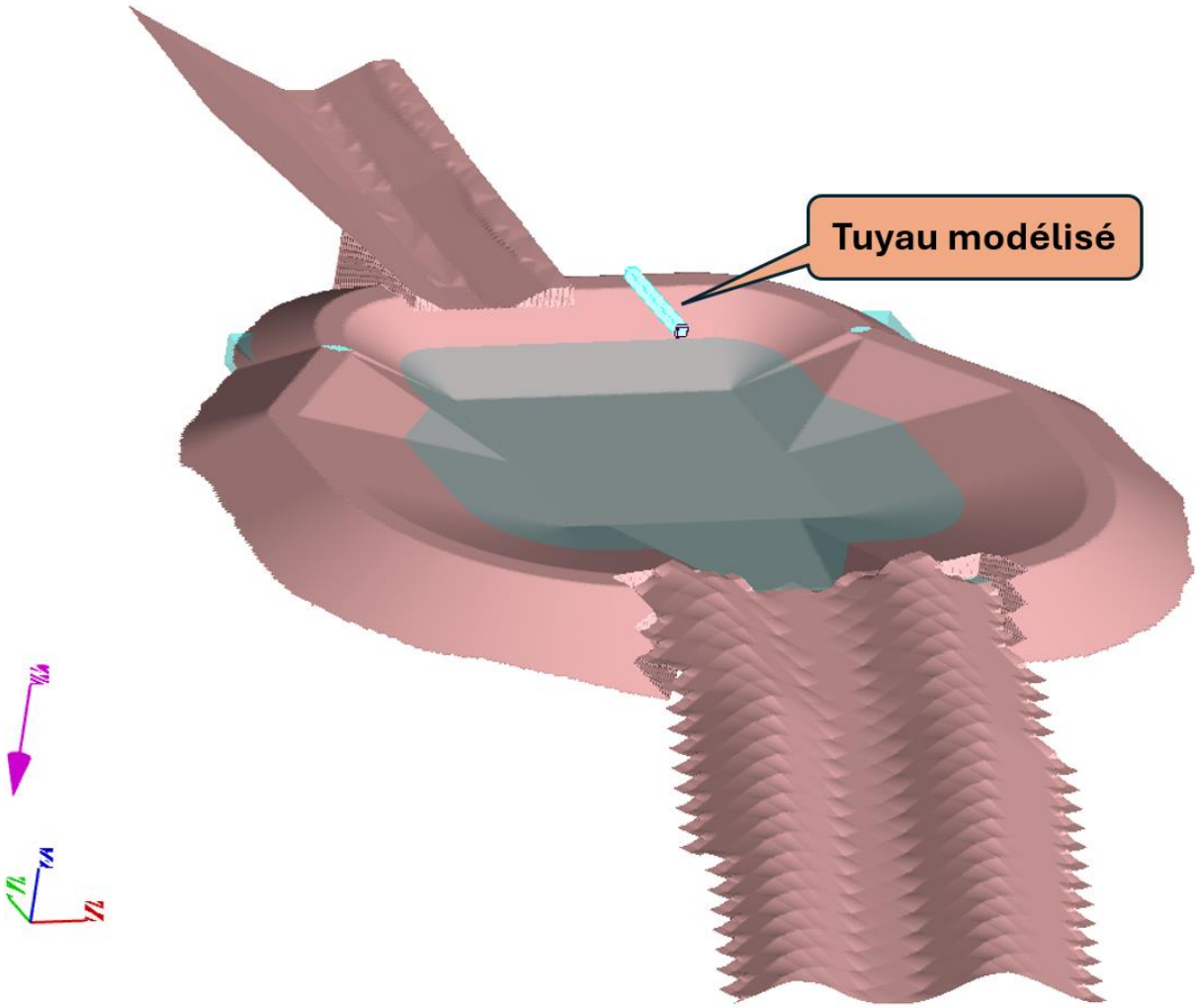


Figure 5-10 : Localisation du tuyau modélisé

5.5.2 Paramètres du modèle FLOW-3D

Le **Tableau 5-2** présente les valeurs de rugosité absolue considérée pour le modèle FLOW-3D. Le **Tableau 5-3** présente la taille du maillage utilisée dans le modèle FLOW-3D.

Tableau 5-2 : Rugosité absolue du modèle FLOW-3D

Localisation	Rugosité absolue (m)
Fossé de drainage	0,23
Bassin de dissipation	0,88
Canal de dissipation	0,14

Tableau 5-3 : Taille du maillage du modèle FLOW-3D

Localisation	Taille du maillage (m)
Fossé de drainage	0,05 à 0,10
Tuyau	0,025
Bassin de dissipation	0,05 à 0,20
Canal de dissipation	0,05 à 0,10
Ruisseau à l'Eau Morte	0,05

Comme indiqué à la **Section 3.1.4**, un tuyau de forme cylindrique ayant un diamètre de 16 pouces se déverse dans le bassin de dissipation. Ce tuyau a été modélisé dans FLOW-3D en le simplifiant comme étant un prisme à base carré. Un cercle ayant un diamètre de 16 pouces a une aire de 0,1297 m^2. Il a été simplifié par un carré ayant des côtés de 0,35 m de longueur et une aire de 0,1225 m^2. L'écoulement provenant du prisme à base carrée est jugé représentatif de celui en forme cylindrique.

6. Résultats des simulations

6.1 Dimensionnement du bassin de dissipation

Comme expliqué à la **Section 5**, un modèle PCSWMM a été développé afin d'évaluer les hauteurs d'eau dans le bassin de dissipation lors des deux scénarios météorologiques présentés à la **Section 3.1.3** tout en ayant l'apport du débit de pompage de 1566 m^3/h présenté à la **Section 3.2**. La **Figure 6-1** présente les niveaux d'eau maximums calculés lors du scénario printanier. La **Figure 6-2** présente les niveaux d'eau maximums calculés lors du scénario été-automne. Le **Tableau 6-1** compare les hauteurs d'eau atteintes dans le bassin de dissipation lors des deux scénarios météorologiques. Il a été calculé que c'est durant le scénario été-automne que la hauteur d'eau est la plus importante dans le bassin de dissipation et c'est donc ce scénario météorologique qui est utilisé pour le dimensionnement du bassin.

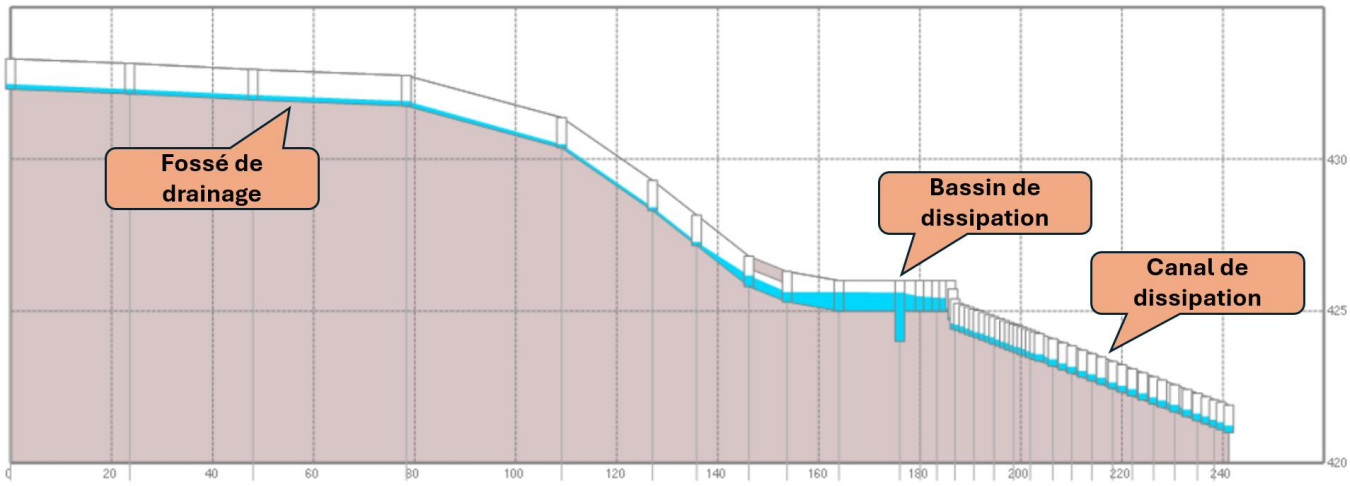


Figure 6-1 : Niveau d'eau maximum (m) – Crue 100 ans – Scénario printanier

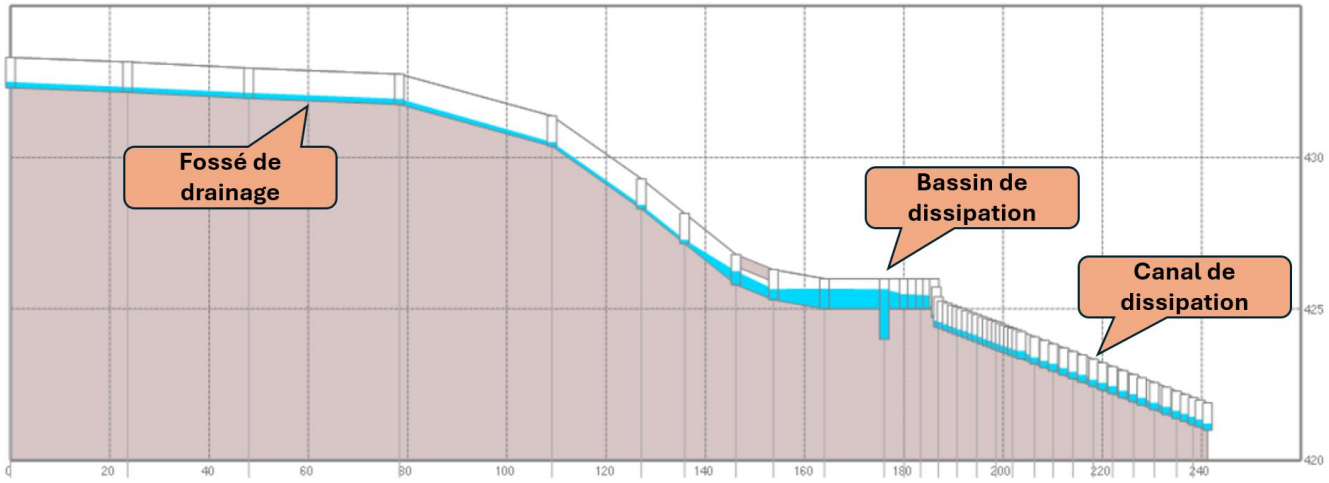


Figure 6-2 : Niveau d'eau maximum (m) – Crue 100 ans – Scénario été-automne

Tableau 6-1 : Comparatif des hauteurs d'eau maximales dans le bassin de dissipation lors des deux scénarios météorologiques

Scénario météorologique	Hauteur d'eau maximale atteinte dans le bassin de dissipation (m)
Printemps	1,61
Été-automne	1,65

Comme expliqué à la **Section 4.1**, le bassin de dissipation doit maintenir une revanche minimale de 0,3 m par rapport à la crête du bassin (Guide de gestion des eaux pluviales, 2024). En ajoutant une revanche de 0,3 m à la hauteur d'eau de 1,65 m, il est donc nécessaire que le bassin ait une profondeur de 2 mètres, calculée entre le fond du bassin et la crête du bassin. Puisque l'élévation du fond du bassin est à 424 m, l'élévation de cette crête est donc à 426 m.

Il a aussi été calculé qu'avoir une élévation de crête à 426 m permet aussi de garantir une revanche de 0,3 m par rapport à la crête du bassin et le niveau des eaux en périphérie extérieur du bassin. En d'autres mots, les eaux à l'extérieur du bassin n'atteindront pas la crête lors de la crue 100 ans.

6.2 Dimensionnement du canal de dissipation

La **Figure 6-3** présente sur une vue en plan les hauteurs maximales calculées le long du canal de dissipation. La **Figure 6-4** présente sur une vue en profil les hauteurs maximales calculées le long du canal de dissipation. L'élévation du haut du talus du canal de dissipation en amont de la marche de 0,6 m doit être la même que celle de la crête du bassin de dissipation, soit 426 m. En aval de la marche de 0,6 m, la profondeur du canal de dissipation doit être au minimum 0,6 m, considérant la hauteur d'eau maximale de 0,3 m et la revanche requise de 0,3 m.

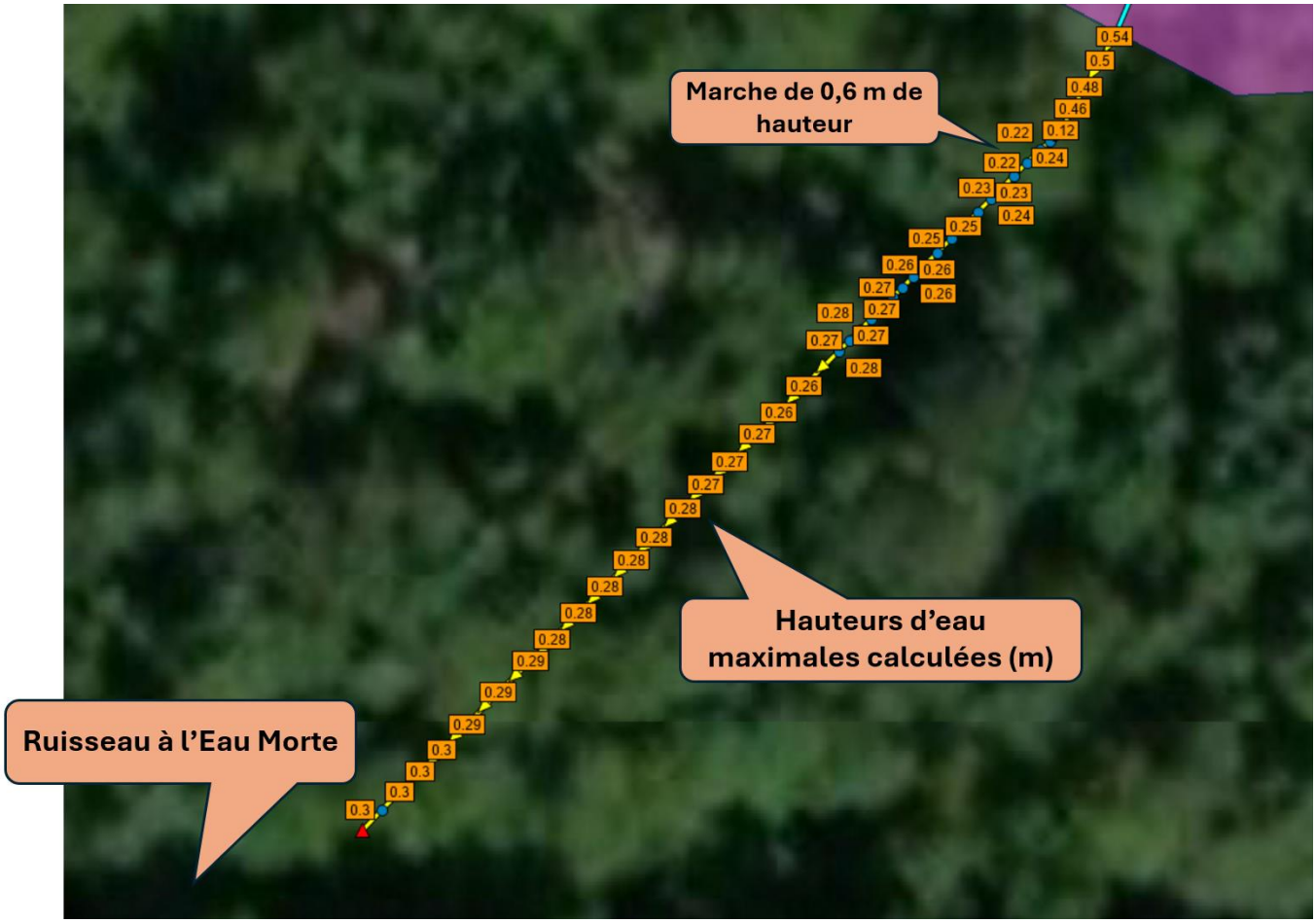


Figure 6-3 : Hauteur d'eau maximale calculée (m) – Pluie été-automne de récurrence 100 ans – Vue en plan

