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REPORT

VOLUME 2 - TECHNICAL STUDY

Consultant Reference: LGA-1-GN-F-FRN-RT-0002_01

2024-03-19

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List *of* Volumes

TRANSPORTATION INFRASTRUCTURE FEASIBILITY STUDY, PHASE I

Executive Summary

Volume 1 - Introduction

Volume 2 - Technical Study

Volume 3 - Socio-Environmental Study

Volume 4 - Market Study (with Phases II and III)

Volume 5 - Economic, Financial and Risk Study

Volume 6 - Appendix

Table *of* Contents

8. TECHNICAL STUDY 1

8.1 Acronyms, Abbreviations and Units 1

8.2 Scope and Objective 6

8.3 Geotechnical and Geomorphology Investigation 6

8.4 Potential Borrow Sources and Quarry Sites 9

8.5 Proposed Billy Diamond Highway Railway and Grevet-Chapais Railway 10

8.5.1 History background of the Grevet-Chapais line 10

8.5.2 Overview 12

8.5.3 Environmental Conditions 13

8.5.4 Right-of-Way (ROW) 14

8.5.5 Fencing 14

8.5.6 Fauna and Flora 15

8.5.7 Wetlands 17

8.5.8 Integration of Cree Perspective and Knowledge in the Railway Alignment Design 19

8.5.9 Noise Control 22

8.5.10 Reference Documents and Standards 23

8.5.11 Comparison to Other Similar Projects 24

8.5.12 Design Criteria 24

8.5.13 Site Visits ... 25
8.5.14 Topography ... 26
8.5.15 Civil and Earthworks ... 28
8.5.16 Track ... 37
8.5.17 Billy Diamond Highway Railway (BDHR) Alignment ... 42
8.5.18 Grevet-Chapais Railway Alignment ... 46
8.5.19 3D Modeling - Civil 3D ... 48
8.5.20 Level Crossings ... 51
8.5.21 Sidings ... 56
8.5.22 Passenger Stations and Platforms ... 56
8.5.23 Transshipment Yards ... 62
8.5.24 Structures ... 67
8.5.25 Hydrology and Drainage ... 96
8.5.26 Signalling and Telecommunication System ... 108
8.5.27 Power Supplied to the Railway ... 114
8.5.28 Railway Operations ... 115
8.5.29 Rolling Stock ... 132
8.5.30 Rolling Stock Maintenance ... 145
8.5.31 MoW Equipment Maintenance Strategy ... 150
8.5.32 Infrastructure Maintenance ... 150
8.5.33 Maintenance-of-Way (MOW) Strategy ... 151
8.5.34 Staffing ... 154
8.5.35 Passenger Services ... 164
8.5.36 Construction Schedule ... 175

8.6 Cost Estimation ... 183

8.6.1 Capital Costs (CAPEX) ... 183
8.6.2 Sustaining Capital ... 186
8.6.3 Operating Expenses (OPEX) ... 188
8.6.4 Construction Cost Cash Flows ... 190

8.7 Community Access Roads ... 192

8.7.1 Introduction ... 192
8.7.2 Design Parameters ... 194
8.7.3 Scope and Objective ... 195
8.7.4 Analytical Approach for Existing Roads ... 195
8.7.5 Community Access Roads and Route du Nord ... 195
8.7.6 Superelevation ... 199
8.7.7 Vertical Profile ... 199
8.7.8 Cross Section ... 202
8.7.9 Access ... 203
8.7.10 Culverts ... 204
8.7.11 Crash Barriers on Access Roads ... 205

8.7.12 Signage and Markings 206
8.7.13 Multipurpose Trails Near Communities 207
8.7.14 Traffic Maintenance 207
8.7.15 Winds and Snow 207
8.7.16 Maintenance work 209
8.7.17 Integration of Cree Perspective and Knowledge 210
8.7.18 Public services 210
8.7.19 Work and Cost Estimate 211

8.8 Mistissini Secondary Access Road – Technical Aspects 212

8.8.1 Background Research 212
8.8.2 Data Retrieved through the Various Ministers 212
8.8.3 Data from the Ministère des Transports Regarding Traffic on the Territory 214
8.8.4 Published Documents Considered in the Study 214
8.8.5 Inputs and Design Recommendation 215
8.8.6 Photo-interpretation 216
8.8.7 Alignments 217
8.8.8 Preliminary Road Construction Design 219
8.8.9 Water Crossings and Drainage 220
8.8.10 Estimation of Quantities (Earthworks) 221
8.8.11 Cost Estimation 222
8.8.12 Conclusion and Recommendations 224

8.9 Additional Technical Studies 224

8.9.1 CN Track Assessment and Estimate of Rehabilitation Costs 224
8.9.2 Battery and Electric Train Propulsion Technologies Study 229
8.9.3 Grevet-Chapais Replacement Trail Study 237

8.10 Conclusion 241

List *of* Tables

Table 8.3–1: Summary of the Preliminary Geotechnical Investigation 7
Table 8.4–1: Summary of the potential borrow source and carry sites identified along the transport infrastructure (Phase I) 9
Table 8.4–2: Summary of Borrow Source Field Investigation 10
Table 8.5–1: Environmental Conditions at Matagami and Chapais 13
Table 8.5–2: Wind Data at Val-d'Or 14
Table 8.5–3: Seismic Data at Val-d'Or 14
Table 8.5–4: General characteristics of the railways 24
Table 8.5–5: Topics covered in the Design Criteria document 25
Table 8.5–6: Gradation Requirements for the Sub-Ballast 29
Table 8.5–7: Factors of safety (FS) for slope stability analysis 36
Table 8.5–8: Summary of Track Criteria 42
Table 8.5–9: BDHR Option Design Hierarchy 43
Table 8.5–10: Technical Score (Cost) of the Baseline and Optimized Alignments 44
Table 8.5–11: Social Environmental Score of the Baseline and Optimized Alignments 44
Table 8.5–12: Final Score of the Baseline and Optimized Alignments 44
Table 8.5–13: Hierarchy of Priorities for Hybrid Alignment 45
Table 8.5–14: Comparison between Baseline, Optimized and Hybrid Alignments 46
Table 8.5–15: Level Crossing Quantities 52
Table 8.5–16: Grade Crossing Surface Criteria 54
Table 8.5–17: General Passenger Station Description 57
Table 8.5–18: Passenger Platform Dimensions 62
Table 8.5–19: Principal Features of the Existing Bridges on the GCR 75
Table 8.5–20: Proposed Works for Existing Bridges on GCR 85
Table 8.5–21: Superimposed Dead Loads 88
Table 8.5–22: Allowable Stresses for Normal Rating 90
Table 8.5–23: Allowable Stress for Maximum Rating 91
Table 8.5–24: Results of GCR Bridge Capacity Analysis 92
Table 8.5–25: Bridge List – Grevet-Chapais Railway 95
Table 8.5–26: Bridge List – Billy Diamond Highway Railway 95
Table 8.5–27: 2080s Climate Change at Matagami 98
Table 8.5–28: 2080s Climate Change at Chapais 98
Table 8.5–29: Drainage Calculations and Hydrologic Method 101
Table 8.5–30: Minimum Design Requirements for Culvert 102
Table 8.5–31: Observations of the Existing Culverts Inspected 105
Table 8.5–32: BDHR infrastructure list 109
Table 8.5–33: Grevet-Chapais Railway infrastructure list 109
Table 8.5–34: Signaling system description and evaluation 110
Table 8.5–35: Summary Freight Traffic 117
Table 8.5–36: BDHR Train Consist 118

Table 8.5–37: GCR Train Consist 119
Table 8.5–38: Summary of the Minimum Running Times Calculated for Each Train 121
Table 8.5–39: Sample Train Cycle Time on BDHR 125
Table 8.5–40 : Sample Train Cycle Time on GCR 126
Table 8.5–41: Freight Train Schedules 127
Table 8.5–42: Location of Operating Buildings and Facilities 128
Table 8.5–43: Administrative Office Requirements 128
Table 8.5–44: Rolling Stock Common Requirements 133
Table 8.5–45: REU characteristics 134
Table 8.5–46: 64’ Flat Car Characteristics 135
Table 8.5–47: Covered Hopper Characteristics 136
Table 8.5–48: Bulkhead Flat Car Characteristics 137
Table 8.5–49: Woodchip Gondola Characteristics 138
Table 8.5–50 : Mill Gondola Characteristics 139
Table 8.5–51: 89’ Flat Car Characteristics 140
Table 8.5–52: Tank-tainer Characteristics 141
Table 8.5–53: Bottom Dump Ballast Car Characteristics 142
Table 8.5–54: Side Dump Ballast Car Characteristics 143
Table 8.5–55: Typical Box Car Characteristics 144
Table 8.5–56: Typical Locomotive Characteristics 145
Table 8.5–57: Preventative Maintenance Approach for Locomotives 146
Table 8.5–58: List of Major Locomotive Components to be Overhauled or Replaced 148
Table 8.5–59: MOW Road and Road/Rail Vehicles 151
Table 8.5–60: Major Mainline Inspection Requirements 153
Table 8.5–61: Major Maintenance Activities to be Contracted OUT 154
Table 8.5–62: Headquarters Administration Staff 155
Table 8.5–63: Supervisory Staff in Operations 156
Table 8.5–64: Yard Crew Employees 157
Table 8.5–65: Train Crew Employees 157
Table 8.5–66: Carload Staffing Total Equivalent Full Time Employees Required 158
Table 8.5–67: Intermodal Positions – Number of Employees 159
Table 8.5–68: Supplementary Staff 159
Table 8.5–69: Total Transportation Department Staffing Requirements 160
Table 8.5–70: Rolling Stock Maintenance Department Staffing 161
Table 8.5–71: Infrastructure Department Staffing 162
Table 8.5–72: Required Employees for Billy Diamond Highway and Grevet-Chapais Railways 163
Table 8.5–73: Permanent Railway Staff by Function and Location 163
Table 8.5–74: Passenger Schedules 167
Table 8.5–75: Passenger Train Characteristics 168
Table 8.5–76: Passenger Train Consist 168
Table 8.5–77: Typical Passenger Coach Characteristics 171
Table 8.5–78: Coach Maintenance and Overhaul Inspection Groups 172
Table 8.5–79: Supervisory Staff for Passenger Services Operations 174
Table 8.5–80: On-Board Service Staff 174

Table 8.5–81: Passenger Station Staff 175
Table 8.5–82: Passenger Service Staffing Summary 175
Table 8.5–83: Temporary Access Road Categories....176
Table 8.5–84: Temporary Access Road Number and Locations 176
Table 8.5–85: Schedule of Construction Activities 180
Table 8.5–86: Key construction activities and dates – Billy Diamond Highway Railway....182
Table 8.5–87: Key construction activities and dates – Grevet-Chapais Railway 183
Table 8.6–1: Capital Cost for the Construction of the BDHR Phase 1 B by Sector (in $M CAD)....185
Table 8.6–2: Capital Cost for the Construction of the Grevet-Chapais Railway by Sector. 185
Table 8.6–3: Capital Cost for the Construction of All Four Community Access Roads by Sector....186
Table 8.6–4: Capital Cost for the Route du Nord by Sector....186
Table 8.6–5: BDHR sustaining capital cost, in million CAD. 187
Table 8.6–6: Grevet-Chapais Railway sustaining capital cost. All costs in millions CAD. 187
Table 8.6–7 Community access roads sustaining capital cost. 188
Table 8.6–8 Route du Nord sustaining capital cost. 188
Table 8.6–9: Track and infrastructure OPEX....189
Table 8.7–1: Design parameters....194
Table 8.7–2: Lidar data 195
Table 8.7–3: Horizontal Curves and Exiting Permissible Speeds 196
Table 8.7–4 : Horizontal curves requiring interventions 197
Table 8.7–5: Slopes greater than 10% 200
Table 8.7–6 : Vertical Curves and Exiting permissible Speeds....202
Table 8.7–7 : Culvert Condition Classes....204
Table 8.7–8: Distribution and Conditions of Culverts (MTMD) 204
Table 8.7–9 : Crash Barrier Work Requirements....205
Table 8.7–10: Maintenance work....209
Table 8.7–11: Issues raised and proposed solutions 210
Table 8.7–12: Power Line Crossings 210
Table 8.7–13: Cost estimate 212
Table 8.8–1: Road Lengths per Class on Category 1 Lands....213
Table 8.8–2: Average Daily Traffic on Existing Roads Around Mistissini 214
Table 8.8–3: Design criteria 216
Table 8.8–4: Location of Borrow Sites 217
Table 8.8–5: Characteristics of Proposed Routes 219
Table 8.8–6: Existing Culverts to Be Replaced and Prescribed Diameter....220
Table 8.8–7: New Culverts to Be Installed....221
Table 8.8–8: Assumed Works on Reconstruction Sections 221
Table 8.8–9: Earthworks Quantities - Section 27+000 à 35+000....222
Table 8.8–10: Earthworks Quantities - Section 37+000 à 41+000....222
Table 8.8–11: Construction Costs 223
Table 8.9–1: Summary of existing infrastructures of CN subdivisions 226
Table 8.9–2: Cost Summary 229
Table 8.9–3: Summary of the Rolling Stock Requirements for Each Scenario 231
Table 8.9–4: Summary of the Energy Consumption for each Scenario 232

Table 8.9–5: Comparison of Infrastructure and other Requirements for Each Scenario, and the Impact on Operations 234
Table 8.9–6: Comparison of the Total Capital Cost of all Scenarios 235
Table 8.9–7: OPEX and Sustaining Capital Comparison for All Scenarios 235
Table 8.9–8: Summary of the Annual Fuel and Emission Reduction 236
Table 8.9–9 : Description of Routes in Conflict 238
Table 8.9–10: Snowmobile Trail Relocation works assumptions 239
Table 8.9–11: Forest Road Relocation works assumptions 239
Table 8.9–12: Snowmobile and forest road relocation costs 240

List *of* Figures

Figure 8.5-1: Map of current CN subdivisions (blue) in Chibougamau - Senneterre Area 11
Figure 8.5-2: CN freight train loading ore concentrate at the mine in Chapais, 1976 12
Figure 8.5-3: Environmental Conditions 13
Figure 8.5-4: Example of Typical Fencing Location 15
Figure 8.5-5: Compact Black Spruce at KP 55 15
Figure 8.5-6: Harvested Area, approximately KP77 16
Figure 8.5-7: Distribution of Woodland Caribou 17
Figure 8.5-8: Wetlands Distribution (approximately KP 76 to KP 84) 18
Figure 8.5-9: Wetland Observed from Billy Diamond Highway, approximately KP 91+300 18
Figure 8.5-10: Bypassing a Lake, approximately KP 178 19
Figure 8.5-11: Meeting with Waswanipi Tallymen - July 2022 20
Figure 8.5-12: Meeting with Waswanipi Tallymen 20
Figure 8.5-13: Woodland Caribou sensitive area 21
Figure 8.5-14: Tallymen camp avoidance 21
Figure 8.5-15: Avoidance of harvesting areas 22
Figure 8.5-16: Open water areas 22
Figure 8.5-17: Dimensions of the Proposed Noise Barrier 23
Figure 8.5-18: Progress of the Visits 26
Figure 8.5-19: Example of the LIDAR Survey Coverage 27
Figure 8.5-20: Example of Image Quality - Billy Diamond 27
Figure 8.5-21: Typical Cross Section for Embankment over Good Ground Conditions 28
Figure 8.5-22: Typical Cross Section for Embankment over Good Ground Conditions 30
Figure 8.5-23: Fill Placement During Embankment Construction 31
Figure 8.5-24: Scanning Electron Microphotograph of James Bay Peat 32
Figure 8.5-25: Typical Cross Section for Embankment Over Compressible Materials 33
Figure 8.5-26: Typical Cross-Section of Removal/Replacement Works 34
Figure 8.5-27: Removal of Granular Surcharge Material – Manual on Compressible Soils 35
Figure 8.5-28: Typical Cross Section for Wet Cutting in Soil < 5m 37
Figure 8.5-29: Track Structure Components 38

Figure 8.5-30: Typical Improved Fair Anchor........39
Figure 8.5-31: Picture of a Typical No. 8 Turnout........40
Figure 8.5-32: Typical CN Bumping Post........41
Figure 8.5-33: Cross Section of the Typical Arrangement of Adjacent Road and Rail........46
Figure 8.5-34: Examples of Erosion and Forest Encroachment on the Chapais Subdivision Trail........47
Figure 8.5-35: Screenshot of 3-D Model used for the Alignment and Earthwork Design - KP18+280 (Easting = 233 386, Northing = 5 518 070)........48
Figure 8.5-36: Screenshot of 3-D Model used for the Alignment and Earthwork Design KP17+900) (Easting = 233 008, Northing = 5 518 038)........49
Figure 8.5-37: Screenshot of 3-D Model used for the Alignment and Earthwork Design - KP19+550 (Easting = 234 589, Northing = 5 518 443)........49
Figure 8.5-38: Rock Area (KP 16+040; Railway will be 60m to the left)........50
Figure 8.5-39: Crossing of a Wetland Area (KP 197+400; Railway will be at 30m to the left)........50
Figure 8.5-40: Two Examples of Minor Level Crossings........53
Figure 8.5-41: View of a Major Level Crossing........53
Figure 8.5-42: Grade Crossing Surface Dimensions........54
Figure 8.5-43: Standard Railway Clearances........55
Figure 8.5-44: Location of High Voltage Lines Crossing the Grevet Chapais Rail Line........55
Figure 8.5-45: Examples of Local Architecture Inspired by the Cree Culture........57
Figure 8.5-46: Passenger Station General Arrangement Diagram........58
Figure 8.5-47: Passenger Station Concept Plan - Option A........58
Figure 8.5-48: Planning Diagram Illustrating General Approach – Passenger Station Option A........58
Figure 8.5-49: Passenger Station Option B Concept Plan........59
Figure 8.5-50: Passenger Station Option B – Planning Diagram Illustrating General Approach........59
Figure 8.5-51: Passenger Station Option C Concept Plan........60
Figure 8.5-52: Passenger Station Option C – Planning Diagram Illustrating General Approach........60
Figure 8.5-53: Plan of Passenger Station – Facilities........61
Figure 8.5-54: Layout of Station Building Rooms........61
Figure 8.5-55: Example of a Passenger Station Platform........62
Figure 8.5-56: Location Plan - Waskaganish Community and Waskaganish Yard........63
Figure 8.5-57: Location Plan - Waskaganish Yard........63
Figure 8.5-58: Location Plan - Waskaganish Yard........64
Figure 8.5-59: Schematic Layout of Waskaganish Yard........64
Figure 8.5-60: Location Plan - Matagami Community and Matagami Yard........65
Figure 8.5-61: Location Plan - Matagami Yard........65
Figure 8.5-62: Schematic Layout of Matagami Yard........66
Figure 8.5-63: Location Plan - Chapais Community, Chapais Station and Chapais Yard........66
Figure 8.5-64: Schematic Layout of Chapais Yard........67
Figure 8.5-65: Reconstruction of Bachelor River Bridge Drawing (1974)........70
Figure 8.5-66: CN Chapais Subdivision 2016 Timetable........71
Figure 8.5-67: Example of Beam Span Bridge........72
Figure 8.5-68: Example of DPG Bridge........73
Figure 8.5-69: Example of TPG Bridge........73
Figure 8.5-70: Example of TPG Bridge........74

Figure 8.5-71: Inspection of O'Sullivan River Bridge....75
Figure 8.5-72: General View of the Bridge at KP 146.50....76
Figure 8.5-73: General View of the Bridge at KP 163.85....77
Figure 8.5-74: General View of the Bridge at KP 167.59....78
Figure 8.5-75: General View of the Bridge at KP 169.95....79
Figure 8.5-76: General View of the Bridge at KP 191.15....80
Figure 8.5-77: General View of the Bridge at KP 196.86....81
Figure 8.5-78: General View of the Bridge at KP 201.72....82
Figure 8.5-79: General View of the Bridge at KP 236.71....83
Figure 8.5-80: General View of the Bridge at KP 156.00....84
Figure 8.5-81: Bridge Scenario Analysis Flowchart....86
Figure 8.5-82: 2D Through Truss Model....87
Figure 8.5-83: Cross Sections of the Truss Bottom-Chord (left) and Plate Girder (right)....87
Figure 8.5-84: Cooper E80 Live Load Diagram....88
Figure 8.5-85: Bridge Capacity Rating Workflow....90
Figure 8.5-86: Typical Structure - DPG....93
Figure 8.5-87: Typical Structure TPG....94
Figure 8.5-88: Typical Structure Through Truss....94
Figure 8.5-89: Return Period Rainfall Rates (mm/hr) at Matagami Station....96
Figure 8.5-90: Return Period Rainfall Amounts (mm) at Matagami Station....97
Figure 8.5-91: Return Period Rainfall Rates (mm/hr) at Chapais Station....97
Figure 8.5-92: Return Period Rainfall Amounts (mm) at Chapais Station....97
Figure 8.5-93: An Example of a Watershed....99
Figure 8.5-94: Overview of the Catchments along the BDHR Alignment....99
Figure 8.5-95: Overview of the Catchments along the Grevet-Chapais Alignment....100
Figure 8.5-96: Example of a CSP Culvert....103
Figure 8.5-97: Example of a Bottomless Structural Steel Plate Arch Culvert....104
Figure 8.5-98: HY-8 Two Sample Results for Culverts Crossing under Grevet-Chapais Alignment....104
Figure 8.5-99: Existing 600 mm Diameter CSP Culvert Crossing Grevet-Chapais Roadbed at KP 132.0....106
Figure 8.5-100: Existing 1000 mm Ø and 600 mm Ø CSP Culverts Crossing Grevet-Chapais Roadbed at KP 164.1....106
Figure 8.5-101: Existing ±1500 mm Ø CSP Culvert Crossing Grevet-Chapais Roadbed at KP 220.1....107
Figure 8.5-102: Existing 3 x 2400 mm CSP Culverts Crossing Grevet-Chapais Roadbed at KP 229.2....107
Figure 8.5-103: Signalling System Configuration....111
Figure 8.5-104: Schematic view of railway lines and installations....114
Figure 8.5-105: Schematic View of the Lines with Electrical Facilities....115
Figure 8.5-106: Potential Traffic Demand Evaluated for the Proposed Project....116
Figure 8.5-107: Train Speeds for a Freight Train Travelling from Waskaganish to the siding at KP 60....120
Figure 8.5-108: Rolling Stock Maintenance Shop Details....130
Figure 8.5-109: Example of a Storage Warehouse – Schematic Layout....131
Figure 8.5-110: Storage and Rail Loadout – Schematic Layout (Estimated and Indicative)....132
Figure 8.5-111: Reinforced Containers for the Transport of Spodumene....134

Figure 8.5-112: Crane (left), Container Stacker (right) 134
Figure 8.5-113: 64' Flat Car Transporting Three ISO containers (top), and Three REUs (bottom).....135
Figure 8.5-114: Covered Hopper for the Transport of Bulk Spodumene 136
Figure 8.5-115 : Bulkhead Flat Car for the Transport of Logs 137
Figure 8.5-116: Woodchip Gondola 138
Figure 8.5-117: Mill Gondola with Plastic Cover 139
Figure 8.5-118: 89' Flat Car 140
Figure 8.5-119: Typical Tank-tainer 141
Figure 8.5-120: Bottom Dump Ballast Car 142
Figure 8.5-121: Side Dump Ballast Car 142
Figure 8.5-122: Box Car 143
Figure 8.5-123: Typical High Horsepower Locomotives. Manufactured by Progress Rail (left) and Wabtec (right) 144
Figure 8.5-124: Scheduled Maintenance Distribution for Locomotives 147
Figure 8.5-125: Pickup Truck (Left), Railroad Truck (Right) 152
Figure 8.5-126: Hi-rail truck (left), Maintenance Trolley (Right) 152
Figure 8.5-127: Railroad Excavator Left), Ballast Regulator (Right) 152
Figure 8.5-128: Railway Staff Organization Chart 155
Figure 8.5-129: Projected Traffic Growth over Project Life 165
Figure 8.5-130: Station Locations 166
Figure 8.5-131: Typical Passenger Coach 171
Figure 8.5-132: Typical Genset Car 171
Figure 8.6-1: Track and infrastructure OPEX, 2022M$ 189
Figure 8.6-2: Rolling Stock Maintenance Costs 190
Figure 8.6-3: Cash flow for the construction of the BDHR. All costs in millions CAD. 191
Figure 8.6-4: Cash flow for the construction of the Grevet-Chapais Railway 191
Figure 8.6-5: Cash flow for the community access roads and the Route du Nord. All costs in millions CAD. 192
Figure 8.7-1: Community Access Road Location Plan 193
Figure 8.7-2: Street View July 2022 - Curve with radius too small at kilometer 69 (Route du Nord) 198
Figure 8.7-3 : Street View July 2022 - Curve at kilometer 242 (Route du Nord) 198
Figure 8.7-4: Line of sight inside a curve 199
Figure 8.7-5: Example of profile between stations 240+498 to 240+743 201
Figure 8.7-6: Vertical curves 201
Figure 8.7-7 Visibility in a vertical crest curve 202
Figure 8.7-8: Roadway cross section 203
Figure 8.7-9: Inspected culverts on the Route du Nord 205
Figure 8.7-10: Site with a lack of crash barrier for a culvert 206
Figure 8.7-11: Example of sign for presence of moose 206
Figure 8.7-12: Traffic control barrier for works 207
Figure 8.7-13: Statistiques de vent et météo Eastmain River Airport - Windfinder 208
Figure 8.7-14: Statistiques de vent et météo Aéroport de Chibougamau/Chapais - Windfinder 208
Figure 8.7-15: High voltage line on Route du Nord 211
Figure 8.8-1: Interactive Map Excerpt Showing Traffic Flows 214

Figure 8.8-2: Map of the Sustainable Snowmobile Circuits....215
Figure 8.8-3: Suggested Mistissini Road Section....216
Figure 8.8-4: Location of Proposed Options....217
Figure 8.8-5: Distribution of Construction Costs....223
Figure 8.8-6: Distribution of Roadway Cost....224
Figure 8.9-1: Overview of the CN Subdivisions....225
Figure 8.9-2: Crossing on Matagami Sub (25 mph Speed Limit)....227
Figure 8.9-3: CN Three-Year Rail Network Plan....228
Figure 8.9-4: Bridge Site and Road Pictures by VEI....238
Figure 8.9-5: Proportion of the forest road and snowmobile trail relocation cost on the overall project costs....241
Figure 8.10-1: Division of Capital Cost for Railways....242
Figure 8.10-2: Division of Capital Cost for Roads....243

List *of* Appendices

Appendix 6.1 – Geotechnical Geomorphology
Appendix 6.2 – Railway Projects Comparison
Appendix 6.3 – Railway Design Criteria
Appendix 6.4 – Railway Geometry
Appendix 6.5 – Railway Schematics and Profiles
Appendix 6.6 – Topography
Appendix 6.7 – Railway Hydrology and Drainage
Appendix 6.8 – Railway Earthwork Cross Sections
Appendix 6.9 – Grevet Chapais Railway Bridge Inspection
Appendix 6.10 – Railway Bridge Load Rating Reports
Appendix 6.11– Railway Detailed Unit Costs
Appendix 6.12 – Railway Level Crossings List
Appendix 6.13 – Construction Schedule
Appendix 6.14 – Environmental Protection Measures
Appendix 6.15 – Full Railway Electrification
Appendix 6.16 – Grevet Chapais trail study
Appendix 6.17 – Mistissini road package
Appendix 6.18 – Railway battery electric propulsion
Appendix 6.19 – Road cost estimate
Appendix 6.20 – Road culvert conditions
Appendix 6.21 – Road geometry
Appendix 6.22 – Road plan profile drawings
Appendix 6.23 – Route du Nord package
Appendix 6.24 – Hydrology bridge
Appendix 6.25 - Wemindji Access Road

8. TECHNICAL STUDY

8.1 ACRONYMS, ABBREVIATIONS AND UNITS

Acronyms	Definition
$	Dollar
$M	Million Dollar
%	Percent
°C	Celsius
2D	Two-dimensional
3D	Three-dimensional
AACE	Association for the Advancement of Cost Engineering
AAR	Association of American Railroads
AC	Alternating Current
ACS	Access Control Subsystem
ADA	Advance Design America
AISC	American Institute of Steel Construction
AM	Ante Meridiem (Before Midday)
AREMA	American Railway Engineering and Maintenance-of-Way Association
ASTM	American Standard Test Method
ATS	Automatic Train Stop
ATV	All-Terrain Vehicle
BDH	Billy Diamond Highway
BDHR	Potential Billy Diamond Highway Railway
BHN	Brinell Hardness
BMS	Beam Span
c′, ϕ′	Drained Strength Parameters
CAD	Canadian Dollar
CAPEX	Capital Expenditure
CBI	Computer-Based Interlocking
CBTC	Communications Based Train Control
CCTV	Closed-Circuit Television
CDC	Cree Development Corporation
CGVD28	Canadian Geodetic Vertical Datum of 1928
CIO	Community Information Officer
cm	Centimetre
CN	Canadian National Railways
CROR	Canadian Rail Operating Rules
CSA	Canadian Standards Association

Acronyms	Definition
CSP	Corrugated Steel Pipe
CSRS	Canadian Spatial Referencing System
CWR	Continuous Welded Rail
DD	Detailed Design
DEM	Digital Elevation Models
DGNSS	Differential Global Navigation Satellite System
DL	Dead Load
DPG	Deck Plate Girder
E.E.P.F.	Eeyou Eenou Police Force
ECP	Electronically Controlled Pneumatic
EIA	Environmental Impact Assessment
EN	European Standards
EPA	Environmental Protection Agency
EPCM	Engineering, Procurement, and Construction Management
ETCS	European Train Control System
EU	European Union
FHWA	Federal Highway Administration
FS	Factor of Safety
ft	Foot
ft^2	Square Foot
GBO	General Bulletin Order(s)
GC	General Contractor
GCR	Grevet-Chapais Railway
GHG	Greenhouse Gas
GP	Poorly Graded Gravel
GPS	Global Positioning System
GSC	Geodetic Survey of Canada
GW	Well Graded Gravel
GW-GM	Well Graded Gravel with Silt
ha	Hectare
HBWD	Hot Box and Wheel Detector
HEP	Head End Power
HFR	High Frequency Rail
HH	Head-Hardened
HP	Horsepower
hr	Hour
HSM	Highway Security Modules

Acronyms	Definition
HTMG	Heavy Track Maintenance Gang
ID	Identifier
IM	Impact
in	Inch
ISO	International Organization for Standardization
IXL	Interlocking (Railway Signalling)
kg	Kilogram
km	Kilometre
km/h	Kilometre per Hour
kN	Kilonewton
kN/m^3	Kilonewton per Cubic Meter
KP	Kilometric Point
kPa	Kilopascal
ksi	Kilo Pound per Square Inch
kV	Kilovolt
kW	Kilowatt
LAN	Local Area Network
lb	Pound (mass)
LIDAR	Laser Imaging, Detection, and Ranging
lin ft	Linear Foot
LL	Live Load
LRU	Line Replaceable Unit
LTE	Long-Term Evolution
m	Metre
M	Million
m/s	Metre per Second
m^2	Square Metre
m3	Cubic Metre
max.	Maximum
MELCC	Ministère de l’Environnement et de la Lutte contre les Changements Climatiques
MEP	Mechanical, Electrical and Plumbing
MERN	Ministère de l'Énergie et des Ressources naturelles
MFFP	Ministère des Forêts, de la Faune et des Parcs
min	Minute
min.	Minimum
mm	Millimetre
MoW	Maintenance-of-Way

Acronyms	Definition
mph	Miles per Hour
MRE	Manual for Railway Engineering
MRT	Minimum Running Time
MSCN	Multi Service Communications Network
MTM	Modified Transverse Mercator
MTMDET	Ministère des Transports, Mobilité Durable et Électrification des Transports du Québec
MTPA	Million Tonnes per Annum
MTQ	Ministère des Transports du Québec
MW	Megawatt
N	North
N/A	Not Applicable
NAD83	North American Datum of 1983
NBCC	National Building Code of Canada
NMS	Network Management System
No.	Number
NTP	Notice to Proceed
NTS	National Topographic System
Ø	Diameter
OCC	Operations Control Center
OCS	Overhead Catenary System
OE	Owner's Engineer
OEM	Original Equipment Manufacturer
OPEX	Operating Expense
PGA	Peak Ground Acceleration
PGRE	Practical Guide to Railway Engineering
PGV	Peak Ground Velocity
PM	Post Meridiem (After Midday)
PMO	Project Management Operations
psi	Pound-Force per Square Inch
PTC	Positive Train Control
PTZ	Pan-Tilt-Zoom
RCS	Radio Communication subsystem
REU	Reinforced Container
RFP	Request for Proposal
RFQ	Request for Quotation
ROW	Right of Way
RTC	Rail Traffic Controller (Dispatcher)

Acronyms	Definition
S	Speed
S&C	Switch and Crossing
S&T	Signalling & Telecommunications
Sa	Spectral Acceleration
SCADA	Supervisory Control and Data Acquisition subsystem
SCS	Soil Conservation Service
SDBJ	Société de Développement de la Baie-James
SFNQ	Société Ferroviaire du Nord Québécois
SIG/TEL	Signalling & Telecommunications
SIL	Safety Integrity Level
Sr	1-in-50-year associated rain load
Ss	1-in-50-year ground snow load
su, cu	Undrained Shear Strength
t/m^3	Tonne per Cubic Meter
TBD	To be determined
TC	Transport Canada
TETRA	Terrestrial Trunked Radio
TIN	Triangulated Irregular Network
TMG	Track Maintenance Gang
TOP	Track Occupancy Permit
TOR	Top of rail
TPA	Tonne per Annum
TPC	Train Performance Calculator
TPG	Through Plate Girder
TT	Through Truss
VEI	Vision Eeyou Istchee Consortium
VWP	Vibrating Wire Piezometer
W	West
W.C.	Water Closet (Toilet)
WAN	Wide Area Network
WFD	Wheel Flaw Detectors
WMS	Weigh-in-Motion System
XXX+XXX.XX	Kilometre Point Chainage

8.2 Scope and Objective

This volume describes all the engineering work to evaluate the feasibility of the infrastructure proposed in Phase 1, namely:

- Upgrades to the access roads between the Billy Diamond Highway and the Cree communities of Waskaganish, Eastmain and Wemindji.
- Upgrade to the access road between the Route du Nord and the Cree community of Nemaska.
- A railway line following, as much as possible, the Billy Diamond Highway between the town of Matagami and km 253 (Rupert River bridge) of the Highway.
- A return to service for the railway line between Grevet (Lebel-sur-Quévillon) and Chapais (approximate distance of 165 km).
- Trans-shipment areas along the Billy Diamond Highway and the Grevet-Chapais railway corridors. Located around km 238 for the Billy Diamond and at Chapais for the Grevet Chapais line.

In the execution of its work, the study team performed the following activities:

- Planning technical field work;
- Conducting visual surveys;
- Interpreting photos, calibrating;
- Validating LIDAR imagery;
- Preparing documentation for geotechnical sampling work;
- Preparing an inventory of aggregate materials;
- Collaborating with the Community Information Officers (CIO) via workshops and meetings;
- Preparing preliminary recommendations related to design, operation and maintenance of the railway infrastructure for both freight and passenger traffic, based on the results of the market survey and field work;
- Producing timelines and overall costs involved in the construction of the infrastructure.

8.3 Geotechnical and Geomorphology Investigation

As part of the Feasibility Study, the scope of work included carrying out a Preliminary Geotechnical Investigation for each of the transportation infrastructure corridors of the project.

The preliminary geotechnical investigation was carried out to determine the site characteristics with regards to the nature and properties of granular materials in place, organic soil deposits, bedrock, and the native mineral soils. The information gathered during this investigation was used to estimate the baseline in-situ conditions at the different sites that feeds the Feasibility Study for the upgrading of these transportation infrastructures.

Preliminary geotechnical investigation was conducted for the following transport infrastructures:

- Potential Billy Diamond Highway Railway;
- Potential Grevet-Chapais Railway;
- Community Access Road (Eastmain, Waskaganish, Wemindji and Nemaska), and;
- Route du Nord.

Before undertaking any geotechnical work on the targeted territory, Vision Eeyou Ischee has ensured to obtain the necessary authorizations and permits for the execution of the work:

- Land use (MERN);
- Tree cutting (MFFP, MRNF), and
- Drilling in wetlands and at proximity of watercourses (Declaration of compliance - MELCC).

All activities conducted on the territory namely land occupancy, wood cutting, exploration trenches and drilling were carried out in compliance with the existing laws and regulations at the time of writing of this report.