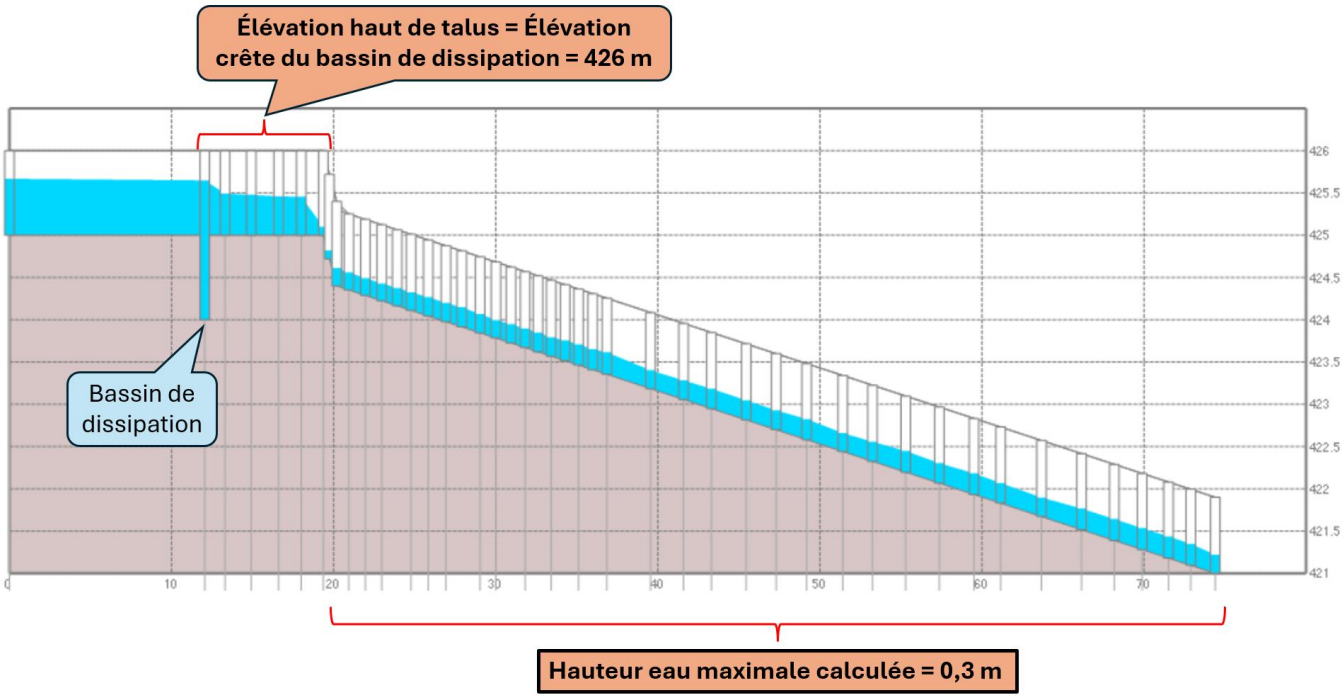


Figure 6-4 : Hauteur d'eau maximale calculée (m) – Pluie été-automne de récurrence 100 ans – Vue en profil

6.3 Influence du ruisseau à l'Eau Morte lors de la crue de récurrence 100 ans

Tel que présenté à la **Section 3.1.4**, deux évènements hydrologiques ont été considérés pour le ruissellement du ruisseau à l'Eau Morte. Le 1er évènement est pour respecter les critères de dilution de la Directive 019 et le 2e évènement est pour vérifier la capacité d'évacuation du canal de dissipation lorsque le ruisseau à l'Eau Morte est en crue centenaire.

Le niveau d'eau du ruisseau à l'Eau Morte à environ 50 m en amont de l'exutoire du canal de dissipation lors de la crue centenaire est de 423,28 m tel que présenté dans la note technique « Remplacement du ponceau du ruisseau à l'Eau Morte » (AtkinsRéalis, 2024).

La **Figure 6-5** présente le niveau des eaux le long des ouvrages lorsque le ruisseau à l'Eau Morte est en crue centenaire. À noter qu'il est considéré lors de cet évènement que la pluie été-automne de récurrence 100 ans tombe aussi sur l'ensemble du site, dont le bassin versant du fossé de drainage, et que le tuyau rejette un débit de 1566 m^3/h.

Considérant que les eaux du ruisseau à l'Eau Morte ne remontent pas jusqu'au bassin de dissipation, il est considéré que le ruisseau à l'Eau Morte n'a pas d'influence sur la capacité d'évacuation du canal de dissipation et du bassin de dissipation lors de la crue centenaire.

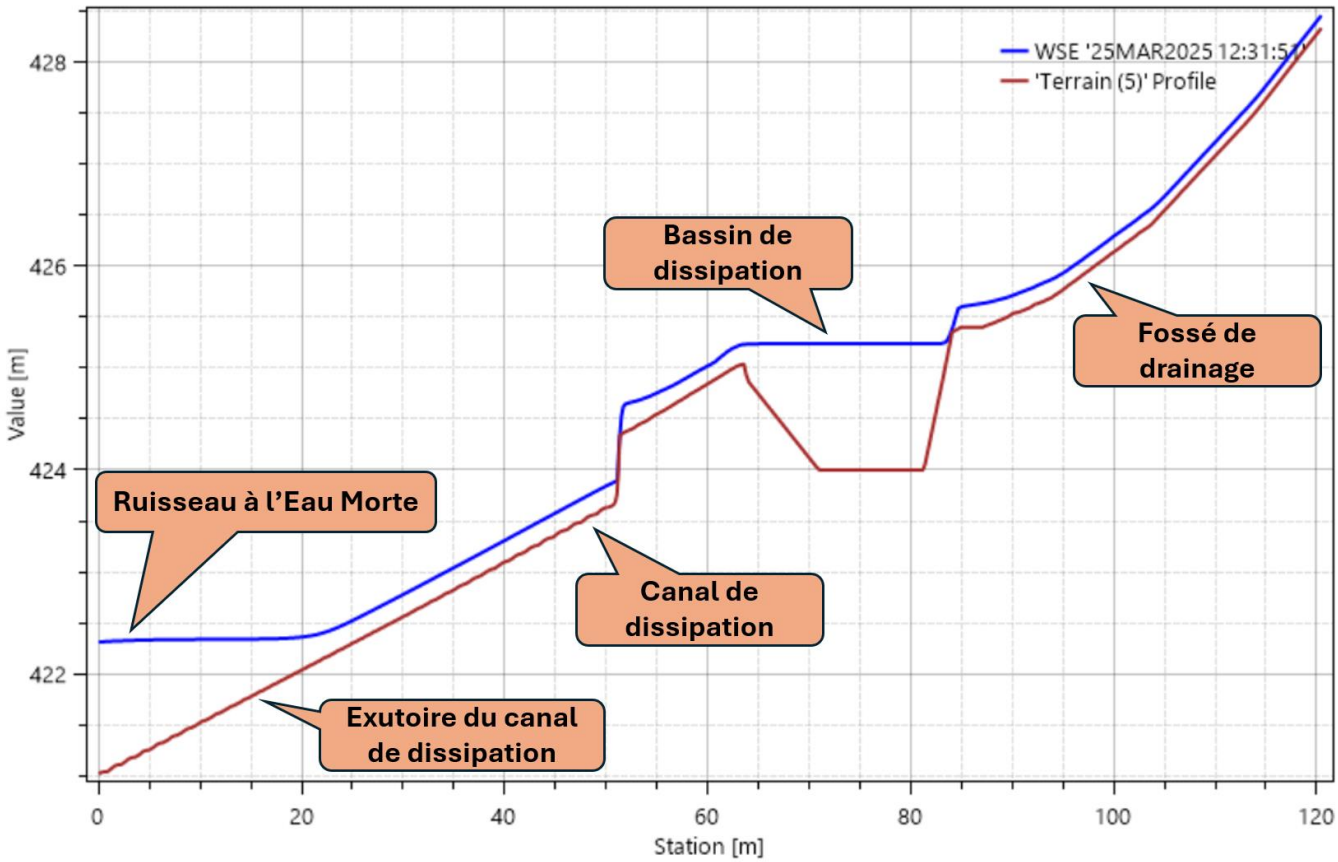


Figure 6-5 : Niveau des eaux le long des ouvrages lorsque le ruisseau à l'Eau Morte évacue la crue centenaire (m)

6.4 Dimensionnement du ponceau

Comme présenté à la **Figure 5-1**, le chemin d'accès aux véhicules hors route croise le chemin d'accès du bassin de dissipation. C'est pourquoi il est nécessaire d'installer un ponceau le long du fossé de drainage qui traversera le chemin d'accès aux véhicules hors route.

Tel que présenté à la **Section 4.3**, ce ponceau doit être dimensionné de manière à ne pas restreindre l'écoulement et produire des débordements sur le chemin d'accès du bassin lors des scénarios météorologiques présentés à la **Section 3.1.3**.

La **Figure 6-6** présente une vue en profil du fossé de drainage incluant le ponceau lors de la pluie été-automne de récurrence 100 ans. Il est montré qu'un ponceau ayant un diamètre de 600 mm permet de ne pas créer de débordement sur le chemin d'accès du bassin.

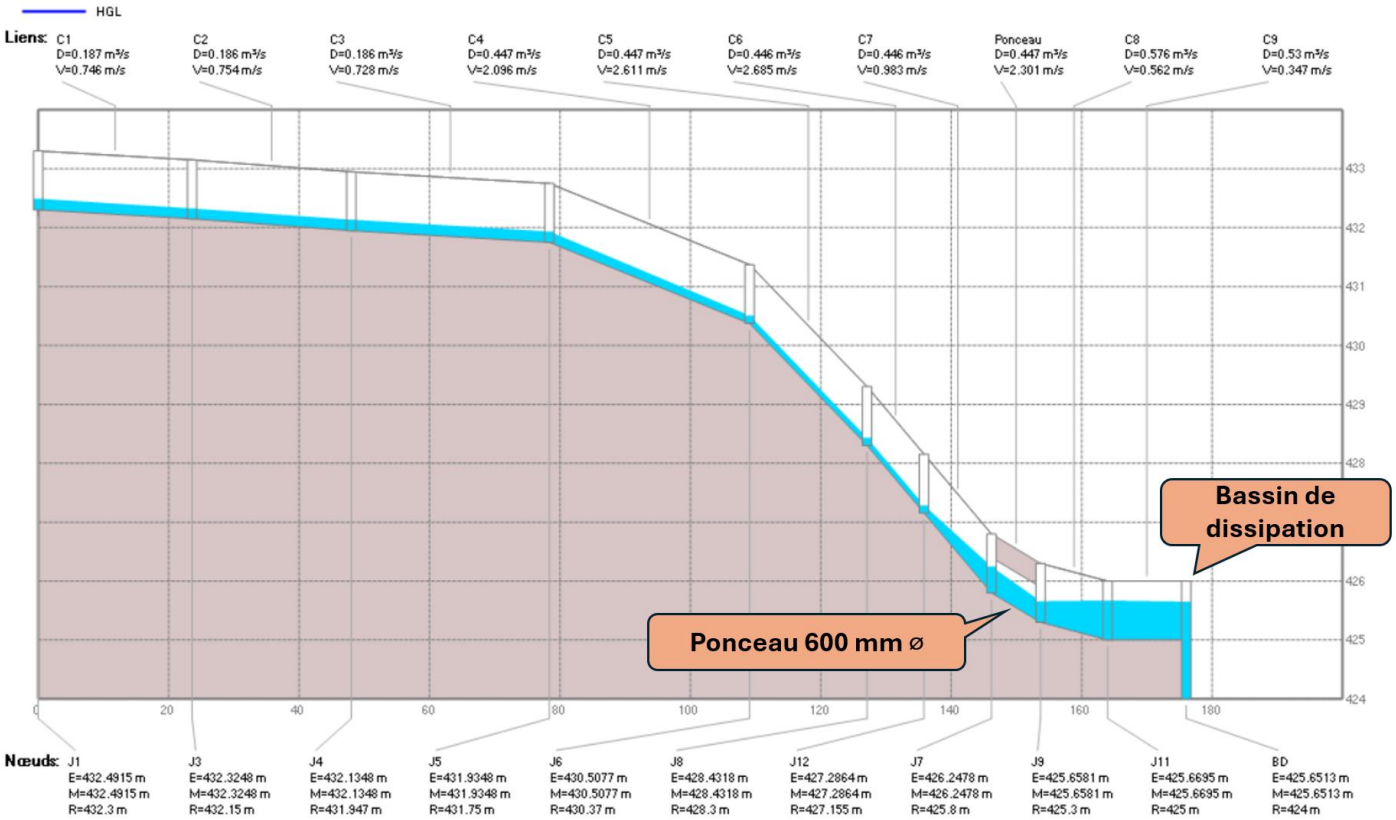


Figure 6-6 : Niveau des eaux le long du fossé de drainage (m) – Dimensionnement du ponceau – Pluie été-automne de récurrence 100 ans – Vue en profil

6.5 Protection contre l'érosion

Comme expliqué à la **Section 5**, un modèle PCSWMM et FLOW-3D ont été développés afin de calculer les vitesses dans le bassin de dissipation et le canal de dissipation lors de la pluie été-automne 100 ans 24h. Les vitesses d'écoulement maximales sont ensuite utilisées pour dimensionner l'empierrement de protection requis dans ceux-ci. Le calibre et le diamètre médian (D_{50}) des pierres ainsi que l'épaisseur de l'empierrement sont dimensionnés selon les recommandations du MTQ (Ministère du Transport du Québec, 2024) et tel que présentés au **Tableau 6-2**.

Tableau 6-2 : Empierrement de protection

Type	Vitesses maximales (m/s)	Calibre (mm)	D_{50} (mm)	Épaisseur (mm)
1	2,0	0 – 200	100	300
2	2,3	100 – 200	150	300
3	2,8	200 – 300	250	500
4	3,2	300 – 400	350	700
5	3,4	300 – 500	400	800

D_{50} : diamètre des particules du matériau dont 50% en masse sont supérieures à cette dimension

6.5.1 Bassin de dissipation

Les risques d'érosion dans le bassin de dissipation proviennent des apports en eau du fossé de drainage et du tuyau. Un modèle FLOW-3D a permis de calculer les vitesses de ces eaux lorsqu'elles se rejettent dans le bassin de dissipation.

La **Figure 6-7** présente la vitesse du rejet d'eau du tuyau dans le bassin de dissipation. L'extrémité du tuyau est positionnée de manière à ce que les eaux se déversent où la profondeur d'eau dans le bassin est à son maximale, soit vis-à-vis le fond du bassin. En d'autres mots, il faut que l'extrémité du tuyau soit positionné de manière à ce que le rejet d'eau ne se fasse pas sur les parois transversales du bassin. C'est pourquoi la longueur minimale du tuyau sortant du chemin d'accès du bassin est de 3,5 m. Aussi, l'étude a été réalisée en prenant en compte que l'élévation du radier de l'extrémité du tuyau est à 426 m. L'élévation du radier du tuyau peut donc être égale ou inférieure à 426 m, mais ne peut être supérieure à 426 m considérant que ce cas n'a pas été étudié et nécessiterait une augmentation du calibre de l'enrochement.

À noter que le cas étudié prend en compte que le niveau d'eau dans le bassin de dissipation est au niveau du seuil du déversoir, ce qui implique que la profondeur d'eau dans le bassin de dissipation est de 1 m. Dans la situation où la profondeur d'eau serait inférieure à 1 m avant le rejet des eaux de l'UTEI, en raison par exemple de l'évaporation, il est nécessaire que le tuyau ne rejette pas les eaux au débit maximal de 1566 m^3/h tel que présenté à la **Section 3.2**. Il faudra donc rejeter un plus faible débit jusqu'à ce que le niveau d'eau atteigne le niveau du seuil du déversoir, pour ensuite pouvoir rejeter le débit de 1566 m^3/h.

La **Figure 6-8** présente la vitesse des eaux provenant du fossé de drainage et se rejetant dans le bassin de dissipation.

Le **Tableau 6-3** présente les vitesses maximales calculées aux parois du bassin de dissipation aux droits du tuyau et du fossé de drainage, ainsi que la protection d'enrochement recommandée.

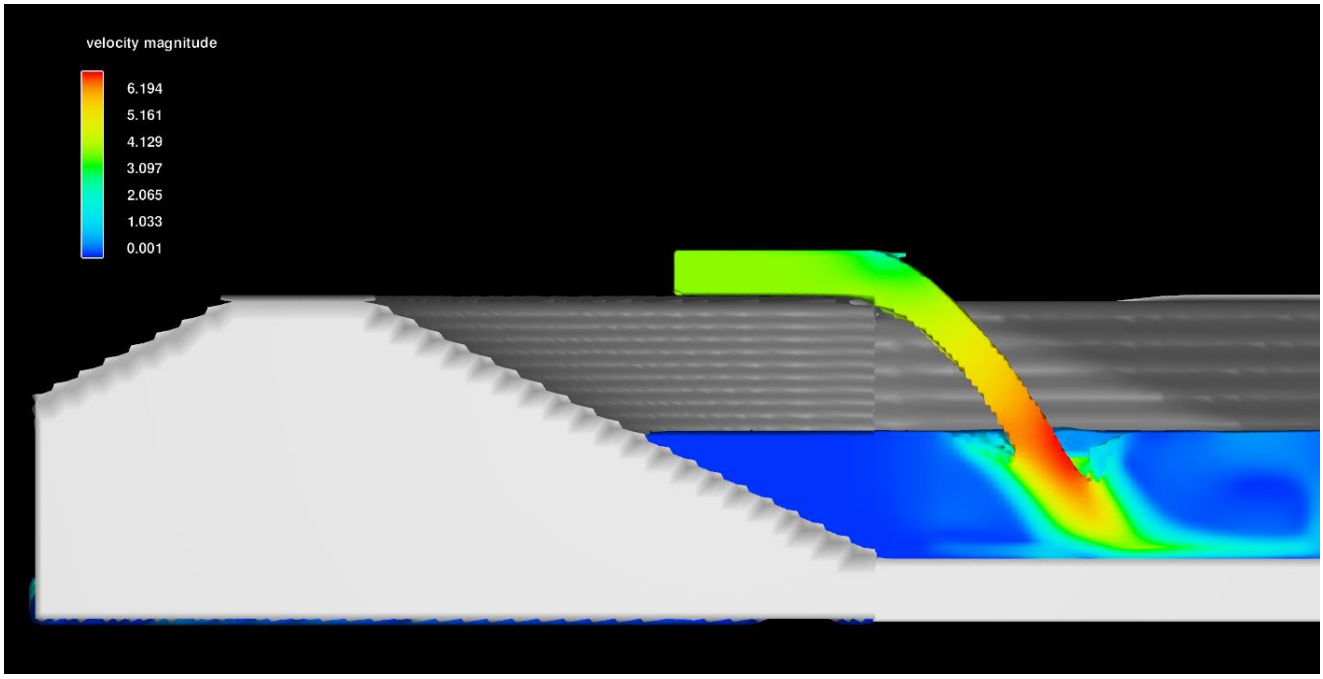


Figure 6-7 : Vitesses calculées du rejet d'eau du tuyau dans le bassin de dissipation (m/s) – Pluie été-automne de récurrence 100 ans

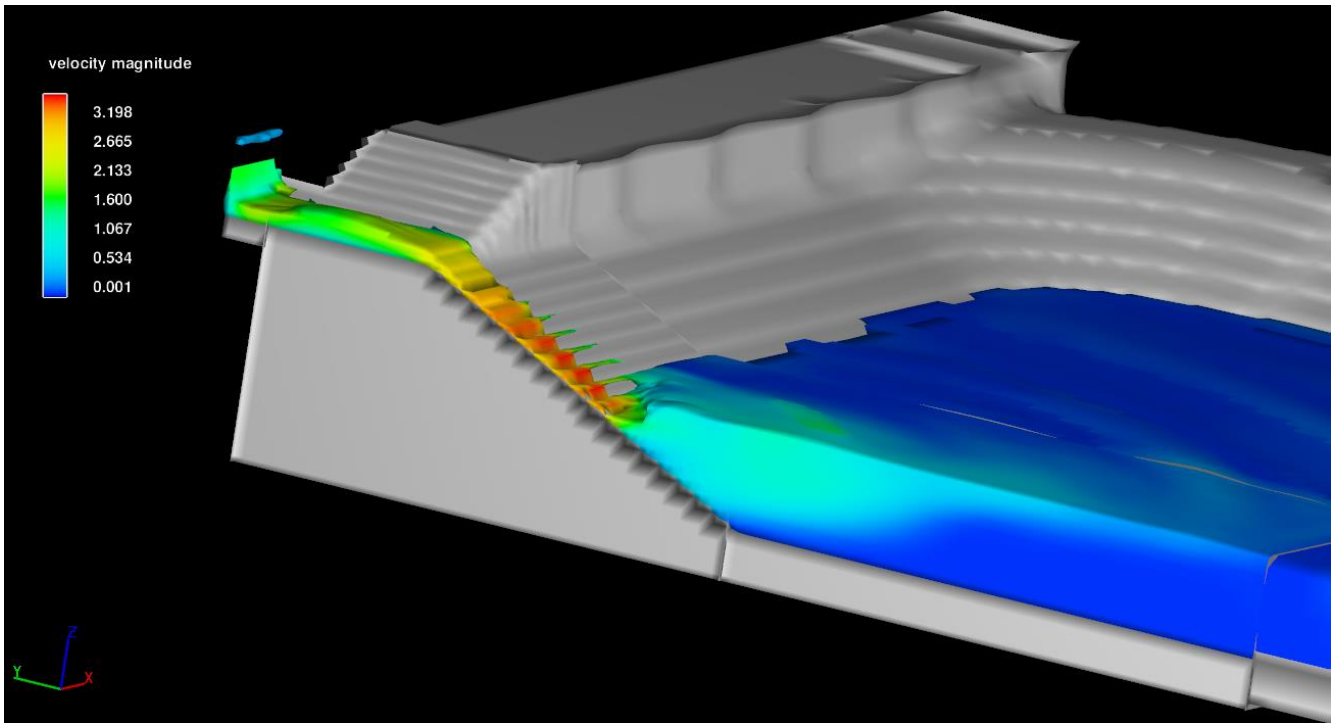


Figure 6-8 : Vitesses calculées des eaux provenant du fossé de drainage et se rejetant dans le bassin de dissipation (m/s) – Pluie été-automne de récurrence 100 ans

Tableau 6-3 : Vitesse maximale calculée aux parois du bassin de dissipation et protection contre l'érosion recommandée

Source d'eau	Vitesse maximale calculée aux parois du bassin de dissipation (m/s)	Protection contre l'érosion
Tuyau	3,4	Enrochement de calibre 300 – 500 mm
Fossé de drainage	3,2	

C'est au droit du tuyau que les vitesses calculées sont les plus importantes. L'enrochement de protection du bassin de dissipation doit donc être conçu pour pouvoir résister à des vitesses de 3,4 m/s. Pour une vitesse maximale de 3,4 m/s, le **Tableau 6-2** spécifie que l'enrochement doit être de type 5, soit de calibre 300 - 500 mm. L'enrochement pour la protection du fond et des talus du bassin de dissipation doit donc être de calibre 300 - 500 mm.

Cependant, considérant la présence de roc affleurant à proximité du bassin de dissipation, il serait possible de réduire la quantité d'enrochement nécessaire pour le bassin. Un relevé du niveau du roc permettra de vérifier cette possibilité.

6.5.2 Canal de dissipation

Les modèles PCSWMM et FLOW-3D ont aussi été utilisés afin de calculer les vitesses le long du canal de dissipation. Comme présenté à la **Section 5.2**, il est nécessaire d'ajouter une marche de 0,6 m de hauteur dans le canal afin d'éviter que les poissons en provenance du ruisseau à l'Eau Morte ne remontent le canal et atteignent le bassin de dissipation.

La **Figure 6-9** présente la vitesse calculée au droit de cette marche. La **Figure 6-10** présente les vitesses calculées entre cette marche et le ruisseau à l'Eau Morte. Le **Tableau 6-4** résume les vitesses maximales calculées le long du canal de dissipation et la protection contre l'érosion recommandée. Comme pour le bassin de dissipation, considérant la présence de roc affleurant à proximité du canal de dissipation, il serait possible de réduire la quantité d'enrochement nécessaire pour le canal. Un relevé du niveau du roc permettra de vérifier cette possibilité.

Les vitesses maximales ont aussi été calculées à l'exutoire du canal de dissipation lorsque celui-ci évacue la pluie 100 ans été-automne dans le ruisseau à l'Eau Morte. Le risque d'érosion du ruisseau à l'Eau Mort est plus important lorsque le niveau d'eau de celui-ci est à son minimum permis, soit lorsqu'il achemine le débit de dilution de 9900 m^3/h. Lorsque le ruisseau à l'Eau Morte achemine le débit de dilution, il a été calculé que le niveau d'eau est de 421,1 m vis-à-vis l'exutoire du canal. La **Figure 6-11** présente les résultats lors de cette condition.

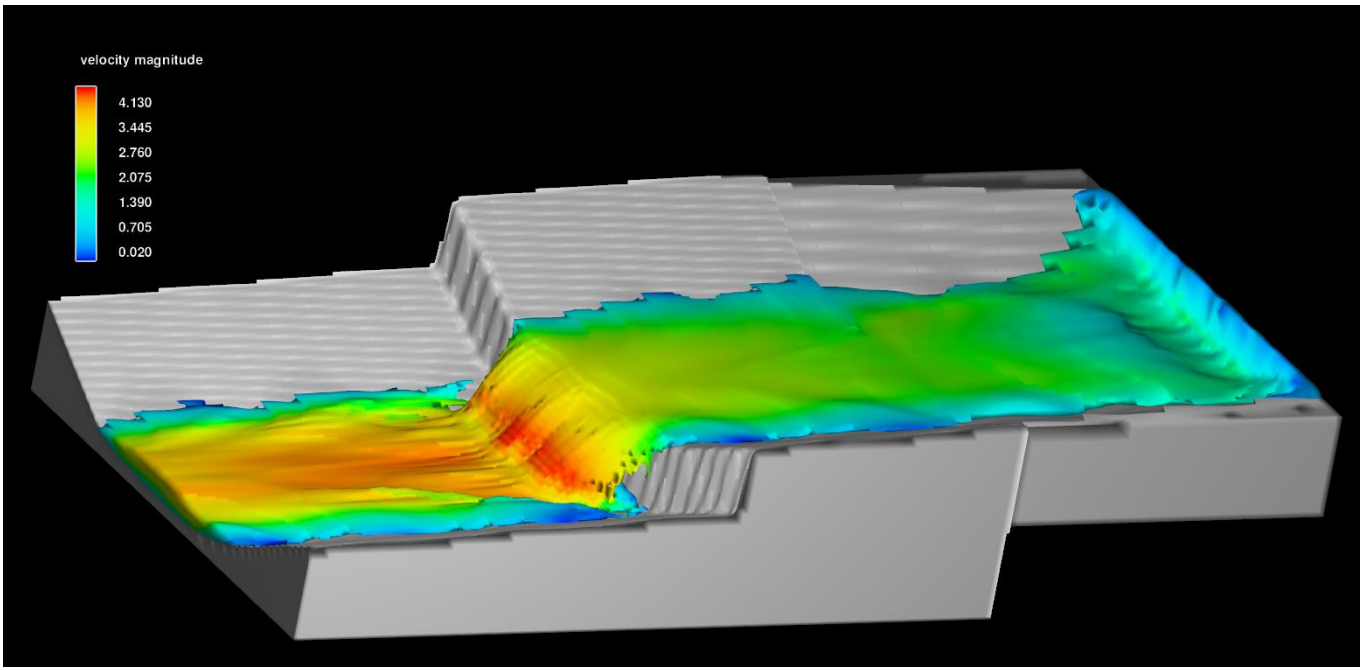


Figure 6-9 : Vitesses calculées au droit de la marche du canal de dissipation (m/s) – Pluie été-automne de récurrence 100 ans

Figure 6-10 : Vitesses calculées entre la marche et le ruisseau à l'Eau Morte (m/s) – Pluie été-automne de récurrence 100 ans

Tableau 6-4 : Vitesse maximale calculée aux parois du canal de dissipation et la protection contre l'érosion recommandée

Localisation	Vitesse maximale calculée le long du canal de dissipation (m/s)	Protection contre l'érosion
Marche	4,1	Dalle de granite ou équivalent
Entre la marche et le ruisseau à l'Eau Morte	2,5	Enrochement calibre 200 - 300 mm

Pour une vitesse maximale de 2,5 m/s, le **Tableau 6-2** spécifie que l'enrochement doit être de calibre 200 – 300 mm. Cependant, pour la protection contre l'érosion juste en aval de la marche, considérant que la vitesse maximale excède 3,4 m/s, il est nécessaire d'installer une dalle de granite ou équivalent.