Before initiating intrusive field works, including preliminary geotechnical investigations, a request was submitted to Info-Excavation and the owners of sites to identify underground public services present in the vicinity of the exploration locations. Also, the employees who participated in this project familiarized themselves with all the relevant Safe Work Practices (SWPs) and the health and safety plan prior to beginning of any fieldwork. In addition, pre-job Health and Safety Checklist, that identifies any health and safety risks, was filled out and signed by all the participants in the fieldwork, including the sub-contractors.

Preliminary geotechnical investigations were carried out on site over a total of 32 weeks from mid-February to mid-November 2022. Table 8.3–1 below summarizes all the geotechnical field investigations that were carried out within the scope of this project.

Table 8.3–1: Summary of the Preliminary Geotechnical Investigation

Transport Infrastructure	Preliminary Geotechnical Field Investigation
Waskaganish Access Road	15 boreholes with road traffic management
Eastmain Access Road	14 boreholes with road traffic management
Wemindji Access Road	15 boreholes with road traffic management
Nemaska Access Road	4 boreholes with road traffic management
Route du Nord	153 boreholes with road traffic management
Potential BDH Railway	41 boreholes & 198 manual test holes on peat
Grevet-Chapais Railway	35 boreholes

The borehole locations were selected in order to obtain a representative characterization of the in-situ conditions with regards to low points, culverts, bridges, streams, peat bogs and embankments. As for the roads, the boreholes were generally positioned at regular intervals of 3 km to 5 km on the road. All boreholes were positioned on site using a 3-m precision handheld GPS before drilling. When boreholes were drilled at a different location than initially targeted, the new coordinates were recorded by the field technician, no geodetic elevations were measured. All the boreholes were carried out directly at existing ground surface, or on the gravel surface course of the roads. All depths mentioned in the geotechnical reports refer to the surface at the time of the works « meter below ground surface (mbgs) ».

All geotechnical soil samples recovered from the boreholes were placed in moisture-proof bags, appropriately labelled, and returned to the Laboratory for detailed visual examination, geotechnical classification and geotechnical laboratory analyses. All of these results are discussed in the geotechnical reports presented in

Appendix 6.1 of this report (Volume 6). The soil samples collected during this study will be stored for a period of 12 months after the issuance of the final report, after which they will be discarded unless otherwise directed.

Surficial material mapping was conducted along a 250-m wide corridor centered on the potential BDH railway and Route du Nord alignments. Surficial material mapping uses training, experience and expert judgement in the identification and delineation of geomorphological landforms visible on the earth's surface to interpret and classify the landscape. It provides the basis to support the geotechnical study and helps with the decision-making process to be conducted as part of the following phases of the project. The final mapping was updated based on the geotechnical field investigation results.

The collected information has been complied into multiple geotechnical reports dedicated to each infrastructure. The following reports are presented in appendix 6.1.1 to 6.1.5 of this report (Volume 6):

- Preliminary Geotechnical Investigation - Waskaganish Access Road
- Preliminary Geotechnical Investigation - Eastmain Access Road
- Preliminary Geotechnical Investigation - Wemindji Access Road
- Preliminary Geotechnical Investigation - Nemaska Access Road
- Preliminary Geotechnical Investigation - Route du Nord
- Preliminary Geotechnical Investigation - Potential BDH Railway
- Preliminary Geotechnical Investigation - Grevet-Chapais Railway

Each report provides engineering input related to the geotechnical design aspects of the different infrastructure based on our interpretation of the available subsurface information, and project requirements. The reports include the following information:

- Introduction: This section provides an overview of the scope of work and a description of the specific infrastructure.
- Methodology: This section describes the various aspects of the preliminary geotechnical investigation, including utility locates, health and safety procedures, field investigation methods, site survey techniques, and laboratory testing procedures.
- Results: This section presents the findings of the investigation, including a description of the subsurface stratigraphy, granular material in place, and groundwater conditions.
- Discussions and Recommendations: This section provides a detailed analysis of the soils in place and offers preliminary design recommendations based on the investigation results.

The discussion and recommendations presented in these reports were intended to provide the designers with functional information for planning and preliminary design purposes only. Furthermore, this information will be reviewed with Cree tallymen and land users at later stages to allow them to validate the collected information as well as any other relevant data.

It's important to note that a detailed geotechnical investigation and design report, which includes additional boreholes, will be required prior to or during the final design stage of the project for each of the transport infrastructures.

8.4 Potential Borrow Sources and Quarry Sites

One of the objectives of the feasibility study was to evaluate the availability of borrow and quarry materials to meet the proposed project's construction and upgrade needs.

For this purpose, an assessment of the potential borrow sources and quarry sites was conducted for the main infrastructure included within the Phase I scope:

- Potential BDH railway;
- Grevet-Chapais railway;
- Community access road (Eastmain, Waskaganish, Wemindji and Nemaska), and;
- Route du Nord.

The preliminary assessment was carried out by interpreting photos, available LIDAR and DEM (digital elevation model) data, as well as recent publicly accessible images (Google Earth and Esri World Imagery), to identify terrain features that are likely to be favorable for the extraction of borrow materials (granular materials) or parent rocks. The number of potential sites identified was determined based on the material requirements for the construction of each transport infrastructure, which mainly consists of MG-112 and crushed stone for the base/sub-base layer and ballast/sub-ballast. This is not an exhaustive inventory of all available materials. Based on the results of the preliminary assessment, a field geotechnical study was planned to evaluate the quality and quantity of borrow material (volume) of the delineated site. The number of sites, and their status, identified along each of the transport infrastructures included in phase 1 is summarized in Table 8.4–1.

Table 8.4–1: Summary of the potential borrow source and carry sites identified along the transport infrastructure (Phase I)

Infrastructure	Potential Granular Borrow Sources			Potential Quarry Sites		
	Existing	New	Selected for geotechnical field investigation	Existing	New	Selected for geotechnical field investigation
Potential BDH Railway	4	1	5	2	4	6
Grevet-Chapais Railway	2		2		3	3
Waskaganish Access Road	1	3		2		2
Eastmain Access Road		3	2		1	1
Wemindji Access Road	1	4	-	1	3	2
Nemaska Access Road	1		-	1		1
Route du Nord	10	1	N/A	3	5	N/A

The initial objective of the geotechnical field investigation was to proceed with the exploration of twenty-three (23) sites. Since the access authorization was denied for one of them, a total of twenty-two (22) sites were investigated. Of these, nine (9) were potential granular deposits and fifteen (15) were potential quarry sites. The completion of a geotechnical field investigation for the potential borrows sources and quarry sites identified along the Route du Nord was not part of this mandate. The Summary of field investigation program for granular materials and bedrock is presented in Table 8.4–2.

Table 8.4–2: Summary of Borrow Source Field Investigation

Transport Infrastructures		Number of Investigated potential quarry sites	Number of boreholes	Number of Investigated potential borrow sources	Number of test pits
Railways	Grevet-Chapais	3	6	2	16
	Potential BDH railway	6	12	5	38
Community Access Roads	Nemaska	1	2	-	-
	Waskaganish	2	4	-	-
	Eastmain	1	2	-	-
	Wemindji	2	4	-	-

Based on the desktop assessment and geotechnical field investigation results, a specific report was prepared for each of the transport infrastructure targeted within Phase I. In each report, the following information are provided:

- Introduction precising the scope of work and the material requirements for the specific infrastructure;
- Methodology of the different aspect of the assessment including desktop assessment, geotechnical field investigation, laboratory testing, calculation of potential suitable material volume and site potential classification;
- Results including a description of each delineated site, area, expected material thickness, environmental constraints, field investigation and laboratory results, and an estimate of the potential suitable material volume;
- Discussion and conclusion regarding material balance in relation to the material needs and available volumes for different types such as granular materials and bedrock.

In addition, a series of appendices provide a general location map and site-specific figure of each site, the test pits and borehole reports, the detailed laboratory test results, and a photographic album of the excavated materials and bedrock cores.

The following reports are presented in appendix 6.1:

- Potential Borrow Sources and Quarry Sites Assessment - Potential BDH Railway (Matagami to Rupert River bridge);
- Potential Borrow Sources and Quarry Sites Assessment – Potential Grevet-Chapais Railway;
- Potential Borrow Sources and Quarry Sites Assessment - Waskaganish Access Road;
- Potential Borrow Sources and Quarry Sites Assessment - Eastmain Access Road;
- Potential Borrow Sources and Quarry Sites Assessment - Wemindji Access Road;
- Potential Borrow Sources and Quarry Sites Assessment - Nemaska Access Road.

8.5 PROPOSED BILLY DIAMOND HIGHWAY RAILWAY AND GREVET-CHAPAIS RAILWAY

8.5.1 History background of the Grevet-Chapais line

The towns of Chapais and Chibougamau are two small and isolated towns in northern Quebec. Their economy is driven by mining and lumbering. Northern Quebec is rich in valuable minerals and the towns of Chapais and Chibougamau both sit on a rich mineralized fault.

In 1946, the Canadian National Railways (CN) had decided to open access to land north of the National Transcontinental Railway in the Senneterre, QC area. This decision was made after the end of Second World War based on the perceived need for more arable land for the returning veterans and their brides and the need for timber for post-war redevelopment.

Construction started at Barraute, QC, on the National Transcontinental Railway, in 1947. The 39-mile-long line was completed in 1948 to a point close to the Bell River; a terminus that became know as Beattyville. Later, the decision was taken to further extend this line all the way to Chibougamau, and construction began in 1954 on the 161-mile-long extension. The line officially opened on October 7, 1957, as the CN Chapais subdivision. The official opening ceremony took place in Chibougamau on November 6, 1957. The CN operated mixed trains combining passenger and freight service on the Chapais subdivision.

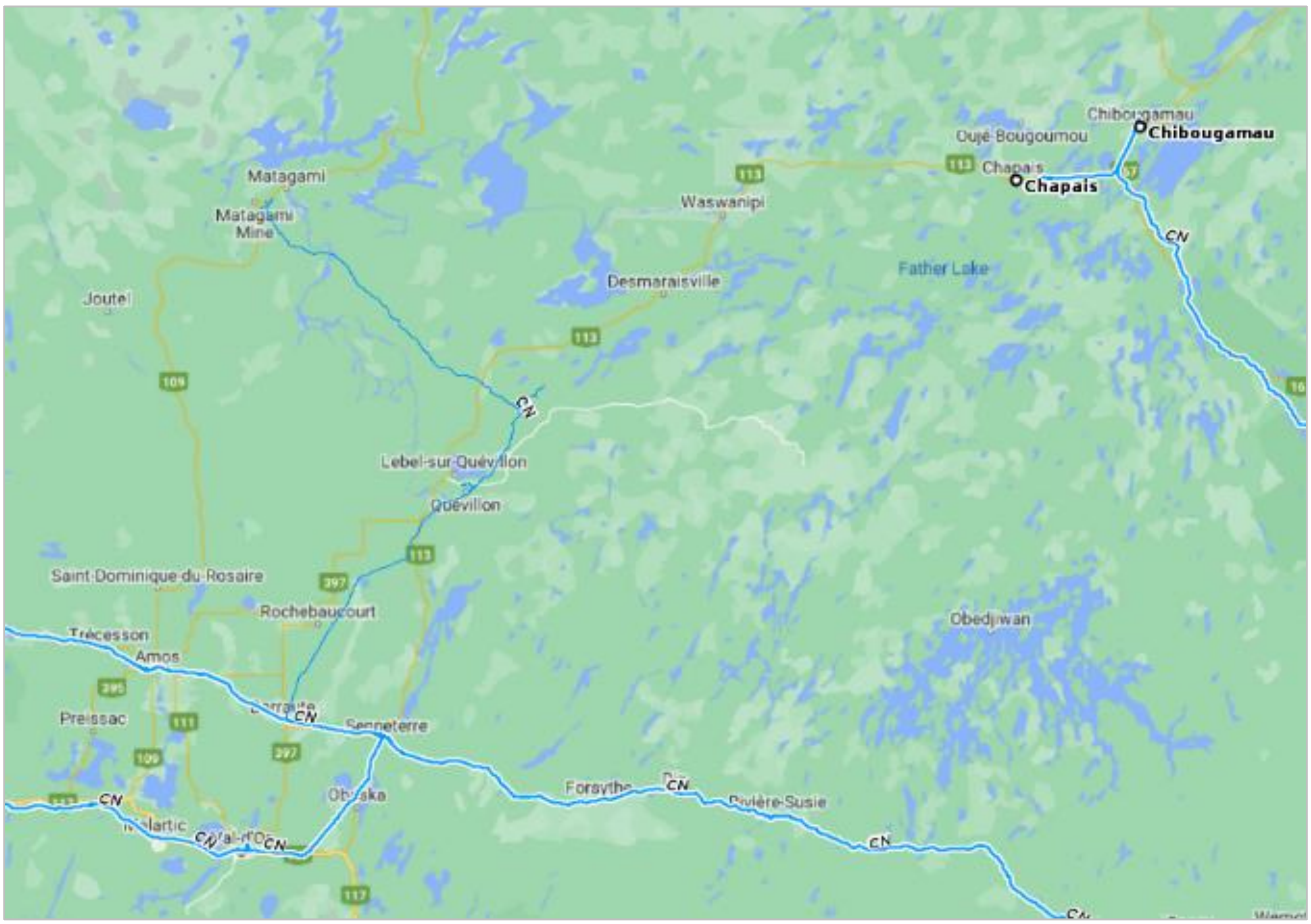

Figure 8.5-1: Map of current CN subdivisions (blue) in Chibougamau - Senneterre Area

Concentrated ore was the main commodity being transported westwards by the CN from Chapais and Chibougamau followed by lumber and by-products of lumber transformation such as wood chips used to make paper. Between 1983 and 1986, an average of 11,500 carloads per year were carried on the Chapais subdivision.

However, from the end of the 1980's, mining operations declined in the Chapais – Chibougamau region. The Opemiska Mine was a major provider of copper and gold ore being transported over the Chapais subdivision to the Horne smelter in Rouyn-Noranda. Its closure in 1991 resulted in a significant drop in the demand for rail transport and a loss of income for the CN. Other users in the area, such as Hydro Quebec also began using the road network, notably Highway 113, for transportation of construction materials for their various projects.

As a result, the CN invested less for infrastructure maintenance; wagons and tracks deteriorated on the Franquet – Chapais section, and train speed was reduced, driving remaining users to trucking rather than rail shipment. The CN had already made the decision to abandon the Franquet – Chapais section by 1986. However, the railway had already left its mark on the surrounding area, given the railway was the first transportation corridor opened across the territory, many people established their land around the train corridor.

Figure 8.5-2: CN freight train loading ore concentrate at the mine in Chapais, 1976

The Billy Diamond Highway was initially constructed to facilitate the construction of the James Bay Hydroelectric Project in the 1970’s. The 620 km road extending from Matagami in the south to Radisson in the north provides an essential link for passengers and freight moving through the territory, as it connects many of the Cree communities which branch off from the main route.

8.5.2 Overview

An overview of the proposed Billy Diamond Highway railway and Grevet-Chapais railway is provided below: the Billy Diamond Highway Railway (BDHR) is on the upper left-hand side, and the Grevet-Chapais Railway on the lower right-hand side.

Figure 8.5-3: Environmental Conditions

8.5.3 Environmental Conditions

Temperature and precipitation data for Matagami and for Chapais are provided in the table below.

Table 8.5–1: Environmental Conditions at Matagami and Chapais[1]

Description	Matagami	Chapais
Average daily maximum temperature	5.5 °C	5.2 °C
Average daily minimum temperature	-6.9 °C	-5.2 °C
Extreme maximum temperature	39.4 °C	35 °C
Extreme minimum temperature	-44.1 °C	-43.3 °C
Temperature range	-23 ; 24°C	-24 ; 22 °C
Extreme daily maximum precipitation (rain)	73.7 mm	75 mm
Extreme daily maximum precipitation (snow)	37.2 cm	32.4 cm
Average annual precipitation (rain)	617.7 mm	659.7 mm
Average annual precipitation (snow)	313.8 cm	301.7 cm

[1] Source: eldoradoweather.com

The National Building Code of Canada (NBCC) provides climate data for Val-d'Or, which is the closest location to the Billy Diamond Highway and Grevet-Chapais Railway. Climate data from Val-d'Or will be used for the design of structures on both railways.

Table 8.5–2: Wind Data at Val-d'Or[2]

Location	Design Temp Jan	Design Temp July Dry, Wet	15 Min Rain (mm)	One Day Rain 1/50 (mm)	Annual Rain (mm)	Annual Precipitation (mm)	Snow Load, kPa 1/50 Ss, FAi	Hourly Wind Pressure, kPa 1/10, 1/50
Val-d'Or	-36	29, 21	20	86	640	925	3.4, 0.3	0.25, 0.32

Seismic data from Val-d'Or will also be used for the BDHR and the GCR.

Table 8.5–3: Seismic Data at Val-d'Or[3]

Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	Sa(5.0)	Sa(10.0)	PGA	PGV
0.135	0.093	0.056	0.029	0.0076	0.0032	0.081	0.074

The geotechnical site class C will be considered for seismic calculations until the geotechnical investigation reveals otherwise.

8.5.4 Right-of-Way (ROW)

The proposed Right-of-Way (ROW) is the area of land occupied by the proposed project. It is defined by three essential parameters which are the horizontal alignment, the longitudinal profile (vertical alignment) and the typical cross sections used.

- The horizontal alignment responds to several considerations, namely the geometric criteria used, the cost of works, the constraints and obstacles encountered along the chosen route.
- The longitudinal profile is also defined by the specified vertical geometric criteria and their combination with the horizontal alignment criteria. It is developed taking the costs of construction into consideration by minimizing the impacts of unavoidable constraints along the route.
- The typical cross sections are applied to the design of homogeneous sections which have similar characteristics. These characteristics are defined by the geotechnical conditions, the presence of peat bogs, the height of the embankments and cuttings, and underlaying soil conditions.

For the BDHR line, the area (footprint) of the right-of-way is approximately 732 ha, this area includes two rail yards, two rail stations, and three rail sidings.

For the Grevet-Chapais line, the estimated footprint is 592 ha, it is defined by the existing footprint according to the CN plans in our possession and additional surfaces occupied by one yard, two stations and two sidings.

8.5.5 Fencing

Fencing has not been considered for the general Right-of-Way of the railway because its use presents significant barriers to the movement of wildlife, and Cree land users. However, fencing is also required to prevent, or control,

[2] Source: National Research Council Canada
[3] Source: National Research Council Canada

public access is provided at locations where there are particular safety issues that are best managed by preventing or controlling public access such as freight yards, stations, sidings and bridge approaches. Approximately 7,300 m of 4ft Woven Wire and 10,300 m of 6-ft Chain Link are needed for the BDHR and approximately 4,200 m of 4-ft Woven Wire and 3,700 m of 6-ft Chain Link for the GC line.

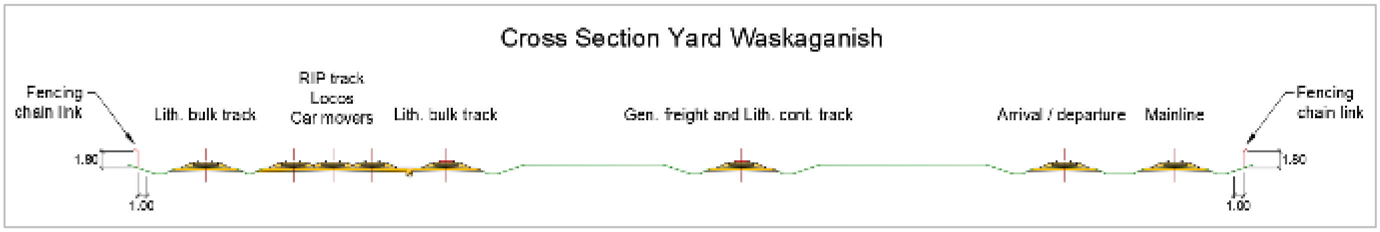

Figure 8.5-4: Example of Typical Fencing Location

8.5.6 Fauna and Flora

The Cree people have been living in close interaction with the local flora and fauna for generations, with many of these species still holding significant cultural and spiritual importance to the Cree community. As such, it is essential that the proposed BDHR project takes every possible measure to minimize its impact on the surrounding vegetation and wildlife.

The proposed BDHR project is located between parallels 49°40' and 51°20' in the boreal zone of Quebec, which is principally comprised of the black spruce-feather moss forest, the largest bioclimatic domain in Quebec (433,600 km^2), covering 28.4% of Quebec territory. With an average annual temperature of -2.5°C to 0°C, its flora only has 100 to 150 days per year to grow. Only 10 species of trees make up its forest canopy, but the diversity of the vascular flora covers 850 species. The forest contains dense, nearly pure strands of black spruce (*Picea mariana*) with feather moss (*Hypnales*) growing on the mesic mid-slope sites of the region. Other conifers are jack pine (*Pinus banksiana*), balsam fir (*Abies balsamea*), and tamarack (*Larix laricina*). Broad-leaf deciduous trees include trembling aspen (Populus tremuloides), balsam poplar (*Populus balsamifera*) and white birch (*Betula papyrifera*). Herbaceous plants (notably *Clitonia borealis*, Canada mayflower and palmate butterbur) and heath plants (blueberries, Greenland teacups and kalmia angustifolia – sheep laurel) are frequently found under the canopy, while mosses and sphagnum of various species cover a considerable proportion of the forest floor.

Figure 8.5-5: Compact Black Spruce at KP 55

Almost half of North America's birds depend on the boreal forest at certain times of the year. Several species migrate from the south through the boreal forest where they breed, such as shorebirds: swans, geese, ducks, loons, grebes, rails, gulls, kingfishers, cranes, and also small birds such as warblers, vireos, thrushes, kinglets, grosbeaks, sparrows and flycatchers. Other bird species, such as woodpeckers, finches, nuthatches, chickadees, owls, grouse, and crows, can live in the boreal forest year-round because they have adapted to the climate.

The boreal forest is home to many species of mammals, including moose, woodland caribou, black bear and wolf – and smaller species, such as beaver, hare lynx, red squirrel, lemming, and vole.

Canada's boreal forest is home to about 130 species of fish. Most fish species in the boreal region are small, such as minnows and stickleback. Larger species, including walleye, northern pike, lake trout, Arctic grayling, yellow perch, brook trout, whitefish, and burbot, are some of the most common game fish.

The boreal forest has been greatly affected by human activity as there are many large, harvested areas.

Figure 8.5-6: Harvested Area, approximately KP77

Between KP 118+400[4] and KP 224+300 (marked by a red ellipse in the illustration below), there is a high density of woodland caribou (green dots on the map). The alignment of the railroad in this section was designed to be as close as possible to the Billy Diamond Highway in order to avoid trapping caribou and to prevent their concentration in the resulting space between the highway and the proposed railroad, thus allowing them to cross more easily. Caribou are an endangered species, and the directive was to limit the impact of the proposed route on the caribou population.

[4] The standard railway nomenclature for chainages (kilometer points) is used in this section. It does not employ decimal points. PK 118+400 should be read as 118 kilometers and 400 meters.

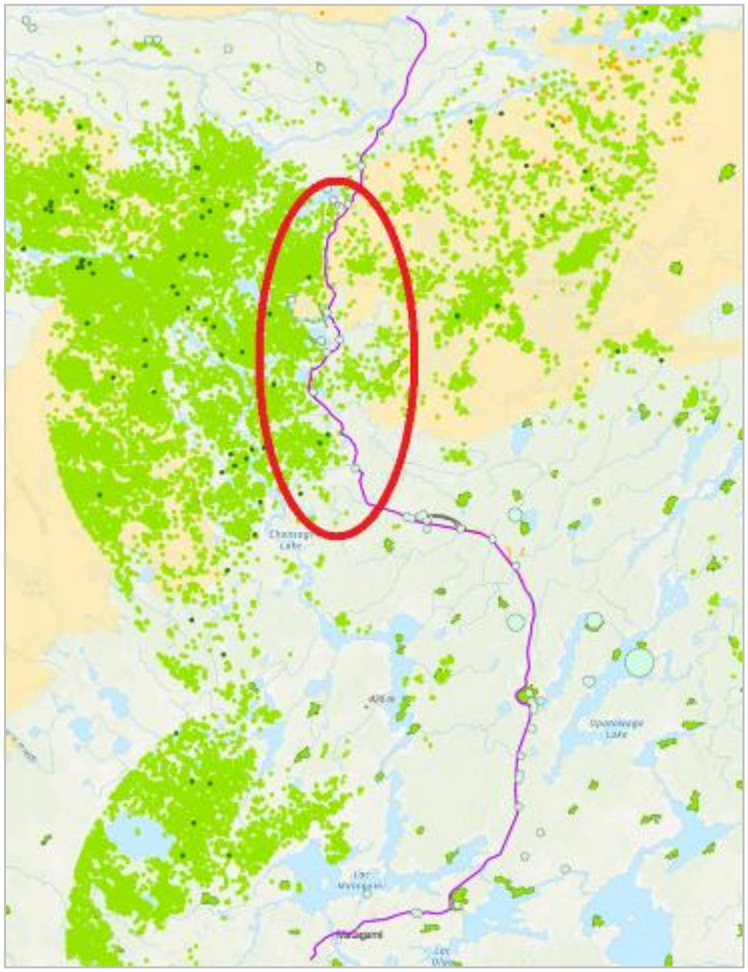

Figure 8.5-7: Distribution of Woodland Caribou

8.5.7 Wetlands

The area being crossed is made up of approximately 50-60% wetlands, which include shallow bodies of water such as ponds and lakes, as well as swamps and bogs. Wetlands are unique ecosystems that support a diverse range of plant and animal species due to their combination of aquatic and terrestrial features. They also provide a variety of environmental conditions and nutrient sources. It's important to note that swamps and bogs within the wetlands contain at least 25% trees or shrubs.

The wetlands are not only ecologically important, but they also hold great cultural significance for the Crees, who have a deep understanding of their ecology and rely on them for activities such as waterfowl hunting and beaver trapping. Due to this importance, there are several laws and regulations in place to protect them. The National Assembly has passed a law called "An Act respecting the conservation of wetlands and bodies of water" which aims to prevent the loss of wetlands and water bodies in Quebec and promote their conservation, restoration, and creation. The Act places the principle of no net loss at its core, meaning that any losses in wetlands and water bodies must be offset by conservation, restoration, or creation of new environments. This approach takes into account the essential functions of wetlands and water bodies and plans the development of the territory from a watershed perspective.

In addition to the "An Act respecting the conservation of wetlands and bodies of water", there are other laws in place to protect wetlands. One such law is the Environment Quality Act, which sets out measures to preserve the quality of the environment and prevent pollution. Another law is "The Law affirming the collective nature of water resources and promoting better governance of water and associated environments", which recognizes water resources as a collective heritage and promotes their sustainable management. Together, these laws aim to protect and preserve wetlands and associated environments for the benefit of present and future generations. The figure below demonstrates the typical presence of wetlands (swamps and bogs) in the region of the BDHR (Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs).

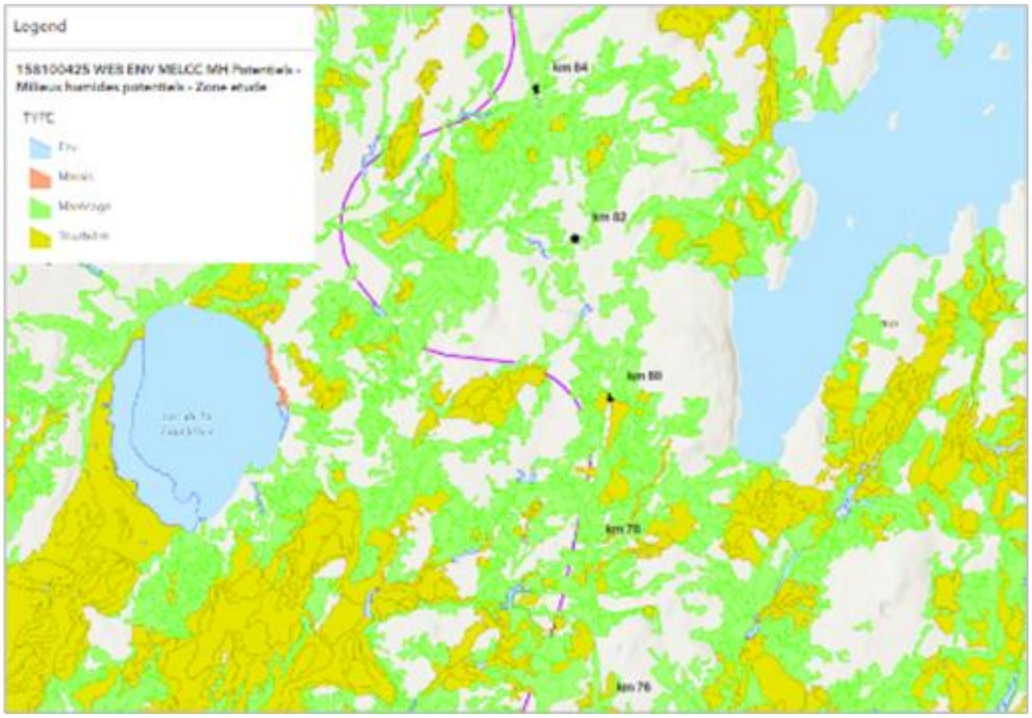

Figure 8.5-8: Wetlands Distribution (approximately KP 76 to KP 84)

Figure 8.5-9: Wetland Observed from Billy Diamond Highway, approximately KP 91+300.

No measures are planned for beaver control, in general the railway alignment bypasses lakes and water points

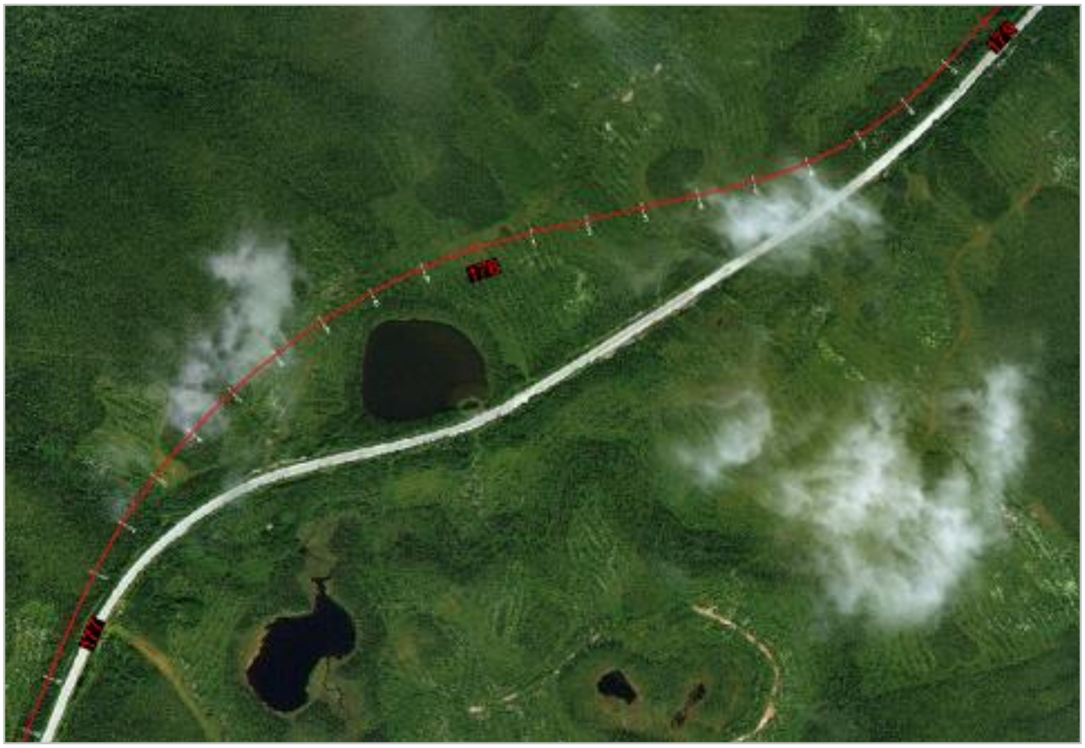

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Figure 8.5-10: Bypassing a Lake, approximately KP 178

8.5.8 Integration of Cree Perspective and Knowledge in the Railway Alignment Design

The most critical element of the feasibility study was the continuous involvement of the Cree communities. Without their input, initial assumptions made by the consortium would not have been validated. Their meaningful participation in the design process is presented below:

1. Continuous Communication:
    a) Individual and group meetings were held with the Tallymen and land users, specifically those whose traplines would be intersected by the proposed railway. A process of validation of existing land use data was enabled by these meetings where the land users were presented with the proposed alignments and given an additional opportunity to comment and/or modify the design. Further information on the information gathered from land users is contained in Chapter 9.2 – Cree Land Use of Volume 3.
    b) Below are two photos from a productive workshop that was held with the Tallymen of Waswanipi whereby the proposed railway alignment was shown on the screen and then "walked" through each of the Tallymen traplines as a group. The Tallymen left the meeting feeling they were involved in the process.

Figure 8.5-11: Meeting with Waswanipi Tallymen - July 2022

Figure 8.5-12: Meeting with Waswanipi Tallymen

2. Socio-Environmental Avoidance criteria:

To set some railway alignment guidelines during the design phase, the following criteria were established:

a) Woodland Caribou avoidance

- Initially, the consortium believed it best to set the railway at some distance from the highway to allow for woodland caribou to first cross the railway, and then the highway. However, after discussions with the Cree communities and wildlife experts, it was suggested that the alignment be placed as close as possible to the existing road to avoid trapping the caribou between the road and rail rights of way. This was considered as the top priority for about 100k m of the 250 km of BDHR. The traplines affected by this strategy were N20, N05, N18.

b) Woodland Caribou avoidance

- Initially, the consortium believed it best to set the railway at some distance from the highway to allow for woodland caribou to first cross the railway, and then the highway. However, after discussions with the Cree communities and wildlife experts, it was suggested that the alignment be placed as close as possible to the existing road to avoid trapping the caribou between the road and rail rights of way. This was considered as the top priority for about 100k m of the 250 km of BDHR. The traplines affected by this strategy were N20, N05, N18.

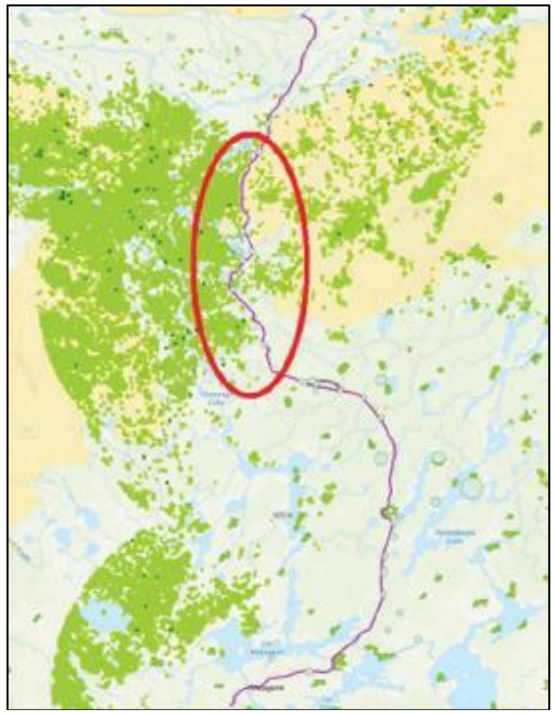


Figure 8.5-13: Woodland Caribou sensitive area

c) Setback distance of 500 m from camps where Tallymen did not want to move their camps.

- During consultations with some Tallymen, they expressed their preference for their camp(s) to remain at their current location, which would require shifting the railway alignment. In instances, such as with Trapline W53, the Tallymen expressed the desire for his camps to not be moved, therefore the proposed railway was moved to the south of the BDH corridor and 500 meters away from the Tallyman's camps. The relocation was used to mitigate potential noise-related issues. A screenshot of this is shown below (purple line is the proposed railway and the road is the black line).

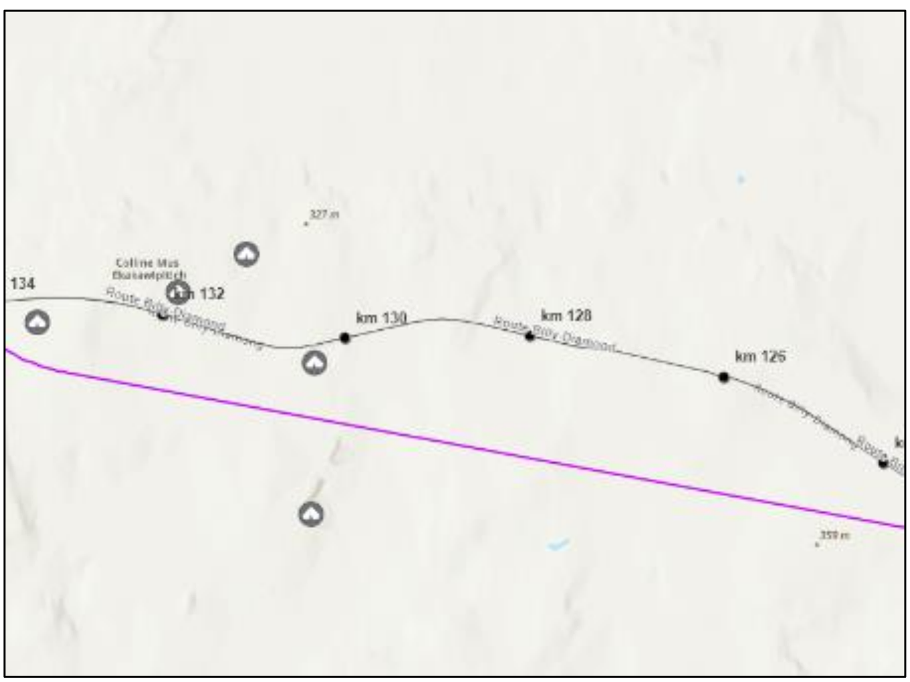


Figure 8.5-14: Tallymen camp avoidance

d) Avoidance of harvesting areas

- The railway alignment considered no setback distance from the harvesting limits so long as the railway right of way limit did not touch the harvesting area limit. An example of this is shown in the adjacent Figure in Trapline W01 (green areas are harvesting areas, the black line is the proposed railway, and the green line is the road). The avoidance of harvesting areas occurred in virtually every Trapline on which the proposed railway crossed.

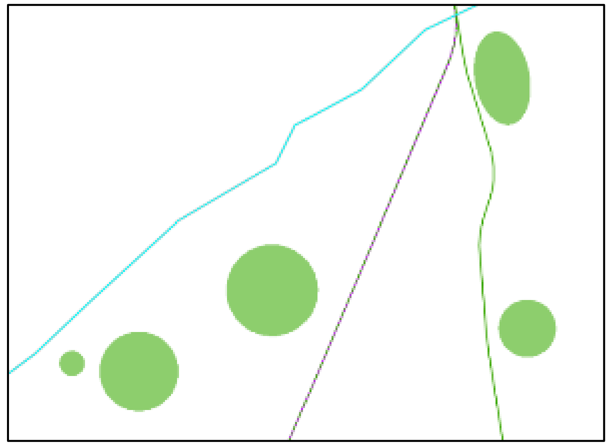


Figure 8.5-15: Avoidance of harvesting areas

3. Other recommendations and information provided by the Cree communities include:

a) Setback distance from archeological sites – ROW must not touch site.

b) Setback distance from Protected Areas – ROW must not touch border.

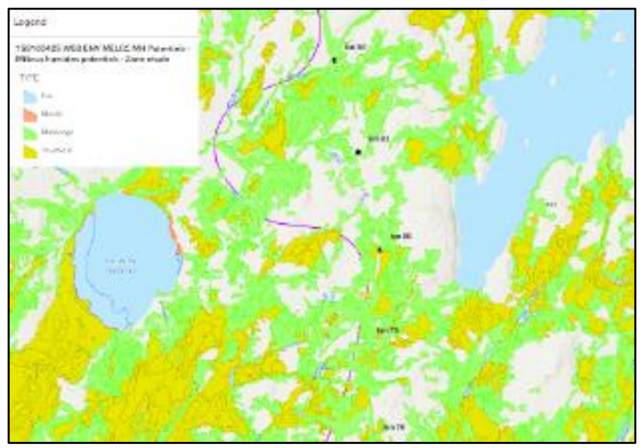


Figure 8.5-16: Open water areas

c) Directions for water crossing structures:

- Avoid earthworks filling in any areas of visible open water (e.g., lakes) and areas where we see wetland against open water.
- We can fill in some wetlands with no open water, but we need to put in culverts to permit water to cross over between areas.

d) Cree land users provided useful information on the quality and location of borrow pits and quarries.

e) Cree land users provided useful information to confirm the presence of swamps and bogs.

8.5.9 Noise Control

The track centerline was designed to avoid dwellings by at least 400 m. However, there are 9 Cree camps located at a distance of less than 400m from the railway axis, therefore we propose protecting these camps by utilizing a 5,500-m noise barrier in total. The material for the proposed noise barrier is local unused cut material from the railway earthworks (unsuitable for embankments, but suitable for the construction of a noise barrier), that will be compacted at 90% modified Proctor. The slopes will be covered with vegetation for protection.

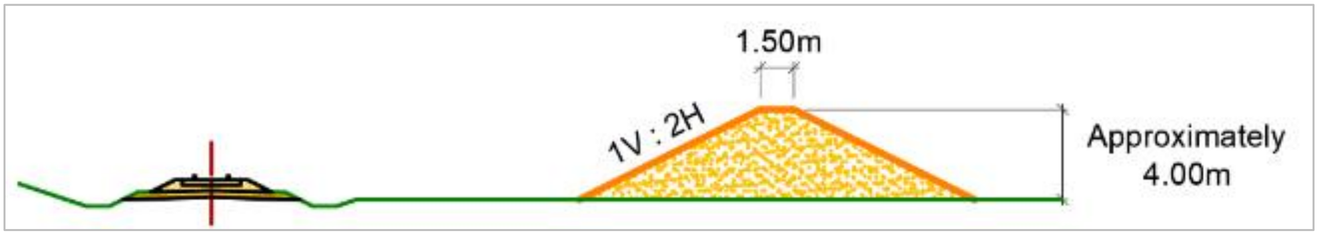


Figure 8.5-17: Dimensions of the Proposed Noise Barrier

8.5.10 Reference Documents and Standards

8.5.10.1 Provincial and Federal Regulations

All relevant federal, provincial, and municipal regulations must be respected when designing the proposed railway.

Provincial Laws and Regulations:

1. Transport Act (chapter T-12)
2. Railway Act (chapter C-14.1)
3. Regulation respecting rail safety (chapter S-3.3, r.2)
4. The codes, regulations, and standards of the Ministère des Transports du Québec (MTQ)
5. Transportation of Dangerous Substances Regulation (chapter C-24.2, r. 43)

Federal Laws and Regulations:

- Canada Transport Act (S.C. 1996, c. 10)
- International Bridges and Tunnels Act (S.C. 2007, c. 1)
- Railway Relocation and Crossing Act (R.S.C., 1985, c. R-4)
- Railway Safety Act (R.S.C., 1985, c. 32 (4e supp.))
- The codes, regulations, and standards of Transport Canada (TC)
- Transportation of Dangerous Goods Act (S.C. 1992, c. 34)
- National Building Code of Canada (NBCC)

8.5.10.2 Standards and Guidelines

Where no specific requirements are set by the MTMD , Transport Canada or the present design criteria document, the railway design will follow the Standards and Specifications described in CN's Engineering Specifications for Industrial Tracks, and CN's Standard Practice Circulars. Where no specific guidance is provided by CN's documentation, the design will be done using the latest version of the Manual for Railway Engineering (MRE) and Practical Guide to Railway Engineering (PGRE) published by the American Railway Engineering and Maintenance-of-Way Association (AREMA).

The design of culverts and bridges must be done in accordance with the following standards and guidelines:

1. Canadian Highway Bridge Design Code, published by the Canadian Standards Association (CSA)
2. AISC Steel Construction Manual, American Institute of Steel Construction
3. FHWA Standards – Federal Highway Administration

8.5.10.3 Datum and Control Line References

Vertical control is based on Geodetic Survey of Canada (GSC) data and a reference/control line is defined along the centreline of the track. All transverse dimensions will be taken from this control line. The vertical profile of the control line is taken at the top of rail (TOR).

8.5.11 Comparison to Other Similar Projects

Numerous studies have been conducted that are similar to the proposed LGA project and are listed in Appendix 6.2 These include SFNQ, Bloom Lake, Baffinland, Tshiuetin, HFR and many others. To demonstrate the similarity, a matrix indicating some 20 parameters of comparison is included in the same appendix with a level of comparison.

The parameters used for comparison are:

- The class of the track
- The targeted customer
- The length of the track
- The mode of transport
- The design speed
- The type of track installation
- The location

8.5.12 Design Criteria

Design criteria was developed during the first stage of the study and were based on the general characteristics defined in the following table:

Table 8.5–4: General characteristics of the railways

Item	Characteristics
Track gauge	Standard Gauge: 1435 mm (56 ½")
Axle load	32.4 tonnes/axle
Speed limits	Class 3 as defined by Transport Canada: • Freight trains: 40 mph • Passenger trains: 60 mph
Anticipated annual transportation	1.5 MTPA
Signaling system	Automatic Fixed Block
Ties	Hardwood
Rail weight	AREMA 115 lb

The Design Criteria report provides the criteria, rules, guidelines, and specifications under which the feasibility study of the Billy Diamond Highway and Grevet-Chapais Railways was carried out.

A full copy of the document can be found in Appendix 6.3. It covers the following topics:

Table 8.5–5: Topics covered in the Design Criteria document

General Criteria	Alignment Criteria	Earthworks Criteria
• Design Speed • Axle Load • Design Life • Rolling Stock • Operations • Classification of Tracks	• Alignment Constraints • Horizontal Alignment • Vertical Alignment • Locations of Alignment Elements • Clearances • Track Centre Spacing • Summary of Alignment Criteria	• Embankment Cut • Embankment Fill • Stability Analysis • Settlement Analysis • Liquefaction Assessment • Ground Improvements
Track Criteria • Track Components • Ballast • Sub-ballast • Subgrade • Passenger Platforms • Level Crossings • Summary of Track Criteria	**Structures Criteria** • Design Forces • Load Combinations • Bridge Types and Decking • Material Properties • Substructure Design • Culverts	**Hydrology** • Rainfall Data • Topographical Data • Ditches • Culverts • Effects of beaver dams on subaortic wetland runoff
Signaling and Communication • Terminology • Telecommunications • Bungalows and Power Supply	**Road Geometry** • Introduction • Road Structure • Buildings Introduction • MEP • Electrical Systems	

8.5.13 Site Visits

A visit to the Grevet-Chapais roadbed took place between September 13th and 17th, 2021.

The visit accomplished several objectives, including:

1. To carry out the platform survey (centerline).
2. To collect information on the status and components of the platform.
3. To visually inspect culverts.
4. To visually inspect structures.
5. To locate the transshipment areas and station on Chapais.

The site visit program proceeded as planned and is structured as shown in the figure below.

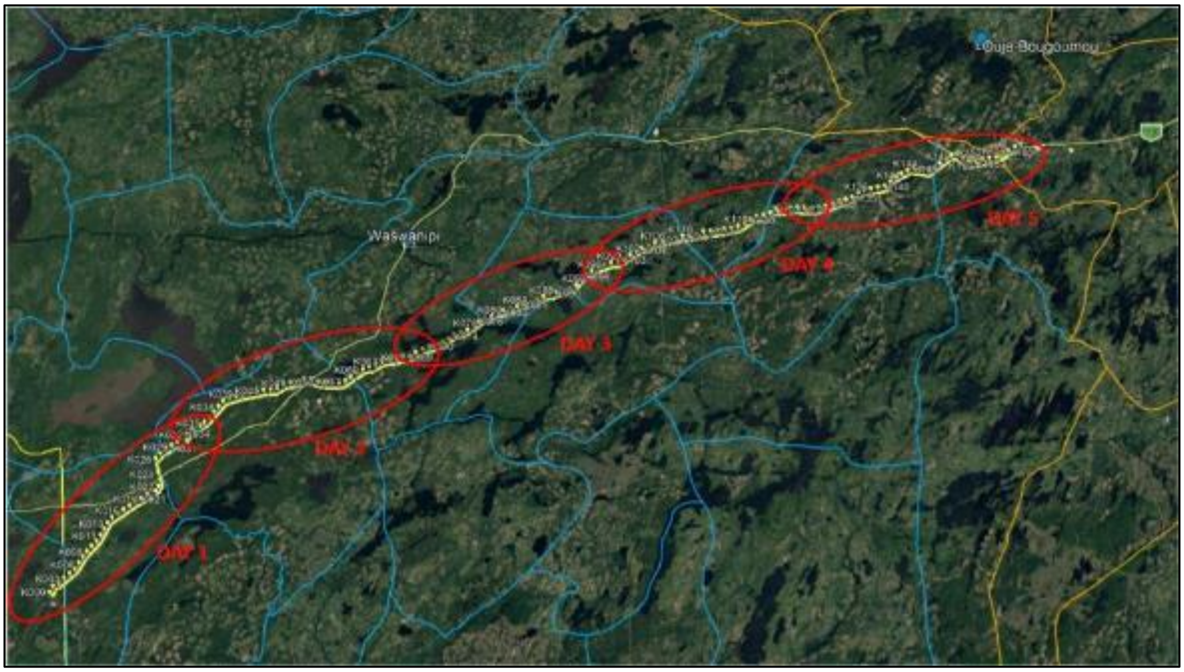


Figure 8.5-18: Progress of the Visits

8.5.14 Topography

The coordinate system used for both corridors Grevet - Chapais and Billy Diamond (Matagami to Rupert River) is NAD83 (CSRS) / MTM zone 9 (Datum: NAD83 Canadian Spatial Reference System) and the vertical coordinate system is CGVD28 (Vertical Datum: Canadian Geodetic Vertical Datum of 1928).

The LIDAR for the Billy Diamond corridor was provided by the Société de Développement de la Baie-James (SDBJ)[5]. This LIDAR covers 100 m on either side of the existing Billy Diamond Highway. In areas where the design extends beyond the scope of the LIDAR, Digital terrain models at 1:20000 scale[6] and MERN geospatial data at 1:50000[7] scale have been used, obtained from Quebec Open Data sources.

An additional LIDAR survey was completed over the summer of 2022 for the Grevet – Chapais Railway corridor that covers 50 m on each side of the alignment of the existing platform and for the BDHR, a strip of approximately 250 m to the west side of the previous LIDAR (SDBJ received on 2021) and also some other larger areas to consider the socio-environmental criteria (Matagami Yard, Cree camps and hunting areas). See the following figure for an example.

[5] Mining Projects - SDBJ.pdf
[6] Modèles numériques de terrain à l'échelle de 1/20 000 – Répertoire complet (format grille) – Données Québec (donneesquebec.ca)
[7] Carte des index de téléchargement (gouv.qc.ca)

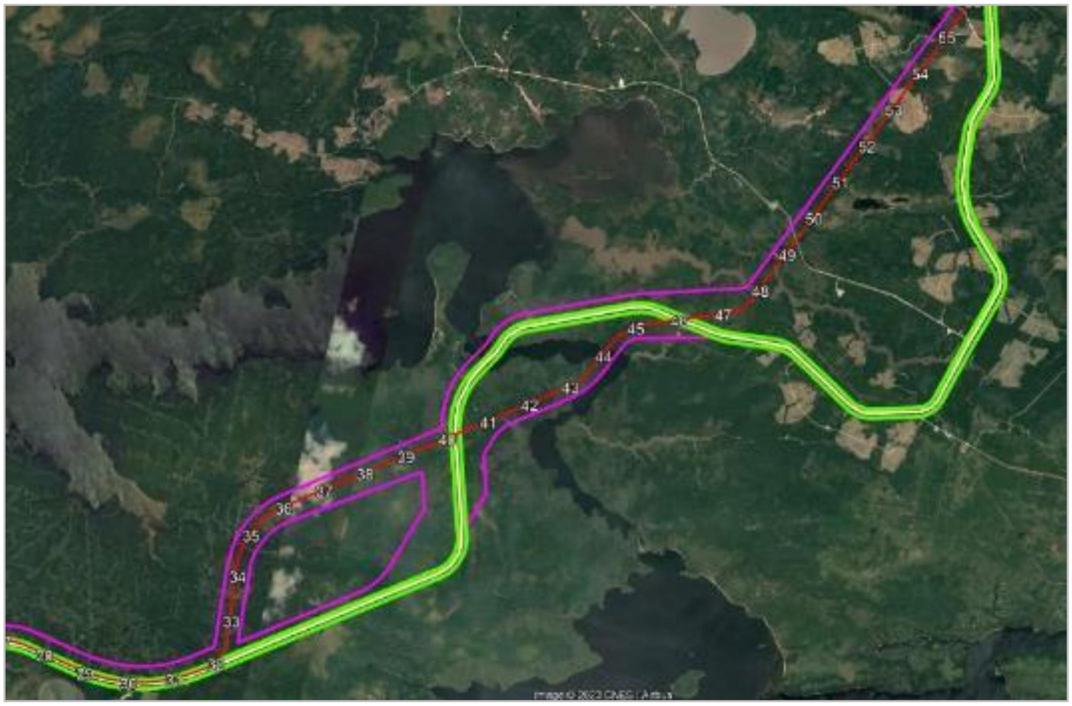


Figure 8.5-19: Example of the LIDAR Survey Coverage

The SDBJ 200m wide corridor for the BDHR is shown in green and the new 2022 survey is shown in purple. The LIDAR survey captured a minimum point density of 2 pts/m² and the aerial images with a pixel size of 16 cm. More information about the survey is found in Appendix 6.1.9 The below figure is an example of the quality of the images obtained.

Figure 8.5-20: Example of Image Quality - Billy Diamond

8.5.15 Civil and Earthworks

This study was carried out in accordance with AREMA recommendations, Ministère du Transport et de la Mobilité durable MTMD, Canadian Foundation Engineering Manual, and American Standard Test Method (ASTM). All assumptions, calculations, and recommendations are based on best engineering judgement and previous experience and consultation within the consortium. At the time of writing, the final geotechnical report was not available, therefore additional recommendations may be given, or some changes may occur following these results in subsequent studies of the project.

The earthworks component of the railway provides the railway platform, or subgrade, which supporting the track structure and is composed of a series of layers. These layers are discussed in detail below.

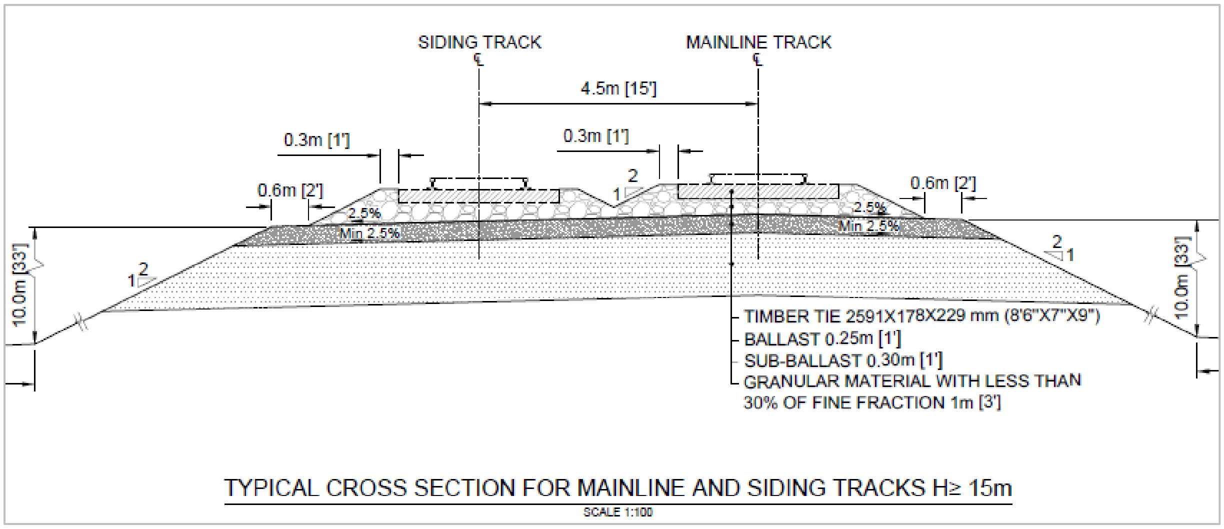


Figure 8.5-21: Typical Cross Section for Embankment over Good Ground Conditions

8.5.15.1 Sub-Ballast Layer

Sub-ballast is placed between the track ballast and subgrade. The functions of sub-ballast are:

- To improve bearing capacity.
- To act as a filter between subgrade and ballast by preventing subgrade fines migrating upward into ballast.
- To protect against erosion.
- To shed water laterally and reduce the infiltration of water into the subgrade material.

The recommended sub-ballast should be a granular material, crushed stone, or rock, where the maximum grain size must not exceed the maximum grain size of the track ballast (50.8 mm). To meet AREMA requirements no more than 5% of the sub-ballast should pass the number 200 sieve. The sub-ballast depth should be not less than 250 mm (10 inches) and the sub-ballast shoulder width should be not less than 600 mm (2 feet). The sub-ballast cross section must also conform to, and respect, the defined limit of excavation as defined in the designed track cross sections.

The gradation and mechanical requirements of granular materials for sub-ballast are presented in the table below.

Table 8.5–6: Gradation Requirements for the Sub-Ballast

ASTM C136 Sieve Analysis Test	
Sieve Size	**% Passing**
150 mm	-
106 mm	-
37.5 mm	-
26.5 mm	100
19.0 mm	85-100
13.2 mm	65-90
9.5 mm	50-73
4.75 mm	35-55
1.18 mm	15-40
300 µm	5-22
75 µm	≤ 5

8.5.15.2 Subgrade Layer

The dominant phenomenon of concern is frost heave, which is a common winter problem throughout most of Canada and can damage infrastructure if not mitigated. When freezing temperatures have penetrated the soil due to the thermal condition of the earth's crust, the increasing presence of ice layers produces an upwards swelling of the soil. This can be exacerbated in fine-grained soils with a high clay content, where capillary action delivers more water to the freezing front, and in other oversaturated regions such as wetlands and bogs.

To avoid this issue, we advise the placement of a-meter-thick layer of granular material, with less than 30% of fine fraction, under the sub-ballast. This material should be sourced from low frost susceptible soils such as granular (gravel) soils (i.e., GW, GP, GW-GM). We also recommend that the subgrade be placed in lifts not exceeding 300 mm and that each lift be compacted to a minimum of 95% Modified Proctor Density (ASTM D1557).

Figure 8.5-22: Typical Cross Section for Embankment over Good Ground Conditions shows the layers of ballast, sub-ballast, and subgrade over good ground conditions where the bearing capacity of the ground surface must be a minimum of 172 kPa. Embankment heights will vary throughout the BDHR, this configuration would be used for lower embankments at 6 m in height.

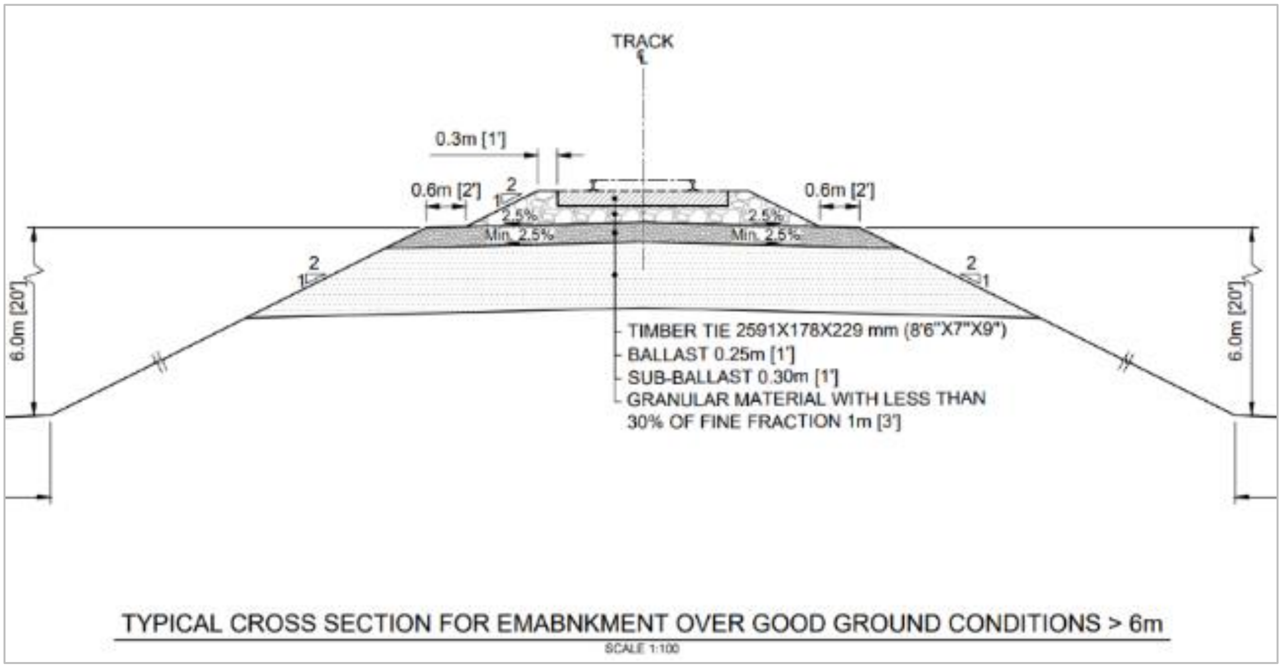


Figure 8.5-22: Typical Cross Section for Embankment over Good Ground Conditions

8.5.15.3 Fill Materials

Common fill materials are non-cohesive and cohesive compatible materials which are free from frost and organics. They may be sourced on-site and/or excavated borrow. Organic materials decompose and settle, so their presence is not desirable in earthworks that are intended to have a high level of stability. Topsoil and surface fill materials that contain organics are not suitable as engineered fill as the organic materials will always create excessive settlement over time under the embankment.

Engineered fill should be placed in maximum 300 mm thick lifts and uniformly compacted to at least 95% Modified Proctor Maximum Density within ≈2% of optimum water content. A good example of the general approach to building the subgrade for a linear project such as a road or railway, in territory similar to that of the La Grande Alliance, is shown in Figure 8.5-23 below. This figure shows an example of fill for a highway embankment in northern Ontario (Source: Geo-Edmonton 2018 conference paper entitled "Highway 66 embankment on soft ground-design, construction and long-term monitoring" by **M. Thibeault** Golder of "Associates Ltd, Sudbury, Ontario, Canada", by **J. P. Dittrich, T. Zalucki** Golder of "Associates Ltd, Mississauga, Ontario, Canada" and by **T. Sangiuliano** of "Ontario Ministry of Transportation, Toronto, Ontario, Canada"). This method is similar to that considered for the construction of a railroad embankment.

Figure 8.5-23: Fill Placement During Embankment Construction

8.5.15.4 Embankment Fill

According to the geological information of the proposed project site, some of the proposed railway alignment is located on wetlands. Wetlands consist of bog, fen, marsh, swamp, and shallow water, and can be characterized by an accumulation of peat which is partially decomposed plant matter found in wet acidic conditions. Peat deposits are the partly decomposed plant matter that have accumulated under water. It is particularly abundant on the Canadian Shield and even more prevalent in James Bay. Peat deposits present difficult subsurface conditions for the construction of roads, railways, and housing developments. It is a particular challenge to the performance of a railway embankment which must deal with the consequent settlement due to compressibility.

One of the distinctive characterization of peats compared to inorganic soils is their extreme compressibility. Peat compressibility includes primary consolidation, which is observed during the increase in effective vertical stress applied by embankment construction, and secondary compression (also referred to as creep), that follows due to the constant effective vertical stress during and mostly after embankment construction. The compressibility of soils, including peats, triggered by building a railway embankment is determined by the peat's in-situ void ratio and the re-arrangement of soil particles.

Figure 8.5-24: Scanning Electron Microphotograph of James Bay Peatpresents the scanning electron microphotograph of a peat sample obtained from the James Bay region showing hollow particles inside the soils that demonstrate the high probability of compression due to the high amount of space between material. (i.e., organic soils) (Source: Engineering Properties of Fibrous Peats by G. Mesri and M. Ajlouni, Journal of geotechnical and Geo environmental Engineering, July 2007).

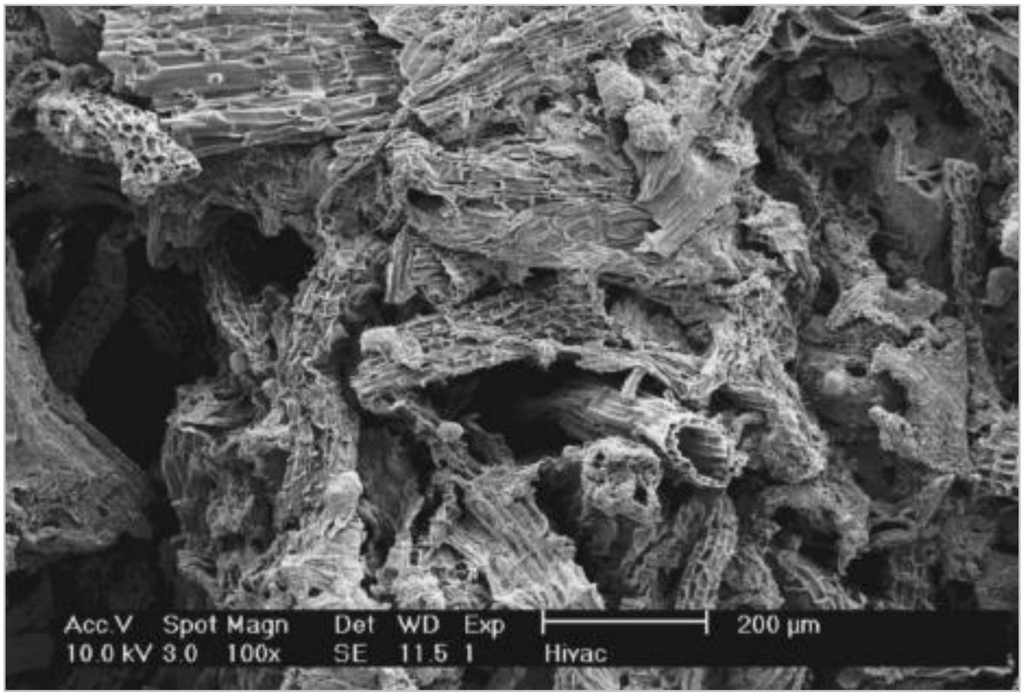


Figure 8.5-24: Scanning Electron Microphotograph of James Bay Peat

Considering the geotechnical data obtained from site investigation, settlement analysis will be required to evaluate vertical deformations for all embankments that can occur during and after the construction of the embankment.

Settlement calculations should include immediate settlement, primary consolidation settlement and creep (i.e., for soft cohesive soils).

To construct the railway embankments on peatlands, the "Guide for the study and construction of road embankments on peat bogs, 2012" published by the Ministère des Transports et de la Mobilité durable was used as a guideline. To treat the peatlands, the following options have been considered:

1. Excavation.
2. Conventional backfill.
3. Conventional embankment.
4. Pre-loading only.
5. Pre-loading with surcharge.

Figure 8.5-25 indicates the typical cross section for the embankment over compressible organic materials that includes all the treatment options. The above methods may need to be modified if soft compressible clays are encountered below the peat deposits. In that case, a robust settlement analysis is required to calculate the long-term settlement of the embankments and to manage embankment settlement issues.

It was assumed that a volume equivalent to an additional 5% of the proposed railway embankment height was needed in locations where the height of the embankment is greater than 2 m over the entirety of the proposed railway alignment to account for settlement over peat. This factor includes the additional material needed by having compressible soil below the peat as well. This factor includes the additional material needed by having compressible soil below the peat as well.

Figure 8.5-25 indicates the typical cross section for an embankment over compressible organic materials with no compressible clay deposits below. It includes all the treatment options. In the absence of the geotechnical site investigation, it is assumed that there is no soft compressible clays under the peat deposits (i.e., organic soils). Where existing soft clay depots are found under the peat layer, a robust settlement analysis combined with a geotechnical investigation (e.g., laboratory tests, field tests, etc.) is required to calculate the long-term settlement of the embankments and to manage embankment settlement issues.

ORGANIC SOIL TREATMENT OPTIONS			
TREATMENT TYPES	HEIGHT		ORGANIC SOILS
	BACKFILL	EMBANKMENT	
CONVENTIONAL BACKFILL - 600mm	> 1.5m	-	< 0.5m
CONVENTIONAL EMBANKMENT - 900mm	-	> 1.5m	0.5m - 1m
CONSOLIDATION WITH PRE-LOADING	> 1.5m	-	1m - 2m
CONSOLIDATION WITH PRE-LOADING & SURCHARGE	< 4m	-	> 2m

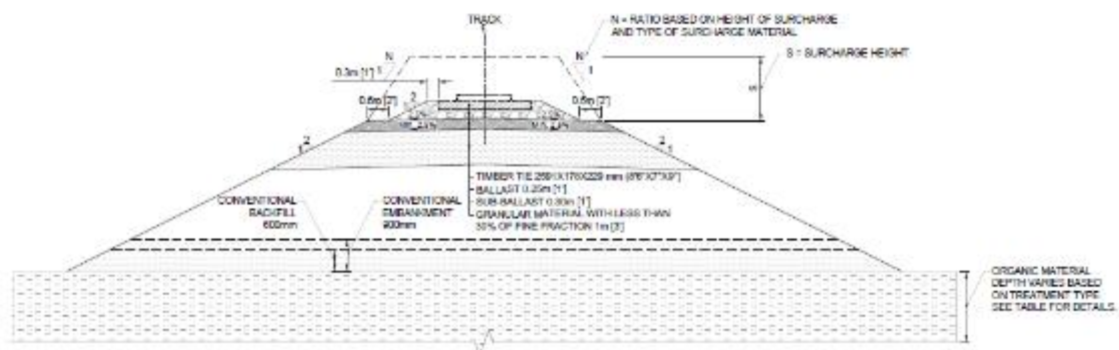


Figure 8.5-25: Typical Cross Section for Embankment Over Compressible Materials

Based on the soil conditions and the embankments heights, the following recommendations related to the above methods are described below.

8.5.15.5 Excavation

Organic materials should be excavated when the embankment height and organic material thickness are less than 1.5 m and 2 m, respectively. If a short length of the alignment encounters a deep deposit of organic soils, i.e., > 2 m, it may be more economical to excavate the organic materials. The bearing capacity of the layer under the organic soils should be verified after the excavation. Depending on the geotechnical information, geotextile installation may be required following the excavation of the organic layer. Figure 8.5-26 shows an example of the excavation work for a railway project (Source: "Ground improvement techniques for railway embankments, 2009", by **A. Arulrajah**, of "University of Technology, Melbourne Australia", by **A. Abdullah** of "Technical Ranhill consulting, Kuala Lumpur, Malaysia", by **M. W. Bo** of "DST Consulting Engineers Inc, Ontario, Canada" and by **A. Bouazza** of "University of Technology, Melbourne, Australia").

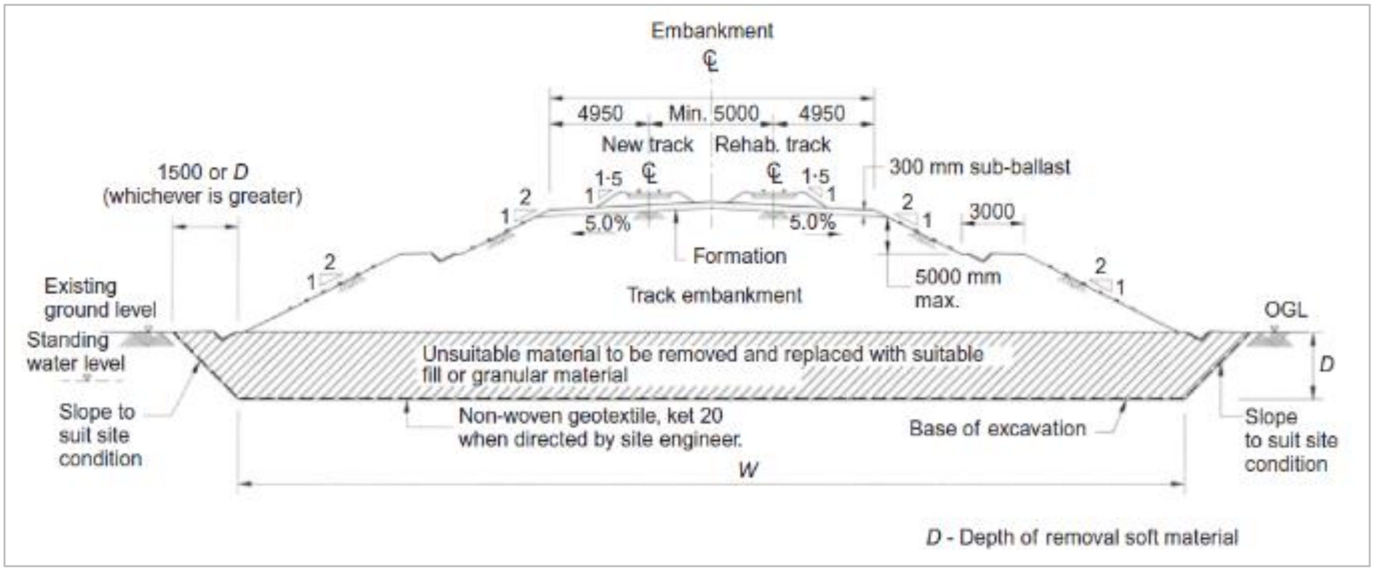


Figure 8.5-26: Typical Cross-Section of Removal/Replacement Works

8.5.15.6 Conventional Embankment (case of organic soil with thickness ≤0.5 m)

Conventional embankment should be applied when the height of the embankment is greater than 1.5 m and the thickness of organic soils is less than 0.5 m. In this case, the embankment should be directly placed over organic soils. MG 112 or equivalent fill materials should be used for the first layer of 600 mm backfill. No instrumentation program (i.e., settlement plates, piezometers) is required for this method.