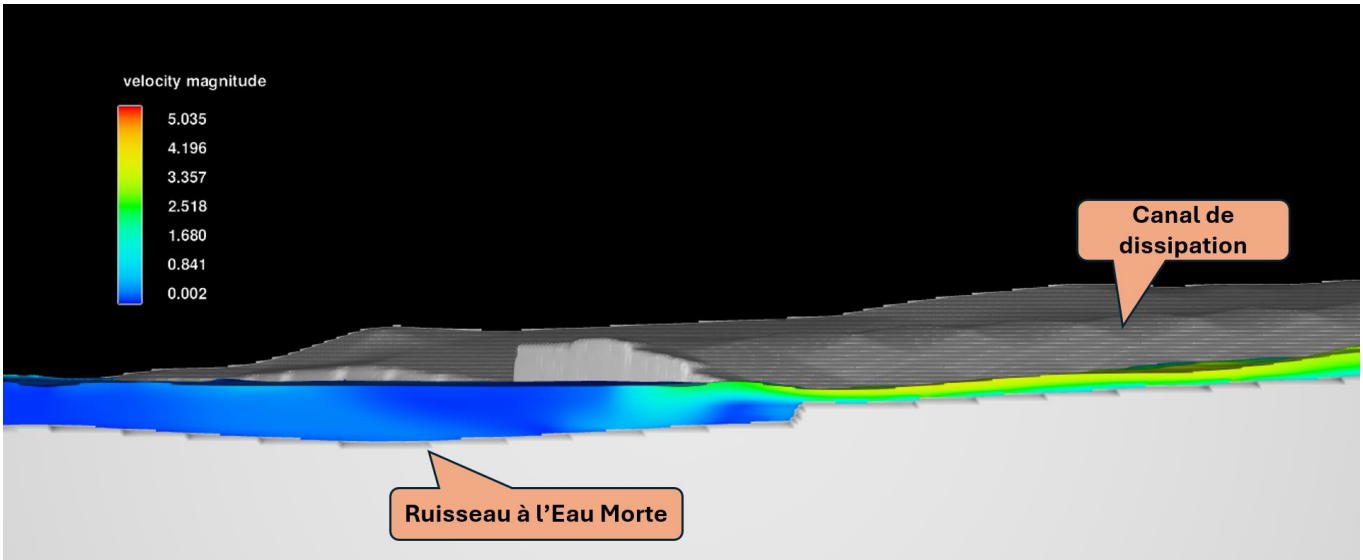


Figure 6-11 : Vitesses calculées à l'exutoire du canal de dissipation (m/s) – Pluie été-automne de récurrence 100 ans

La **Figure 6-11** montre que la vitesse maximale calculée à l'exutoire du canal de dissipation est de 2,5 m/s. Considérant que le lit du ruisseau à l'Eau Morte est composé majoritairement de blocs tel que montré sur la **Figure 6-12** ci-dessous, il est jugé que la vitesse maximale de 2,5 m/s ne pose pas de risque d'érosion pour le lit du ruisseau.

Figure 6-12 : Lit du ruisseau à l'Eau Morte

6.6 Protection et isolation du tuyau

Comme présenté à la **Figure 5-1**, le chemin d'accès aux véhicules hors route intersecte le chemin d'accès du bassin de dissipation. Considérant que le tuyau reliant l'UTEI au bassin de dissipation longe le chemin d'accès du bassin, il est donc nécessaire de le protéger contre les passages des véhicules hors route. Il est proposé de l'insérer dans un ponceau seulement au niveau du chemin d'accès aux véhicules hors route.

Aussi, pour protéger le tuyau contre le gel, il est nécessaire d'isoler l'extrémité du tuyau et d'y ajouter une gaine chauffante. À noter qu'il sera donc nécessaire d'ajouter un branchement électrique à l'extrémité du tuyau.

7. Dimensionnement et vérification de la conception existante

Cette section compare la conception précédente (GHD, 2025) à celle présentée dans cette étude.

7.1 Bassin de dissipation

Le **Tableau 7-1** compare la conception du bassin de dissipation. Les principales différences sont l'augmentation de la profondeur du bassin et la réduction du calibre de l'enrochement par rapport à l'ancienne conception. À noter que le chemin d'accès du bassin devra être rehaussé à proximité du bassin afin de pouvoir s'y raccorder.

Tableau 7-1 : Comparaison de la conception du bassin de dissipation

Bassin de dissipation		
	Ancienne conception	**Nouvelle conception**
Largeur x Longueur du fond du bassin (m)	10 x 10	10 x 10
Pente latérale	4H : 1V	2H : 1V côté amont et 4H : 1V pour les trois autres côtés
Profondeur (seuil du déversoir) (m)	1	1
Profondeur (haut du talus) (m)	1,5	2
Enrochement	600 - 1500 mm	300 - 500 mm

7.2 Canal de dissipation

Le **Tableau 7-2** compare la conception du canal de dissipation. Les légères différences entre l'ancienne et la nouvelle conception s'expliquent principalement par la relocalisation de l'exutoire du canal plus vers l'aval du ruisseau à l'Eau Morte. Il est à noter qu'avec la nouvelle conception, il est prévu d'implanter une marche de 600 mm de hauteur dans le canal afin d'éviter que les poissons en provenance du ruisseau à l'Eau Morte ne remontent le canal et atteignent le bassin de dissipation.

Tableau 7-2 : Comparaison de la conception du canal de dissipation

	Canal de dissipation	
	Ancienne conception	**Nouvelle conception**
Largeur de la base (m)	2	1,5
Pente latérale	2H : 1V	2H : 1V
Profondeur (m)	1	0,6
Pente (%)	2 - 4	5 - 6
Enrochement	100 - 200 mm	200 - 300 mm
Divers	-	Ajout d'une marche de 600 mm de hauteur

8. Conclusion

À la lumière des résultats présentés à la **Section 6**, voici les modifications apportées à l'ancienne conception :

- Il est nécessaire d'augmenter la profondeur du bassin de dissipation, elle est maintenant de 2 m. Il est aussi possible de réduire le calibre de l'enrochement de protection du bassin de dissipation, il est maintenant de calibre 300 – 500 mm. Il est aussi nécessaire que le chemin d'accès du bassin soit rehaussé à proximité du bassin afin de pouvoir s'y raccorder.
- L'extrémité du tuyau doit être positionnée de manière à ce que les eaux se déversent où la profondeur d'eau dans le bassin est à son maximale, soit vis-à-vis le fond du bassin. La longueur minimale du tuyau sortant du chemin d'accès du bassin est de 3,5 m. L'élévation du radier du tuyau peut être égale ou inférieure à 426 m, mais ne peut être supérieure à 426 m considérant que ce cas n'a pas été étudié et nécessiterait une augmentation du calibre de l'enrochement.
- De légères modifications dans le dimensionnement du canal de dissipation sont nécessaires à la suite de la relocalisation de l'exutoire plus en l'aval du ruisseau à l'Eau Morte. Cette relocalisation a pour but d'améliorer la dilution de l'effluent dans le ruisseau à l'Eau Morte. Il est aussi prévu d'implanter une marche de 0,6 m de hauteur dans le canal afin d'éviter que les poissons en provenance du ruisseau à l'Eau Morte ne remontent le canal et atteignent le bassin de dissipation.
- Cependant, considérant la présence de roc affleurent à proximité du bassin de dissipation et du canal de dissipation, il serait nécessaire d'effectuer un relevé du niveau du roc afin de minimiser les travaux de déblai de roc et de possiblement réduire la quantité d'enrochements de protection nécessaire.
- Prévoir un ponceau ayant un diamètre de 600 mm dans le fossé de drainage à la croisée entre le chemin d'accès aux véhicules hors route et le chemin d'accès du bassin de dissipation.
- Afin de protéger le tuyau contre le passage des véhicules hors route sur celui-ci, il est nécessaire d'insérer ce tuyau dans un ponceau au niveau du chemin d'accès aux véhicules hors route.
- Afin de protéger l'extrémité du tuyau contre le gel, il est nécessaire de l'isoler et d'y ajouter une gaine chauffante. Un branchement électrique devra y être ajouté.

9. Références

AtkinsRéalis (2024) : Note technique – Remplacement du ponceau du ruisseau à l'Eau Morte, décembre 2024 (réf. 701617-0000-4HER-0001-00).

AtkinsRéalis (2025) : Note technique – Détermination des OER et des impacts sur la qualité des eaux de surface, juillet 2025 (réf. 701617-0001-4EER-0001-PA).

Forêt Ouverte (2024). *Catalogue/Téléchargement - Lidar*. Récupéré sur Forêt Ouverte: https://www.foretouverte.gouv.qc.ca/

GHD (2025) Note technique – Conception chemin et émissaire, janvier 2025 (réf. 12646006-RPR-1-CI-0001-C01).

GHD (2025) Plans – CHEMIN ET ÉMISSAIRE, janvier 2025.

Maidment, D.R. (1993). *Handbook of Hydrology*. Chapter 1 – Hydrology. Vol. 9780070. McGRAW-HILL Inc, New-York, U.S. 1993.

MELCCFP (2012) : ministère du Développement durable, de l'Environnement et des Parcs, Directive 019 sur l'industrie minière, mars 2012.

MDDEFP (2024) : Guide de gestion des eaux pluviales, septembre 2024. Disponible sur https://www.environnement.gouv.qc.ca/eau/pluviales/guide-gestion-eaux-pluviales.pdf

MTMD (2024) : Manuel de conception des ponceaux, juin 2024. Disponible sur https://www.publicationsduquebec.gouv.qc.ca/produits-en-ligne/ouvrages-routiers/guides-et-manuels/ouvrages-dart/manuel-de-conception-des-ponceaux/

Simonovic, S.P., A. Schardong, R. Srivastav, and D. Sandink (2015), *IDF_CC Web-based Tool for Updating Intensity-Duration-Frequency Curves to Changing Climate – ver 8.0*, Western University Facility for Intelligent Decision Support and Institute for Catastrophic Loss Reduction, open access https://www.idf-cc-uwo.ca

SNC-Lavalin (2018) : Note technique – Étude de préfaisabilité du projet Matawinie de SNC-Lavalin, février 2018 (réf. 649609-7000-4GER-0001).

SNC-Lavalin (2020) : Note technique – Rapport de faisabilité sur la gestion de l'eau, des résidus et stériles miniers, mars 2020 (réf. 654068-4000-40ER-0001).

SRK Consulting (2024) : Memo - Site overall Water Balance for BC1 and BC2 Sizing, juillet 2024 (réf. CAPR002717)

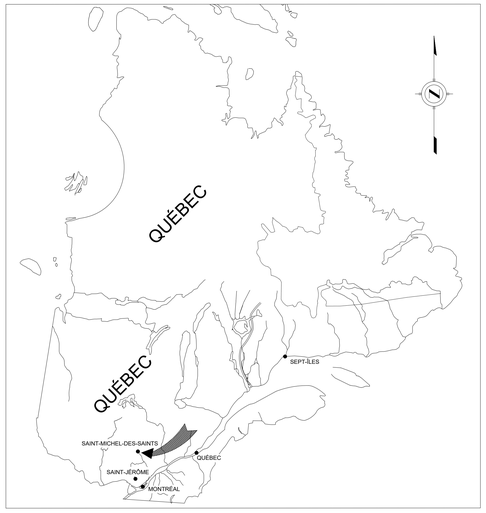
SRK Consulting (2025) : Memo - GoldSim Water Balance Design Basis Memorandum, juin 2025 (réf. CAPR003306)

Technosub (2025) : Rapport d'ingénierie - RAPPORT ET RECOMMANDATIONS, janvier 2025 (réf. R1_P2403041)

ANNEXES

Annexe A. Plans de GHD

PAS POUR CONSTRUCTION



PROJET MATAWINIE
CHEMIN ET ÉMISSAIRE

POUR : NOUVEAU MONDE GRAPHITE

PAR : GHD

LISTE DES PLANS

DESSIN	DESCRIPTION	RÉVISION / DATE
G-001	FRONTISPICE	S / 2025-01-15
G-002	PLAN GÉNÉRAL DU SITE	S / 2025-01-15
G-003	PLAN, PROFIL LONGITUDINAL ET DÉTAILS DU BASSIN DESSIPATION	S / 2025-01-15
G-004	COUPES TYPES DU CHEMAIN	S / 2025-01-15
G-005	DÉTAILS DE PONCEAU ET TABLEAUX DES EXIGENCES DES MATÉRIAUX	S / 2025-01-15

POUR PERMIS

No.	Émission	Vérifié	Approuvé	Date
S	POUR PERMIS	P.A.	P.L.	2025-01-15
B	POUR COMMENTAIRE	P.A.	P.L.	2024-12-20
A	POUR COMMENTAIRE	P.A.	P.L.	2024-11-21

Auteur M. NABAVI | Dessin Vérifié P. ALLARD, ing. | Chargé de Projet P. LUKOV, ing.
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Projet CHEMIN ET ÉMISSAIRE
Numéro de Projet | Date 2025-01-15 | Échelle N.A.

Titre CHEMIN ÉMISSAIRE FRONTISPICE
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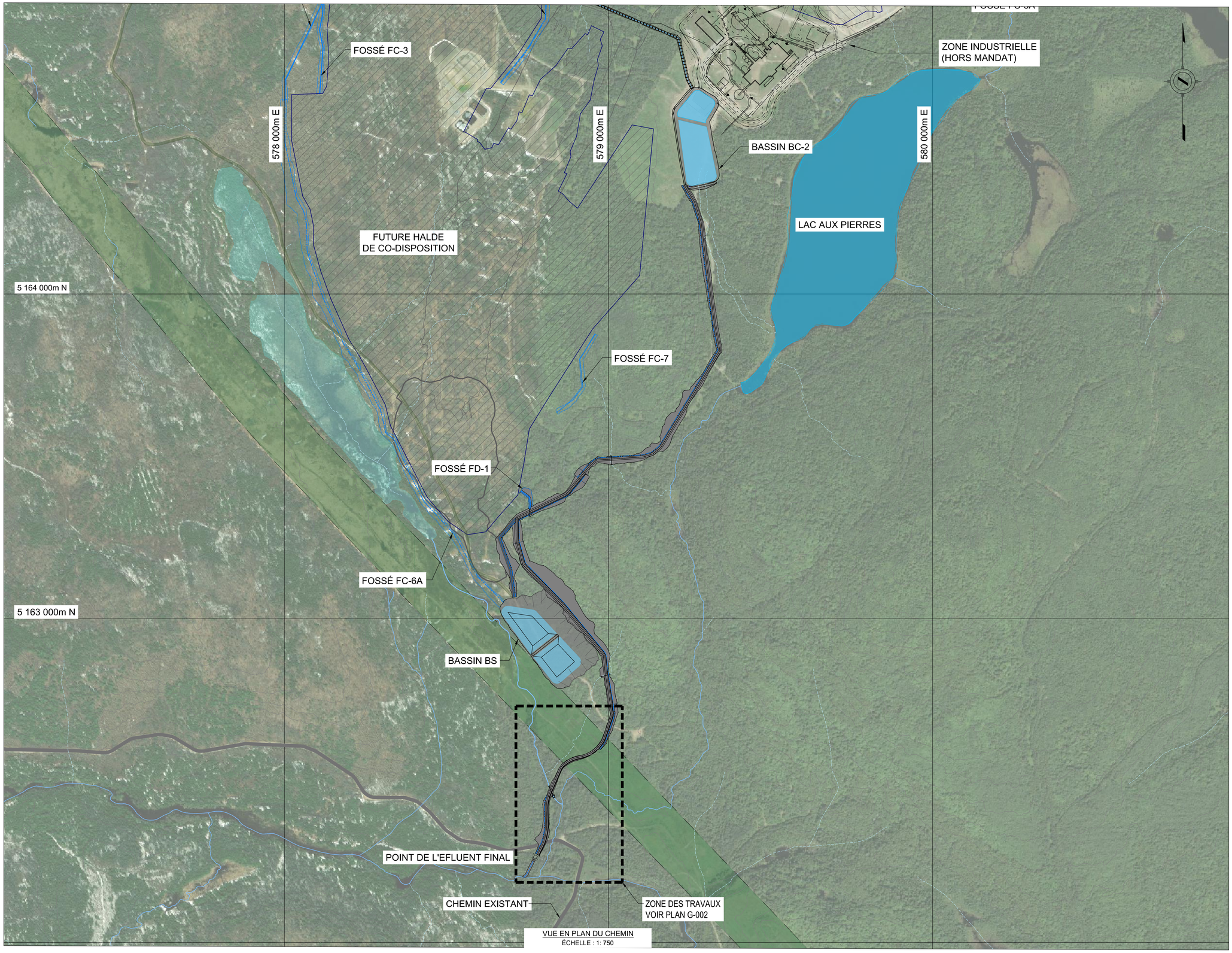
Code de statut
No. Feuille G-001
Feuille sur



VUE EN PLAN DU CHEMIN
ÉCHELLE : 1: 750

COURS D'EAU:

Cours_Eau_Intermittent_SNC_20190605.shp
Cours_Eau_SNC_20190605.shp
MILIEU_HUMIDE_SNC_20190605.shp

COURS D'EAU INTERMITTENT
COURS D'EAU PERMANENT
MILIEU HUMIDE

LACS:

dde_20k_hyd_sur_ori_vue.dxf

LACS

FOSSE:

EOPM_YEAR 5.dxf
EOPM_YEAR 5(18-08-20)

FUTURE HALDE
DE CO-DISPOSITION
HALDE_MORT-TERRAIN
654068-Deposition_Y26_2019 (2019-09-30)
CHEMIN EXISTANT
BASSIN
CORRDIOR DE LA LIGNE H.Q.
FOSSÉ
CHEMIN PROPOSÉ
PONCEAU

NOTES:

1. PROJECTION: UTM NAD 83 FUSEAU 18 NORD.
2. ISOCONTOURS À INTERVALLES DE 1 m.
3. LES COORDONNÉES ET LES ÉLÉVATIONS ET LES CHÎNAGES SONT APROXIMATIFS ET SERONT AJUSTÉS SUR LE CHANTIER SELON LE PROFIL RÉEL DU TERRAIN.

ÉCHELLE: 1:4000
0 200 400m

POUR PERMIS

No.	Émission	Vérifié	Approuvé	Date
S	POUR PERMIS	P.A.	P.L.	2025-01-15
B	POUR COMMENTAIRE	P.A.	P.L.	2024-12-20
A	POUR COMMENTAIRE	P.A.	P.L.	2024-11-21

Auteur **M. NABAVI** Dessin Vérifié **P. ALLARD, ing.** Chargé de Projet **P. LUKOV, ing.**
Conception **K. HABOUB, CPI** Conception Vérifié **P. LUKOV, ing.** Directeur de Projet **S. McNICOLL, ing.**

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Client **NOUVEAU MONDE GRAPHITE**
Projet **CHEMIN ET ÉMISSAIRE**

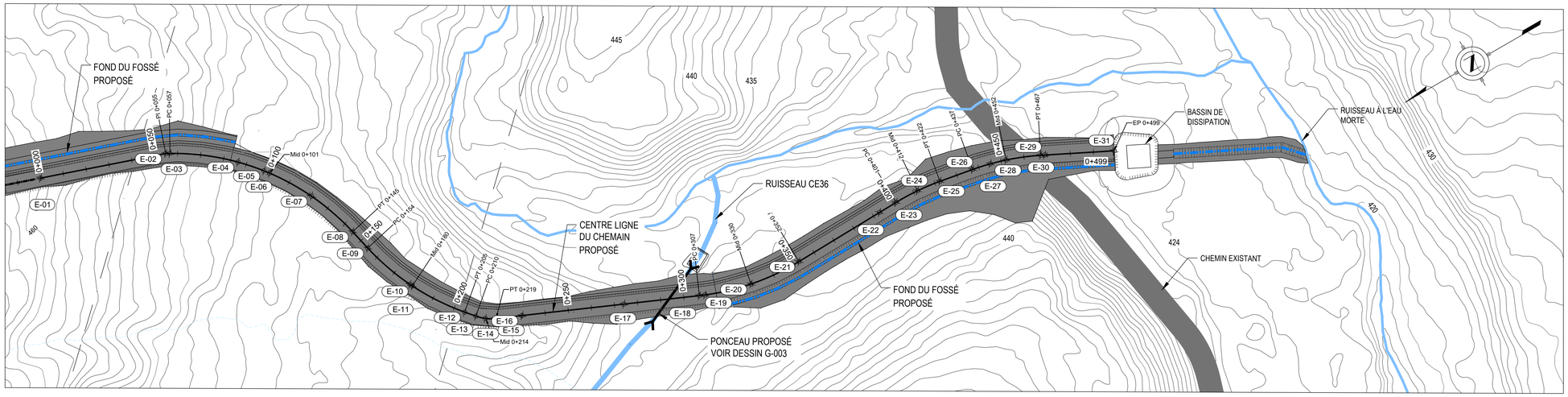
Numéro de Projet
Date **2025-01-15**
Échelle **N.A.**

Titre **CHEMIN ÉMISSAIRE**
PLAN GÉNÉRAL

Format **ISO A0**
Code de statut
No. Feuille **G-002**
Feuille sur

Imprimé le: 16 janvier 2025 - 11:42 Imprimé Par: Mohamad Ghods Nabavi Fichier CAD et Localisation: C:\Users\mghodsnabavi\GHD\Petar Lukov - Wood\Plans\DWG\Émissaire\Chemin BC2 vers Effluent Final_D5-RevB_recover.dwg

PAS POUR CONSTRUCTION

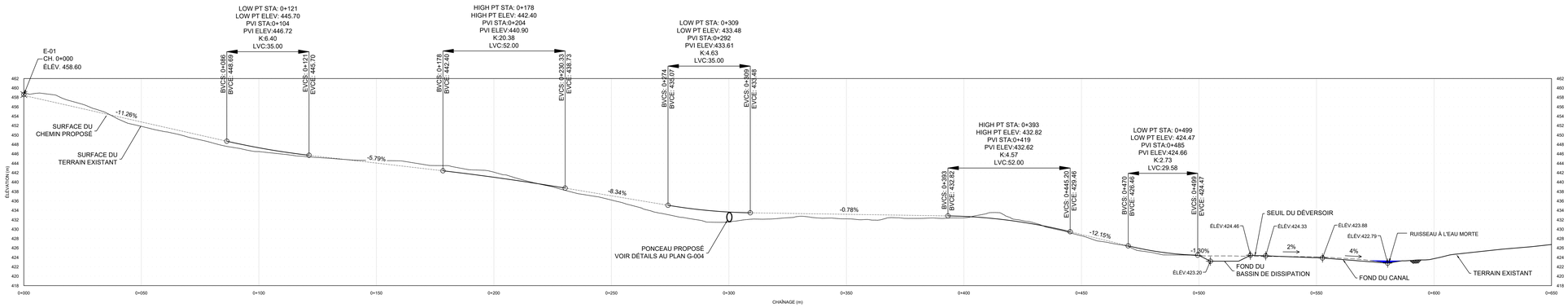


VUE EN PLAN DU CHEMIN
ÉCHELLE : 1: 750

COORDONNÉES DES POINTS DU CENTRE LIGNE DU CHEMIN UTM FUSEAU 18 NORD					
POINT	CHAINAGE (m)	EST (m)	NORD (m)	ELE. (m)	DÉSCRIPTION
E-01	0+000	579 002	5 162 677	458.60	DEBUT DE CHEMIN
E-02	0+055	578 985	5 162 626	451.94	PI
E-03	0+057	578 984	5 162 624	451.72	PC
E-04	0+086	578 966	5 162 600	448.69	BVC
E-05	0+098	578 957	5 162 593	447.04	PVI
E-06	0+101	578 955	5 162 591	446.81	MID : R=105m
E-07	0+121	578 937	5 162 580	445.70	EVC
E-08	0+145	578 915	5 162 573	444.37	PT
E-09	0+154	578 906	5 162 571	443.89	PC
E-10	0+178	578 882	5 162 562	442.63	MID : R=105m
E-11	0+188	578 883	5 162 563	442.40	BVC
E-12	0+205	578 861	5 162 548	441.20	PT
E-13	0+210	578 857	5 162 545	440.85	PC
E-14	0+214	578 854	5 162 542	440.53	MID : R=55m
E-15	0+219	578 852	5 162 538	440.16	PT
E-16	0+230	578 848	5 162 528	438.73	EVC
E-17	0+274	578 830	5 162 487	434.07	BVC
E-18	0+307	578 817	5 162 457	433.50	PC
E-19	0+309	578 816	5 162 455	433.48	EVC
E-20	0+330	578 810	5 162 436	433.28	MID : R=105m
E-21	0+352	578 808	5 162 413	433.11	PT
E-22	0+393	578 809	5 162 372	432.82	BVC
E-23	0+401	578 809	5 162 364	432.74	PC
E-24	0+412	578 809	5 162 353	432.50	MID : R=105m
E-25	0+422	578 808	5 162 343	431.94	PT
E-26	0+437	578 805	5 162 328	430.59	PC
E-27	0+445	578 803	5 162 321	429.46	EVC
E-28	0+452	578 801	5 162 314	428.81	MID : R=105M
E-29	0+467	578 796	5 162 300	426.98	PT
E-30	0+469	578 795	5 162 298	426.85	BVC
E-31	0+499	578 782	5 162 272	424.40	EVC -FIN DE CHEMIN

PC : POINT DE DEBUT DE LA COURBE HORIZONTALE
PT : POINT DE FIN DE LA COURBE HORIZONTALE
MID : LE POINT DE MILIEU DE LA COURBE HORIZONTALE

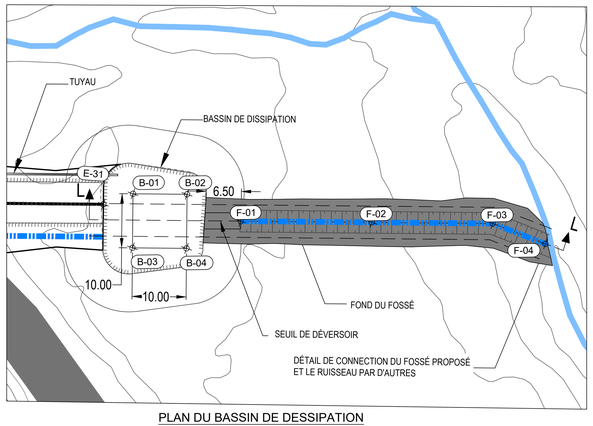
BVC : POINT DE DÉBUT DE LA COURBE VERTICALE
EVC : POINT DE FIN DE LA COURBE VERTICAL



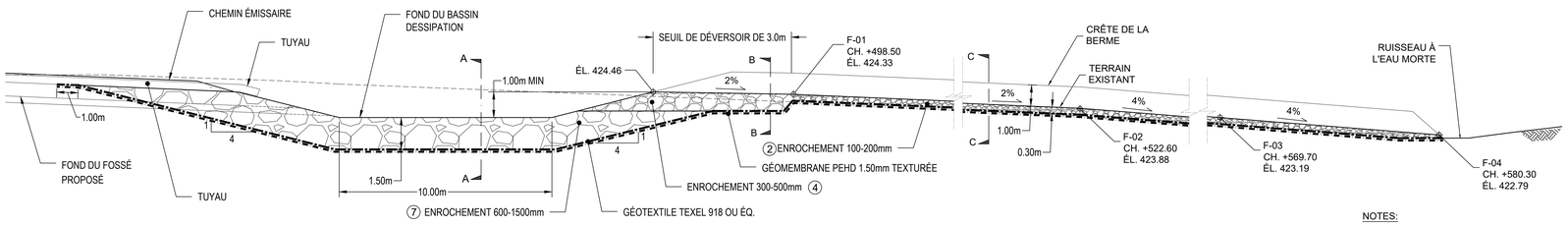
PROFIL LONGITUDINAL DU CH. 1+600 m AU CH. 2+132 m
ÉCHELLE HORIZONTALE: 1: 750
ÉCHELLE VERTICALE: 1: 375

COORDONNÉES DES POINTS DU CENTRE LIGNE DU FOSSÉ UTM FUSEAU 18 NORD			
POINT	EST (m)	NORD (m)	ÉLE. (m)
F-01	578 768	5 162 250	424.38
F-02	578 757	5 162 228	423.88
F-03	578 747	5 162 208	423.21
F-04	578 739	5 162 201	422.79

COORDONNÉES DES POINTS DU 4-COTÉS DU BASSIN DE DESSIPATION UTM FUSEAU 18 NORD			
POINT	EST (m)	NORD (m)	ELE. (m)
B-01	578 781	5 162 266	423.20
B-02	578 776	5 162 257	423.20
B-03	578 772	5 162 270	423.20
B-04	578 767	5 162 261	423.20



PLAN DU BASSIN DE DESSIPATION
ÉCHELLE : 1: 40



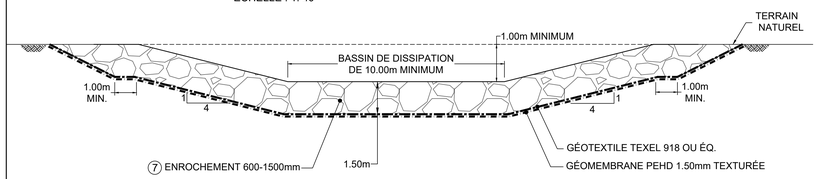
COUPE L- L
COUPE LONGITUDINALE DU BASSIN DE DISSIPATION
ÉCHELLE : 1: 100

LÉGENDE:

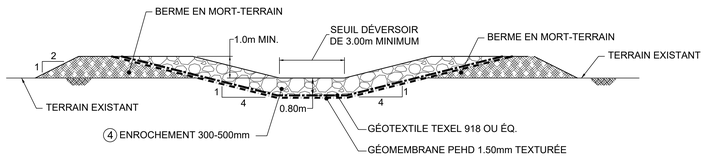
- ISOCONTOUR MAJEUR
- ISOCONTOUR MINEUR
- EMPRISE DU CHEMIN
- PROFIL DU CHEMIN PROPOSÉ
- FOSSÉ PROPOSÉ
- COURS D'EAU INTERMITTENT
- COURS D'EAU PERMANENT
- CORRIDOR DE H.Q.

NOTES:

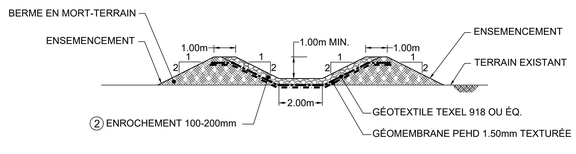
1. PROJECTION: UTM NAD 83 FUSEAU 18 NORD.
2. ISOCONTOURS À INTERVALLES DE 1 m.
3. LES COORDONNÉES ET LES ÉLÉVATIONS ET LES CHÎNAGES SONT APROXIMATIFS ET SERONT AJUSTÉS SUR LE CHANTIER SELON LE PROFIL RÉEL DU TERRAIN.
4. LE DÉTAIL ET LE MATÉRIAUX DE CONSTRUCTION DE LA BERME À L'APPRROCHE DU RUISSEAU À L'EAU MORTE DEVORNT ÉTRE CONFIRMÉS EN FONCTION DES SPÉCIFICATIONS DE CONNEXION AU RUISSEAU (PAR D'AUTRES).