8.5.15.7 Conventional Embankment (case of organic soil with thickness between 0.5 m and 1 m)

Conventional embankment should be used when the height of the embankment is greater than 1.5 m and the thickness of organic soils is between 0.5 m and 1 m. In this case, the embankment will be placed directly over organic soils. MG 112 or equivalent fill materials should be used for the first layer of 900 mm backfill. No instrumentation program (i.e., settlement plates, piezometers) is required for this method.

8.5.15.8 Pre-loading

Pre-loading should be considered when the embankment height is greater than 1.5 m and the thickness of the organic soils is between 1 m and 2 m. Preload site preparation involves the placement of the embankment material to allow the subgrade soils to compress under the weight of the embankment, resulting in a reduced potential post-construction settlement. Time will be required for pore water to be dissipated and the settlement to occur. A time-settlement analysis and monitoring program, that includes settlement and pore water pressure monitoring, will be required to evaluate the post-construction settlements. The analysis will verify if the post-construction settlement is within reasonable preload periods. MG 112 or equivalent fill materials should be used for the first layer of 900 mm backfill. Geogrid could be recommended if stone fills are used as a first layer.

8.5.15.9 Pre-loading with Surcharge

Pre-loading and surcharging should be considered when the height of the embankment is less than 4 m and the thickness of the organic soils is greater than 2 m. Pre-loading and surcharging involve the placement of temporary additional fill (surcharge) in addition to the permanent fill, this increases the load and speeds up consolidation of the soil beneath the embankment. The thickness of the applied temporary surcharge varies depending on the degree of acceleration needed for the soil consolidation process as dictated by the construction schedule. Depending on the temporary height of the embankment, slope stability analysis is required to ensure that the staged embankments meet the required factor of safety during the construction. Time-settlement analysis including an instrumentation program for settlement and pore water pressure monitoring, will be required to evaluate the post-construction settlements. MG 112 or equivalent fill materials should be used for the first 900 mm layer of backfill. Geogrid could be recommended if stone fills are used as a first layer.

In general, the treatment recommended for peatland are applicable using borrowed materials such as MG 112 or MG 20. When there is no access to these materials, the equivalent in-situ materials can be recommended to avoid the punching issue on organic soils. In this case, using geotextiles and geogrids would be essential. Figure 8.5-27 below (Source: Geo-Edmonton 2018 conference paper entitled "Highway 66 embankment on soft ground-design, construction and long-term monitoring" by **M. Thibeault** Golder of "Associates Ltd, Sudbury, Ontario, Canada", by **J. P. Dittrich, T. Zalucki** Golder of "Associates Ltd, Mississauga, Ontario, Canada" and by **T. Sangiuliano** of "Ontario Ministry of Transportation, Toronto, Ontario, Canada"), shows the section of surcharge being removed when the ground improvement has been completed.

Figure 8.5-27: Removal of Granular Surcharge Material – Manual on Compressible Soils

8.5.15.10 Application of Geogrids

The installation of geogrids on organic soils should be recommended in the following situations:

- Crossing ditches;
- Culvert transition;
- Peat bogs with lakes;
- Surface of peat bogs on the route due to the passage of heavy machinery;
- First layer of backfill constructed with a material other than MG 112 and MG 20.

8.5.15.11 *Instrumentation Program*

Instrumentation and monitoring will be required during the placement of embankments on organic soils for pre-loading and surcharging methods. The instrumentation program comprises:

- Layer indicators: to ensure the uniformity of the layers of backfill during placement.
- Settlement plates: these are installed on the embankment subgrade, with rods extending through the embankment fill, to monitor the settlement.
- Piezometers: Vibrating Wire Piezometers (VWPs) are installed to measure excess porewater pressure and to determine the time before placing the next layer.
- Lateral displacement indicators: Inclinometers are used to measure the horizontal displacements of slopes during the placement of embankment material.

The above instrumentation program should be provided by the contractor and construction timing should be established in consideration of the instrumentation program.

8.5.15.12 *Embankment Slope Stability*

Two stages should be checked for the slope stability analysis:

- Short term (total stress analysis) using undrained shear strength (su or cu).
- Long term (effective stress analysis) using drained strength parameters (c′, ϕ′).

In all loading conditions, the railway load should be considered. The slope stability of the embankments under earthquake conditions should be analyzed using pseudo-static analysis. Based on the design criteria, the slopes must meet the required factor of safety indicated in Table 8.5–5.

Table 8.5–7: Factors of safety (FS) for slope stability analysis

Conditions	Factor of safety (FS)
Static permenant (long term)	FS ≥ 1.5
Static temporary (short term)	FS ≥ 1.3
Siesmic	FS > 1.1

The parameters that affect the factor of safety of slope stability analysis are:

- The geometry of the slope
- The type of the soils within the slope
- The unit weight of the slope
- The ground water condition
- The soil strength parameters
- The external loads on the slope (i.e., train load)
- The compaction of the fill materials

The slope stability analysis should be carried out based on the borehole information obtained from site investigation. During the analysis, the organic soil deposits should be considered since they could have shear strength lower than needed to support the backfill. To ensure slope stability of the embankments during construction, the slope rate should not be steeper than 2H:1V i.e., for every meter of vertical climb, there are two meters of horizontal offset (two units in the horizontal direction to one unit in the vertical direction). Gentler slopes might be applied whenever required.

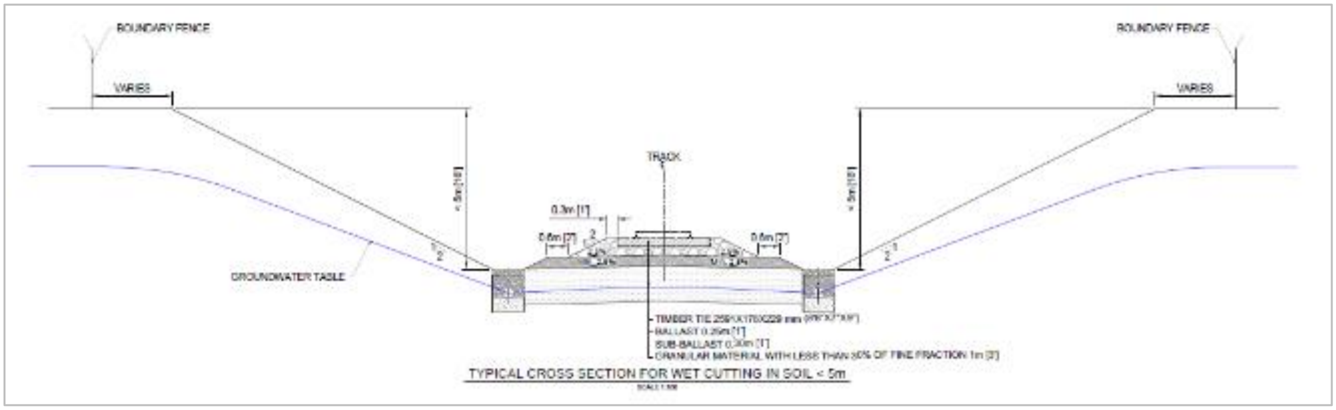


Figure 8.5-28: Typical Cross Section for Wet Cutting in Soil < 5m

Figure 8.5-28 shows the typical cross section of an excavation for cutting in soils with the height of less than 5 m. In the absence of geotechnical site investigation, the slope rate for cutting with the height of less than 5 m can be considered at 1V:2H. Slope stability analysis is required for cuts larger than 5 m. For this mandate, the slope rate of 1V:2H with a 3 m bench for every 5 m height is hypothetically considered. The typical cross sections are presented in Appendix 6.8.

In the calculation of cut and fill and mass haul quantities, 80% of cut material along the alignment were used for fill. The organic materials along the alignment were assumed to be used for slope re-vegetation only.

8.5.16 Track

8.5.16.1 Track Structure

The track components have been selected based on AREMA standards. An analysis was carried out for the loads that must be supported by the track structure and transmitted to the subgrade.

The recommended track structure will be constructed on a roadbed formation with a crown of 2.5% to the center line of the roadbed. The bearing pressure that the sub-ballast applies to the subgrade should not exceed 173 kPa (25 psi).

8.5.16.2 Track Structure Components

Generally, the operating parameters of a railway influence the design of the track structure. The following figure provides an example of the track components and design information supporting such selection.

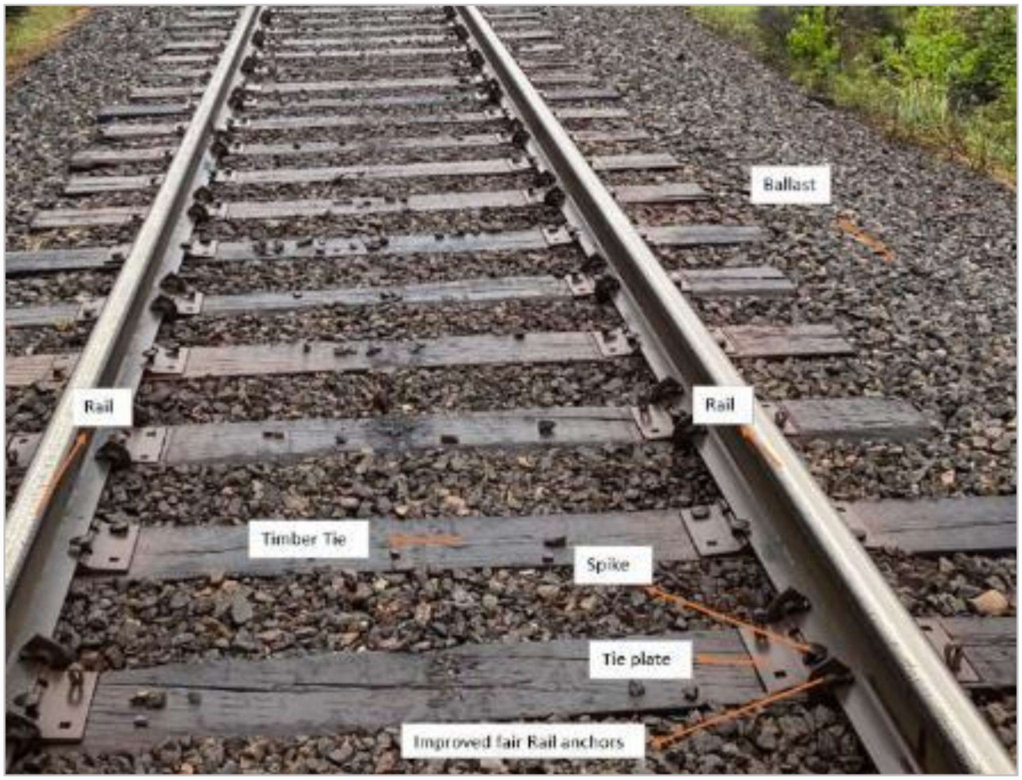


Figure 8.5-29: Track Structure Components

8.5.16.3 Rail

The selection of the rail profile, and type, was primarily based on the anticipated tonnage, axle loading, train speed, and rail wear. The 136 lb. RE rail section meets all of the strength requirements for 286,000-pound cars (32.4 tonne axle loading) and is the recommended rail section. Rail wear will not be aggressive on this railway due to the minimum curve radius of 500 m on the railway alignment, however it is the predominant profile used on neighbouring railways which is a consideration that has also influenced the choice of profile.

Thus, for the reasons mentioned above, the following rail is recommended:

- 136 lb. RE low alloy, intermediate strength, head-hardened (HH) rail with a Brinell Hardness (BHN) in the range of 325 - 350. The chemical composition should be as per AREMA, Manual for Railway Engineering, Volume 1, Chapter 4, for low alloy intermediate steel. The low alloy rail steel is being recommended on the basis of improved wear characteristics at weld joint areas, and superior resistance to rolling contact fatigue, and gauge-face wear (longer life).
- The length of rail sections to be purchased will be determined by the construction methodology and/or ship capacity for delivery. This decision will be formulated during the detailed design phase.

8.5.16.4 Ties

The type of tie was chosen to meet the operational requirements of the track. The ties must resist the vertical and horizontal forces to maintain the alignment of the track. The wood tie has been the preferred tie for railway tracks for the last century in North America and has performed satisfactorily. The wood tie is recommended based on the following:

- Its ability to meet track performance specifications in terms of holding alignment, surface, cross-level and gauge, i.e., lower maintenance costs,
- Life cycle cost.
- Increased average service life of 30 years.
- The selected wood ties 7" x 9" x 8'6" follow North American approved standards as per AREMA.

8.5.16.5 Fastenings System

The rail will be fastened with spikes on a 14" tie plates with improved fair rail anchors. A typical improved faire anchor is shown in the picture below.

Figure 8.5-30: Typical Improved Fair Anchor

8.5.16.6 Turnouts

No. 8 , No. 10 and No. 20 turnouts in 136 RE rail are recommended.

To facilitate the flow of trains it is important that the trains can clear through the mainline turnouts without encountering excess delay, and mainline turnouts must be sized to meet the operational requirements. The No. 20 turnouts are recommended for mainline placement and are all considered to have motorized (dual-controlled) switch points and are equipped with air blower systems. The air blowers are used in the winter to blow snow away from the heart of the switch and prevent ice buildup which could block the switch movements.

Manually operated No. 8 turnouts are recommended for yard and shop tracks. Some of the No. 8 turnouts identified at critical locations in the yards will also be equipped with a cold-air blower system.

No. 10 turnout are recommended to connect main tracks to yard access tracks.

The track geometry of turnouts should conform to AREMA recommendations. A typical No. 8 turnout is shown in Figure 8.5-31.

Figure 8.5-31: Picture of a Typical No. 8 Turnout

8.5.16.7 Ballast

The ballast should be composed of crushed rock with high wear and abrasive qualities to withstand the impact of traffic loads and track maintenance by heavy tamping machines without excessive degradation. The ballast grading recommended should meet AREMA size No. 4 requirements.

Ballast depth should not less than 250 mm (10 inches) under the tie. Ballast shoulder width should not be less than 300 mm (12 inches).

AREMA MRE Chapter 30, Article 1.3.6.1, recommends a maximum pressure on the ballast of 450 kPa (65 psi) or 585 kPa (85 psi) depending on the quality of the ballast. Kerr[8] recommends limiting the pressure to 515 kPa (75 psi). For the purpose of this design, we will limit the pressure on the ballast to 515 kPa (75 psi).

8.5.16.8 Typical Ballast Cross-Section

The dimensions of the typical ballast cross-section are dependent on the bearing capacity of the roadbed formation, type of tie, width of ballast shoulder, and depth of ballast.

The resistance provided by the ballast in the shoulder of the section is fundamental to maintaining good horizontal alignment for the track. It is generated through the friction coefficient between ballast particles. The resistance is generated as the tie end plows through the shoulder ballast. The bottom of the sub-ballast is generally assigned a width that matches the width of the top of subgrade and sloped at a 1V:2H for the designed depth of the sub-ballast.

[8] Arnold D. Kerr, author of Fundamentals of Railway Track Engineering, an industry recognised engineering textbook.

8.5.16.9 Guard Rails

Guard rails should be provided on all bridges and arched culverts with an opening larger than 4.5 m. The guard rails size will be 132 RE. Guard rails contain a train and keep it inside the envelope of the track in a derailment scenario.

8.5.16.10 Derailers

Derails must be installed on both ends of tracks wherever there is a possibility that parked equipment could be moved by wind or gravity and obstruct the mainline or siding. Generally, derails should be installed where unattended rolling stock is regularly stored. The placement and use of derails will meet Transport Canada's Canadian Rail Operating Rules (CROR) most recent guidelines on derails.

8.5.16.11 Bumping Post

Bumping posts should be mechanical type Hayes WG bumping posts.

Mechanical bumping posts should be dimensioned as per CN's typical Bumping Post Detail drawing.

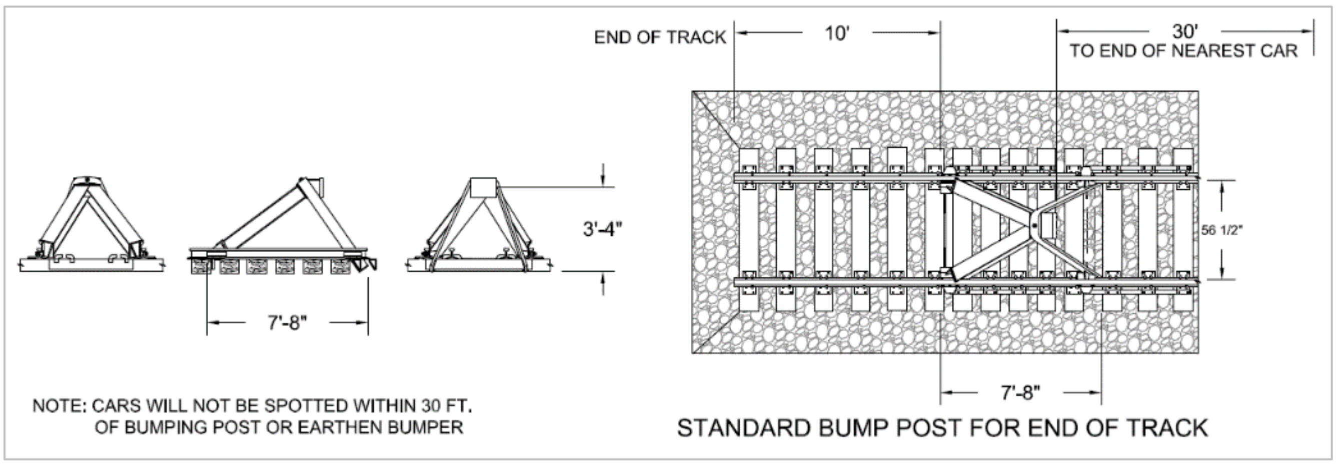


Figure 8.5-32: Typical CN Bumping Post

8.5.16.12 Track Structure Design Summary

The table below provides a summary of the track structure design.

Table 8.5–8: Summary of Track Criteria

Track Element	Criteria	
	Mainline and Sidings	Yard Tracks and Storage Tracks
Rail	• All tracks: 136 lb RE • Guard Rails :132 lb RE	• All tracks: 136 lb RE • Guard Rails :132 lb RE
Joints	Welded (CWR)	Jointed
Ties	Hardwood 7'' x 9'' x 8'6''	Hardwood 7'' x 9'' x 8'6''
Tie spacing	560 mm (22 in)	560 mm (22 in)
Fasteners	Spikes, 14-in tie plates and fair improved anchors	Spikes, tie plates and fair improved anchors
Turnouts	Dual Motorized/Manual – AREMA No. 20	Dual Motorized/Manual or Manual – AREMA No. 10 et 8
Ballast shoulder width	300 mm (12 in) minimum	150 mm (6 in) minimum
Depth of ballast under tie	250 mm (10 in) minimum	230 mm (9 in) minimum
Ballast shoulder slope	1V:2H	1V:2H
Depth of sub-ballast	300 mm (12 in) minimum	300 mm (12 in) minimum
Sub-ballast shoulder width	Minimum 600 mm (2 feet)	Minimum 600 mm (2 feet)
Slope of sub-ballast shoulder	1V:2H	1V:2H
Sub-ballast cross slope	2.5%	2.5%

8.5.17 Billy Diamond Highway Railway (BDHR) Alignment

The potential railway project of Phase 1 crosses traplines belonging to the following Cree communities: Washaw Sibi[9], Waswanipi, Waskaganish, Oujé-Bougoumou and Nemaska. One of the main challenges in the design of the railway corridor/right-of-way (ROW) is to minimize as much as possible, its intersection with wetlands and Cree land use areas such as hunting and fishing areas, and camps. The study team worked with the Cree land users to identify these locations and understand ways to avoid these areas in an acceptable manner.

The initial intention was to design the track to Class 4 standards, but as the study progressed, it was increasingly evident that Class 3 would be more appropriate, which allows the use of tighter curves and makes it possible to respect the new socio-environmental criteria. This includes respecting the high-density caribou area, by following the Billy Diamond Highway as closely as possible.

A key design principle for the horizontal alignment has been not to encroach on the ROW of the existing road, which is 45 m wide (22.5 m on either side of the center line of the Billy Diamond Highway).

[9] The Washaw Sibi community is recognized by the Crees but is not necessarily legally recognized by the Gouvernement du Québec. In the lens of the study, the community of Washaw Sibi was considered equivalent to all other participating Cree communities. The study team does not allude to make any legal statements regarding their status, but this is rather an initiative to be as inclusive as possible.

The vertical geometry has been designed to respect a maximum compensated gradient of 1.5%. In addition, it has been ensured that there is sufficient coverage over culverts and that a reasonable vertical distance has been maintained between the profile and level crossings (approx. max. 3 m, for road slopes). The stations and transfer areas for the BDHR alignment are located at Matagami and Waskaganish.

In Summer and Fall 2022, LIDAR data for the Billy Diamond corridor was prepared. Following analysis of the new LIDAR data, the Billy Diamond profile has been updated to ensure the requisite distance between the bottom of the sub ballast and the top of the culvert is maintained.

After preparing a draft railway alignment for the BDHR that prioritized the design of the track to stay inside a 200-m wide corridor of the Billy Diamond Highway, it was observed that due to the significant number of curves on the Billy Diamond highway, some value could be unlocked by designing a second BDHR alignment that focussed less on staying inside the 200 m wide corridor and more on reducing curves and track length, and by consequence, possibly reduce capital cost, operating cost and travel time. This second alignment was henceforth referred to as the "Optimized" version. To summarize the hierarchy of priority of the alignment design, the following table was produced.

Table 8.5–9: BDHR Option Design Hierarchy

	"Baseline" Railway Alignment	"Optimised"Railway Alignment
Top Priority	Avoid Cree Land Use Areas Avoid Archeological Sites Avoid Protected Areas e.g., biological refuges Avoid Other Highly Sensitive Areas Avoid Urban Areas	Avoid Cree Land Use Areas Avoid Archeological Sites Avoid Protected Areas e.g., biological refuges Avoid Other Highly Sensitive Areas Avoid Urban Areas
2nd Priority	Avoid wetlands/water bodies Avoid sensitive flora and fauna locations Maximize length within 200m width of BDH	Avoid wetlands/water bodies Avoid sensitive flora and fauna locations Minimize Travel Time Minimize CAPEX, OPEX
3rd Priority	Minimize CAPEX, OPEX Minimize Travel Time	Stay within 200m of BDH
4th Priority	Avoid Mining Titles Avoid Forestry Titles Geotechnical considerations (Weak material, distance to borrow pits)	Avoid Mining Titles Avoid Forestry Titles Geotechnical considerations (Weak material, distance to borrow pits)

The two alignments were analyzed to:

1. Identify the best route between the baseline and optimized (fewer obstacles),
2. Find the least expensive route,
3. Have the least impact on the environment,
4. Have the best geometry in terms of quality versus cost.

The Baseline and Optimised alignments were scored against two types of components: Technical and Socio Environmental and a final score was developed by weighting the overall value of the two components to the proposed project. The tables below show the scoring for the baseline, optimised and hybrid alignment that was consequently developed.

Table 8.5–10: Technical Score (Cost) of the Baseline and Optimized Alignments

Criteria	1	2	3	4	5
Construction Cost Operating Cost Lifecycle Cost	Expensive compared to similar railways	Somewhat expensive	Neutral	Somewhat economical	Economical

Criteria	Magnitude ($)	Weighting	Baseline	Optimized
Construction Cost	Billions (spent at the start)	50%	4.00	4.00
Operating Cost	Hundreds of Millions (spread over 50 years)	20%	3.50	4.00
Lifecycle Cost	Hundreds of Millions (spread over 50 years)	30%	3.00	4.00
		Total	**3.60**	**4.00**

Table 8.5–11: Social Environmental Score of the Baseline and Optimized Alignments

Criteria	1	2	3	4	5
Fauna, Flora, Wetlands, Cree Land Use, Archeology, Servitudes & Titles	Negative impact	Somewhat negative	Neutral or TBD	Minimal	Positive

Criteria	Importance	Weighting	Baseline	Optimised
Fauna	Effect on Caribou & other endangered species	25%	4.00	2.00
Flora	Effect on sensitive plant life	5%	4.00	4.00
Wetlands	Effect on critical habitats, watersheds, and wetlands	15%	4.00	3.50
Cree Land Use	Effect on Cree Land Use	25%	4.00	4.00
Archeology	Effect on Archeological Sites	25%	4.00	4.00
Servitudes & Titles	Effect on Servitudes and Titles	5%	4.00	4.00
		Total	**4.00**	**3.43**

Table 8.5–12: Final Score of the Baseline and Optimized Alignments

Criteria	Weighting	Baseline	Optimised
Technical Study Criteria	45%	**3.60**	**4.00**
Socio-Environmental Study Criteria	55%	**4.00**	**3.43**
	Total	**3.82**	**3.69**

A third alignment, referred to as the Hybrid Alignment, was developed from these two original alignments as recommended in the Interim Report LGA-1-GN-T-TGN-RT-0002_00 submitted in October 2021. This alignment focussed on combining the best performing sections of the Baseline and Optimized alignments and as a result, a hierarchy of priorities was developed as per below:

Table 8.5–13: Hierarchy of Priorities for Hybrid Alignment

	"Hybrid" Railway Alignment
Top Priority	• Avoid Cree Land Use Areas • Avoid Archeological Sites • Avoid Protected Areas e.g., biological refuges • Avoid Other Highly Sensitive Areas • Avoid Urban Areas
2nd Priority	• Avoid wetlands/water bodies • Avoid sensitive flora and fauna locations • Maximize length within 200m width of BDH • Minimize CAPEX, OPEX
3rd Priority	• Minimize Travel Time
4th Priority	• Avoid Mining Titles • Avoid Forestry Titles • Geotechnical considerations • (Weak material, distance to borrow pits)

The Hybrid Alignment is 253.1 km long, with 41% of the alignment in curves. The minimum curve radius is 500 m. Approximately 58% of the combined alignment is adjacent to the Billy Diamond Highway, i.e., the corridor is located between 22.5 and 100 m away from the road.

The combined CFRBD alignment is characterized by regular curves with a minimum radius of 1.150 m. However, to avoid building a bridge, encroaching on the right-of-way or for other types of constraints, the radius is exceptionally set at 500 m, with a speed reduction considered to be 85 km/h. This limitation is encountered at the beginning of the road near the Matagami station, between KP 1+426 and 3+228 where the track crosses the road, and at approximately KP 147+534, KP 157+391 and KP 212+483.

In terms of vertical profile, the elevation of the natural terrain is irregular, varying between a maximum elevation of 326 m and a minimum elevation of 192 m, which represents a difference of 134 m. With a maximum compensated gradient of 1.5% for the proposed profile, the variation is from 322 m to 197 m, corresponding to a difference of 125 m.

Table 8.5–14: Comparison between Baseline, Optimized and Hybrid Alignments

	BASELINE		OPTIMIZED		HYBRID	
Object	**Quantity**	**Total Length (m)**	**Quantity**	**Total Length (m)**	**Quantity**	**Total Length (m)**
Total Alignment Length	-	263,276	-	250,510	-	253,113
Level Crossings	75	-	81	-	85	-
Bridges	8	935	10	1,220	17	1,525
Wetlands	482	70,600	541	75,933	466	74,503
Lakes	12	1,020	13	853	8	417
Total Length in Tangents	-	124,804	-	157,902	-	149,796
Total Length in Curves	-	138,472	-	92,608	-	103,317
% Curves	136	52,60%	71	36.97%	71	40.82%
Relationship to BD Highway 200 m Corridor						
Length Outside Corridor	-	65,458		148,390		107,536
% Outside Corridor	-	24.86%		59.24%		42.49%
Earthworks of Mainline, Sidings, Matagami Yard, and Waskaganish Yard (m^3)						
Cut	9,148,618		9,425,043		8,876,834	
Fill	6,436,883		9,208,058		9,430,438[2]	
Vegetal Soil and Peat	1,973,082		1,958,926		2,887,141[3]	

Notes:

[2] Fill includes bottom and top layers of granular material MG 112

[3] Organic material includes vegetal soil and peat, the more accurate geotechnical measurements used for the hybrid alignment design show sections with deeper deposits of organic material/ peat than assumed for the baseline and optimized alignments.

The geometry of the proposed profile respects all relevant standards with no required speed restriction.

The maximum gradient is 1.5%. The shortest length of vertical curve is 60 m.

Figure 8.5-33: Cross Section of the Typical Arrangement of Adjacent Road and Rail

8.5.18 Grevet-Chapais Railway Alignment

The railway line linking Grevet to Chapais is abandoned, with 160 km of the subdivision being used for various activities. These include approximately 90 km of snowmobile trails and 70 km for forest industry as a major logging master road and there is also a significant resort and tourism area. Cree communities affected are Washaw Sibi, Waswanipi, Ouje-Bougoumou.

The extent of civil works required to recommission this line have been based on site visits and inspections of the alignment and structures. The inspections and the works proposed for rail bridges and drainage structures are described in detail in sections “Site Visits. Structures and Hydrology and Drainage”.

To reduce its construction cost, the proposed track will follow the geometry of the existing track platform, both horizontally and vertically, however some earthworks will be needed. The bulk of this work comprises clearing the platform side slopes and ROW of trees, and brush, and re-establishing the platform cross section where it has been deformed by erosion and surface wear from logging trucks and snowmobiles.

Figure 8.5-34: Examples of Erosion and Forest Encroachment on the Chapais Subdivision Trail

Additional works of a similar nature may also be required for the proposed sites of the Chapais Yard, Chapais Passenger Station, Waswanipi Passenger Station and where adjustment to some horizontal curves is recommended to reduce the number of locations requiring slow speed zones for the passenger service.

The geometry is characterized by an average horizontal radius of 800 m. To meet the client’s request that the rebuilt railway remains within the ROW and uses the existing bridges as much as possible, a speed reduction is recommended in certain locations, for an approximate total of 11.5 km or 7% of the railway. The speed limit in the affected sections is 60 km/h and includes horizontal curves with a minimum radius of 420 m. The criteria used for the BDHR with respect to grades and curve lengths was applied to the design. For GCR except that the existing track platform was followed as closely as possible.

The maximum elevation of the existing platform is approximately 396 m, and the minimum elevation is approximately 270 m, a difference of 126 m. The maximum elevation of the proposed profile is 396 m while the minimum elevation is 271 m, a difference of 125 m.

The Grevet-Chapais alignment is 164.6 km long, 26% of which is in curves. The minimum horizontal curve radius is 420 m. The maximum gradient is 1.32% and the minimum gradient is 0.07%. The shortest length of vertical curve is 60 m.

The alignment design was carried out using LIDAR data provided in 2022 and information obtained during the 2021 site visits, which including measurements of GPS points in the center of the existing platform, and of the platform dimensions, namely width, height, slope values and type of terrain, i.e., regular or rock.

The main constraint on the design was the original CN ROW, which varied considerably on each side of the existing route. The design was carried out to Class 3 standards (40 mph for freight, 60 mph for passenger trains), but with several speed restriction zones for the passenger trains.

The first version of cut and fill and mass haul quantity calculations, undertaken in 2021, took borrow pits only into account. Further calculations incorporated bedrock quarries to ensure the levels of ballast and sub-ballast.

The Stations and Transfer areas for the Grevet-Chapais alignment are located at Chapais and in the vicinity of Desmaraisville and Road 113, to serve Waswanipi.

8.5.19 3D Modeling - Civil 3D

3D modeling of the railway platform and track for both rail corridors use a definition of the existing ground surfaces, the designed alignment and profile (horizontal and vertical geometry of the railway track) and the railway track structure (rail, tie, ballast and sub-ballast dimensions).

To prepare triangulated Civil 3D surfaces, the raw LIDAR data (laz files) were merged and split to cover 10 km segments of the alignment. Recap files were created from laz files, and then imported in Civil 3D software to create triangulated (TIN) surfaces.

The units and geographic reference system defined for this study were respected to ensure compatibility between the reference data and data used by the Consultant.

Figure 8.5-35 provides a screenshot of imported LIDAR data on the corridor Grevet-Chapais, with classified points (ground, water, vegetation, bridge, noise). Only the ground and water points were used to create Civil 3D surfaces.