COUPE A-A
ÉCHELLE : 1: 100



COUPE B-B
ÉCHELLE : 1: 100



COUPE TYPE DU FOSSÉ - COUPE C-C (VOIR NOTE 4)
ÉCHELLE : 1: 100

ÉCHELLE: 1:100
0 5 10m

ÉCHELLE: 1:750
0 25 50 75 100m

ÉCHELLE: 1:325
0 25 50m

POUR PERMIS

No.	Émission	Vérifié	Approuvé	Date
S	POUR PERMIS	P.A.	P.L.	2025-01-15
B	POUR COMMENTAIRE	P.A.	P.L.	2024-12-20
A	POUR COMMENTAIRE	P.A.	P.L.	2024-11-21

Auteur **M. NABAVI** Dessin Vérifié **P. ALLARD, ing.** Chargé de Projet **P. LUKOV, ing.**
Conception **K. HABOUB, CPI** Conception Vérifié **P. LUKOV, ing.** Directeur de Projet **S. McNICOLL, ing.**

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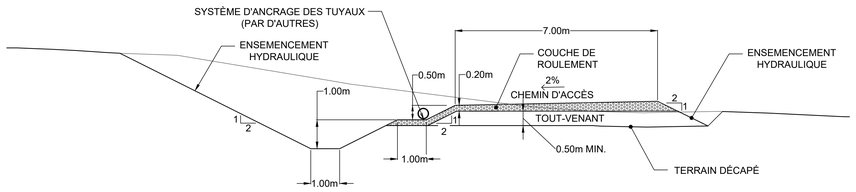
Client **NOUVEAU MONDE GRAPHITE**
Projet **CHEMIN ET ÉMISSAIRE**

Numéro de Projet
Date **2025-01-15**
Échelle **N.A.**

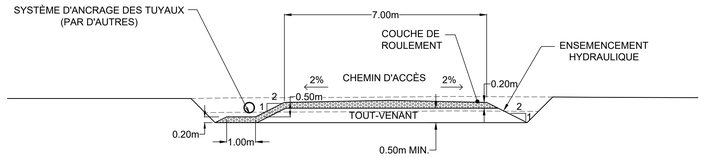
Titre **CHEMIN ÉMISSAIRE PLAN, PROFIL LONGITUDINAL ET DÉTAILS DU BASSIN DESSIPATION**

Format **ISO A0**
Code de statut
No. Feuille **G-003**
Feuille sur

PAS POUR CONSTRUCTION



COUPE TYPE (LORSQU'EN DÉBLAI) DU CH. 0+000 m AU CH. 0+086 m
ÉCHELLE 1: 75



COUPE TYPE (LORSQU'EN DÉBLAI) DU CH. 0+086 m AU CH. 0+220m
ÉCHELLE 1: 75

LÉGENDE:

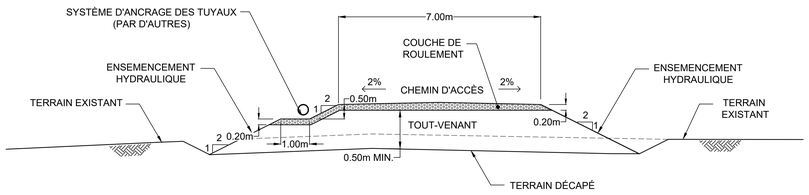
TERRAIN EXISTANT
GÉOTEXTILE
ENROCHEMENT
COUCHE DE ROULEMENT
TUYAU

NOTE:

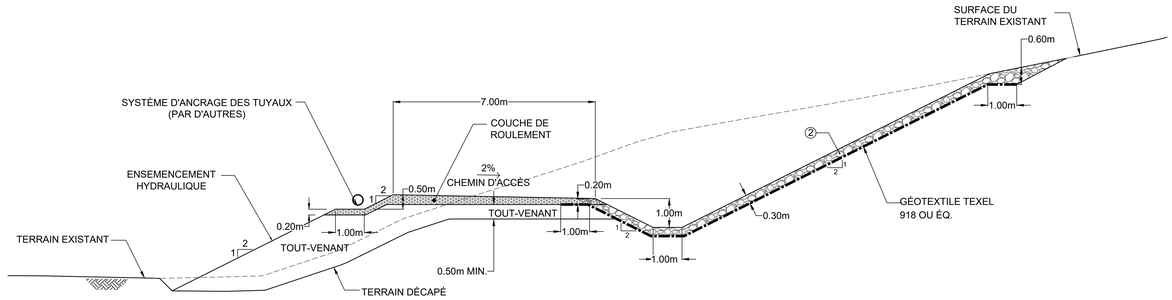
1. LES COORDONNÉES ET LES ÉLÉVATIONS SONT APROXIMATIVES ET SERONT AJUSTÉES SUR LE CHANTIER SELON LE PROFIL RÉEL DU TERRAIN.

ÉCHELLE: 1:75

0 1 2 3 4 5m



COUPE TYPE (LORSQU'EN REMBLAI) DU CH. 0+220m AU CH. 0+393m
ÉCHELLE 1: 75



COUPE TYPE (LORSQU'EN DÉBLAI) DU CH. 0+393 m AU CH. 0+499m
ÉCHELLE 1: 75

POUR PERMIS

No.	Émission	Vérifié	Approuvé	Date
S	POUR PERMIS	P.A.	P.L.	2025-01-15
B	POUR COMMENTAIRE	P.A.	P.L.	2024-12-20
A	POUR COMMENTAIRE	P.A.	P.L.	2024-11-21

Auteur M. NABAVI | Dessin Vérifié P. ALLARD, ing. | Chargé de Projet P. LUKOV, ing.
Conception K. HABOUB, CPI | Conception Vérifié P. LUKOV, ing. | Directeur de Projet S. McNICOLL, ing.

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Client NOUVEAU MONDE GRAPHITE
Projet CHEMIN ET ÉMISSAIRE

Numéro de Projet | Date 2025-01-15 | Échelle N.A.

Titre CHEMIN ÉMISSAIRE FRONTISPICE

Format ISO A0
Code de statut
No. Feuille G-004
Feuille sur

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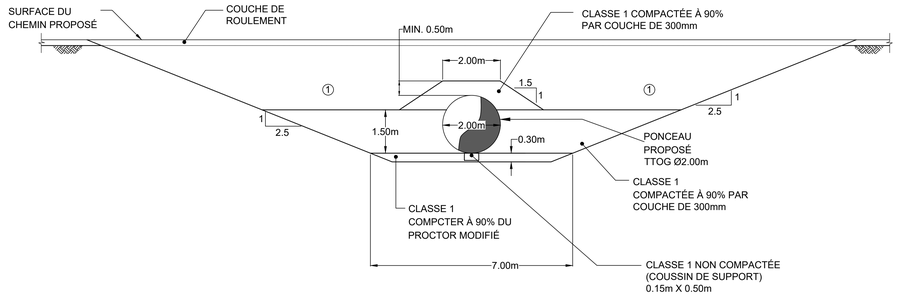
PAS POUR CONSTRUCTION

EXIGENCES DES MATÉRIAUX

CLASSE	DESCRIPTION	GRANULOMÉTRIE		TENEUR EN EAU À LA MISE EN PLACE	ÉPAISSEUR MAXIMALE DES COUCHES	DEGRÉ DE COMPACTAGE REQUIS
		TAMIS (mm)	PASSANT %			
1	SABLE ET GRAVIER	80.000	100	-2% À +1% DE L'OPTIMUM	300mm	≥95% DE LA DENSITÉ SÈCHE MAXIMALE PROCTOR STANDARD
		20.000	76-95			
		5.000	56-75			
		0.630	26-45			
		0.315	17-35			
		0.080	0-10			
2	ENROCHEMENT SÉLÉCTIONNÉ 100-200	-ETALÉ ENTRE 200 mm MAXIMUM ET 100 mm -MAXIMUM 5% PLUS PETIT QUE 100 mm -ROC MASSIF SAIN OU CAILLOUX SAINS		N/A	NA	N/A
3	ENROCHEMENT SÉLÉCTIONNÉ 100-300	-ETALÉ ENTRE 300 mm MAXIMUM ET 100 mm -MAXIMUM 5% PLUS PETIT QUE 100 mm -ROC MASSIF SAIN OU CAILLOUX SAINS		N/A	N/A	N/A
4	ENROCHEMENT SÉLÉCTIONNÉ 300-500	-ETALÉ ENTRE 500 mm MAXIMUM ET 300 mm -MAXIMUM 5% PLUS PETIT QUE 300 mm -ROC MASSIF SAIN OU CAILLOUX SAINS		N/A	N/A	N/A
5	ENROCHEMENT SÉLÉCTIONNÉ 100-300	- 50% PLUS GRAND QUE 200 mm - MAXIMUM 5% PLUS PETIT QUE 150 mm - ROC ARRONDI ET SAIN		N/A	N/A	N/A
6	ENROCHEMENT SÉLÉCTIONNÉ 100-500	- 50% PLUS GRAND QUE 300 mm - MAXIMUM 5% PLUS PETIT QUE 150 mm - ROC ARRONDI ET SAIN		N/A	N/A	N/A
7	ENROCHEMENT SÉLÉCTIONNÉ 600-1500	-ETALÉ ENTRE 1500 mm MAXIMUM ET 600 mm -BLOQUE DU ROC MASSIF SAIN		N/A	N/A	N/A



COUPE C-C
ÉCHELLE 1: 75

LÉGENDE:

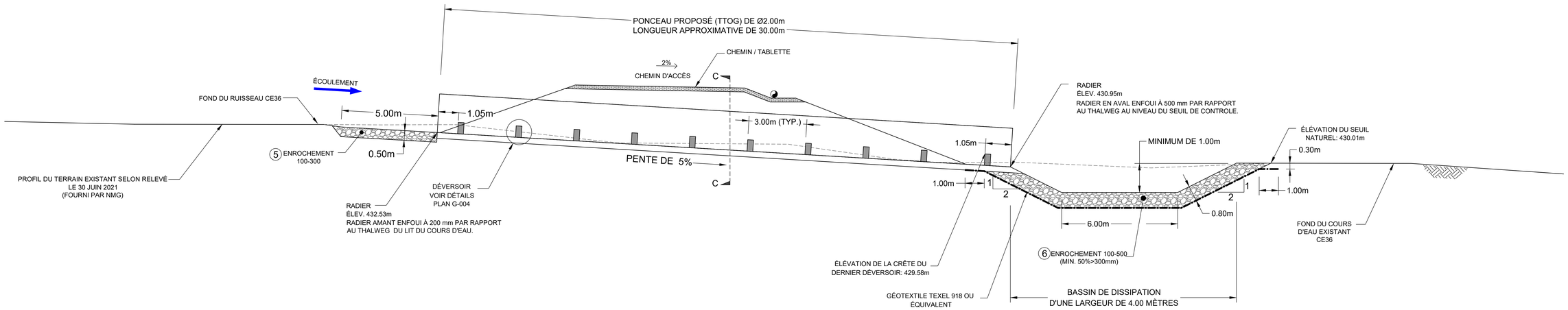
- TERRAIN EXISTANT
- GÉOTEXTILE
- ENROCHEMENT
- COUCHE DE ROULEMENT
- TUYAU

NOTE:

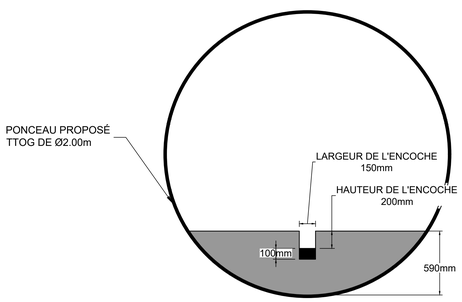
1. LES COORDONNÉES ET LES ÉLÉVATIONS SONT APROXIMATIVES ET SERONT AJUSTÉES SUR LE CHANTIER SELON LE PROFIL RÉEL DU TERRAIN.
2. LES PRATIQUES ÉNUMÉRÉES CI-DESSOUS SONT INTERDITES :
   LES SOUDURES EN CHANTIER.
   LA COUPE AU CHALUMEAU D'ÉLÉMENTS EN ACIER.
   LE PERÇAGE DE TROUS AU CHALUMEAU.

ÉCHELLE: 1:75
0 1 2 3 4 5m

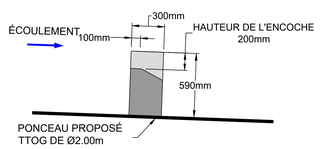
ÉCHELLE: 1:20
0 1 2m



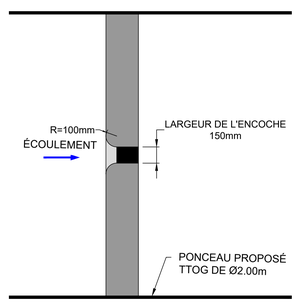
COUPE LONGITUDINALE DU PONCEAU PROPOSÉ
ÉCHELLE 1: 75



DÉVERSOIR - DÉTAIL
VUE EN COUPE
ÉCHELLE 1:20



DÉVERSOIR - DÉTAIL
VUE EN PROFIL
ÉCHELLE 1:20



DÉVERSOIR - DÉTAIL
VUE EN PLAN
ÉCHELLE 1:20

NOTE:
DÉVERSOIR EN ACIER GALVANISÉ FABRIQUÉE D'UNE BASE EN FORME DE DEMI-LUNE

POUR PERMIS

No.	Émission	Vérifié	Approuvé	Date
S	POUR PERMIS	P.A.	P.L.	2025-01-15
B	POUR COMMENTAIRE	P.A.	P.L.	2024-12-20
A	POUR COMMENTAIRE	P.A.	P.L.	2024-11-21

Auteur	M. NABAVI	Dessin Vérifié	P. ALLARD, ing.
Conception	K. HABOUB, CPI	Conception Vérifié	P. LUKOV, ing.
Chargé de Projet	P. LUKOV, ing.	Directeur de Projet	S. McNICOLL, ing.

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Client: NOUVEAU MONDE GRAPHITE
Projet: CHEMIN ET ÉMISSAIRE
Numéro de Projet
Date: 2025-01-15
Échelle: N.A.

Titre: CHEMIN ÉMISSAIRE
DÉTAILS DE PONCEAU ET TABLEAUX DES EXIGENCES DES MATÉRIAUX

No. Feuille: G-005
Format: ISO A0
Code de statut
Feuille sur

Imprimé le: 16 janvier 2025 - 9:05 Imprimé Par: Mohamad Ghods Nabavi Fichier CAD et Localisation: C:\Users\mghodsnabavi\GHD\Petar Lukov - Wood\Plans\DWG\Émissaire\Chemin BC2 vers Effluent Final_D5-RevB_recover.dwg

Annexe B. Note technique de GHD

Conception chemin et émissaire

Note technique

Nouveau Monde Graphite

15 Janvier 2025

→ La force de l'engagement

Titre du projet	NMG - Plans pour construction chemin et émissaire
Titre du document	Conception chemin et émissaire | **Note technique**
Numéro de projet	12646006
Nom du fichier	12646006-RPR-1-CI-0001-C01-Note technique chemin et émissaire.docx

Code	Révision	Auteur	Réviseur		Approuvé pour envoi		
			Nom	Signature	Name	Signature	Date
S3	A	Kamilia Haboub	Petar Lukov		Scott McNicoll		14-11-2024
A1	0	Kamilia Haboub	Petar Lukov		Scott McNicoll		15-01-2025

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1. Mise en contexte

Nouveau Monde Graphite (NMG) a confié à GHD le mandat de concevoir un chemin d'accès reliant le bassin BC-2 au point de rejet final des effluents dans le cadre du projet minier Matawinie. Ce projet, une mine de graphite à ciel ouvert exploitée par NMG, se situe à environ 5 km au sud-ouest de la municipalité de Saint-Michel-des-Saints et à 150 km au nord de Montréal. La mine devrait être opérationnelle pendant une durée de 26 ans, avec une production annuelle prévue de 100 000 tonnes de concentré de graphite.