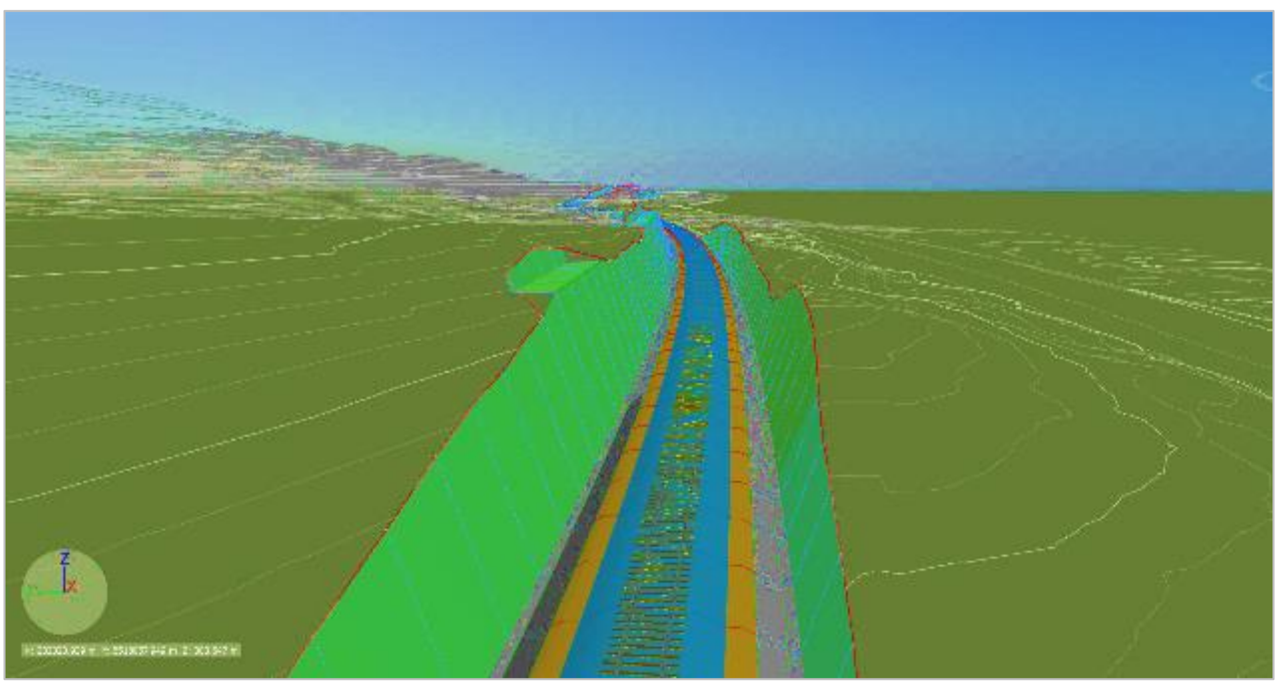


Figure 8.5-35: Screenshot of 3-D Model used for the Alignment and Earthwork Design - KP18+280 (Easting = 233 386, Northing = 5 518 070)

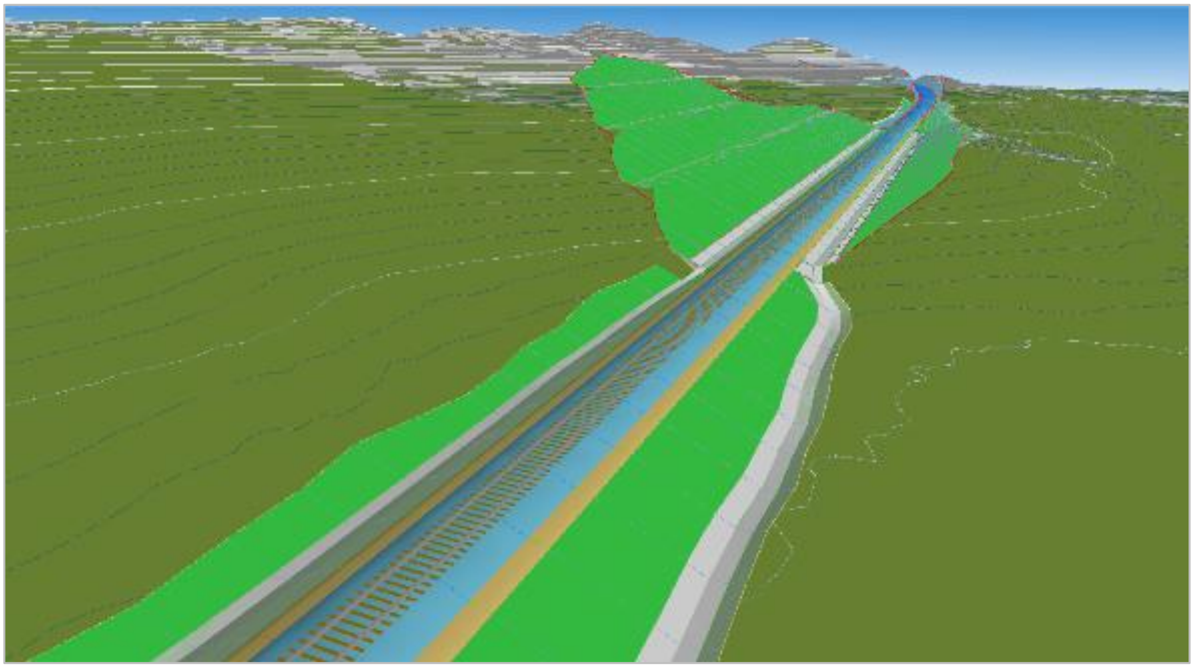


Figure 8.5-36: Screenshot of 3-D Model used for the Alignment and Earthwork Design KP17+900) (Easting = 233 008, Northing = 5 518 038)

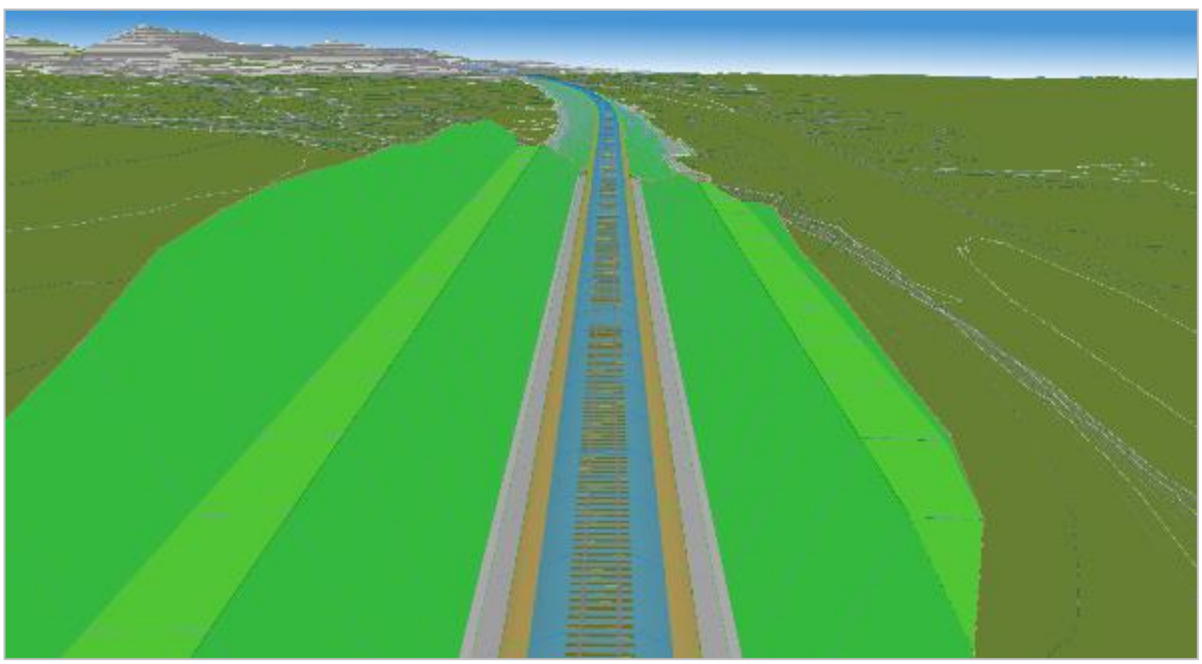


Figure 8.5-37: Screenshot of 3-D Model used for the Alignment and Earthwork Design - KP19+550 (Easting = 234 589, Northing = 5 518 443)

Due to the length of the two railway lines, the corridors were split in five segments for BDHR of approximately 50 km each, and six segments for Grevet-Chapais of approximately 30 km each. The 3D corridors created along the alignment used, embankment and cut side slopes, of 1V:2H. In cases where embankments were higher than 6 m and cuts were deeper than 5 m, benches 3 m wide were used with slopes were kept at 4%. The subgrade top with width is constant along the mainline at 7.8 m, while the subgrade widths are wider and variable in zones such as the yards, stations, sidings and backtracks, which are also maintained with a 0% slope (flat). Side slopes of 3V:1H were used in some rocky areas of the BDHR corridor.

Figure 8.5-38: Rock Area (KP 16+040; Railway will be 60m to the left)

Figure 8.5-39: Crossing of a Wetland Area (KP 197+400; Railway will be at 30m to the left)

For the proposed BDHR, being a greenfield project, four categories defining the materials involved have been used in the calculation of quantities, they are as follows:

- Peat (organic material) that needs to be removed
- Regular fill is used
- Granular material (MG 112) needed
- Reusable cut materials are excavated

To calculate these quantities, 3 types of corridor were defined, each defining a specific type of ground surface.

1. Target Surface: Existing Ground - Peat layer (by zones of peat thickness)
   - Produces: All Fill (for excavated zones) and reusable cut material
2. Target Surface: Existing Ground
   - Produces: Top Fill (for excavated zones),
     - All Cut and All Fill (for MG 112 zones)
3. Target Surface: Top of MG 112 layer
   - Produces: Top Fill (for MG 112 zones)

The corridor design provides the footprint of the railway embankment on the existing ground and permits verification that there is no overlapping onto the right-of-way of the Billy Diamond Highway.

It must be noted that the main purpose of the 3D model is the calculation of earthwork quantities. As such, the full details of the track super-structure are not modeled. Also, at the current stage of design, the ditches on each side of the track follow the same alignment as the track itself. This is adequate for the purpose of estimating excavation quantities. During the detailed design phase, they should be re-designed with a dedicated ditch profile having a minimum grade of 0.25% to meet water flow requirements.

To calculate cut and fill quantities the method using section areas (quantity takeoff criteria) every 50 m was used. This is necessary to estimate the mass haul diagram. To consider the additional embankment quantities due to settlement, the designed Top of Rail profile was adjusted (raised) according to the peat thickness and the embankment height.

8.5.20 Level Crossings

The criteria used for the level crossing analysis are:

- Access to properties (buildings etc.);
- All the roads that seem major (validation by street view) are retained;
- Elimination of certain roads when they intersect each other or when the access can be done by another road at a maximum distance of 5 km;
- Certain trails are retained when validated by subsequent analysis;
- Snowmobile trails are retained when identified. When they intersect each other, only one access is retained;
- When the roads cross the railway tracks several times and the road is considered major, a deviation is to be made by maintaining a single access (the deviation study has not yet been done);
- When the intersections of several roads are close, priority is given to those where we have better visibility, and the profile suits us;
- Access to the trappings;
- When possible, adjustment of the track profile to create a level crossing was considered.

Level crossings were designed in accordance with Transport Canada Grade Crossing Regulations. Sightline distances were evaluated as per Transport Canada’s document “Determining Minimum Sightlines at Grade Crossings.” Due to the large number of gravel forestry roads that cross the BDHR, we recommend consolidating some crossings to reduce the number of level crossings and increase safety. The crossings with the largest sightlines and most desirable approach gradients will be kept as the consolidated crossing and detours will be built for to the roads being cut off by the rail to provide continued access.

The proposed Billy Diamond and Grevet-Chapais railway alignments intersect with several existing roads and pathways used by vehicles and pedestrians. To ensure the safe use of these existing roads and pathways, crossings should be constructed.

To identify the number of crossings required, the proposed alignments have been reviewed against multiple data sources. Google Earth and other satellite imagery has been used to locate the points where the alignments cross existing roads and pathways. The alignments have also been compared against existing snowmobile and hiking trails, obtained from the Arc GIS data. To determine the type of crossing required, surface elevation data has been used to assign the crossing points an elevation so that the difference in height between the existing paths and the proposed railway could be calculated. The initial list of crossings points was reviewed to determine where it would be beneficial for crossings to be combined.

Based on the above methodology, a total number of 123 crossings have been identified; 85 of these are on the BDHR and 38 are on the Grevet-Chapais railway. A study of the paths and tracks was carried out to optimize the placement of the level crossings to increase the safety.

The following table shows the number and type of level crossings on the Grevet-Chapais and Billy Diamond lines.

Table 8.5–15: Level Crossing Quantities

Crossings	Minor	Major	Paved major
Grevet-Chapais	36	0	2
Billy Diamond	54	29	2

There are several types of level crossing, the categories below have been used to distinguish the different types of routes crossed by the railway:

- **Minor:** Crossing with a forestry trail, a domestic road, or a snowmobile trail.
- **Major:** Crossing with a non-asphalted road.
- **Paved Major:** Crossing with a major asphalted road.

A complete list of all the crossings on both lines is available in Appendix 6.12.

Figure 8.5-40: Two Examples of Minor Level Crossings

The left one is a level crossing with wood plank-based surface whereas the one the right is with a rubber-pad surface.

Figure 8.5-41: View of a Major Level Crossing

Due to the topography of the land, some level crossings need to be modified so that they respect the alignment of the track. Sections were made using LIDAR data of the area to obtain accurate models of each crossing.

In accordance with Transport Canada regulations, crossing surface on all passages must be smooth and continuous and must be in accordance with the following figure and table.

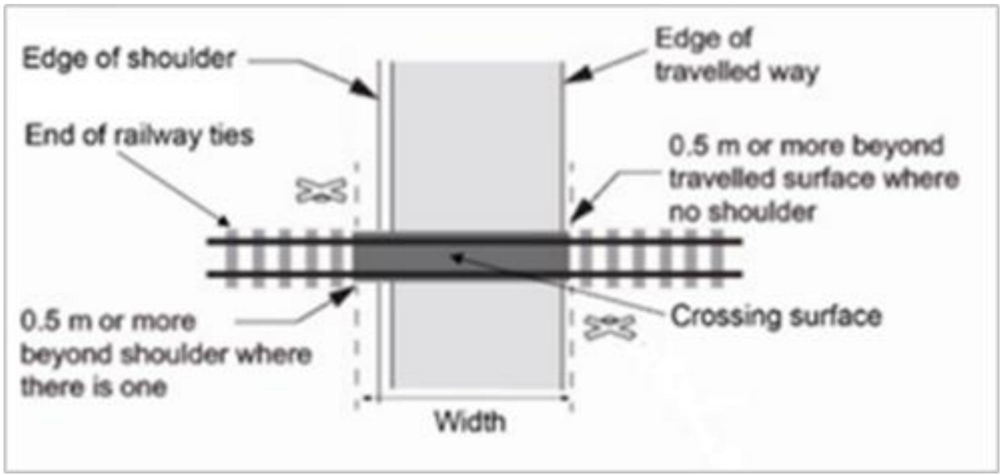


Figure 8.5-42: Grade Crossing Surface Dimensions

Table 8.5–16: Grade Crossing Surface Criteria

Flangeway			Width
Width	Minimum		65 mm
	Maximum	for public sidewalks, paths or trails all other crossing	75 mm 50 mm
Depth	Minimum		50 mm
	Maximum	for public sidewalks, paths or trails all other crossing	75 mm No limit
Elevation of the top of the rail relative to the crossing surface	Maximum above Crossing Surface		13 mm
	Minimum below Crossing Surface		7 mm

All crossings must have a sign providing warning (Railway crossing sign). The sign must:

- have a retroreflective coating that covers the entire surface of the signs,
- have a 50 mm border on the front of each blade, with transparent red ink silk-screen processed over sheeting material.

A sign indicating the number of tracks at a grade crossing (Number of Tracks sign) must:

- have a retroreflective coating that covers the entire front surface of the sign,
- have a digit and symbol that is transparent red inked silk- screened processed.

8.5.20.1 Clearances

Transport Canada's TC-E05 standard determines clearances for structures crossing or near the railway track. The standard states the following: “Every structure over or beside the railway track except bridges, snowsheds, and timber bridges shall afford the minimum clearances set out in Diagram 1.” Diagram 1 is reproduced in the figure below.

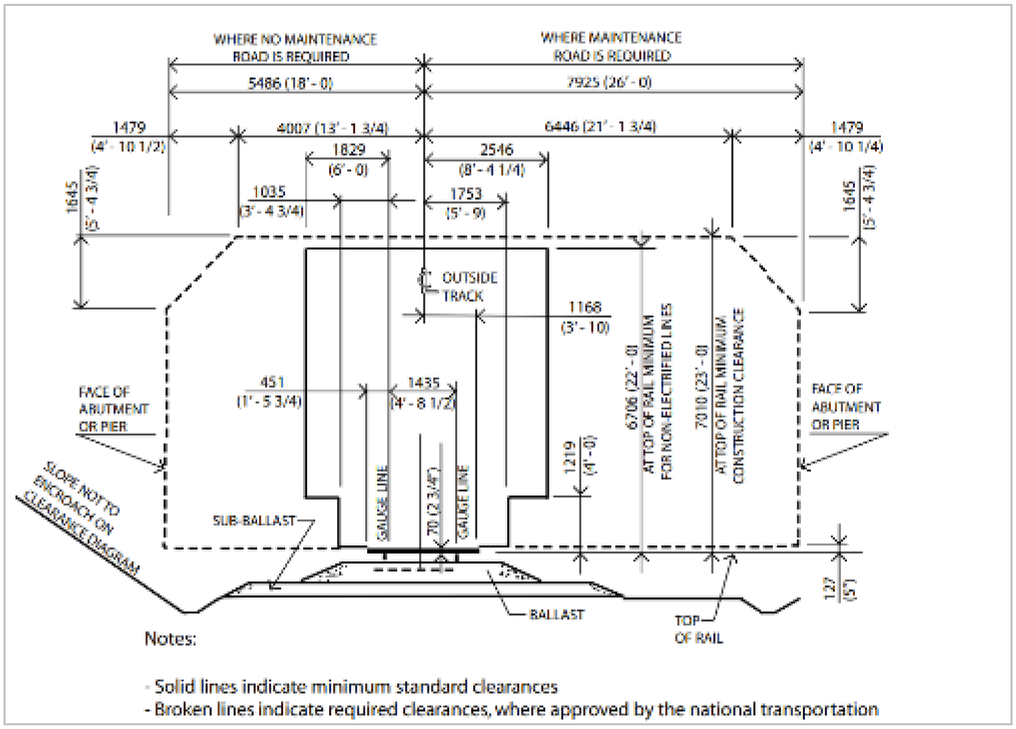


Figure 8.5-43: Standard Railway Clearances

The only utility crossings of the proposed project's railways are Hydro Québec high voltage line on the Grevet Chapais line (indicated in Figure 8.5-44). The lines are more than 32 feet above ground level and do not present any clearance problems for the railway.

The crossings are located at the following chainages of the of the Grevet Chapais line: 171+400, 223+000, 230+000, 263+000, and 272+600.

Figure 8.5-44: Location of High Voltage Lines Crossing the Grevet Chapais Rail Line

8.5.21 Sidings

The useful, and operationally safe, length of sidings, is defined as the length of the longest train to use the siding, plus an additional 10%. This distance is measured between the fouling points. The fouling point is also known as the Clearance point. It is a point identified at each end of a siding track which delineates the section of the siding where a train can safely stand without being hit by another train passing on the main line. Beyond this point the siding track moves closer to the main line. The longest train proposed is 1200 m long and 1300 m between fouling points has been used a basis for the design of the sidings to provide approximately 10% operational buffer.

On the Grevet-Chapais railway, the longest recommended train total length is 700 m long and 780 m between fouling points has been used a basis for the design of the sidings to provide a 10% operational buffer.

the gradient of sidings has been limited to less than 0.6%. For security purposes, backtracks would be on a 0.1% downgrade towards the bumping post at the terminating end of the backtrack.

Three sidings are proposed for the BDHR mainline alignment, and every siding has a backtrack. There are three sidings with back tracks on Grevet-Chapais line. The siding at the western end of the line has two tracks so that it can function as an exchange point with the connecting CN trains. All backtracks are 200 m long beyond the fouling point.

The distance between the mainline track and the siding tracks is 4.5 m minimum (this has been widened in some cases on Grevet-Chapais due to the mainline alignment curvature) and the distance between the siding tracks and the backtracks is 6 m. Some exceptions may be considered due to spacing or geographic restraints. The log/pole siding on the BDHR has been designed following the CN Industrial Track Standard which requires a minimum of 25 ft (7.62 m) track spacing for log/pole loading facilities.

8.5.22 Passenger Stations and Platforms

Two passenger train stations, Matagami and Waskaganish, are served by the BDHR railway. The site proposed for the Matagami Station is on the north-west side of the Bl Industriel and just south of the junction with the Bd Matagami. The site proposed for the Waskaganish Station is at the Billy Diamond Highway and Waskaganish Road junction and immediately adjacent to the proposed railway yard. The Grevet-Chapais line also has two stations. The site proposed for the Waswanipi Station is adjacent to Road 113 where it is crossed by the railway line approximately 1.5 km north of Desmaraisville. The proposed site for the Chapais Station is immediately to the south of the community and a 700 m road connects it to the Rue de l'Assainissement.

One design concept can be applied to the buildings and platforms of all four stations. The development of the station design concept is described in the following section.

Two passenger train stations (Matagami and Waskaganish) are served by Billy Diamond mainline railway and two other stations (Waswanipi and Chapais) are served on Grevet-Chapais mainline railway. One design concept could be applied for the four stations' buildings and platforms.

Some Local architecture inspired by the culture of the Cree community (examples are shown in the figures below) are considered as good references that demonstrate the expression of the Cree community values in terms of architecture:

- The use of natural elements (i.e., wood).
- Open views to maintain the connection with the exterior.
- The reduction of footprint in the territory to maximize the natural space and make the building the most space efficient.

Figure 8.5-45: Examples of Local Architecture Inspired by the Cree Culture

They are, from left to right - Aanischaaukamikw Cree Cultural Institute, Waskaganish Fire Hall & Eeyou Eenou Police Force (E.E.P.F.) Detachment -Waskaganish. The following table presents the different components considered in the design.

Table 8.5–17: General Passenger Station Description

Component	Description
Platform	Allows a safe access to the train. It is wide enough to allow easy circulation of passengers, maintenance, and snow removal activities
Train Station Building	• Public toilets • Passenger waiting area • Ticketing office room • Maintenance facilities
Outdoor Shelter Space	Allows passengers to be protected while still being outdoors. It is a connection between the waiting area and the Platform.
Parking	25 parking spots with 1 parking for people with disabilities.

Passenger stations require an enclosed space which should meet the minimum requirements for operational purposes. Suitable spaces should be considered for the staff, for maintenance operations, and for passengers. A parking lot accommodate up to 25 vehicles including one spot for people with disabilities is also proposed for each station. The figure below illustrates the general arrangement of a station.

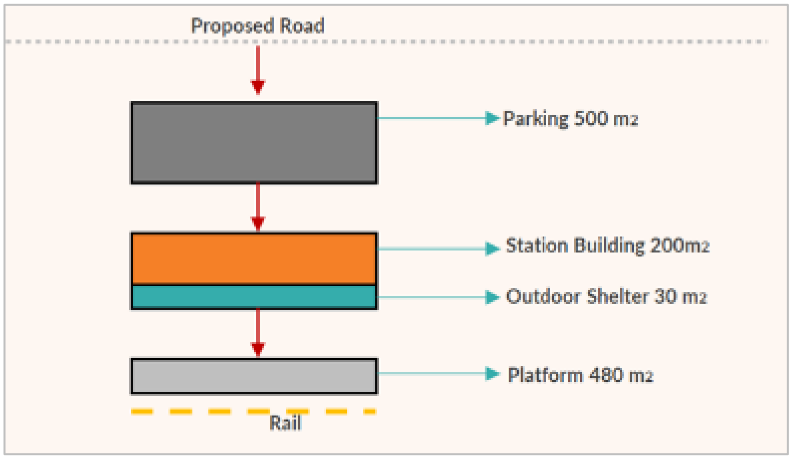


Figure 8.5-46: Passenger Station General Arrangement Diagram

Three different configurations are proposed for the concept of the passenger station. **Option A:** The station building is located to the side of the pedestrian connection between the parking lot and the station platform. This provides a direct connection between the three elements (parking lot, building and platform).

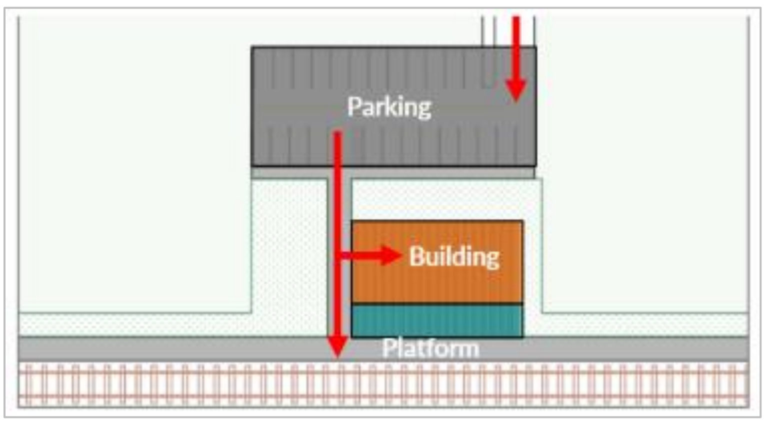


Figure 8.5-47: Passenger Station Concept Plan - Option A

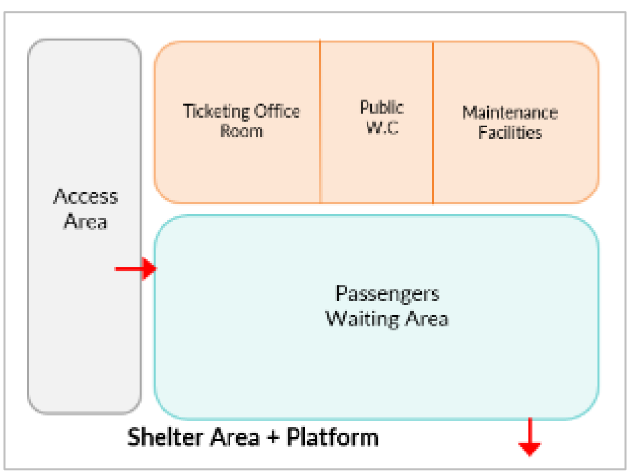


Figure 8.5-48: Planning Diagram Illustrating General Approach – Passenger Station Option A

Option B: Two buildings, the waiting room for passengers and facilities for railway employees, are separated in this option: Passenger circulation to and from of the platform passes through an area protected by a roof common to the public and railway personnel buildings.

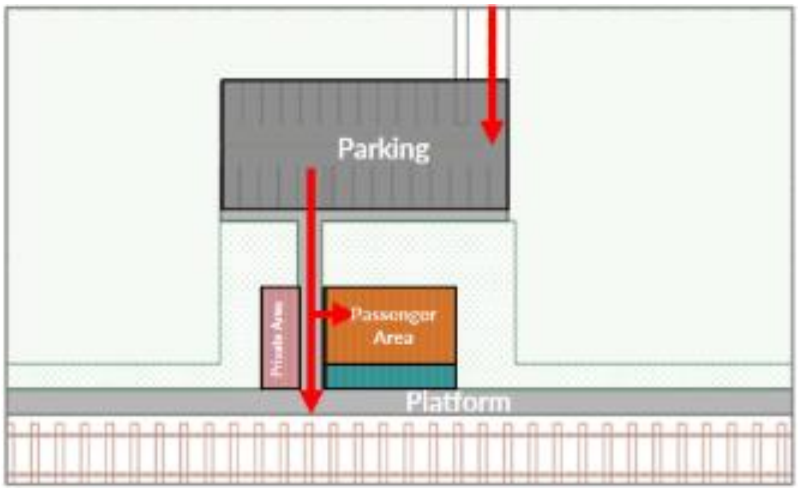


Figure 8.5-49: Passenger Station Option B Concept Plan

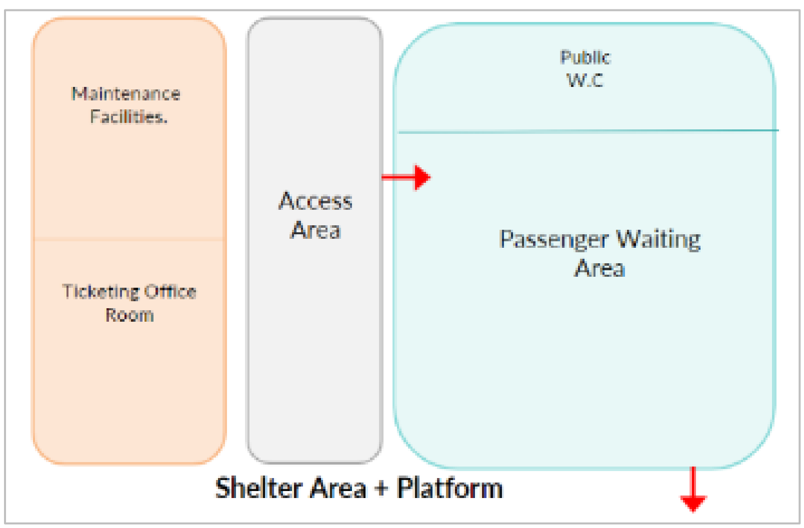


Figure 8.5-50: Passenger Station Option B – Planning Diagram Illustrating General Approach

Option C: A single building contains all the functions required for the train station with the main circulation through the building.

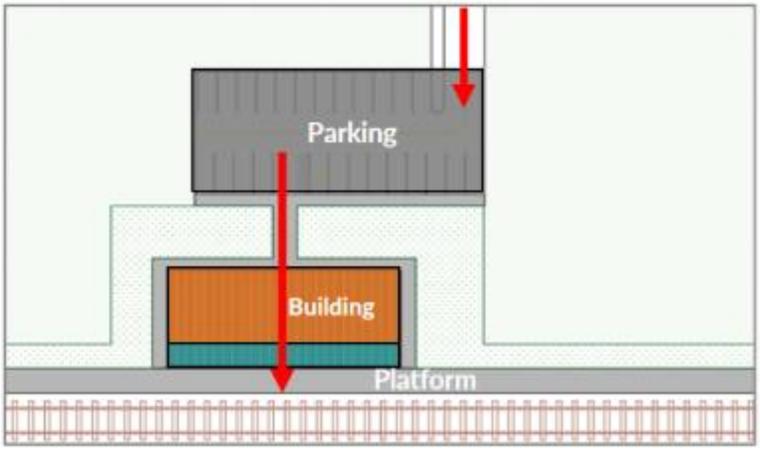


Figure 8.5-51: Passenger Station Option C Concept Plan

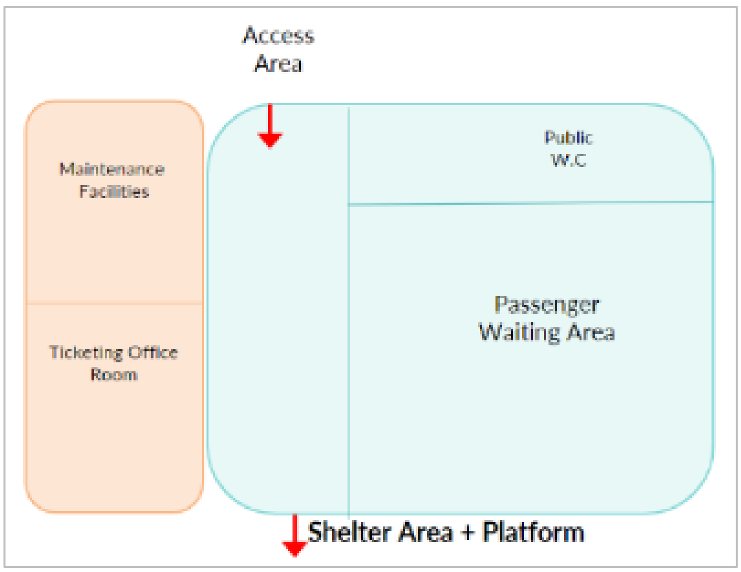


Figure 8.5-52: Passenger Station Option C – Planning Diagram Illustrating General Approach

8.5.22.1 Access & Circulation

The primary means of entry to the station building and/or the platform, from the parking lot should be an accessible pathway that is barrier free and wide enough to allow circulation to everyone. The main access can be located on the side of the building, this creates a direct link to the platform and a link to the platform for those needing to also enter the building, in case of rain or snow for example. The configuration of the station should respond to the parameters and needs of the environment and to local requirements.

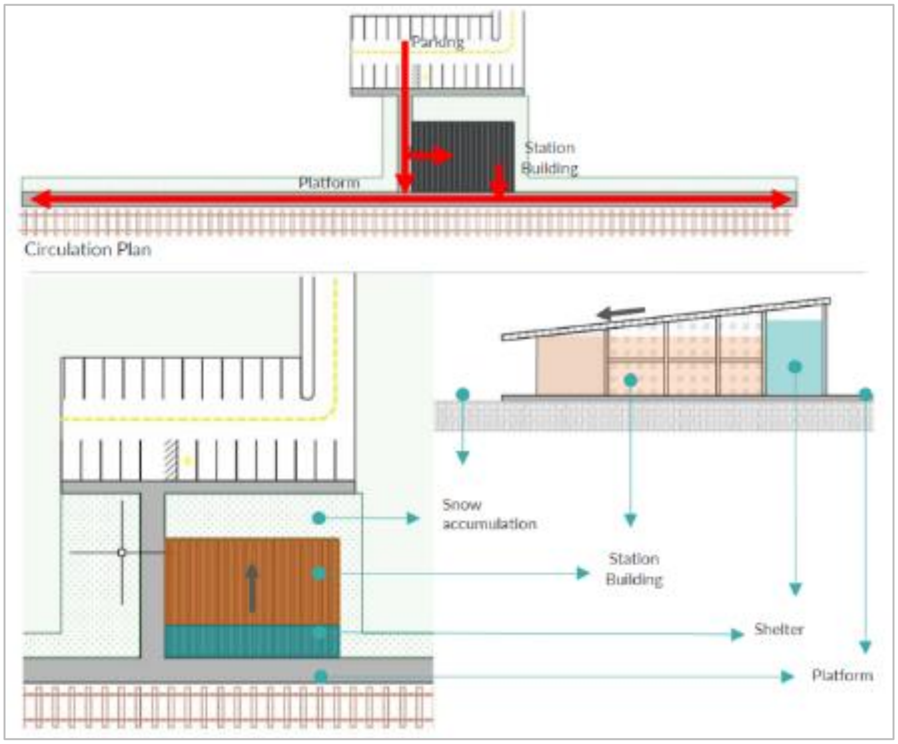


Figure 8.5-53: Plan of Passenger Station – Facilities

Figure 8.5-54: Layout of Station Building Rooms

8.5.22.2 *Passenger Platforms*

Passenger platforms must respect the following dimensions:

Table 8.5–18: Passenger Platform Dimensions

Dimension	Requirement
Minimum low-level platforms	203 mm (8") Above the top of rail 1676 mm (5'-6") From the centreline of the adjacent track to edge of the platform
Minimum high-level platforms	1308 mm (4'-3-½") Above the top of rail 1702 mm (5'-7") From the centreline of the adjacent track to edge of the platform
Minimum side platform width	3048 mm (10')

Figure 8.5-55: Example of a Passenger Station Platform

8.5.23 Transshipment Yards

Freight yards provide tracks and laydown areas for loading/unloading freight trains, carrying out safety inspections, garaging idle equipment, turning locomotives, effecting minor running repairs and exchanging traffic with other operating railways.

Three yards are included in this proposed project: two yards for BDHR and one for GCR. The configuration of each yard varies depending on the commodities handled. The yards in Matagami also provides access to the rolling stock maintenance shop. For more information about the buildings inside this these yards, please review the section on Railway Operations.

8.5.23.1 *Waskaganish Yard*

The proposed Waskaganish Yard is located near the intersection of Waskaganish Road and Billy Diamond Highway and is approximately 103 kilometres from the Waskaganish community. This location was considered more advantageous over a location near the Rupert River (KP 253) for the following reasons:

1. The Tallymen of the trapline (N23) disclosed that they hunt moose in a section of land west of the railway near Rupert River that would conflict with a yard on the west side of the railway at that location. The Tallymen stated that they agreed with the current proposed location of the yard (adjacent to the Waskaganish access road).
2. There is a long, broad horizontal curve in the railway prior to the Rupert River that will severely limit the location of the switches needed to connect a yard to the mainline.
3. The proposed yard's close proximity to the Waskaganish access road provides good access for passengers and the site has suitable topography that minimizes cut and fill quantities.

The estimated travel time by car between the yard and the community is about 1 hr 36 min with the current condition of the road, however when the proposed phase I upgrades of the Waskaganish road are completed, the travel time will decrease to a little over 1 hour. The accommodations found at the camp near the Rupert River will be used for any railway staff that need to stay overnight.

Figure 8.5-56: Location Plan - Waskaganish Community and Waskaganish Yard

Figure 8.5-57: Location Plan - Waskaganish Yard

Figure 8.5-58: Location Plan - Waskaganish Yard

The Waskaganish Passenger Station is located between the Yard and the Waskagansh Road. There is sufficient space to locate a gasoline service station on the Waskaganish Road adjacent to the access road to the station and the access road to the yard.

The following buildings will be required in the Waskaganish yard:

1. Maintenance of Way Building – to store maintenance of way equipment
2. Office building – to house crew change out area for yard workers
3. Lithium Bulk 01 – to store lithium product from a miner before loading on a rail car
4. Lithium Bulk 02 – to store lithium product from a miner before loading on a rail car

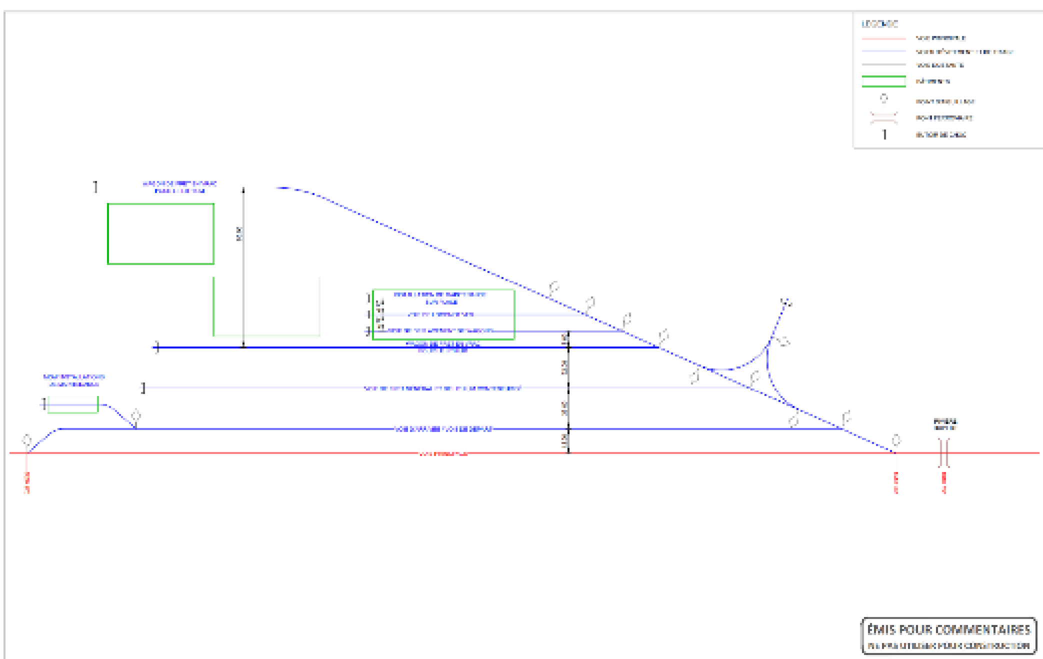


Figure 8.5-59: Schematic Layout of Waskaganish Yard

8.5.23.2 *Matagami Yard*

The proposed Matagami yard is located near the Bd Industriel (Road 109). Approximately 7 kilometres from the Matagami community. The estimated traveling time by car is about 8 min.

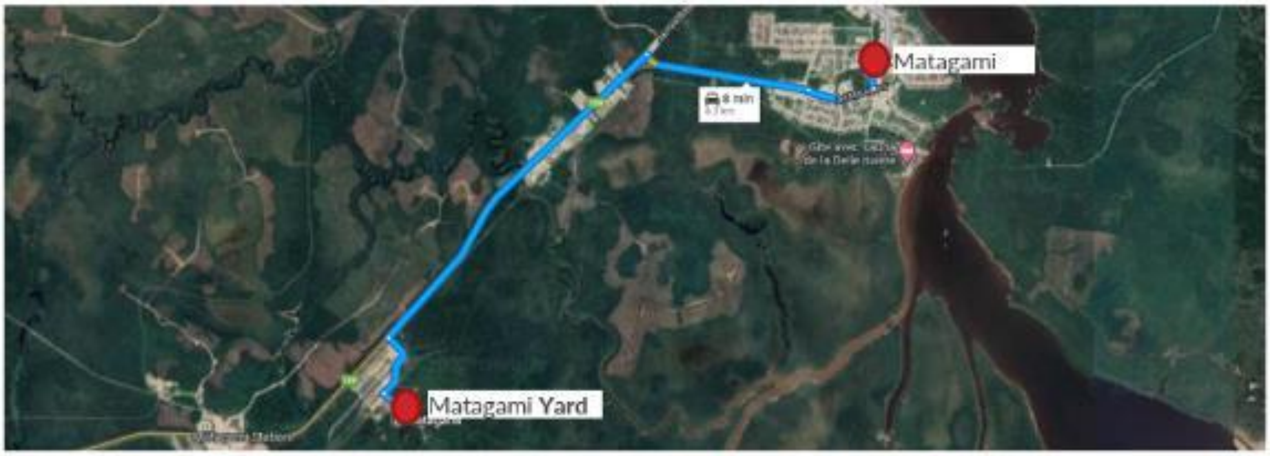


Figure 8.5-60: Location Plan - Matagami Community and Matagami Yard

Figure 8.5-61: Location Plan - Matagami Yard

The following elements will be required in Matagami Yard:

1. Maintenance of way – to store and maintain MOW equipment
2. Depot – to maintain rolling stock (also known as workshop)
3. RIP Track – to store car movers

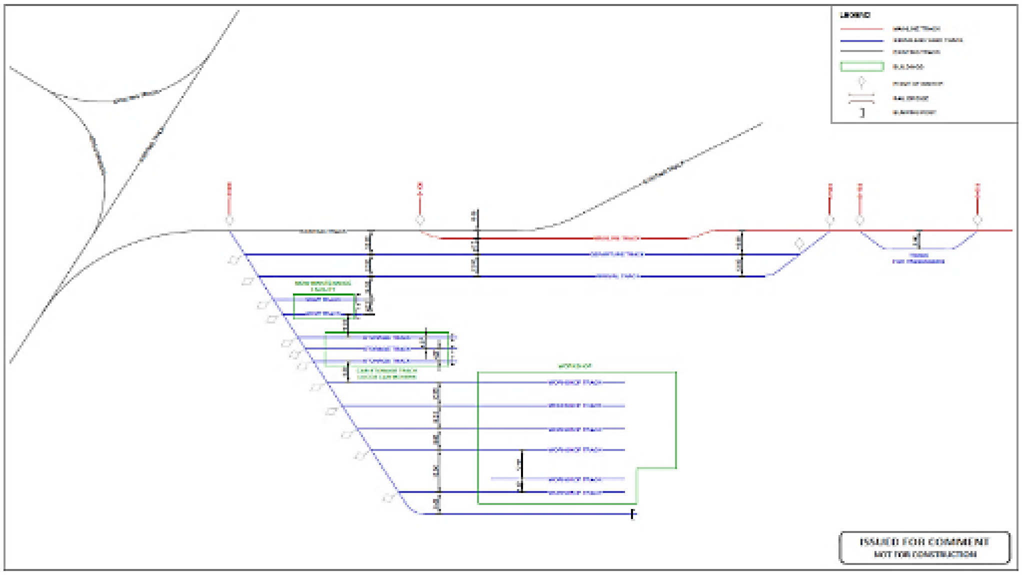


Figure 8.5-62: Schematic Layout of Matagami Yard

8.5.23.3 Chapais Yard

The proposed Chapais Yard is located south of Road 113 approximately 2 kilometres east of the Chapais community.

Figure 8.5-63: Location Plan - Chapais Community, Chapais Station and Chapais Yard

The following buildings will be required in the Chapais Yard:

1. Maintenance of way – to store and maintain MOW equipment
2. Lithium Bulk – to store lithium product from a miner before loading on a rail car
3. Copper Bulk 01 – to store copper product from a miner before loading on a rail car
4. Copper Bulk 02 – to store copper product from a miner before loading on a rail car
5. RIP Track - Loco Car movers – to store car movers.

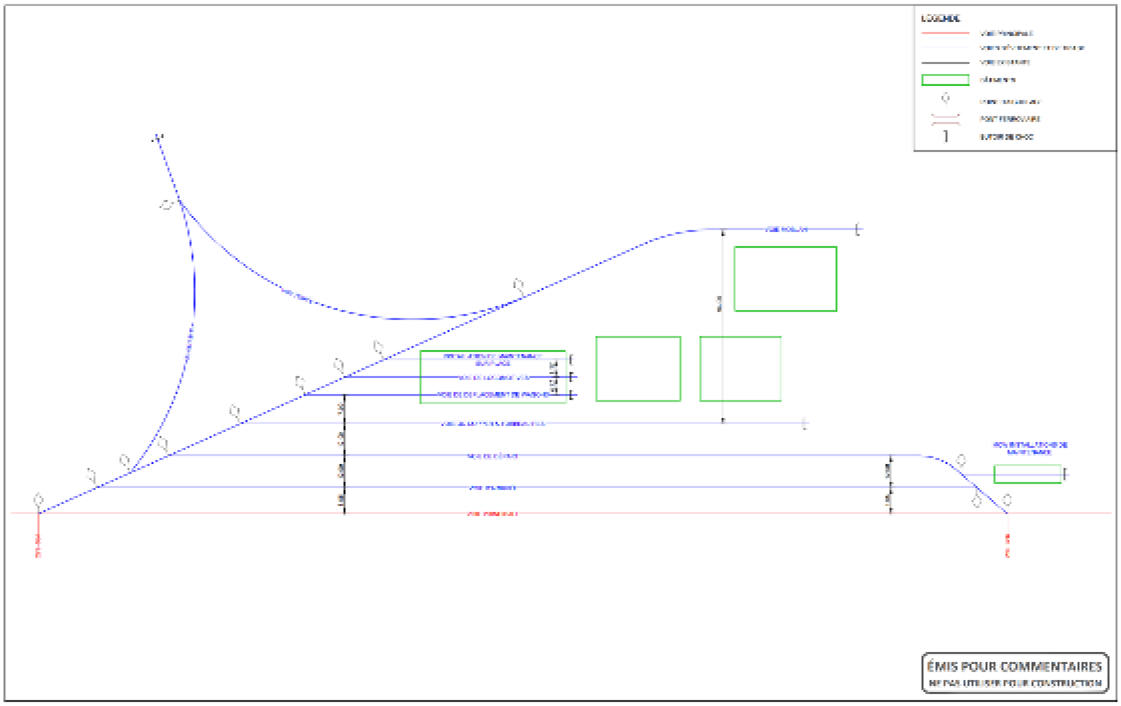


Figure 8.5-64: Schematic Layout of Chapais Yard

8.5.24 Structures

This section evaluates the works required on new and existing structures along the proposed new BDHR, and the abandoned section of the Grevet-Chapais Subdivision. The structures study can be summarized in four activities as cited in the list below:

- Create an inventory of existing structures.
- Define the works required at new and existing structures.
- Organize the information into individual recommendation information sheets.
- Define pay items and calculate quantities for a capital cost estimate.

8.5.24.1 Definitions

The following terms appear frequently in this section of the report; as such it is important that the reader be familiar with the following terminology in the context of this section.

Abutment: Substructure forming the endpoints of the span, supporting the bridge superstructure, and resisting lateral earth pressures. For this report, the low kilometre point abutment is classified as Pier I, while the high kilometre point is classified as Pier 'N'.

Bearing Seat: Component of abutment on which the superstructure is supported.

Bracing: Bridge component used to stabilize main girders or truss members by preventing buckling, distributing load and maintaining bridge geometry.

Capacity Rating: The maximum safe axle load permitted on a bridge expressed in terms of the Reference Load. A Service Load is deemed to be considered safe if its Equipment Rating is less than the Capacity Rating for each structural member of the bridge.

Deck Plate Girder (DPG): A structural steel span whose track and/or deck is supported directly by the top flanges of two steel plate girders. Often, the railway ties can act as the structural deck for a DPG.

***Deck* Truss:** A bridge span whose load-bearing superstructure is composed of a floor system, and a trussed girder - a structure of connected elements usually forming triangular units. The connected elements (typically straight) may be stressed in tension or compression from applied dead and railway live loads. The deck is composed of a floor system supported by the top chords and therefore, passes over the truss structure.

Equipment Rating: The axle load of a specific trainset that generates an equivalent internal reaction on a bridge member to that created by the Reference Load.

Fixed/Expansion Bearing: Bridge component transmitting forces from the superstructure and substructure. Fixed bearings prevent lateral and longitudinal translation whereas expansion bearings only prevent lateral motion.

Floor Beam: Horizontal, lateral beams forming part of the floor system and connecting the two sides of a truss bridge. Floor beams receive the load from the stringers and transfer it to the panel points of the truss.

Gusset Plate: Steel plates that are used to connect various structural members. A gusset plate can be fastened to a permanent member either by bolts, rivets, welding, or a combination of the three. Gusset plates not only serve as a method of joining steel members together, but they also strengthen the truss nodes.

Joint: Connection between members of a truss or floor system using gusset plates or clip angles.

Pier: Component of substructure providing intermediate support to the superstructure, each pier separates two spans.

Plate Girder: I-shaped beams composed of two flanges and one web plate welded together to form one composite member. The plate girder is the main structural component of a DPG span.

Pot Bearing: Expansion or fixed bearing supporting vertical and horizontal loads while allowing limited rotation around any horizontal axis and lateral translation.

Reference Load: A standard axle spacing and tonnage that is used to compare multiple Service Loads. For this report, the Reference Load is the Cooper E 80, the standard in many North American railways.

Rehabilitation Works: Maintenance works performed to return the structure, or component, to its original state or condition.

Rocker Bearing: Expansion bearing with curved top and bottom permitting horizontal translation by rotating.

Scour: The removal of sediment from around bridge abutments and piers due to fast moving water, undermining the supports and compromising structural integrity.

Service Load/Train: Axle spacing and tonnage of the trainset presently operating on the railway, or proposed to operate on the railway.

Strengthening Works: Works performed to increase the capacity rating of a member.

Stringer: Horizontal, longitudinal beams comprising part of the floor system. Stringers receive the load from the rails and transfer it to the floor beams.

Truss Member: Individual members forming a truss. They may be stressed from tension, compression, or sometimes both in response to dynamic loads.

Through Plate Girder (TPG): A structural steel span where the rails are carried low down between the plate girders.

Through Truss: A bridge span whose load-bearing superstructure is composed of a truss girder, a structure of connected elements usually forming triangular units. The connected elements (typically straight) may be stressed in tension or compression from applied dead and railway live loads. The deck of a Through Truss span is supported by the bottom chords and therefore, passes through the truss structure.

Wing Wall: Walls adjacent to the abutments acting as ballast retaining walls.

8.5.24.2 Review of Existing Information

Original Engineering Drawings

The Consultant acquired from Canadian National Railways (CN) original engineering drawings for all bridge locations on the Grevet-Chapais Subdivision. On some of the general arrangement drawings, the foundation types (piles, or spread footings) were also shown. Engineering drawings with corresponding design calculations were legible on some of these drawings as well.

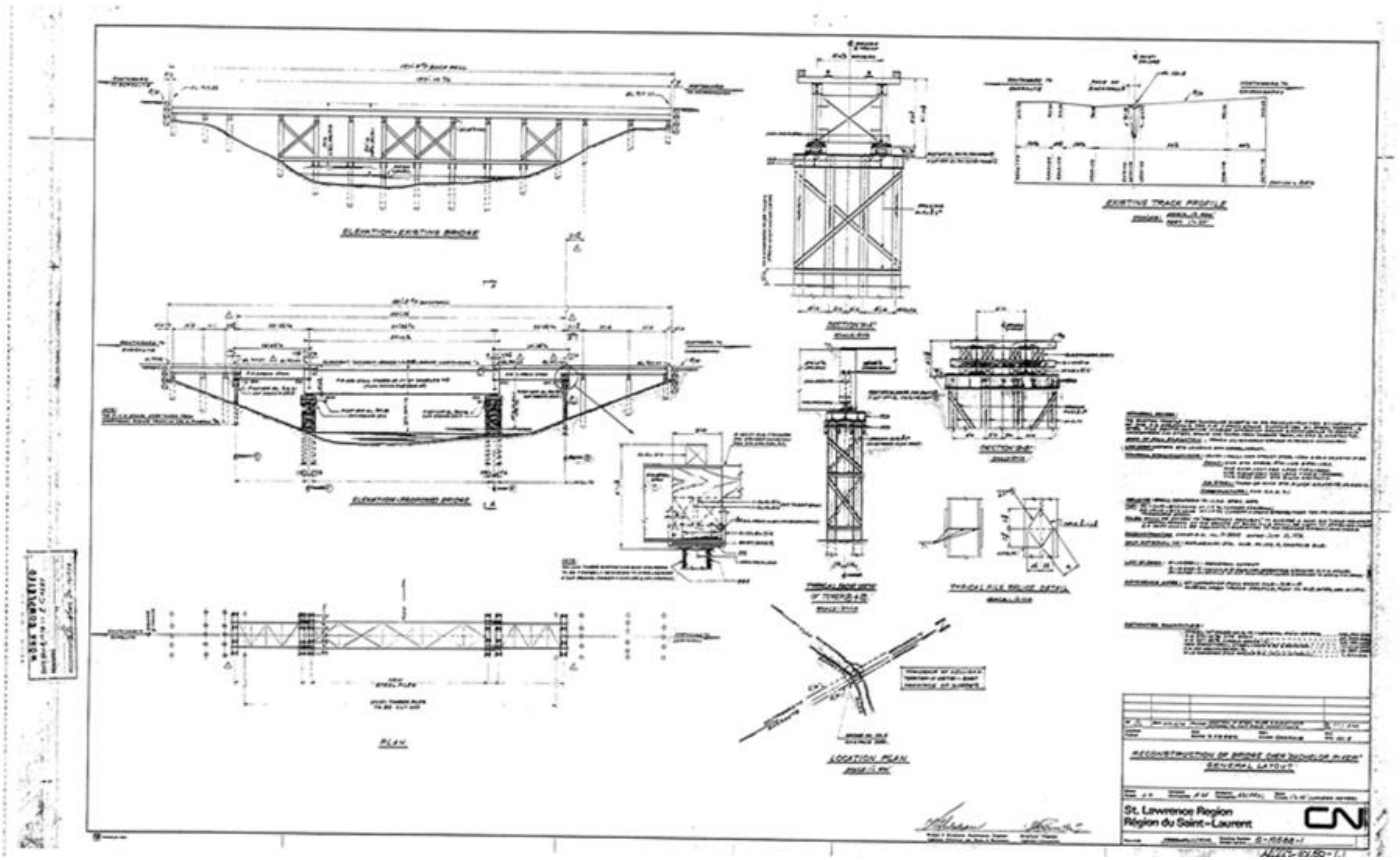


Figure 8.5-65: Reconstruction of Bachelor River Bridge Drawing (1974)

Chapais Subdivision Timetables

In addition to the engineering drawings, the Consultant also obtained the original CN operating timetables for the Chapais Subdivision, which indicated the maximum axle load and operating speed permitted across each of these bridges.

TIME TABLE NO 84 JULY 5, 2016	CN			CHAPAIS SUB PAGE 157
METHOD OF CONTROL	**CHAPAIS** SUBDIVISION N ↓ S ↑	MILE	TGBO LIMITS	RTC STANDBY CHANNELS
STK	BARRAUTE (Jct with Taschereau sub)	0.0	0.0	C6 T2 (36.0)
1.0 ↑ OCS	QUEVILLON	55.5	↕	C81
↓ 70.0 STK	FRANQUET Y (Jct with Matagami sub)	72.1		T2
	END OF TRACK	78.06	78.06	
Tracks has been removed between mile 78.06 and mile 177.5				
177.5 ↑ OCS	END OF TRACK	177.5	177.5	C 6 T2
↓ 190.4	FARIBAULT (Jct with Cran sub)	191.1	↕	
STK	CHIBOUGAMAU Y	199.1		
	END OF TRACK	200.19	200.19	
Subdivision standby channels 0.0 - 36.0 : C6 36.0 - 78.06 : C81 169.4 - 200.19 : C6				

CHAPAIS SUBDIVISION FOOTNOTES

Figure 8.5-66: CN Chapais Subdivision 2016 Timetable

8.5.24.3 LIDAR Data

LIDAR data is an extremely useful tool when designing railway bridges. By obtaining the existing ground elevation and comparing that with the proposed track elevation, bridge pier, abutment, and wing wall heights can be calculated.

8.5.24.4 Hydrological Conditions

To obtain the minimum clearance heights between the bottom of the bridge, and the river/stream which it crosses, the hydrological conditions must be known. By studying the existing and estimated future conditions at each bridge site, the bridge dimensions and track elevation can be calculated.

8.5.24.5 Grevet-Chapais Structure Types

8.5.24.5.1 Beam Spans (Timber/BMS)

Beam spans are a common bridge type found throughout the railway industry, as they are easy to install and are typically used for short crossings less than 20 m. In this railway, there are timber and steel beam spans, which are composed of beams running parallel with the track and connected to the transverse railway ties. These stringers are supported by either wooden timber bents or steel sections that are driven directly into the riverbed.

Figure 8.5-67: Example of Beam Span Bridge

8.5.24.5.2 Deck Plate Girder (DPG)

A deck plate girder (DPG) bridge is a structural steel span comprised of two parallel steel plate girders. The girders are braced together with horizontal and vertical bracing with wooden ties transferring the loads from the rails directly to the top flanges of the girders. The bridges composed of DPG spans are typically used to traverse short to medium (20-40 m) crossings along the alignment.

Figure 8.5-68: Example of DPG Bridge

8.5.24.5.3 Through Plate Girder (TPG)

A through plate girder (TPG) bridge is a common choice for medium crossings (between 30 – 50 m), and where there is limited vertical clearance under the bridge. The main structural elements is composed of the floor system, which is composed of stringers and floorbeams attached to the girder webs on either side of the bridge.

Figure 8.5-69: Example of TPG Bridge

8.5.24.5.4 Through Truss (TT)

Similarly, a through truss bridge is a structural steel span whose deck and track are supported by stringers laid on top of transverse floor beams attached to the bottom chords of a truss, passing forces through the truss structure and to the supports on either side of the span. These types of spans are typically used for the longer crossings i.e., greater than 50 m.

Figure 8.5-70: Example of TPG Bridge

8.5.24.5.5 Current Situation – Grevet-Chapais

Portions of the abandoned section of the CN Chapais Subdivision is now being used as a forestry road (<20 km directly west of Chapais) for logging trucks throughout the year, and as a skidoo trail during the winter (<50 km around KP 175). Much of the infrastructure has been ripped up and sold off by CN prior to abandonment, and the majority of the remaining infrastructure requires varying levels of rehabilitation prior to resuming railway operations.

During the bridge inspections, additional information pertaining to a structure's location, type, length, and other details were found to populate the bridge inventory. Given that there were no recent pictures or inspection reports of these bridges, it was deemed necessary to visit all bridges found in the abandoned section of the subdivision. Along this abandoned portion of the Grevet-Chapais Subdivision, there are nine existing railway bridges which are summarized in the below table:

Table 8.5–19: Principal Features of the Existing Bridges on the GCR

Bridge ID	CN Mile Point	KP	Crossing	Span Length (m)	Existing Layout
1	91	146+500.10	O'Sullivan River	57 (187 ft)	3 x DPG
2	101.8	163+848.42	Bachelor River	48 (157 ft)	3 x DPG
3	104.1	167+585.33	Stream	27 (89 ft)	6 x Timber
4	105.6	169+953.95	Bachelor River	32 (105 ft)	7 x Timber
5	118.8	191+146.30	River	23 (75 ft)	3 x TPG
6	122.3	196+859.91	Opawica Lake	42 (138 ft)	2 x DPG
7	125.3	201+720.11	Opawica Lake	89 (292 ft)	TT + 2 DPG
8	141.7	236+711.18	Ross River	58 (190 ft)	13 x Timber
9	156	250+961.65	Obotog River	95 (312 ft)	12 x BMS

*Note: the kilometer point (KP) increases from west to east

8.5.24.5.6 Visual Inspections

A site visit to each of the bridges along the Grevet-Chapais railway was completed September 14-15, 2021. The following items were inspected at each bridge to obtain the general condition of each of the following elements:

6. Abutments/Piers
7. Steel members
8. Walkways
9. Bearings
10. Joints (bolted, welded or rivets)
11. Handrails

Figure 8.5-71: Inspection of O'Sullivan River Bridge

An additional inspection was carried out from June 15th to 18th at the through truss (Bridge 7 – KP 201+720.11) to verify certain member dimensions for the capacity analysis.

8.5.24.5.7 Existing Grevet-Chapais Structures

1. KP 146.50 (1955)			
No. of Spans	3	**Total Length**	56,69m (186')
Span Lengths	13,7m - 27,1m - 13,7m (45' - 90' - 45')	**Feature Crossed**	O'Sullivan River
Structure Type(s)	DPG-DPG-DPG		
Foundation Type	Footings		
Works to do	• Results of capacity rating: • Plate girders need to be strengthened.		

Figure 8.5-72: General View of the Bridge at KP 146.50

2. KP 163.85 (1974)			
No. of Spans	5	**Total Length**	46m (152')
Span Lengths	7m -7m -18m -7m -7m (23' - 23' - 59' - 23' - 23')	**Feature Crossed**	Bachelor River
Structure Type(s)	TIMBER-BM-DPG-BM-TIMBER		
Foundation Type	Steel piles		
Works to do	Results of capacity rating: • The rating of the Deck plate girders confirms that they are adequate. Bents are not adequate to resist the longitudinal forces.		

Figure 8.5-73: General View of the Bridge at KP 163.85

3. KP 167.59 (1976)			
No. of Spans	3	**Total Length**	23 m (75‘)
Span Lengths	7,6m - 7,6m - 7,6m (25‘ - 25‘ - 25‘)	**Feature Crossed**	Creek
Structure Type(s)	TPG-TPG-TPG		
Foundation Type	Steel piles		
Works to do	Results of capacity rating: • The rating of the Deck plate girders confirms that they are adequate. Bents are not adequate to resist the longitudinal forces. • Demolish and replace with 1 x 30 m TPG.		

Figure 8.5-74: General View of the Bridge at KP 167.59

4. **KP 169.95**			
No. of Spans	7	**Total Length**	32m (105’)
Span Lengths	4,6m (15’)	**Feature Crossed**	BachelorRiver
Structure Type(s)	Beam Spans		
Foundation Type	Timber Piles		
Works to do	Demolish & replace with 2 x 25m DPG		

Figure 8.5-75: General View of the Bridge at KP 169.95

5. **KP 191.15**			
No. of Spans	3	**Total Length**	23 m (75’)
Span Lengths	7.6m (25’)	**Feature Crossed**	River
Structure Type(s)	TPG-TPG-TPG		
Foundation Type	Steel Piles		
Works to do	Results of capacity rating: • Replace backwalls • Install wingwalls • Replace ballast, waterproof deck • Evaluate piles • Remove beaver dam • Install walkway • Concrete core drilling		

Figure 8.5-76: General View of the Bridge at KP 191.15

6. KP 196.86 (1956)			
No. of Spans	2	**Total Length**	41m (135’)
Span Lengths	27,4m - 13,7m (90’ - 45’)	**Feature Crossed**	Crossing Opawica Lake
Structure Type(s)	DPG-DPG		
Foundation Type	Footings		
Works to do	Results of capacity rating: • The rating of the deck plate girders confirms that they are adequate for the projected live loads.		

Figure 8.5-77: General View of the Bridge at KP 196.86

7. KP 201.72 (1956)			
No. of Spans	3	**Total Length**	89m (293’)
Span Lengths	13,7m - 60m - 13,7m (45’ - 197’ - 45’)	**Feature Crossed**	Crossing Opawica Lake
Structure Type(s)	DPG-Truss-DPG		
Foundation Type	Footings		
Works to do	Results of capacity rating: • Through Truss span is not adequate to support the projected passenger and freight cars traffic; principal members need structural strengthening.		

Figure 8.5-78: General View of the Bridge at KP 201.72

8. **KP 236.71**			
No. of Spans	13	**Total Length**	58m (190’)
Span Lengths	4m x 4,6m (13 x 15’)	**Feature Crossed**	Ross River
Structure Type(s)	13 Timber		
Foundation Type	Timber piles		
Works to do	Bridge to be demolished. Recommended to replace with 2x30m’ DPGs with 2 new abutments and 1 pier.		

Figure 8.5-79: General View of the Bridge at KP 236.71

9. **KP 250.96**			
No. of Spans	12	**Total Length**	95m (313’)
Span Lengths	3,7x8m (12 x 26’)	**Feature Crossed**	Obotog River
Structure Type(s)	12 BMS		
Foundation Type	Steel piles		
Works to do	Bridge to be demolished due to lack of capacity and general overall poor condition. Recommend replacing with 4 new 25m TPG spans.		

Figure 8.5-80: General View of the Bridge at KP 156.00

8.5.24.5.8 Visual Inspection Results

Following the site visit and the completion of the visual inspection at each bridge, the Consultant has prepared a list of proposed works for each structure. After reviewing existing information and visual inspection results, it has been recommended to demolish and replace all timber structures with steel structures, and for existing steel structures, a capacity analysis was recommended. Details on the proposed works for each structure is presented in the below.

Table 8.5–20: Proposed Works for Existing Bridges on GCR

Bridge ID	Crossing	Span Length (m)	Proposed Works
1	O'Sullivan River	57	Detailed inspection and capacity analysis required Replace bridge deck Hydraulic study required
2	Bachelor River	48	Detailed inspection and capacity analysis required
3	Stream	27	Demolish & replace with 2 x 30m TPG
4	Bachelor River	32	Demolish & replace with 2 x 25m DPG
5	River	23	Detailed inspection and capacity analysis required Replace backwalls Install wingwalls Replace ballast, waterproof deck Evaluate piles Remove beaver dam Install walkway Concrete core drilling
6	Opawica Lake	42	Detailed inspection and capacity analysis required
7	Opawica Lake	89	Detailed inspection and capacity analysis required
8	Ross River	58	Demolish & replace with 2 x 30m DPG
9	Obotog River	95	Demolish & replace with 4 x 25m DPG

The bearing capacity assessment consisted of the evaluation of the steel spans and piers, as recommended in the Railway Best Practice. During the field visits, particular attention was paid to the level of the piers, abutments, existing retaining walls and the condition of the foundations in order to validate whether major defects and even signs of distress were present. Some river hydraulic studies were recommended due to the presence of erosion of existing piers and abutments. Some stabilisation work on the existing piers and abutments is part of our recommendations and has been considered in our estimates. It should be noted that since the solid concrete piers and abutments did not show any major problems, neither structural nor geotechnical instability, we do not see the relevance of carrying out exhaustive studies on their capacity, nor on the existing foundations. For a traffic of less than 5 MGTM, these elements will not be overstressed to cause major problems in the medium term. Speeds can be reduced below class 3 if necessary.

8.5.24.5.9 Capacity Analysis

Following the visual inspection, VEI team undertook a capacity analysis for the five bridges where a capacity analysis was recommended. The objective of the capacity analysis is to evaluate member dimensions, assess conditions, verify structural capacities, and recommend strengthening works where required. The general methodology of a capacity analysis is detailed in the below figure and subsequent text.

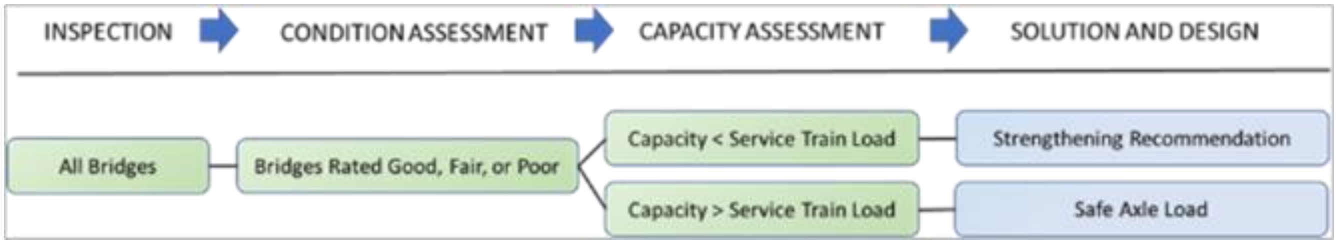


Figure 8.5-81: Bridge Scenario Analysis Flowchart

After thoroughly reviewing the bridge properties, geometry, and member sections, the Consultant used structural analysis software to analyze critical structural members for each structure. The software uses an iterative process to calculate the axial force, shear force, and bending moment in each member based on the position of a train moving over the structure. The user of the software can set the parameters of the analysis to increase or decrease the incremental distance to be evaluated.

Next, the Consultant added dynamic effects such as impact loads to obtain the maximum stress applied to each member to obtain an Equipment Rating.

The Reference load used for comparison was the Cooper E80, the standard used for most railways in North America.

Finally, a Member Rating was obtained by comparing the member's structural capacity to the forces generated in the member by the live load.

Once the capacity of the member, and the forces generated by the live load into the member are determined an 'E' value was obtained to determine if there is any overstressing in the member, or conversely, what excess capacity remains when under load. If the member has an E value greater than 80 than that member can adequately carry the train loads.

8.5.24.5.10 Structural Modelling

To determine the axial forces (compression and tension) in the critical members, a 2D model of each span was prepared using Advance Design America (ADA) software. The forces obtained from the model were reported in MathCad calculation sheets, where the different stresses and "E-rating" were determined based on the normal and maximum allowable stresses. The figure below shows the 2D model of the truss span of the bridge at KP 125.30.

The maximum bending moments and shears in the girders, floor beams and stringers were determined using ADA software in conjunction with MathCad calculations. It is important to note that floorbeams and stringers were considered as simply supported beams.

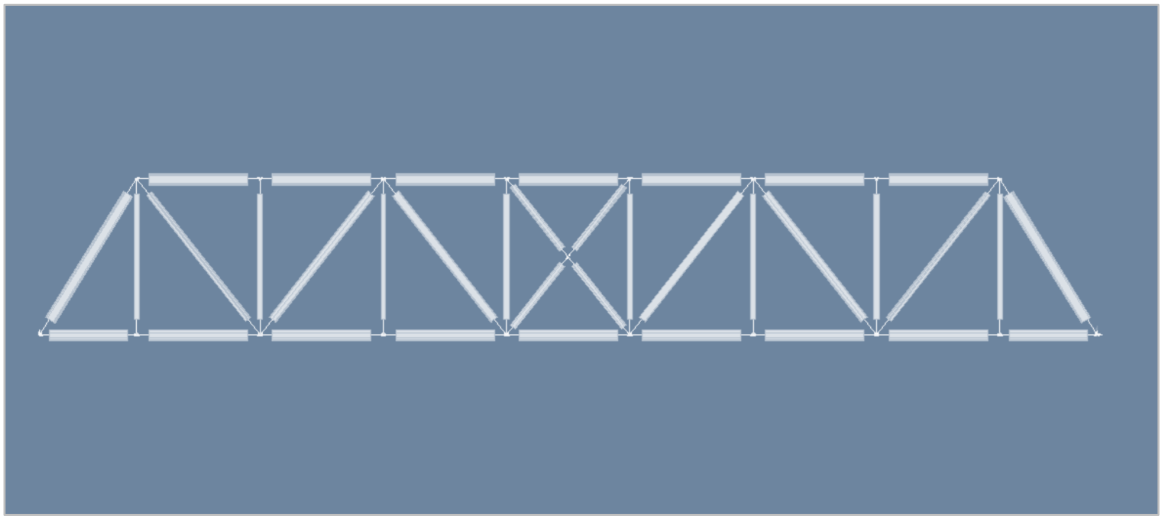


Figure 8.5-82: 2D Through Truss Model

In addition, the maximum bending moment and shear for the Cooper E80 live load, in the built-up deck plate girders, were determined by interpolation of the values presented in AREMA, Figure 8.5-82.

The cross-sectional properties of the built-up truss members and plate girders were determined, by modelling the critical gross and net sections using “ShapeBuilder” software. Figure 8.5-83 shows the gross built-up sections of the bottom chord members and the deck plate girder.

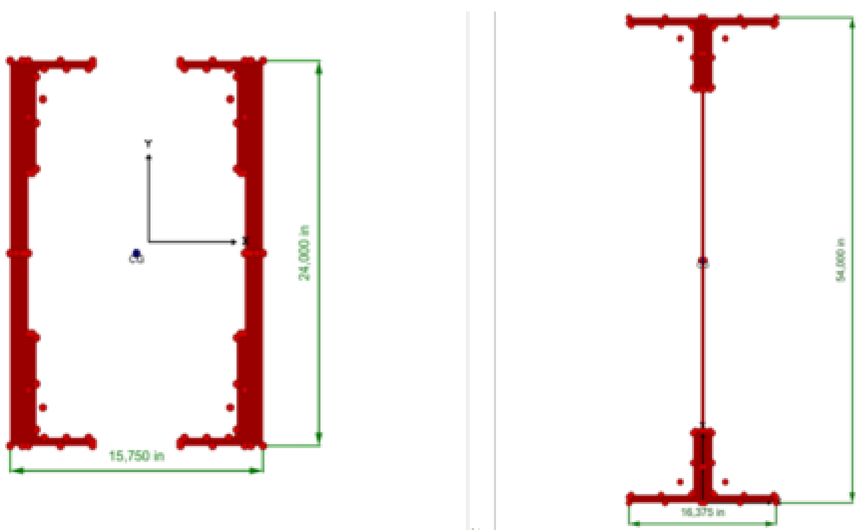


Figure 8.5-83: Cross Sections of the Truss Bottom-Chord (left) and Plate Girder (right)

8.5.24.5.11 Loads

Chapters 7 and 15 of the AREMA were used to determine the loads to which the existing structure is subjected. The following loads / combinations were considered:

- Primary load combination including dead loads (DL), live loads (LL) and impact (IM). The impact was reduced, based on the speed, in accordance with AREMA 15-7.3.2.3a.
- Secondary load combination including the lateral forces from equipment and the wind loads (W) both on the bridge and the rail cars, in addition to the primary loads. For this combination, the allowable stresses are increased by 25% from the normal rating.

8.5.24.5.12 Dead Load

The dead load imposed by the self-weight of the steel members was automatically calculated by the S-Frame 11 software based on member length and sectional dimension. The superimposed dead loads were calculated using the values stipulated in the 2016 AREMA Manual for Railway Engineering (MRE) Chapter 15, Section 1.3.2.

Additional note, the girders dead load was estimated based on each component weight and was increased by 20% to consider the weight of the rivets, gussets and splices.

Table 8.5–21: Superimposed Dead Loads

TYPE	lbs/ft²/ft	kN/m²/m
Steel	490	77
Concrete	150	23.5
Sand, gravel, and ballast	120	18.9
Asphalt-mastic and bituminous macadam	150	23.5
Granite	170	26.7
Paving bricks	150	23.5
Timber	60	9.4

8.5.24.5.13 Live Load

The live load used in the capacity analysis of each of the structures was the AREMA Cooper E80 load, seen in the figure below. The Cooper E80 load is a standard railway live load used for most bridge analysis in North America.

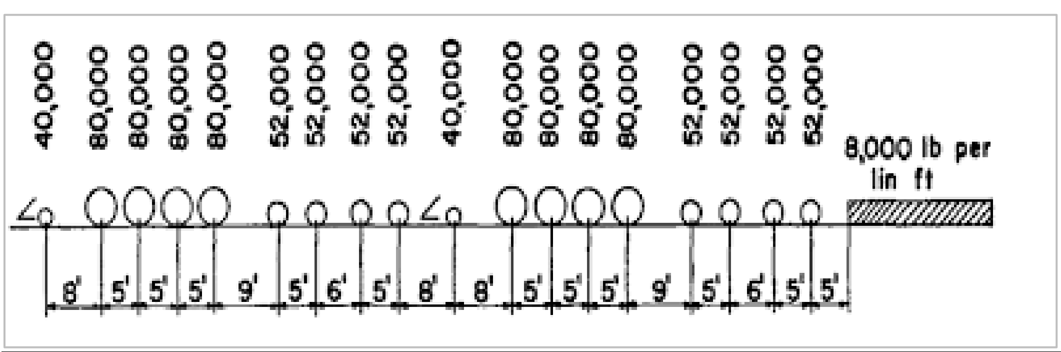


Figure 8.5-84: Cooper E80 Live Load Diagram

8.5.24.5.14 Impact Load

The live load impact formula used was obtained from the 2016 AREMA MRE Chapter 15, Section 1.3.5. The impact load due to vertical effects, expressed as a percentage of live load applied at each rail was determined by the following formula:

For L less than 80 feet: $I = 40 - \frac{3L^2}{1600}$

For L greater than 80 feet: $I = 16 + \frac{600}{L-30}$

Where:

L = Center-to-centre length of supports for stringers, transverse floor beams without stringers, longitudinal girders and trusses (main members), in feet.