Durant la période d'exploitation, les eaux provenant de la fosse, du ruissellement et les eaux recirculées pour le procédé seront dirigées vers trois bassins principaux : BC-1, BC-2 et BS. Les eaux des bassins BC-1 et BS seront transférées par pompage vers le bassin BC-2, puis acheminées vers l'usine de traitement des eaux (UTE). Après traitement, les eaux s'écouleront seront retournées vers le concentrateur, ou lorsque nécessaire, pompées vers l'émissaire.

Afin de permettre l'installation des conduites de pompage reliant l'UTE au point de rejet final, la construction d'un chemin d'accès est requise.

Une portion de ce chemin, dont l'alignement est illustré dans le plan TX20035103-15000-DGE-série 100 (WSP, 2022a), a déjà été soumise pour autorisation auprès du ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs. NMG a retenu les services de GHD Consultants Ltd. (ci-après « GHD ») pour concevoir la dernière portion du chemin permettant d'accéder à l'effluent final. Cette conception inclut également l'installation d'un ponceau traversant le chemin au niveau du ruisseau CE36, ainsi qu'un bassin de dissipation à la sortie de l'émissaire.

La présente note technique vise à détailler la conception de ces infrastructures afin de soutenir la demande des permis nécessaires avant le début des travaux de construction.

1.1 Portée et limitations

Ce rapport a été préparé pour Nouveau Monde Graphite et peut être utilisé uniquement par Nouveau Monde Graphite aux fins convenues entre GHD et Nouveau Monde Graphite lesquelles sont décrites à la section 1.1.

GHD décline toute autre responsabilité envers toute autre personne que Nouveau Monde Graphite découlant du présent rapport. GHD exclut aussi les garanties et conditions implicites, dans la mesure permise par la loi.

Les services rendus par GHD dans le cadre de la préparation du présent rapport se limitent à ceux qui y sont précisément décrits et sont assujettis aux limitations de la portée établie dans le rapport.

Les opinions, conclusions et recommandations fournies dans ce rapport sont basées sur les conditions rencontrées et sur les informations examinées à la date de la préparation du rapport. GHD n'a aucune responsabilité ni obligation de mettre à jour ce rapport pour tenir compte d'événements ou de changements survenant après la date à laquelle le rapport a été préparé.

Les opinions, conclusions et recommandations fournies dans le présent rapport sont basées sur les hypothèses formulées par GHD et décrites dans ce dernier (voir la section 1.1 du rapport). GHD décline toute responsabilité découlant de l'inexactitude de l'une ou l'autre de ces hypothèses.

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2. Données de base et provenance

Cette section présente les données utilisées pour la conception des fossés collecteurs et les bassins de rétention :

- Les données climatiques de la station St-Michel des Saints (7077571) localisée à proximité du site minier et fournies par Environnement Canada ;
- Analyse IDF de la hauteur de pluie présentée dans le Tableau 2 fournie par Environnement Canada ;
- Mémo technique CAPR002717_NMG_Matawinie_Orografic_Effect_Final_Memo_20240718 (SRK, 2024), « Precipitation parameters correction due to orographic effect » ;
- Note de calculs 701617_3000_4H_0001 Rev E00 - Note ponceau CE36_2024-09-03 (AtkinsRéalis, 2024), « Évaluation des débits au ponceau CE36 » ;
- La topographie de la zone d'étude fournie par NMG (Shapefile : Lidar_1m_Contour_20160525.shp) ;
- Les empreintes des bassins et infrastructures fournie par NMG (Shapefile : NMG_EMPREINTE_ModifSNC_20230601.shp) ;
- Localisation des cours d'eau intermittents, permanents ainsi que les milieux humides (Fichiers CAD : snc653897_phy_hydro_l_240813.dxf et snc653897_veg_milhumide_s_240812.dxf) ;
- Localisation de la ligne de haute tension de HQ effectuée en 2020 (Shapefile : LIGNES_HQ [25012020]) ;
- Étude d'impact environnemental et social fournie par NMG ;
- Rapport P2403041 (Technosub, 2024) « Rapport et recommandations » ;
- Plans pour permis TX20035103-15000-DGE-série 100 (WSP, 2022a) « Chemin d'accès reliant le bassin BC-2 et l'effluent final » ;
- Note technique TX20035103-15000-NGE-001-0 (WSP, 2022b), « Conception du chemin d'accès reliant le bassin BC-2 à l'effluent final » ;
- Note technique TX20035103-16000-AGE-001-2 (WSP, 2023), « Quantités d'excavation chemin d'accès et bassins BC-2 et BS ».

3. Guides, critères et hypothèses de conception

3.1 Guides

Les principaux guides consultés et utilisés pour la conception des fossés collecteurs et des bassins d'eau sont les suivants :

- Règlement sur l'aménagement durable des forêts du domaine de l'état (RADF) ;
- La loi sur la qualité de l'environnement (MELCCFP).

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- Lignes directrices pour les traversées de cours d'eau du Québec, édition 2016 du MPO ;
- Le guide de gestion des eaux pluviales (MDDEFP et MAMROT, 2012) ;
- Le manuel de calcul et de conception des ouvrages municipaux de gestion des eaux pluviales (MDDELCC, 2017) ;
- Manuel de conception des ponceaux (MTMD, 2024) ;
- HEC-14 Hydraulic Design of Energy Dissipators for Culverts and Channels (FHA, 2006).

3.2 Critères de conception

3.2.1 Conception du chemin

Les critères et contraintes suivants ont été considérés pour la géométrie du chemin :

- Le chemin sera utilisé uniquement pour le passage des pick-up de type F-150 et comme assise pour les tuyaux de pompage ;
- Une largeur de 7 mètres pour permettre le passage des pick-up ;
- Une tablette de 1 mètre devra être aménagée pour permettre l'installation sécuritaire du tuyau de pompage entre le bassin BC-2 et l'effluent. Le tuyau sera de type PEHD DR17 de 350 mm de diamètre tel que spécifié dans le rapport technique de Technosub (2024) ;
- Un alignement du chemin de telle sorte à éviter les milieux humides existants ;
- Une pente longitudinale descendante en continu pour permettre la vidange par gravité des tuyaux lors de l'arrêt des systèmes de pompage ;
- Une pente longitudinale maximale de 15 % pour faciliter la circulation des véhicules ;
- Des pentes latérales minimales de 2H : 1V ;
- Des barrières de sécurité faites de blocs de roc de ± 1 m de diamètre devront être aménagées où requis selon les règles de SST en vigueur ;
- Une épaisseur minimale de 0.5 m pour la fondation de chemin ;
- Un alignement de chemin de telle sorte à relier l'effluent final au chemin menant vers le bassin BC-2, dont le tracé est défini dans le plan TX20035103-15000-DGE-série100 ;
- Une conception des ponceaux, selon les règles d'art et la réglementation en vigueur, pour assurer le libre passage des poissons.

3.2.2 Conception du ponceau

Les critères ci-dessous ont été retenus pour la conception des ponceaux dans l'alignement du chemin :

- Le ponceau a été conçu pour gérer adéquatement un débit d'une récurrence de 1 : 100 ans plus une majoration de 18% pour tenir compte des changements climatiques ;
- Lignes directrices pour la conception d'un ponceau à déversoir selon les lignes directrices pour traversées de cours d'eau du Québec ;
- Des ponceaux de type TTOG avec un coefficient de Manning de 0,028 ont été considérés.

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3.2.3 Conception des fossés

Les hypothèses émises pour la conception des fossés collecteurs le long du chemin sont les suivantes :

- Le fossé a été conçu afin d'être capable d'évacuer adéquatement une crue estivale ayant une récurrence de 1 : 10 ans, une majoration respective de 14% et 18% a été considérée pour tenir compte des effets orographiques et du changement climatique ;
- L'écoulement dans le fossé est considéré comme étant uniforme et en régime permanant ;
- Un coefficient de Manning de 0,035 a été utilisé pour les fossés en supposant que ceux-ci seront excavés dans le sol naturel et protégés avec de l'enrochement (Chow, 1959) ;
- Le sol du bassin versant contribuant au fossé est considéré comme étant saturé en eau ;
- Les fossés auront :
    - Une section de forme trapézoïdale ;
    - Une largeur minimale à la base de 1,0 m ;
    - Une profondeur minimale de 1,0 m ;
    - Une pente minimale de 0,1 % ;
    - Le fossé sera protégé avec de l'enrochement sur les tronçons où la vitesse est importante.
    - Des pentes latérales minimales de 2H : 1V ;
    - Une revanche minimale de 0,30 m.

3.2.4 Conception du bassin de dissipation

Les éléments ci-dessous ont été retenus pour la conception du bassin de dissipation :

- Le débit maximum pompé est de 1800 m^3/h (Technosub, 2024) ;
- A la sortie de l'émissaire, la vitesse maximum attendue est de 5.8 m/s (Technosub, 2024) ;
- Une dissipation d'énergie d'au moins 50% doit être atteinte.

4. Conception hydrotechnique

La conception du chemin de l'émissaire comprend deux fossés et un ponceau afin de permettre le drainage des eaux de surface considérées propres vers l'environnement. Le système de drainage du chemin a été optimisé afin de favoriser l'écoulement gravitaire en considérant la topographie et développement du site. Puisque le système draine uniquement des eaux propres vers l'environnement, le critère de conception considéré dans le dimensionnement de ces ouvrages est une pluie de récurrence de 1 : 10 ans tel que recommandé dans le guide de préparation des projets routiers (MTQ, 2018).

Les sections suivantes présentent les données utilisées pour le dimensionnement des ouvrages ainsi que les principaux résultats obtenus à l'issue de l'étude.

4.1 Données climatiques

Le projet minier Matawinie est situé à environ 5 km au sud-ouest de la municipalité de Saint-Michel-des-Saints et à 150 km au nord de Montréal. La station climatique la plus proche du site est celle St Michel des Saints (7077570-7077571) aux coordonnées Lat: 46°48'56,010" N; Long: 74°05'38,050" O et à l'élévation 429.9 m.

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Les données pluviométriques de la station climatiques sont présentées dans le Tableau 4-1 et le Tableau 4-2.

Les débits du ruisseau CE36 pour chaque période de retour ont été tirées de la note te calcul préparée par AtkinsRéalis (2024) et sont présentées dans le Tableau 4-3 ci-dessous.

Tableau 4-1 Quantité de pluie (mm) à la station St Michel des Saints (7077570 - 7077571)

Période de retour (ans)	Pluie 24h (mm)
2	41,9
5	59,8
10	71,7
25	86,7
50	97,8
100	108,9

Tableau 4-2 Intensité de pluie (mm/h), pour une récurrence de 10 ans à la station St Michel des Saints

Durée	Intensité de pluie Printemps (mm/h)	Intensité de pluie Été-Automne (mm/h)
5 min	8.2	10,8
10min	12.0	15,8
15 min	15.0	19,8
30 min	20.5	27,0
1h	29.1	38,3
2h	38.6	50,8
6h	46.4	61,1
12h	50.8	66,9
24h	54.5	71,7

Tableau 4-3 Débits au ruisseau CE36 par période de retour (AtkinsRéalis, 2024)

Période de retour (ans)	Débit (m^3/s)
2	0,45
5	0,55
10	0,64
20	0,72
25	0,74
50	0,84
100	0,91

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4.2 Délimitation des bassins versant

La zone se drainant vers les fossés du chemin de l'émissaire a été divisée en deux bassins versants, soient le BV16 et le BV17, tels que présentés dans la Figure 4-1. Entre les chainages approximatifs 0+086 et 0+393 le terrain se draine naturellement loin du chemin. La superficie des deux bassins versants est montrée dans le Tableau 4-4 ci-dessous. Le bassin versant BV16 a une superficie cumulative de 0,8 hectares puisqu'il draine également le bassin versant BV15B (WSP, 2022).

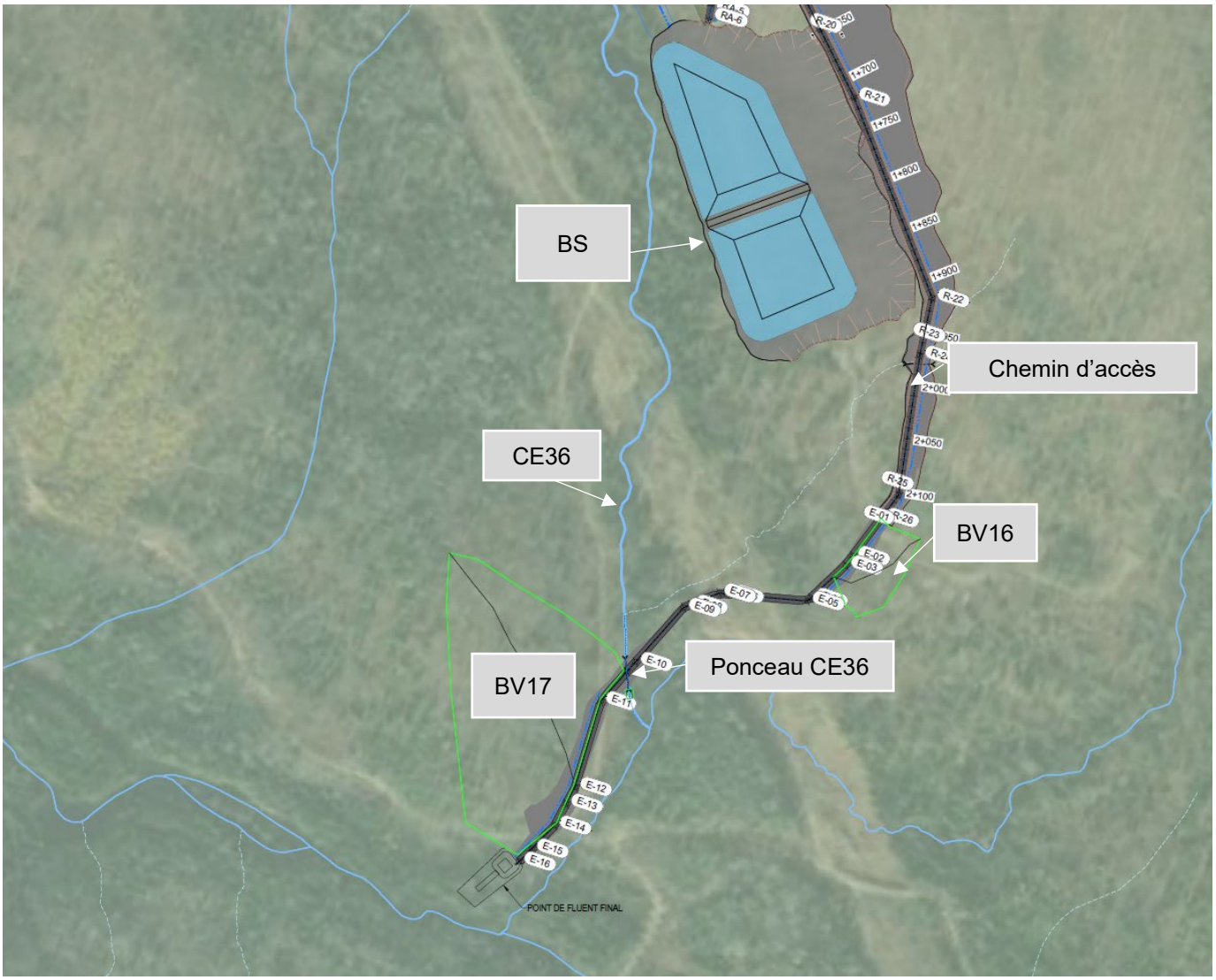

Figure 4-1 Délimitation des bassins versants

4.3 Coefficient de ruissellement

Le choix d'un critère de ruissellement dépend de l'utilisation du territoire, du type de sol et de la topographie. Étant donné la nature similaire des bassins versants du chemin de l'émissaire, le même critère de ruissellement a été appliqué. Ce coefficient de ruissellement a été estimé basé sur le guide d'application du règlement sur l'aménagement durable des forêts du domaine de l'État. Dans le cadre de la présente étude, un coefficient de 0,26 a été adopté pour les deux bassins versants du chemin de l'émissaire.