8.5.24.5.15 Speed Effect on Impact Load

The maximum operating speed on the railway has been considered to be 40 mph for freight service, and 60 mph for passenger service.

Using AREMA (Chapter 15, Section 7.3.2.3), it is possible to reduce the impact load on each structure for train speeds below 60 mph. Reducing the impact load on the structure, decreases the stresses in a member, and consequently increases the allowable tonnage of the Service Load.

The impact forces stated above can be multiplied by the reduction factor below to account for speeds below 60 mph:

$$1 - \frac{0.8}{2500}(60 - S)^2 \geq 0$$

Where:

S = Speed, in mph

8.5.24.5.16 Capacity Rating

The rating of existing bridges in terms of carrying capacity can be done by the computation of stresses using applied loads and the section properties of the members while accounting for the actual physical condition of members. As the physical condition of a member deteriorates, the effective net area also decreases, resulting in an increase in stress within the member. As discovered during the site investigation, members have shown virtually no section deterioration, and as such the full member size has been used for analysis.

The capacity rating of a structure follows the workflow diagram shown below:

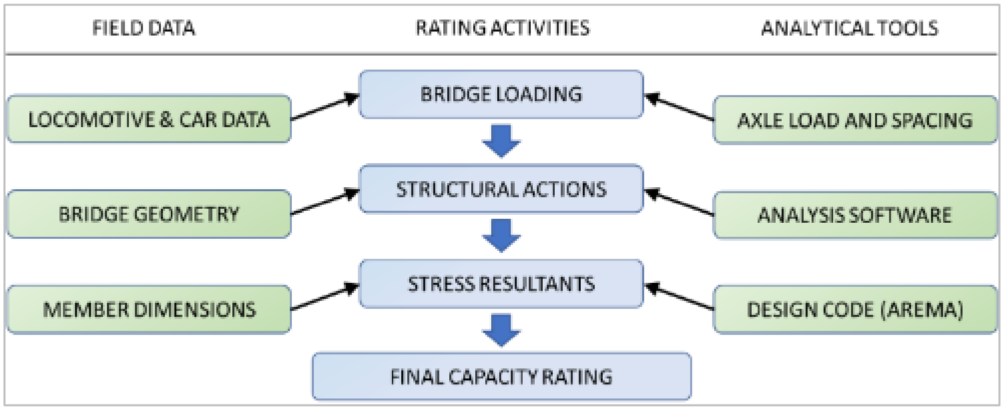


Figure 8.5-85: Bridge Capacity Rating Workflow

Member Stresses

To assess each bridge, the Consultant has used the Normal Rating procedure as outlined in the 2017 AREMA Manual for Railway Engineering (MRE) Chapter 15, Section 1.4 - Basic Allowable Stresses.

Structural Steel Properties

Given that the steel's yield and ultimate strengths are missing on the original drawings, a value between 30 - 44 ksi (kilo pound per square inch) has been taken for the yield strength, F_y, and 60 ksi for ultimate strength, F_u. These values are based on the year of construction from the CSA S6, Canadian Highway Bridge Design Code.

Allowable Stresses

The following table summarizes the allowable stresses stipulated in AREMA MRE under different load conditions for both the Normal and Maximum Ratings.

Table 8.5–22: Allowable Stresses for Normal Rating

Stress Area	Allowable Stress
Axial tension and bending, structural steel, gross section	$0.55F_y$
Axial tension and bending, structural steel, effective net area	$0.47F_u$
Axial compression, gross section:	
For compression members centrally loaded,	
when $kl/r \leq 0.629/\sqrt{F_y/E}$	$0.55F_y$
when $0.629/\sqrt{F_y/E} \leq kl/r \leq 5.034/\sqrt{F_y/E}$	$0.60F_y - (17{,}500\frac{F_y}{E})^{3/2}\frac{kl}{r}$
when $kl/r \geq 5.034/\sqrt{F_y/E}$	$\frac{0.514\pi^2 E}{(kl/r)^2}$
Where: *kl* = the effective length of the compression member, inches, under usual conditions *k* = 3/4 for members with riveted, bolted, or welded end connections *r* = the applicable radius of gyration of the compression member, inches	
Shear in webs of rolled beams and plate girders, gross section	$0.35F_y$

Table 8.5–23: Allowable Stress for Maximum Rating

Stress Area	Allowable Stress
Axial tension and bending, structural steel, gross section	$0.8F_y$
Axial tension and bending, structural steel, effective net area	$0.67F_u$
Axial compression, gross section:	
For stiffeners of beams and girders, and splice material	$0.8F_y$
For compression members centrally loaded,	
when $kl/r \leq 3{,}388/\sqrt{F_y}$	$0.8F_y$
when $3388/\sqrt{F_y} \leq kl/r \leq 27{,}111/\sqrt{F_y}$	$1.091(0.8F_y) - 0.8{F_y}^{3/2}\frac{kl}{37{,}300r}$
when $kl/r \geq 27{,}111/\sqrt{F_y}$	$\frac{0.8F_y}{0.55F_y}\left(\frac{147{,}000{,}000}{\left(\frac{kl}{r}\right)^2}\right)$
Where: *kl* = the effective length of the compression member, inches, under usual conditions *k* = 3/4 for members with riveted, bolted, or welded end connections *r* = the applicable radius of gyration of the compression member, inches	
Shear in webs of rolled beams and plate girders, gross section	$0.6F_y$

The Consultant used the Normal Rating when considering which allowable stress value to use such that fatigue stresses would not affect the service life of the bridges.

8.5.24.5.17 Member Rating

The basic approach to rating members, as presented by AREMA, begins with determining the allowable tensile (T_A), compressive (C_A), bending (M_A) and shear (V_A) stresses in an element of the bridge. Forces generated by the dead load are subtracted from the allowable values to determine the maximum force that can be imposed by the live load. Once the stresses from the live load are determined, it is possible to find the equivalent Cooper Rating or ‘E value’ of the member.

The rating of members can be summarized in the following steps:

- Determine maximum permissible stresses (A) in the primary structural member(s) as per AREMA 2017
- Calculate contribution of dead load (D) to the maximum permissible stress
- Convert the remaining allowable stress (R) to the appropriate internal force (ex. MR, VR, NR)
- Compute the internal reactions (LL+I) developed by a reference load travelling over the span at a pre-determined speed (ex. MLL+I, VLL+I , NLL+I)
- Determine the ratio of the maximum allowable internal force to the internal reaction caused by reference load (R / [LL+I])

8.5.24.5.18 Results of Capacity Analysis

The results of the capacity analysis are presented below. Given the relative age of each of the structures, and the fact that they have been abandoned and not maintained for many years, four of the five structures require some form of work to allow for the new railway operation.

Table 8.5–24: Results of GCR Bridge Capacity Analysis

Bridge ID	KP	Proposed Works
1	146+500.10	Plate girders to be strengthened
2	163+848.42	Bent columns to be strengthened/replaced
5	191+146.30	Bent columns to be strengthened/replaced
6	196+859.91	All members are adequate for projected live loads
7	201+720.11	Strengthen: • Top chord • Hangers • Diagonals Replace: • Floor System

These proposed works have been estimated and included in the structures section of the CAPEX. For the full presentation of results and individual capacity analysis per bridge, see Appendix 6.10

8.5.24.6 Hydraulic Analysis of Bridge on Grevet-Chapais, KP 125.3

The railway bridge on the Grevet-Chapais line was not the subject of a hydraulic study since bathymetric surveys could not be carried out due to the presence of strong currents. Nevertheless, during the field visit a steel-wood bridge downstream of the railway bridge was observed allowing us to make a visual analysis of the hydraulic conditions of the sector.

The characteristics of this steel-wood bridge are much lower than those of the railway bridge. Indeed, the soffit of the latter is much lower than the railway bridge as well as its free opening. Although the date of construction of the steel-wood bridge is unknown, the stonework in front of the wooden abutments seems stable (no sign of scour) suggesting that the hydraulic conditions are not critical.

Consequently, we consider that the hydraulic conditions of the sector are not an issue for the concrete abutments of the railway bridge whose free opening is greater.

8.5.24.7 BDHR Structures

Given that there is no existing railway infrastructure along the Billy Diamond Highway, all railway structures will be built new. The objective of the bridge design process along this segment has been to minimize the number of required bridges and reduce the total span length. This has been done to both reduce the environmental impact and reduce capital costs where possible. In doing so, the original number of 31 bridges has been reduced to 17, with a total span length of 1 525 m.

As with the Grevet-Chapais alignment, all bridges along the BDHR alignment have been designed to Cooper E80 loading, which is equivalent to an axle load of 356 kN, or 36 metric tonnes. This axle load has been chosen based on the operating plan, as all freight cars will be loaded to their full capacity. Like the Grevet-Chapais alignment, all bridges on the Billy Diamond Highway Railway alignment have been designed according to AREMA Volume 2 – Chapter 8 – Concrete Structures & Foundations, and Chapter 15 – Steel Structures.

All new bridges will be constructed of a steel span superstructure, supported by concrete abutments, and piers where required, which are resting on a concrete pile foundation. Given the scope of the feasibility study, dimensions for main steel and concrete structural elements were calculated to determine final quantities for the capital cost estimate. Pile foundations have been chosen at this stage of the study, as geotechnical information has not yet been confirmed at the time of writing. Where geotechnical conditions are suitable concrete spread footings can be used in lieu of pile foundations to reduce the amount of equipment and manpower required for construction. In addition, some concrete elements can be precast to further reduce the environmental impact and construction schedule.

8.5.24.7.1 Proposed Typical New Structures

The new steel DPG spans should be standardized as much as possible. To minimize the required quantity of design work, four standard span lengths; 15 m, 20 m, 25 m, and 30 m have been applied through the alignment. An example of one of a typical DPG span is presented in the below figure.

Typical Structures – Deck Plate Girders (DPG)

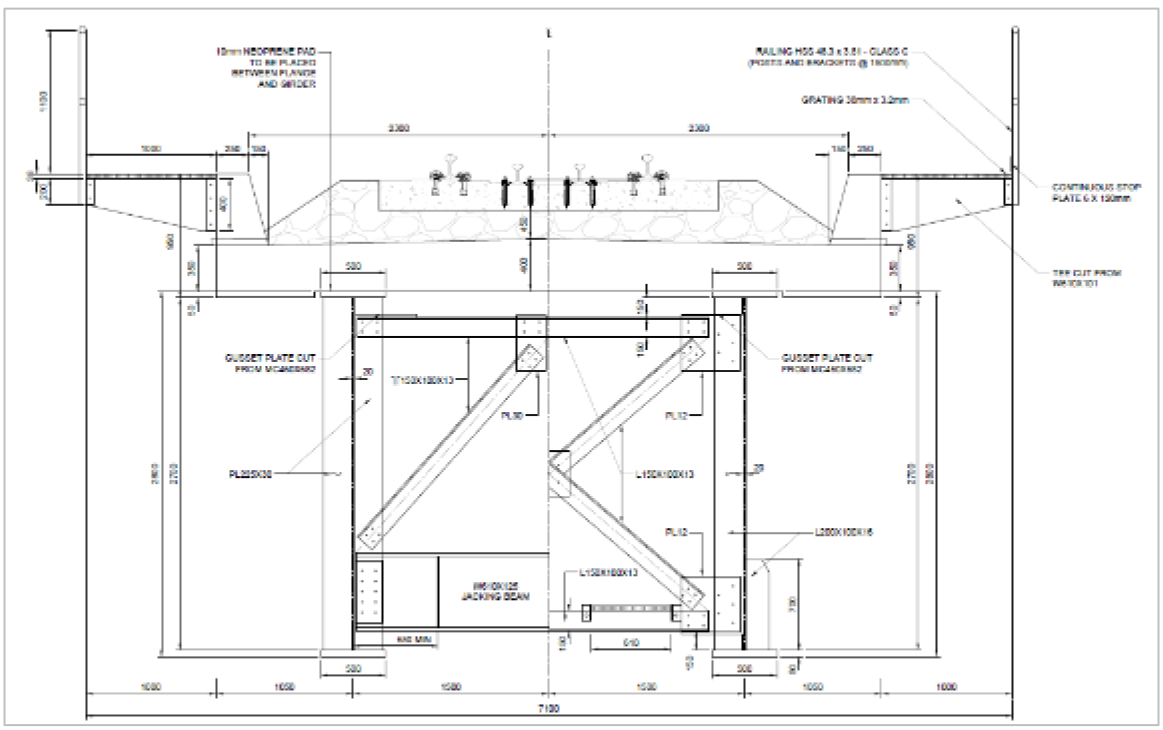


Figure 8.5-86: Typical Structure - DPG

Typical Structures - Through Plate Girders (TPG)

Much like the DPG spans, an effort has been made to standardize spans as much as possible to reduce the amount of design work needed. The typical TPG span lengths that are required throughout both alignments are 20 m, 25 m, 30 m, and 35 m. Where possible, TPG spans have been avoided due to their higher cost per metre. However, given the limited clearances between water and track level, at some points TPGs have been chose. A typical TPG span is presented in the figure below.

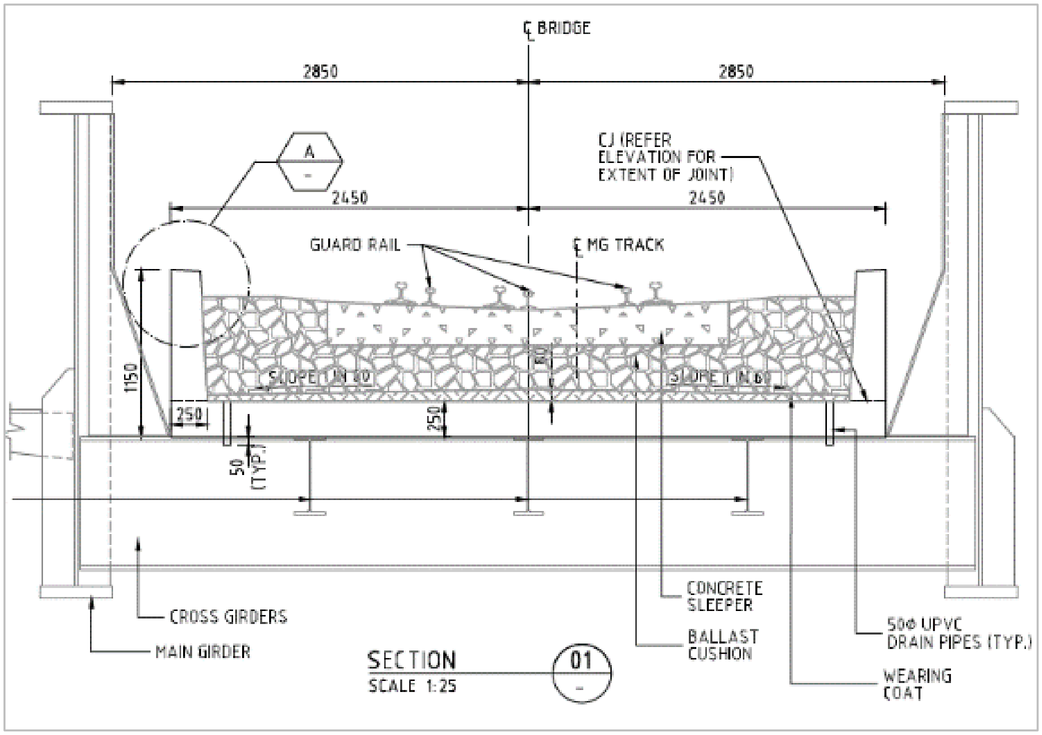


Figure 8.5-87: Typical Structure TPG

Typical Structures – Through Truss

Through Trusses are much more complex to design and install, therefore they have only been used when a DPG or TPG would not work, or to avoid the largest water crossings. At this stage of the study, there are three TT span lengths: 60 m, 80 m, and 100 m. A typical through truss span is presented below.

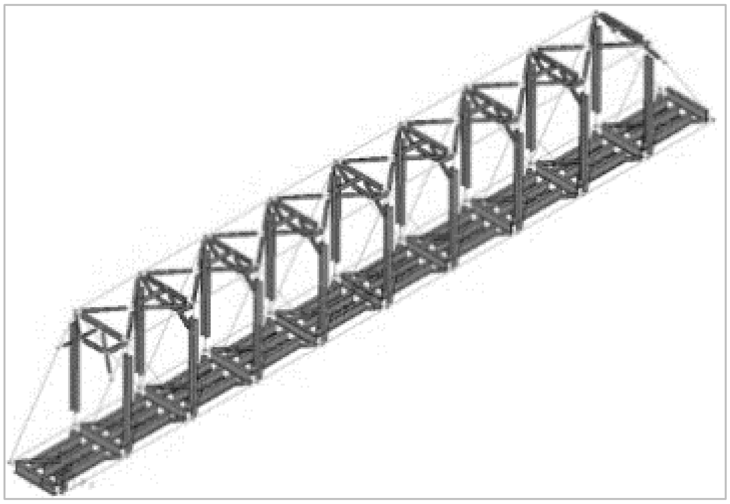


Figure 8.5-88: Typical Structure Through Truss

8.5.24.7.2 Structures List

Table 8.5–25: Bridge List – Grevet-Chapais Railway

Bridge ID	Subdivision	KP	Description	Span Length (m)	New layout
1	Chapais	146+500.10	O'Sullivan River	60	3xDPG (15m - 30m - 15m)
2	Chapais	163+848.42	Bachelor River	50	3xDPG (15m-20m-15m)
3	Chapais	167+585.33	Stream	30	1xTPG (30m)
4	Chapais	169+953.95	Bachelor River	30	1xDPG (30m)
5	Chapais	191+146.30	River	30	1xTPG (30m)
6	Chapais	196+859.91	Opawica Lake	45	2xDPG (30m - 15m)
7	Chapais	201+720.11	Opawica Lake	90	1xDPG + 1 x TT + 1 x DPG (15m - 60m-15m)
8	Chapais	236+711.18	Ross River	60	3xDPG (15m - 30m - 15m)
9	Chapais	250+961.65	Obotog River	100	4xTPG (25m)

Table 8.5–26: Bridge List – Billy Diamond Highway Railway

Bridge ID	Subdivision	KP	Description	Span Length (m)	New Layout
1	Billy Diamond	3.8	Lalanne Creek	50	2 x DPG (25m - 25m)
2	Billy Diamond	7.4	Bell River	400	4 x TT (100m - 100m - 100m - 100m)
3	Billy Diamond	11.7	Canet River	35	1 x TPG (35m)
4	Billy Diamond	40.4	Billy Diamond Hwy 1 (ROAD)	30	1 x DPG (30m)
5	Billy Diamond	44	Waswanipi River 1	120	3 x DPG (40m - 40m - 40m)
6	Billy Diamond	46.05	Billy Diamond Hwy 2	60	4 x DPG (15m - 15m - 15m - 15m)
7	Billy Diamond	47.95	Canet River	100	1 x TT (100m)
8	Billy Diamond	58.4	Creek 1	40	1 x DPG (40m)
9	Billy Diamond	63.9	Amphibolite River	70	2 x TPG (35m - 35m)
10	Billy Diamond	67.58	Nottaway River	60	2 x DPG (30m - 30m)
11	Billy Diamond	110.7	Creek 2	45	2 x TPG (20m - 25m)
12	Billy Diamond	128.22	Creek 3	50	2 x DPG (25m - 25m)
13	Billy Diamond	130.65	Kakaskutatakuch River 1	95	3 x TPG (30m - 35m - 30m)
14	Billy Diamond	135.5	Kakaskutatakuch River 2	140	1 x TPG + 1 x TT + 1 x TPG (40m - 60m - 40m)
15	Billy Diamond	138.24	Kakaskutatakuch River 3	50	2 x DPG (25m - 25m)
16	Billy Diamond	230.65	Broadback River	60	2 x DPG (30m - 30m)
17	Billy Diamond	252.9	Rupert River	120	2 DPG + 1 x TT (20m - 80m - 20m)

8.5.25 Hydrology and Drainage

As part of the current feasibility study, a hydrological study was performed for the Billy Diamond Highway Railway (BDHR) railway alignment and the Grevet-Chapais railway alignment. This study consists of a hydrological analysis to determine the stormwater surface runoff (design flow) at each water crossing and a preliminary culvert design for these water crossings.

8.5.25.1 Hydrological Analysis

The hydrological analysis of the catchments consists of the following steps:

- Identification of the type (intermittent stream or permanent watercourse) and the location of each water crossing along the alignments.
- Delineation of the catchments associated with the identified water crossings.
- Identification of the topographical and hydrological characteristics of the catchments including the surface area, the length and the slope of the flow path, land use, soil type, and the presence of swamps and lakes.
- Determination of the design flow for each water crossing.

The meteorological stations in closest proximity to the study area are Environment Canada's Chapais station (Climate ID: 7091299 Latitude: 49˚49' N; Longitude: 74˚59'W; Elevation: 381 m) and Matagami station (Climate ID: 7094639 Latitude: 49˚46'; Longitude: 77˚49'W; Elevation: 281 m).

Rainfall intensity from a representative IDF curve is applicable when using the Rational Method for calculating the peak flow rate whereas the precipitation volume is applicable when using the SCS Method.

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	89.9	120.4	140.7	166.2	185.2	204.0	20
	+/- 13.9	+/- 23.4	+/- 31.6	+/- 42.6	+/- 51.0	+/- 59.4	20
10 min	64.8	86.8	101.4	119.8	133.5	147.1	20
	+/- 10.0	+/- 16.9	+/- 22.8	+/- 30.8	+/- 36.8	+/- 42.9	20
15 min	51.6	70.7	83.4	99.4	111.2	123.0	20
	+/- 8.7	+/- 14.7	+/- 19.8	+/- 26.7	+/- 32.0	+/- 37.2	20
30 min	31.2	41.9	49.0	58.0	64.6	71.2	20
	+/- 4.9	+/- 8.2	+/- 11.1	+/- 14.9	+/- 17.9	+/- 20.8	20
1 h	19.4	26.1	30.5	36.1	40.3	44.4	20
	+/- 3.1	+/- 5.2	+/- 7.0	+/- 9.4	+/- 11.2	+/- 13.1	20
2 h	11.6	16.2	19.3	23.2	26.1	28.9	20
	+/- 2.1	+/- 3.6	+/- 4.8	+/- 6.5	+/- 7.7	+/- 9.0	20
6 h	5.3	7.2	8.4	9.9	11.1	12.2	20
	+/- 0.8	+/- 1.4	+/- 1.9	+/- 2.6	+/- 3.1	+/- 3.6	20
12 h	3.0	4.0	4.6	5.4	6.0	6.5	20
	+/- 0.4	+/- 0.7	+/- 1.0	+/- 1.3	+/- 1.6	+/- 1.8	20
24 h	1.7	2.2	2.6	3.0	3.3	3.6	21
	+/- 0.2	+/- 0.4	+/- 0.5	+/- 0.7	+/- 0.8	+/- 1.0	21

Figure 8.5-89: Return Period Rainfall Rates (mm/hr) at Matagami Station

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	7.5	10.0	11.7	13.9	15.4	17.0	20
10 min	10.8	14.5	16.9	20.0	22.3	24.5	20
15 min	12.9	17.7	20.8	24.8	27.8	30.8	20
30 min	15.6	21.0	24.5	29.0	32.3	35.6	20
1 h	19.4	26.1	30.5	36.1	40.3	44.4	20
2 h	23.2	32.5	38.6	46.4	52.1	57.8	20
6 h	31.9	43.0	50.4	59.7	66.5	73.4	20
12 h	36.3	47.6	55.1	64.5	71.6	78.5	20
24 h	41.5	53.6	61.5	71.6	79.1	86.5	21

Figure 8.5-90: Return Period Rainfall Amounts (mm) at Matagami Station

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	85.4	114.4	133.7	158.0	176.0	193.9	48
	+/- 8.5	+/- 14.4	+/- 19.4	+/- 26.2	+/- 31.3	+/- 36.5	48
10 min	60.5	81.3	95.1	112.5	125.4	138.2	48
	+/- 6.1	+/- 10.3	+/- 13.9	+/- 18.8	+/- 22.4	+/- 26.1	48
15 min	48.8	64.6	75.0	88.2	98.0	107.7	48
	+/- 4.6	+/- 7.8	+/- 10.5	+/- 14.2	+/- 17.0	+/- 19.8	48
30 min	31.4	40.8	47.0	54.8	60.6	66.4	48
	+/- 2.7	+/- 4.6	+/- 6.3	+/- 8.4	+/- 10.1	+/- 11.8	48
1 h	19.6	25.6	29.6	34.7	38.5	42.2	48
	+/- 1.8	+/- 3.0	+/- 4.1	+/- 5.5	+/- 6.5	+/- 7.6	48
2 h	11.3	14.5	16.6	19.2	21.1	23.1	48
	+/- 0.9	+/- 1.6	+/- 2.1	+/- 2.8	+/- 3.4	+/- 3.9	48
6 h	5.2	6.5	7.4	8.6	9.4	10.2	48
	+/- 0.4	+/- 0.7	+/- 0.9	+/- 1.2	+/- 1.5	+/- 1.7	48
12 h	3.1	3.9	4.4	5.0	5.5	6.0	48
	+/- 0.2	+/- 0.4	+/- 0.5	+/- 0.7	+/- 0.9	+/- 1.0	48
24 h	1.9	2.4	2.7	3.1	3.5	3.8	48
	+/- 0.1	+/- 0.2	+/- 0.3	+/- 0.5	+/- 0.5	+/- 0.6	48

Figure 8.5-91: Return Period Rainfall Rates (mm/hr) at Chapais Station

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	7.1	9.5	11.1	13.2	14.7	16.2	48
10 min	10.1	13.6	15.8	18.7	20.9	23.0	48
15 min	12.2	16.1	18.8	22.1	24.5	26.9	48
30 min	15.7	20.4	23.5	27.4	30.3	33.2	48
1 h	19.6	25.6	29.6	34.7	38.5	42.2	48
2 h	22.7	28.9	33.1	38.4	42.3	46.1	48
6 h	31.0	39.1	44.5	51.3	56.4	61.4	48
12 h	36.8	46.3	52.5	60.5	66.3	72.2	48
24 h	45.2	57.3	65.3	75.4	82.9	90.4	48

Figure 8.5-92: Return Period Rainfall Amounts (mm) at Chapais Station

In addition to the rainfall data from the Matagami and Chapais Stations, according to Climate Profile Study dated August 27, 2021, an increase of 18.6% and 20.1% should be applied respectively on the peak flow with a 25-year and 100-year recurrence periods on peak flows crossing BDHR to take into account the accelerated runoff caused by climate change. An increase of 24.2% and 24.1% was applied respectively on the peak flow with a 25-year and 100-year recurrence periods on peak flows crossing Grevet-Chapais railway for the same reason.

Table 8.5–27: 2080s Climate Change at Matagami

T (years)	2		5		10		20		25		50		100	
5 min	8.49	15.2%	11.75	17.0%	14.27	19.9%	16.42	19.0%	17.04	18.6%	19.46	19.4%	21.98	20.2%
10 min	11.97	15.2%	16.23	17.1%	19.87	19.9%	23.34	19.0%	24.41	18.6%	28.73	19.4%	33.66	20.2%
15 min	14.19	15.3%	19.63	17.1%	24.34	19.9%	28.91	19.0%	30.31	18.5%	36.03	19.4%	42.59	20.2%
30 min	17.78	15.2%	24.54	17.1%	29.65	19.9%	33.94	19.0%	35.13	18.5%	39.86	19.4%	44.7	20.1%
1 h	21.85	15.2%	30.21	17.1%	36.76	19.9%	42.44	19.0%	44.08	18.6%	50.55	19.4%	57.37	20.1%
2 h	25.5	15.2%	36.09	17.1%	45.35	19.9%	54.52	19.0%	57.38	18.6%	68.93	19.4%	82.31	20.2%
6 h	35.59	15.2%	48.6	17.1%	59.44	19.9%	69.44	19.0%	72.47	18.6%	84.54	19.4%	97.91	20.2%
12 h	40.46	15.2%	53.99	17.1%	65.42	19.9%	75.99	19.0%	79.2	18.5%	92.16	19.4%	106.66	20.2%
24 h	46.55	15.2%	61.3	17.1%	73.59	19.9%	84.66	19.0%	87.98	18.5%	101.4	19.4%	116.21	20.2%

Table 8.5–28: 2080s Climate Change at Chapais

T (years)	2		5		10		20		25		50		100	
5 min	8.19	15.2%	10.94	14.7%	13.3	19.4%	15.97	25.9%	16.84	28.0%	19.83	35.2%	23.21	43.6%
10 min	11.66	15.7%	15.79	16.5%	19.16	20.9%	23.07	27.8%	24.31	29.7%	28.2	34.9%	32.52	41.1%
15 min	14.3	17.3%	19.1	18.3%	22.79	21.5%	27.1	27.5%	28.35	28.6%	31.98	30.5%	36.19	34.4%
30 min	19.21	22.2%	24.81	21.7%	28.69	22.1%	32.62	23.3%	33.75	23.1%	37.12	22.5%	40.68	22.6%
1 h	23.78	21.6%	31.02	21.1%	36.22	22.2%	41.39	23.6%	43.09	24.1%	47.82	24.3%	52.41	24.2%
2 h	28	23.5%	35.39	22.2%	40.27	21.6%	45.05	21.5%	46.34	20.8%	50.37	19.2%	54.59	18.4%
6 h	38.1	23.1%	47.52	21.5%	53.89	21.1%	60.38	21.5%	62.14	21.1%	67.63	19.9%	73.64	19.9%
12 h	45.02	22.3%	56	21.0%	63.79	21.4%	71.76	22.5%	74	22.4%	80.85	21.9%	88.26	22.3%
24 h	55.57	23.0%	69.57	21.5%	79.06	21.1%	88.71	21.5%	91.34	21.1%	99.48	19.9%	108.42	19.9%

Surface runoff is greatly influenced by topography, soil conditions, and land use. The geographic areas of study (BDHR and Grevet-Chapais Railway) are located in the Canadian subarctic region where peak runoff period occurs in the spring. This region is dotted with thousands of lakes, streams, and swamps. Although the soil in the area is relatively saturated – resulting in more surface water runoff, the runoff slows down due to the relatively flat topography and the influence of lakes and swamps.

A watershed (or drainage basin) is an area of land where all flowing surface water converges to a single point (water crossing).

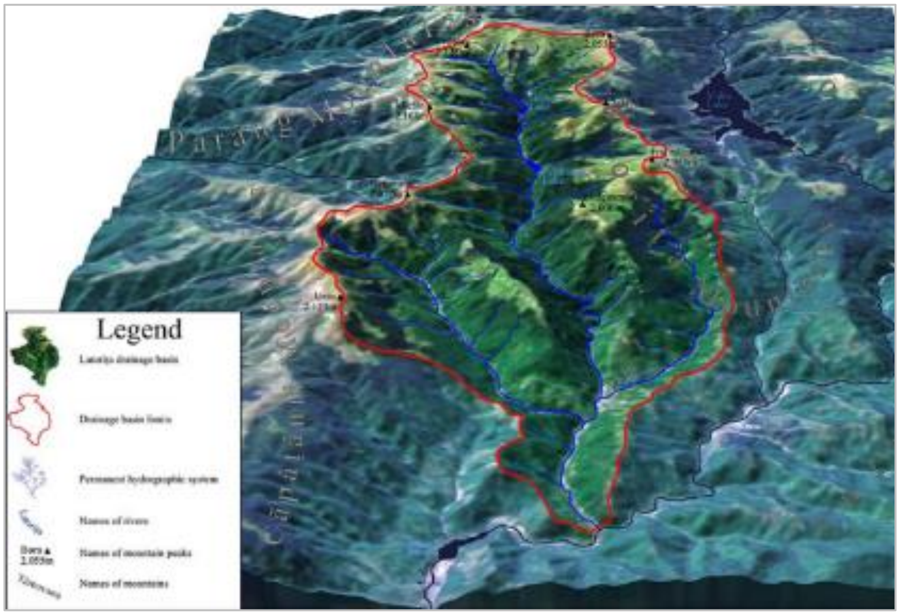


Figure 8.5-93: An Example of a Watershed

The digital 1:250 000 scale maps, produced by National Resources Canada (NRCan) and conforming to the Canada's National Topographic System (NTS), were used for delineating catchments, calculating the surface area of lakes and swamps in each catchment, calculating the catchment slope and the flow path for each of the catchments. Google imagery was used to identify the location and the width of the major watercourses. In addition to the topographical data, the soil type, according to its hydrological characteristics, was used for this study based on the soil map at Chapais.

Figure 8.5-94: Overview of the Catchments along the BDHR Alignment

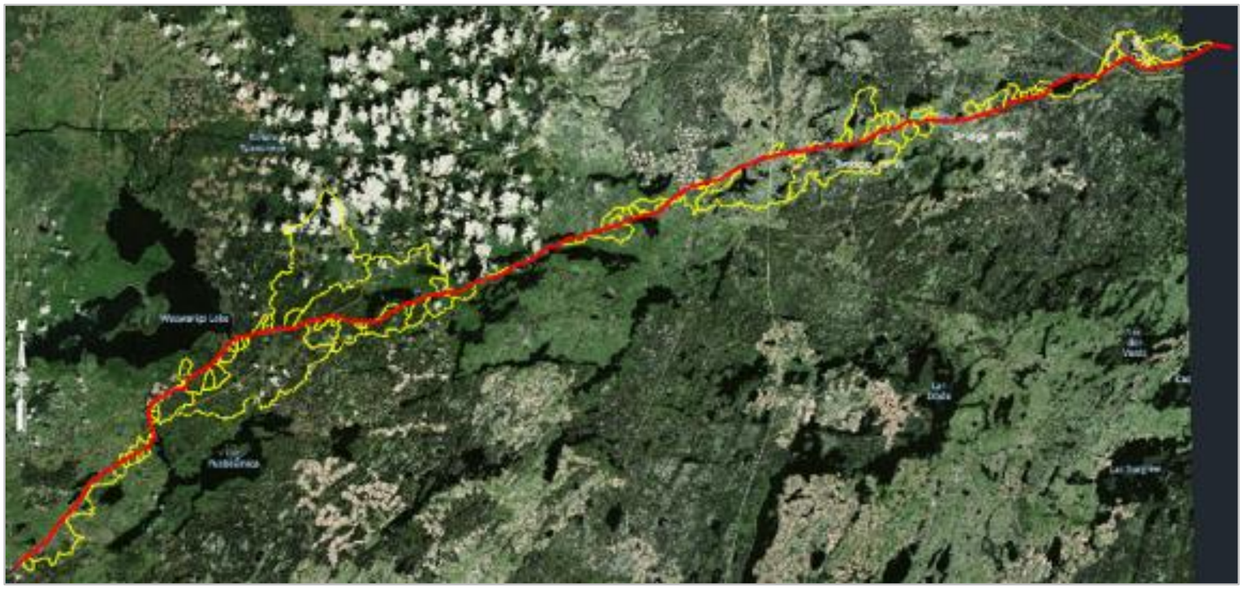


Figure 8.5-95: Overview of the Catchments along the Grevet-Chapais Alignment

In summary, 307 catchments were delineated for the Billy Diamond Highway Railway alignment and 145 catchments for the Grevet- Chapais alignment. The characteristics of the catchments and the corresponding design flows can be found in Appendix 6.7.

The hydrological design criteria shown below summarize the standards required by, but not limited to, the Ministère des Transports du Québec (MTQ), Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs, and AREMA.