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4.4 Estimation des débits de pointe

Afin d'estimer les débits de pointes de ruissellement pour la conception des fossés du chemin, la méthode rationnelle présentée dans le manuel de calcul et de conception des ouvrages municipaux de gestion des eaux pluviales (MELCC, 2017) a été retenue.

Ainsi, l'équation utilisée pour calculer le temps de concentration de chaque bassin versant est la suivante :

$$T_c = (3{,}26\left(1{,}1 - C_p\right) L_c^{0,5})/S_C^{0,33}$$

Où les paramètres sont :

- T_c temps de concentration (min);
- C_p coefficient de ruissellement (-);
- L_c longueur d'écoulement (m);
- S_c pente moyenne (%).

L'intensité de pluie choisie correspond au temps de concentration du bassin versant considéré. Le Tableau 4-4 présente les paramètres utilisés pour estimer le débit de pointe pour l'évènement de conception.

Tableau 4-4 Paramètres des bassin versants et débit de pointe calculés

Nom du bassin versant	Superficie (ha)	Superficie cumulée (ha)	Coefficient de ruissèlement	Temps de concentration (min)	Intensité de pluie (mm/h)	Débit de pointe (m3/s)	Pente moyenne (%)
BV16	0,39	0,80	0,26	60	52	0,03	12
BV17	2,88	2,88	0,26	90	60	0,12	11

4.5 Conception du réseau de drainage

Le réseau de drainage comprend deux fossés conçus pour intercepter les eaux de ruissellement provenant du terrain naturel avant qu'elles n'entrent en contact avec la surface du chemin. Le premier fossé débutera au chainage 0+000 et s'écoulera directement sur le terrain naturel à son extrémité, située au chainage approximatif 0+086.

Entre les chainages approximatifs 0+086 et 0+393, aucune excavation de fossé n'est nécessaire, car les eaux de ruissellement s'écoulent naturellement loin du chemin. Le deuxième fossé sera aménagé le long de la section du chemin comprise entre les chainages approximatifs 0+393 et 0+499. Ce fossé s'écoulera directement dans le bassin de dissipation situé à l'extrémité du chemin.

Le bassin de dissipation, équipé d'un déversoir et d'un canal de sortie, sera aménagé à la fin du chemin pour dissiper l'énergie des eaux à la sortie du tuyau de pompage de l'émissaire, assurant ainsi un écoulement contrôlé jusqu'au ruisseau à l'Eau Morte.

Pour traverser le ruisseau CE36 et garantir le libre passage des poissons, un ponceau sera installé dans l'alignement du ruisseau, au chainage approximatif 0+300.

Compte tenu de la topographie du terrain naturel et de l'emplacement du chemin, les fossés de drainage du chemin ne recevront aucune eau contaminée.

4.5.1 Conception des fossés

Le dimensionnement hydraulique des fossés a été réalisé en utilisant l'équation de Manning pour un régime d'écoulement permanent. Le diamètre D50 de l'enrochement a été déterminé en utilisant la méthodologie proposée dans le manuel d'ingénierie « *Hydraulic Design of Flood Control Channels* » (*US Army Corps of Engineers*, 1994).

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À la suite des calculs hydrauliques, une section optimale a été retenue pour les fossés situés au pied du chemin d'accès. Les fossés recommandés auront une section de forme trapézoïdale avec une largeur à la base de 1 m et des pentes latérales de 2H : 1V. Une revanche de 0,3 m doit être ajoutée aux profondeurs d'écoulement.

Le Tableau 4-5 présente les débits de conception, les profondeurs d'eau maximales et minimales, les vitesses maximales atteintes ainsi que le diamètre D50 de l'enrochement de protection contre l'érosion pour le fossé 17.

Compte tenu du faible débit de pointe du BV16 et de la faible vitesse d'écoulement associée dans le fossé 16, aucun enrochement de protection n'est nécessaire. Cependant, il est recommandé de procéder à l'hydroensemencement de ce dernier.

Tableau 4-5 Dimensionnement hydraulique des fossés collecteurs du chemin de l'émissaire

	Débit de conception (m3/s)	Pente min. (%)	Pente max. (%)	Profondeur d'écoulement (m)	Vitesse moyenne d'écoulement (m/s)	Enrochement D50 requis (mm)
Fossé 17	0,12	0,35	13,26	0,19	0,46	100

4.5.2 Conception ponceau

Le Tableau 4-6 résume les dimensions du ponceau à déversoirs CE36 ainsi que les vérifications effectuées pour assurer le libre passage des poissons selon les lignes directrices pour les traversées de cours d'eau au Québec et pour assurer la capacité du ponceau à passer d'un débit d'une récurrence de 1 :100 ans avec une majoration de 18% pour tenir compte des changement climatiques.

Tableau 4-6 Dimensionnement du ponceau CE36

Élément	Unités	Valeur	Critères & contraintes
Propriétés du ponceau proposé et du cours d'eau CE36			
Pente cours d'eau	%	3,7	NA
Pente amont ponceau	%	4	NA
Pente ponceau	%	5	NA
Diamètre ponceau	mm	2000	MIN. 1500 mm et réduction LDPB ≤ 20%
LDPB (largeur au débit plein bord)	m	3,2	NA
Longueur ponceau	m	26,2	NA
Vérification selon les contraintes des lignes directrices			
Réduction LDPB	%	12,5	Réduction LDPB ≤ 20%
Ratio de pentes (RP)	-	1,35	≥ 1.25
Élévation crête du 1er déversoir	m	433,12	Même élévation que le point bas du premier seuil en aval du ponceau
Élévation radier amont	m	432,53	NA
Élévation radier aval	m	430,98	NA
Dimensionnement des déversoirs			
Dénivelé	mm	40	NA
Ennoiement	mm	50	NA
Espacement entre les déversoirs	m	1,8	MIN. 1.8

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Élément	Unités	Valeur	Critères & contraintes
Hauteur de l'encoche	mm	90	Hauteur minimale encoche = dénivelé + hauteur ennoiement
Largeur de l'encoche	mm	160	Largeur minimale de l'encoche est de 150 mm
Débit de l'encoche coulant pleine	m^3/s	0,006	Calcul débit encoche coulant pleine selon équation : Formule tirée de Larinier (2003)
Dimensionnement du bassin de dissipation			
Largeur du bassin	m	4	MIN. 2 fois Diamètre ponceau
Longueur du bassin	m	6	MIN. 3 fois Diamètre ponceau
Profondeur bassin	m	1	MIN. 1m (profondeur mesurée à partir de la crête du 1er déversoir)

4.5.3 Conception bassin de dissipation

La conception d'un dissipateur d'énergie à la sortie de l'émissaire est nécessaire pour réduire la vitesse élevée et prévenir l'érosion en aval. La vitesse d'écoulement à la sortie de l'émissaire sera significativement élevée lors de la dernière phase (5,8 m/s). Le manuel de conception des ponceaux (MTDT,2024) et HEC-14 présente les éléments de conception d'ouvrage de dissipation d'énergie. Un bassin de dissipation d'énergie avec un déversoir suivi d'un canal de dissipation a été sélectionné pour contrôler le déversement vers l'environnement.

La vitesse d'écoulement à la sortie du bassin sélectionné est de 2,39 m/s.

Le Tableau 4-7 résume les dimensions retenues pour le bassin de dissipation

Tableau 4-7 Dimensionnement du bassin de dissipation

Élément	Unité	Valeur	Critères & contraintes
Dimension du bassin	m	10x10	
Pente latérale	H :1V	4	
Longueur totale	m	18	
Pente du bassin	%	1	
Profondeur	m	1,00	MIN. 1m
Enrochement D50	mm	1000	Masse équivalente (1300 kg)

4.5.4 Conception du déversoir et du canal de dissipation

Le déversoir retenu est de forme trapézoïdale, avec une base de 3 m de largeur, des pentes de talus 4H :1V et une profondeur de 1 m.

Le canal de dissipation a été conçu après le déversoir pour assurer une dissipation d'énergie contrôlée jusqu'au ruisseau à l'Eau Morte.

Le Tableau 4-8 ci-dessous résume les critères de conception utilisés et les dimensions du canal sélectionnées.

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Tableau 4-8 Dimensionnement du canal de dissipation

Élément	Unité	Valeur
Débits de conception		
Apport du bassin de dissipation	m^3/s	1,27
Apport du fossé 17	m^3/s	0,12
Dimensions		
Largeur de la base	m	2
Pente des talus	H :1V	2
Profondeur	m	1
Pente min.	%	2
Pente max.	%	4
Enrochement D50	mm	150

5. Quantités d'excavation

La présente section fournit une estimation des quantités d'excavation nécessaires pour l'exécution du chemin de l'émissaire, le bassin de dissipation et son déversoir. Les hypothèses utilisées pour effectuer les calculs des volumes des matériaux y sont également détaillées.

5.1 Information géotechnique

La stratigraphie des sols dans l'emprise du chemin de l'émissaire et le bassin de dissipation a été approximée selon la description des données géotechniques fournie dans la note technique présentant les quantités d'excavation pour le chemin d'accès et bassins BC-2 et BS (WSP, 2023).

D'après ces informations, la géologie de surface dans le secteur du chemin comprend une couche superficielle de sols organiques majoritairement sableux, d'une épaisseur variante entre 150 et 250 mm. Cette couche est suivie par une couche de sable et de silt, dont les proportions varient, avec une épaisseur comprise entre 1 et 5 mètres selon l'emplacement. Ces deux couches reposent sur le socle rocheux. Ces données proviennent des résultats de forages et/ou puits d'exploration réalisés sur le site de Matawinie, mais à l'extérieur de l'emprise projetée du chemin.

En 2024, NMG a réalisé 21 puits d'explorations dans les premiers 1200 m de l'alignement du chemin entre les bassins BC-2 et BS pour obtenir plus d'informations sur l'élévation du socle rocheux. Les données recueillies indiquent une profondeur moyenne de 2.8 mètres. Le mort-terrain par-dessus le roc est constitué majoritairement de sable silteux avec présence de gravier, cailloux et blocs. Aucun échantillon n'a été prélevé dans les puits d'exploration.

5.2 Hypothèses de calcul

GHD a pris en compte les hypothèses suivantes lors du calcul des quantités :

- Les travaux de décapage sont strictement limités à l'intérieur de l'emprise des infrastructures, sans inclure de surfaces situées en dehors des limites projetées dans les calculs.
- Une épaisseur de 500 mm a été adoptée pour la couche de sols organiques dans l'emprise des travaux.
- Le socle rocheux sous l'emprise du chemin d'accès se situe à une profondeur de 2,5 m sous la surface naturelle du terrain.
- L'ensemble du mort-terrain excavé dans l'emprise du chemin est présumé constitué de sable.

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5.3 Estimation des quantités

5.3.1 Surface de décapage

Le Tableau 5-1 présente une estimation des superficies à décaper pour les ouvrages

Tableau 5-1 Surface de décapage estimées

Ouvrage	Superficie (hectare)
Chemin de l'émissaire	0,85
Bassin de dissipation et déversoir	0,18

5.3.2 Excavation

Le Tableau 5-2 présente une estimation des quantités de matériaux à excaver pour la construction du chemin et du bassin de dissipation.

Tableau 5-2 Quantités d'excavation estimées

Matériau	Quantité	Unité
Chemin de l'émissaire		
Décapage	4150	m^3
Mort terrain	5075	m^3
Roc	830	m^3
Bassin de dissipation et déversoir		
Décapage	900	m^3
Mort terrain	960	m^3
Roc	-	m^3

Les matériaux de décapage en provenance des travaux d'excavation seront entreposés dans la halde de terre végétale.

Le mort-terrain excavé lors du déblai du chemin d'accès sera réutilisé pour la construction des sections du chemin en remblai. Tout matériau excédentaire ou ne répondant pas aux exigences des matériaux de remblai sera transporté vers la halde de mort-terrain.

La roc extrait lors des travaux de construction du chemin d'accès sera utilisé pour produire l'enrochement nécessaire à la protection contre l'érosion des sections du fossé, du bassin de dissipation et du ponceau. Les matériaux excédentaires seront stockés en attendant leur traitement au concasseur.

6. Conclusion et recommandations

Cette note technique présente la conception du chemin de l'émissaire, du ponceau qui traverse le chemin au niveau du ruisseau CE36 ainsi que du bassin de dissipation à la sortie de l'émissaire.

Cette note technique servira de base pour l'obtention de permis et l'autorisation du ministère avant de débuter la construction.

La construction des infrastructures devra tenir compte des recommandations suivantes :

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– Une révision de la conception pourrait être nécessaire dans le cas où des différences entre la surface du terrain, au moment de la construction, et la surface (topographie) considérée lors de la conception seraient constatées.
– Il est recommandé d'effectuer des inspections régulières – au minimum durant et après la fonte printanière et après tout événement de précipitation majeure. Ainsi, les travaux d'entretien et de nettoyage permettront d'assurer la pérennité de l'ouvrage et de conserver la capacité hydraulique des structures.
– Dans le cas où des problèmes/des dommages localisés tels que l'érosion du lit et des parois du canal ou encore le déplacement de l'enrochement de protection contre ces derniers seraient constatés pendant les inspections régulières, il est important de mettre en place des mesures correctives rapidement.
– Dans le cas où des accumulations excessives de sédiments seraient constatées pendant les inspections régulières dans les fossés ou dans le bassin existant, il est important de procéder à un nettoyage.

7. Références

Department of the Army U.S. Army Corps of Engineers (1994). *Hydraulic Design of Flood Control Channels.*

MDDEFP Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs, et MAMROT Ministère des Affaires municipales, des Régions et de l'Occupation du territoire (2014). *Guide de gestion des eaux pluviales.*

Ministère des Forêts, de la Faune et des Parcs. *Guide d'application du Règlement sur l'aménagement durable des forêts du domaine de l'état*, [En ligne], Gouvernement du Québec. [mffp.gouv.qc.ca/RADF/guide].

MTQ Ministère des Transports du Québec (2018). *Guide de préparation des projets routiers.*

Pêche et Océans Canada (2016). *Lignes directrices pour les traversées de cours d'eau au Québec.*

U.S. Department of Transportation, Federal Highway Administration (2006). *Hydraulic Design of Energy Dissipators for Culverts and Channels*, Hydraulic Engineering Circular No. 14.

Chow, V.T. (1959). *Open-Channel Hydraulics.*

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