Table 8.5–29: Drainage Calculations and Hydrologic Method

Item	Criteria
Design Rainfall	For Culverts: • 25 Year Rainfall at Matagami Station and Chapais Station and • 100 Year Rainfall at Matagami Station and Chapais Station For Bridges: • 100 Year Rainfall Data at Matagami Station and Chapais Station
Catchment ≤ $25km^2$ Regular Crossings	Rational Method: Q (m^3/s) = 0.00275 x C_p x I x A_b Q: Peak flow (m^3/s), C_p: Runoff coefficient, I: Rainfall intensity (mm/hr), A_b: Catchment surface area (ha)
Catchment > 25 km^2 Regular Crossings	Soil Conservation Service (SCS) Curve Number Method: $Q_T = \frac{0.2083 \times S \times P_c}{0.5D + 0.6\,T_c}$ $P_c = \frac{(X_T - 0.2E)^2}{(X_T + 0.8E)}$ $E = (\frac{25400}{CN}) - 254$ CN: Curve number, Potential retentions (mm), X_T: 24-hour rainfall corresponding to the design return period (mm), Q_T: Peak runoff in T years of design return period (m^3/s), Pc: Direct surface runoff (mm), S: Catchment area (km^2), Tc: Catchment time (hr), D: The duration of excessive rainfall (Assume D=0.5Tc)
Navigable Crossings	Design with 2-year return period rainfall
Watershed Slope	85/10 Method: $S_w = 100\left[\frac{\Delta h - h_f}{0.75(L - L_f)}\right]$ Δh = different in elevation (m) between the 85% points and the 10% point obtained from contours Hf = sum of heights of rapids and waterfalls between 10% and 85% points (m) L= total length of the main channel including the undefined flow path to head of the basin (m) Lf = sum of lengths of rapids and waterfalls up to 10% of L (m)
Time of Concentration	For C > 0.4: Tc = 0.057 x L x $A^{-0.2}$ x $S^{-0.1}$ For C < 0.4: Tc = 3.26 (1.1 – C) x $L^{0.5}$ x $S^{-0.33}$ (C < 0.4) C = Runoff coefficient L = Flow path distance (m) A = Catchment area (ha) S = Flow path slop (%) Note: Minimum time of concentration = 10 min.

8.5.25.2 *Preliminary Culvert Design*

Railway drainage culverts are primarily constructed to convey water through a railway embankment. A culvert that does not perform this function properly may jeopardize safe railway operations and cause excessive property damage. The preliminary design of the proposed culvert consists of two design elements:

- Identification of the type of the culvert based on the characteristics (width and presence of fish) of the water crossing.
- Hydraulic analysis for designing the proposed culverts.

The culvert design criteria shown below summarize the standards required by, but not limited to, the Ministère des Transports et de la Mobilité durable (MTQ), Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs, and AREMA.

Table 8.5–30: Minimum Design Requirements for Culvert

Item	Criteria
Type of Culvert	• Corrugated Steel Pipe (CSP) Culvert: Diameter ranges from 0.6 m to 2.0 m • Bottomless Structural Steel (Bolt-a-Plate) Culvert: Span ranges from 2 m to 10 m • Bottomless Structural Steel (SuperCor) Culvert: Span ranges from 10 m to 25 m Span Note: The prefabricated concrete foundations for short-span arch bridges and the sheet piles will have to be designed by the contractor responsible for carrying out the work, based on site conditions and foundation materials during the construction, to minimize the alteration of watercourses by suspended particles.
Design Flow	• A 25-year flood without static head at the entrance (a maximum headwater to culvert diameter/rise ratio (HW/D) of 1.0) • A 100-year flood with maximum 2 ft headwater below base of rail at the entrance or results in a HW/D not exceeding 1.5, whichever is less
Minimum Diameter of Pipe Culvert	• 24 in (600 mm) for main line track • 18 in (450 mm) for other tracks
Minimum Height of Cover	Minimum 12 in (300mm) between the top of the CSP culvert to the bottom of ties (1200 mm based on CN Standards)
Minimum Permissible Spacing between Culverts in Parallel	• 12 in (0.3 m) (For 24 in diameter culverts and smaller) • 0.5D (For 24 in - 72 in diameter culverts) • 36 in (0.9 m) (For 72 in and larger diameter culvert) • where D = diameter of culverts
Design Considerations for Fish Passage	Bottomless Structural Plate Culvert to be used. If CSP culvert are used, then: 1) The bottom of CSP buried below riverbed by 10% of its diameter 2) Min. 200 mm depth of water flowing at the bottom of a CSP 3) Maximum drop at the outlet of a CSP = 300 mm 4) Permissible Flow velocity in culvert: • For culvert length ≤ 25 m: 1.2 m/s • For culvert length > 25 m: 0.9 m/s 5) If width of waterway is reduced by culvert by 20-50% • For the culvert length ≤ 25m: 1.0 % max slope of culvert • For the culvert length > 25m: 0.5 % max slope of culvert

Item	Criteria
Minimum Thickness of CSP Culvert	2 mm
CSP Foundation	• Width: D/3, where D = diameter of CSP • Thickness: 150 mm to 450 mm depending on the CSP diameter

In addition to the design criteria above, the Cooper E-80 railroad live load and embankments with a soil density of 22.5 kN/m^3 are also structural design parameters for culvert. Note that all culverts must have a lifespan of at least 50 years.

CSP culverts were designed for the intermittent streams whereas bottomless structural Steel Arch culverts were designed for permanent watercourse to avoid any impacts to the environmental conditions of these watercourses.

Figure 8.5-96: Example of a CSP Culvert

Figure 8.5-97: Example of a Bottomless Structural Steel Plate Arch Culvert

A hydraulic analysis determines the hydraulic requirements of the culvert to adequately convey the design discharge. These requirements determine the size, shape, slope, and inlet and outlet treatments of the culvert. Culvert hydraulic analysis has been carried out with the HY-8 Culvert Hydraulic Analysis Program, which is software developed by the United States Federal Highway Administration (FHWA) and used by the MTQ) and Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs for drainage management. For illustrative purposes, the figures below show the HY-8 hydraulic analysis results for the culvert 3005 and the culvert 655 crossing under BDHR alignment and Grevet-Chapais alignment, respectively.

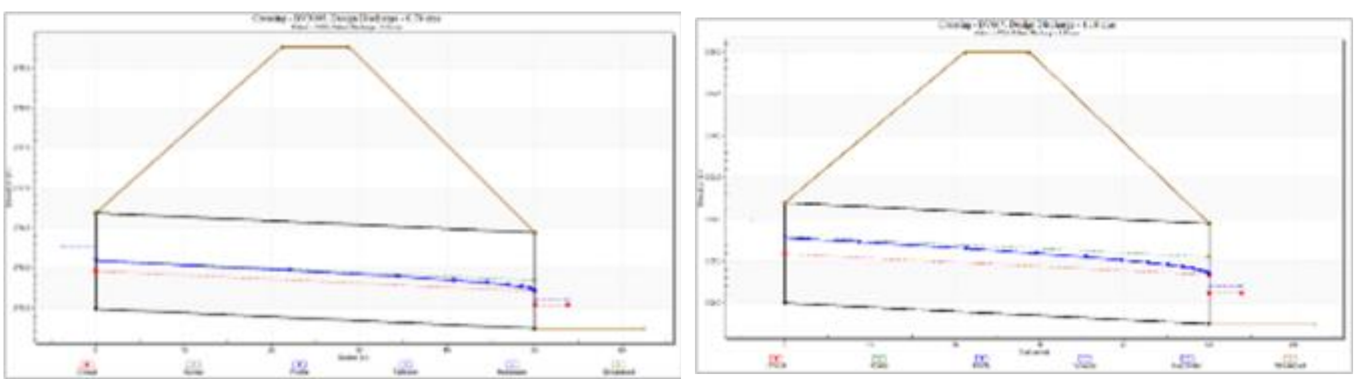


Figure 8.5-98: HY-8 Two Sample Results for Culverts Crossing under Grevet-Chapais Alignment

Based on the results of the site visit carried out from September 13 to 17, 2021, the table below summaries the current conditions of some of the existing culverts crossing under the existing Grevet-Chapais railway roadbed.

Table 8.5–31: Observations of the Existing Culverts Inspected

Location (KP)	Culvert Dimensions	Observations
127.3	1 X 2 m	Functional
128.7	1 X 1 m	Functional
132	1 X 0.6 m	Rusted, but not damaged or clogged
137.4	1 X 1 m	Functional
140.5	1 X 1 m	Functional
157.9	1 X 1.5 m, 1 X 1 m	Need to be replaced
158.4	1 X ≈1 m	Functional
164.1	1 X ≈1 m, 1 X 0.6 m	Functional
170.9	1 X ≈1 m	Functional
178.1	1 X ≈2 m	Functional
184.7	1 X ≈0.8 m	Crushed (broken)
187.1	1 X ≈1 m	Crushed
204.5	1 X ≈1 m	Crushed
220.1	1 X ≈1.5 m	Broken
229.2	3 X 2.4 m	Good condition
254.8	3 X 1.8 m	All of the 3 barrels are clogged
257.7	1 X 1.7 m	Good condition, not blocked
260.7	1 X 1.8 m	Completely submerged
264.1	N/A	Washed out (no culvert present)
267.4	3 X 2 m	25% blocked, good condition

The figures below provide some examples of the condition of the existing culverts.

Figure 8.5-99: Existing 600 mm Diameter CSP Culvert Crossing Grevet-Chapais Roadbed at KP 132.0
(The culvert is rusted but seems functional)

Figure 8.5-100: Existing 1000 mm Ø and 600 mm Ø CSP Culverts Crossing Grevet-Chapais Roadbed at KP 164.1.
(The culverts are rusted and slightly dented but seem functional)

Figure 8.5-101: Existing ±1500 mm Ø CSP Culvert Crossing Grevet-Chapais Roadbed at KP 220.1 (The culvert is rusted and broken).

Figure 8.5-102: Existing 3 x 2400 mm CSP Culverts Crossing Grevet-Chapais Roadbed at KP 229.2

The proposed culverts crossing the BDHR alignment as well as the existing culverts crossing the Grevet-Chapais alignment have been designed and re-designed to ensure that their hydraulic capacities will be able to accommodate the increased rainfall resulting from climate change. The proposed structures for BDHR and Grevet-Chapais alignments are shown in Appendix 6.7. Due to the lack of details of the existing culverts crossing under the Grevet-Chapais alignment, further inspection of the existing culverts will be required prior to any rehabilitation or replacement with the proposed culverts. There were some beaver dams found during the site visit, therefore, it will be important to minimize the effects of sudden changes in the flow rates caused by beaver dams both upstream and immediately downstream.

8.5.26 Signalling and Telecommunication System

The three main purposes of the signalling and telecommunication systems are:

- Allow the safe operation of the railway by its personnel.
- Enable the safe passage of trains on the railway.
- Allow the maintenance of the railway in a secure manner.

Modern signalling systems are typically comprised of onboard, wayside and centralized equipment. Among the main functions of the signaling system are:

- Field equipment (IXL, switches, signals, detectors, grade crossings, snow clearing devices, etc.)
- Command and control of signalling equipment (ex: switch, signal).
- Train scheduling.
- Automatic route setting.
- Automatic train regulation.
- Rolling stock management.

Telecommunication systems provide services to other systems. The provision of the networking infrastructure (LAN and WAN) in both normal and degraded modes. The provision of cybersecurity appliances embedded in the networking infrastructure and GPS network time synchronization are also provided. A Network Management System (NMS) is also be provided.

To meet the requirements of Canadian Rail Operating Rules (CROR), mobile voice communications must be provided to allow communications between a train crew, maintenance crew and RTC in the OCCs. The entire rail network must be covered.

A SCADA system is also provided to handle command and control of non-signaling system equipment. It is typical of SCADA systems to provide a centralized handling of alarms and events for all the provided systems.

Access Control should also be provided to secure the facilities of the network. A CCTV system is also part of typical railway systems as a complement to access control and to provide site and passenger security.

The following sections describe the main assumptions for these systems and the solutions considered to establish the cost estimate, they will not provide a system architecture.

8.5.26.1 Assumptions

The proposed frequency of trains on both lines is at most two per day in each direction. A fleet of four locomotives for the freight trains, one locomotive for passenger service and one spare are to be provided.

For the BDHR line, the following infrastructure must be supported:

Table 8.5–32: BDHR infrastructure list

Location	Start	End
Matagami Yard	-0+680.06	0+941.95
Matagami Station	5+158.23	5+617.80
Timber Siding	60+788.33	62+480.16
Siding 1	92+240.00	93+807.10
Siding 2	167+619.06	169+258.96
Waskaganish Station	235+795.81	236+495.22
Waskaganish Yard	236+525.22	238+313.71

For the Grevet-Chapais line, the following infrastructure must be supported:

Table 8.5–33: Grevet-Chapais Railway infrastructure list

Location	Start	End
Siding at Beginning	123+201	124+262
Siding I + Station	173+671	174+840
Siding II	226+838	227+927
Chapais Station	277+505	278+024
Chapais Yard	279+023	280+387

Each line is operated by the Operations Control Centre (OCC) Redundancy should be ensured for all systems. An existing fiber optic installation in proximity to the wayside of both lines can be reused. It was considered that a maximum of 30 handheld radios will be available.

8.5.26.2 Signalling System

A brief review of the different signalling systems is provided in the following table.

Table 8.5–34: Signaling system description and evaluation

Signalling System Types	Description	Advantages	Disadvantages
Non signalled	CROR rules dictate this type of territory is governed by Occupancy Control System Rules. The RTC should supervise the territory by means of clearances, TOP, GBO and other instructions as required.	• Minimum infrastructure required. • Minimum maintenance requirements	• Safety is entrusted to RTC and train crew. • No train tracking system.
Automatic Block Signal System	The railway is divided into blocks. Movement between blocks is controlled automatically (in the field) by signals.	Works best with low traffic (no meets) single line railways.	• No ATS functions are available. • No train tracking system.
Centralized Traffic Control System – Fixed Block	Referred to as fixed block signalling where the length of the blocks is determined by the length and speed of the train. Entrance into a block is controlled by signals. Wayside equipment is controlled by centralized application servers.	• Increases traffic capacity • Increases traffic regularity • Improves railway operations	• System with the most equipment. • Higher maintenance costs.
Communications Based Train Control (CBTC) – Moving Block	The position of a train is evaluated onboard and relayed to the ground by radio using equipment located along the line.	• Increased capacity • Reduced headway	High cost
Positive Train Control (PTC)	PTC can maintain train separation, line speed and handle temporary speed restrictions.	• Allows the determination of a train's precise location, direction and speed. • Ability to stop trains Can stop a train	• High cost • Relies on train-wayside radio (cybersecurity)
European Train Control System (ETCS), Level 2	Continuous supervision of train movement with constant communication via GSM-R between the train and trackside	• Safest system • Permits lowest headway • Improved railway operations	Highest cost

Given the assumptions, the content of Table 8.5–34 and the requirements of the "Canadian Rail Operating Rules" (CROR – May 9, 2022, version) our recommendation is to use a combination of the systems described above. For the purpose of this study an automatic block signalling system with axle counters in combination with some PTC components.

Field Appliances

- Axle Counter system
  - The AC detectors are connected to track rails by drilling or clamping.
  - The detectors may have a nearby trackside electronics unit but will connect to the evaluator via direct fiber (to avoid processing/communication delays).
  - The Evaluator units are centralized in the OCC.
  - User-friendly and safe resetting of blocks including procedures as needed.
  - Data interface to the interlocking (CBI) is used.
- Point Machines
  - Electro-mechanical point machines.
  - Position and locking detection are independent of movement controls.
  - SIL4 proven-in-service design.
- Level Grade Crossing Kits
  - At roadway crossings where no bridge is provided, a Level Crossing kit is controlled by the CBI via the OC's.
  - A Level Crossing kit consists of flashing warning lights and signage. As defined by the "Engineering Standards for Grade Crossing Warning Systems Used at Restricted Grade Crossings" from Transport Canada
- Ground-based Differential GNSS Transmitter
  - Only required if Satellite-based accuracy or reliability is insufficient for safety.
  - A Differential GNSS Transmitter is used to increase accuracy of train positioning.
- Wayside Bungalows

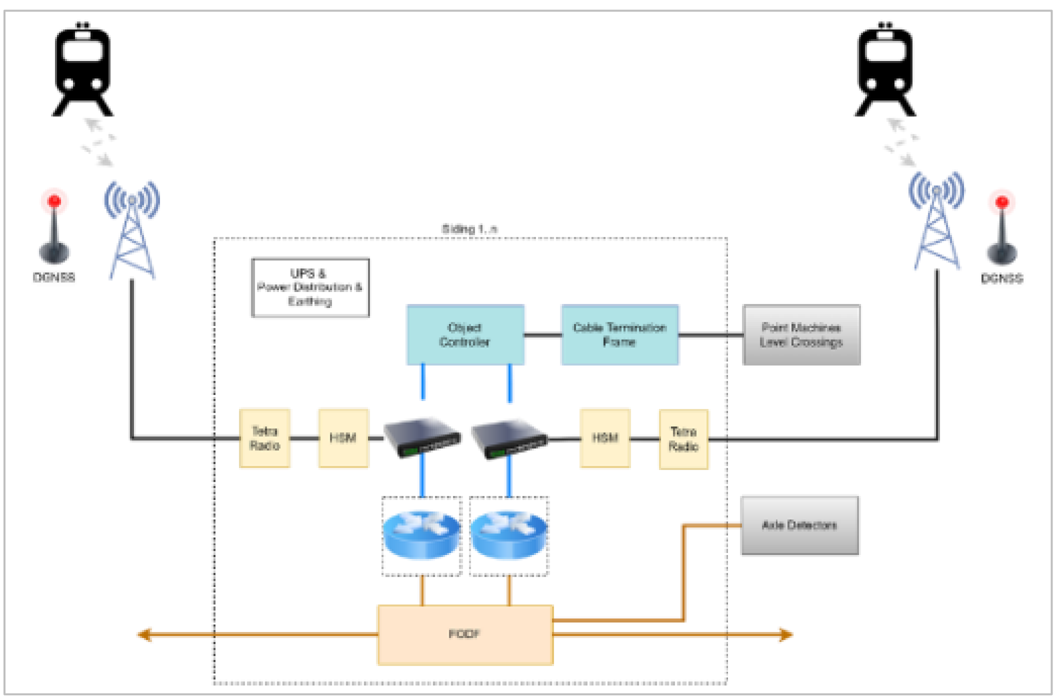


Figure 8.5-103: Signalling System Configuration

HSM = Hardware Security Modules
DGNSS = Differential Global Navigation Satellite System

8.5.26.3 Telecommunication System

For the proposed "Grande Alliance" railway project, the following subsystems should be included in the cost estimate of the Telecommunications system:

- Access Control Subsystem (ACS).
- Multi Service Communications Network (MSCN).
- Closed Circuit Television subsystem (CCTV).
- Network Management System (NMS).
- Supervisory Control and Data Acquisition subsystem (SCADA).
- Radio Communication Subsystem (RCS).

Land users should be able to plug into the system to have stops. The MSCN is based on a fault-tolerant, dual-ring network architecture using open standard Inter protocols. The backbone rings are optical fiber for performance (single mode – min 24 fibers). The network design follows the EN 50159 standard. Accordingly, the wayside network design is closed, whereas the radio network air gap is open and so uses a voice and data radio or separate radios. Two possible solutions can be considered: TETRA radio with Hardware Security Modules (HSMs) on both sides of the radio link or a Private LTE network with built-in security. These options encrypt the data and authenticate the sender, and are part of the cybersecurity solution to prevent attack vectors from motivated individuals/groups (e.g. as protest or ransomware).

NMS should be used to monitor all network equipment and all links.

The ACS should be deployed in the OCC, stations and maintenance buildings. Any room with technical equipment (electrical or telecommunication equipment) needs to be protected. Any solution should include readers, controllers, cards, workstations and application servers.

The CCTV should be deployed in the OCC, stations (platforms, common area) and yards. Any solution should include cameras (fixed, PTZ), local recorders, workstation software and application servers.

The RCS should cover all sites associated with the railway. It is based on having dual independent paths for network connectivity within the overarching ring architecture. There are two independent towers with overlapping coverage in the area. Voice radio users (mobile and train-borne) and data radio users (train-borne) can send digital data on the network through the wayside voice and data radio. Security is maintained using HSM's on both ends of the open parts (air gap) of the network.

8.5.26.4 Defect Detection

Many wayside equipment defect detection technologies have been developed in recent years for railroads to improve the safe operation of trains on a section of track. In addition, after certain incidents and accidents that occurred over a long period of time, some of these devices are required by federal law. The detectors prevent accidents caused by rail and rolling stock defects; thus, it strengthens the security for the users and the operators.

The following section describes the purpose and function of each monitoring system, along with a description of the specific faults that are monitored. It should be noted that many commercial systems combine one or more of these monitoring functions.

Wheel Flaw Detectors (WFD)

A Wheel Flaw Detector (WFD) is a safety system used to identify a defective wheel by measuring the dynamic impact on the track. This helps protect the rail infrastructure, prevent derailments and catastrophic failures, and reduce service disruptions and unplanned maintenance costs for rolling stock. WFDs are designed to operate with bi-directional traffic. The North American rail industry has developed a standardized impact range warning level that combines speed and load to identify when the wheel should be removed from service.

Weigh-in-Motion System (WMS)

Weighing locomotives and railcars serves two purposes. The first is to ensure that the vehicle itself is not loaded beyond its maximum carrying capacity, and the second is to ensure that the load is evenly distributed throughout the vehicle.

Measuring the load distribution requires the use of a more complex weighing system. Its purpose is to alert the train controller to uneven weight distribution within a particular vehicle that could potentially lead to a derailment. Uneven load distribution on a bulk loaded car carrying ore, or mineral concentrates, means that the weight of the car is not evenly supported by all wheels. In extreme circumstances, the result is derailment of the car when the least loaded wheel(s) fail to provide sufficient contact with the rail head, particularly when passing through curves or over switches.

Hot Box and Wheel Detector

Hot Box and Wheel Detectors (HBWD) are trackside devices designed to monitor the temperature of axles, wheels, and brakes, and indicate any overheating that could lead to derailments. They also transmit this data to the Operations Control Center (OCC).

HBWDs are set to sound an alarm when the detected temperature of a wheel bearing or wheel is above a particular threshold.

Dragging Equipment Detectors

The dragging equipment detectors are used to detect low-level dragging equipment (for example, loose pipes or tarps) and hanging wheels on the moving train. These are potential hazards on the track and can cause tie damage and even a derailment. These dragging pieces are detected mechanically (using a detection plate slightly above rail level) or optically.

General Considerations

Additional detectors can also be installed to ensure the security of the installations. These include water level detectors for the platform and wind detectors.

The rules for the placement of the detectors are as follows:

- The detector must be located on the track in a straight line.
- It is preferable that the detector be located where the track does not slope.
- The detector must be located at least 1500 feet (457 m) from the end of a curve.
- The detector should be located where the train speed is at least 10 mph (16 km/h).
- The detector should be located where train braking is minimal.
- A detector should be placed at intervals of approximately 30 miles (50 km).

- The detector should not be located where prolonged shutdowns may occur.

Recommendations

Detectors will be placed on the Billy Diamond Highway Railway and Grevet-Chapais lines.

On the BDHR line, train condition detectors will be positioned at the entrance and exit of the line. This will ensure that the train and cars are in good condition before they run on the railway mainline. This equipment will be present at the Matagami (KP 001) and Waskaganish stations (KP 235). The close positioning of the stations will also facilitate the power supply and maintenance operations. On the Grevet-Chapais line, train condition detectors will be placed at the exchange siding at the west end of the line and at the exit of the line at the Chapais Yard.

The systems presented above will be installed in line (WFD and WMS) and on gantry (HBWD and DPTD). The figure below indicates the placement of the detectors along the two lines.

In a future where the traffic on the track increases considerably, it would be possible to place new sensors before the siding to regulate and control the state of the trains more easily. However, this solution is not recommended at this time because of the low traffic on the lines.

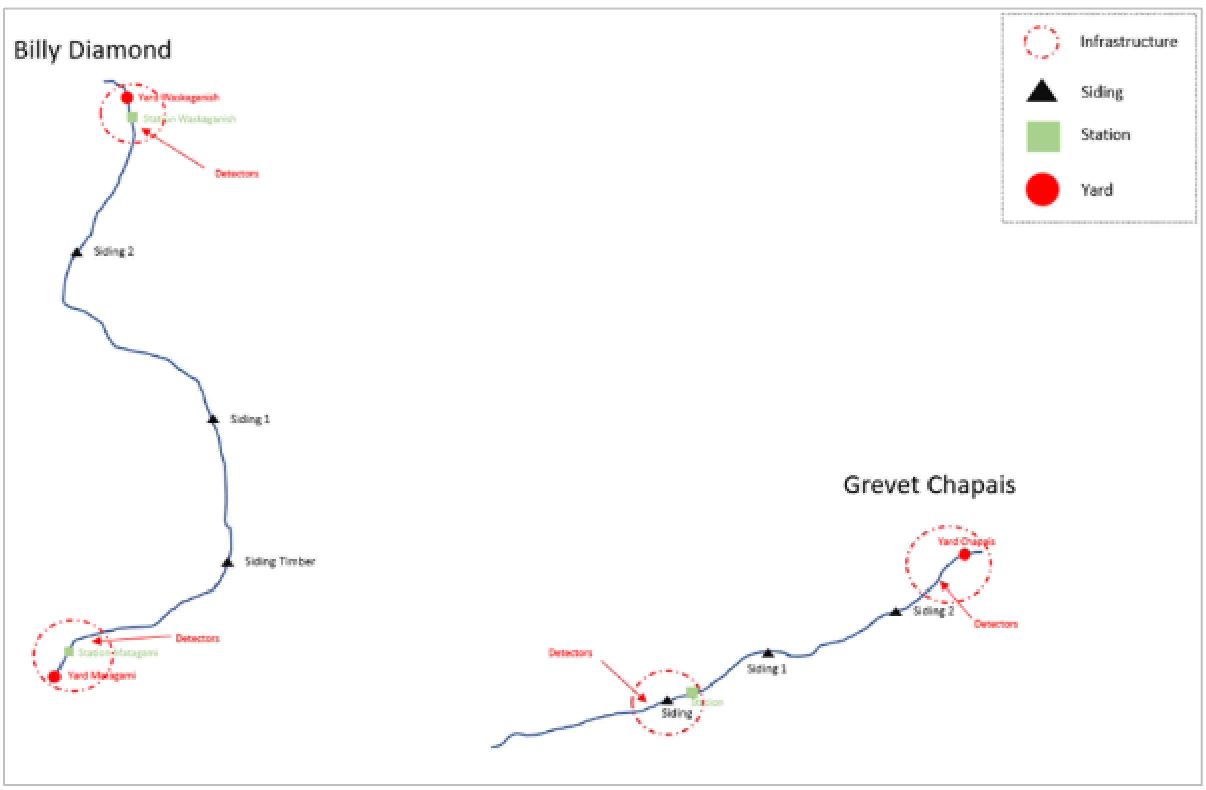


Figure 8.5-104: Schematic view of railway lines and installations

8.5.27 Power Supplied to the Railway

The detectors and other track devices require a power supply for their operation. Since the railway lines are in remote areas facilities are required to obtain power at strategic locations on the railroad. A connection will be established with the Hydro-Québec high voltage network to supply the different zones. Then, step-down transformers will be positioned to obtain low DC voltage values adapted to the needs.

- For The BDHR line, there will be a connection to the Hydro-Québec network in Matagami. A medium voltage line (15 kV) will be installed along the track to supply power to the Waskaganish area.
- For the Grevet-Chapais line, two configurations are possible:
  - Configuration 1: A connection to the high voltage network at Chapais will allow the line to be supplied with electricity.
  - Configuration 2: A medium voltage connection from Matagami will supply the line with electricity through medium voltage lines.

For Grevet-Chapais, Configuration 2 will be more interesting from a financial and material point of view although it requires more earthworks. Configuration 2 is 20% less expensive than configuration 1.

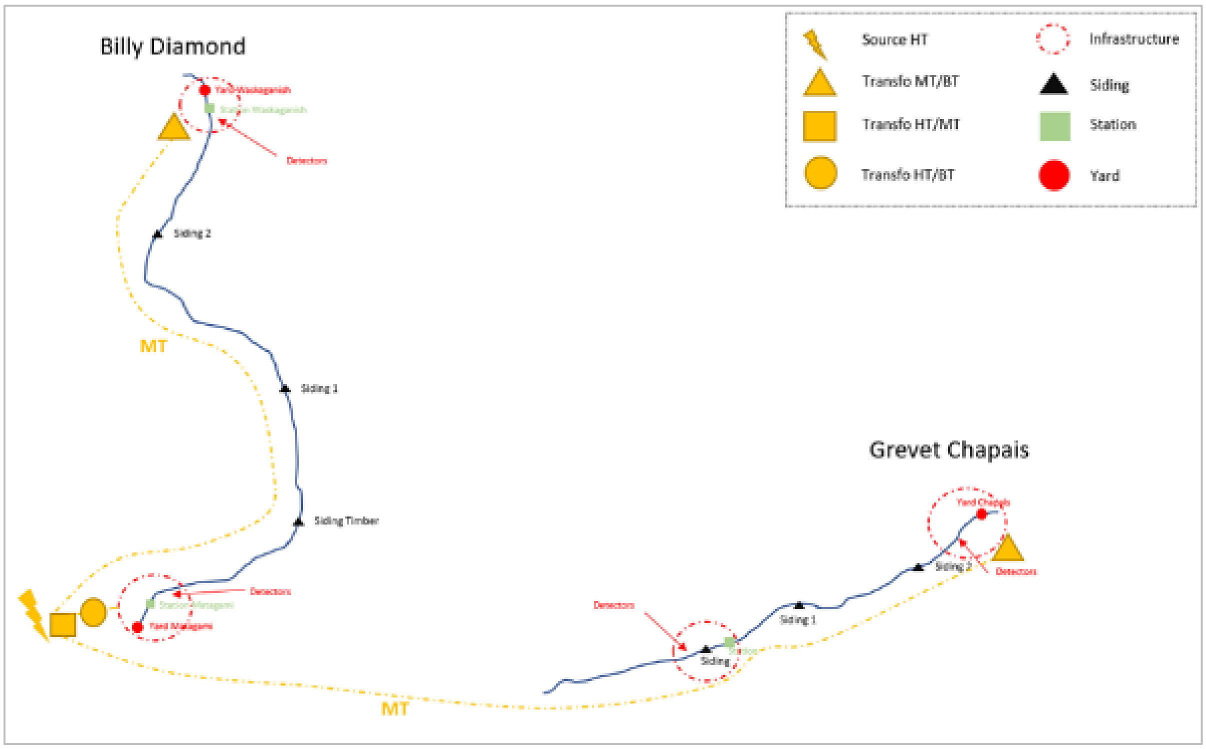


Figure 8.5-105: Schematic View of the Lines with Electrical Facilities

8.5.28 Railway Operations

8.5.28.1 Overview

An important step in evaluating a railway project, once traffic levels have been estimated, is to determine the train operations required to move the traffic over the line from origin to destination and the personnel and facilities required to maintain and operate the railway. The approach to operations planning used for the study is to manage a scheduled railroad.

The operating plans discussed here identifies the equipment, infrastructure, and personnel requirements needed to provide the potential customers with a reliable service. The train types included in this study are intermodal (container) and general freight which can include all types of traffic and wagon categories. Passenger trains are discussed under the section dedicated to "Passenger Services".

8.5.28.2 Freight Traffic Demand

Two potential traffic levels have been evaluated for the proposed project – a base case and an optimistic mining growth. The base case is a likely achievable traffic level. The optimistic traffic reflects the materialization of the Duncan Lake (Century/Augya) iron ore mine. The market study report describes the type and volume of the potential traffic and the manner in which it was determined in detail. The figure below shows the location of potential freight sources (and in some cases destinations) and the estimated tonnages.

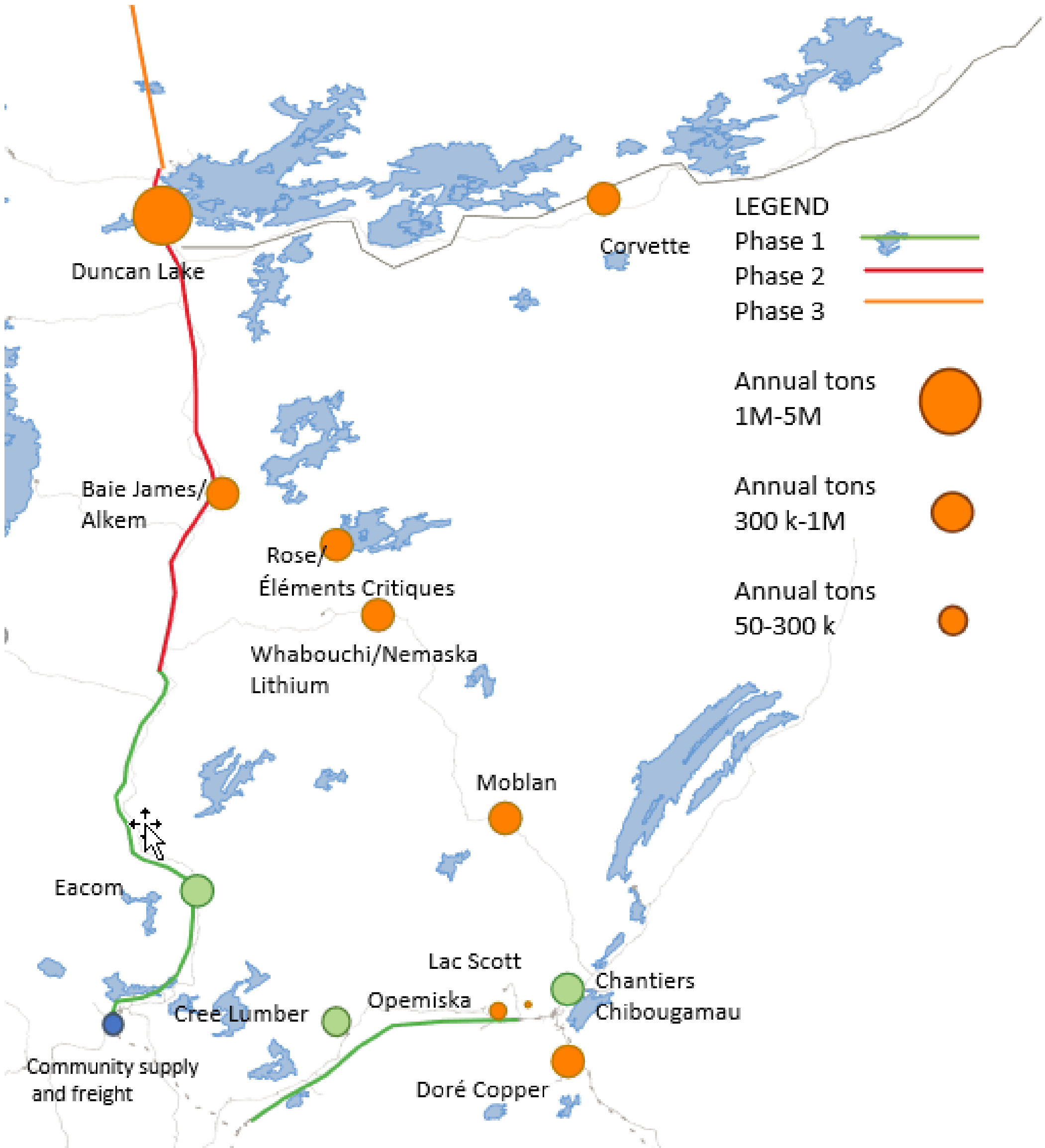


Figure 8.5-106: Potential Traffic Demand Evaluated for the Proposed Project

The base case annual freight demand forecast has been used to plan the operation for BDHR and for GCR. These freight volumes are considered mostly constant over the analysis period, the forestry and mining sector industries foresee a steady volume of production for each plant or site, while the supply of general goods which should grow with the evolution of population will nevertheless remain a small share of total demand.

On BDHR, a total of 1 381 200 TPA is estimated to be shipped by rail under the base case scenario. This volume represents mostly mining commodities related to lithium, principally spodumene concentrate (a lithium ore), and wood logs and, more marginally, some construction equipment and materials, goods procurement and Hydro-Québec equipment and materials.

Similar to many mining railways, BDHR will also be used for bulk and general freight trains to support the mining operations and communities in the region. The freight trains will originate from Waskaganish Yard and will consist of various wagon types depending on the product. To accommodate these trains, it will be necessary to include switching tracks at the yard for loading and unloading of the bulk and containerised spodumene concentrates.

On GCR a total of 1 007 800 TPA would be shipped by rail under the base case scenario. This volume includes 517 400 TPA of mining ore and 480 4000 TPA of wood inputs. Construction material and general consumer goods amounts to a small volume (111,600 TPA). The GCR freight trains will also consist of various wagon types depending on the products transported.

The following table summarizes the mining ore, bulk, and general freight traffic requirements anticipated on the rail line. The bulk and freight quantities are approximate and were estimated and are subject to change as more mining input information becomes available.

Table 8.5–35: Summary Freight Traffic

Commodity	Base case annual quantity (TPA)		Wagon Type
	BDHR	GCR	
Containerised Spodumene Concentrate in 20' RTEUs	951 000		64' flat car
		200 000	Covered hopper
Bulk Copper Concentrate		317 400	Covered mill gondola
Logs	318 600		Bulkhead flat car
Wood Chips		426 400	Wood chip gondola
Softwood lumber		54 000	Flat Car
Construction Equipment and Materials	5 000		Flat Car
Hydro Quebec Equipment and Materials	9 100		Flat Car
Fuel	7 500		Tank-tainer
Goods procurement	90 000	10 000	Flat Car
Total	**1 381 200**	**1 007 800**	**2,389,900**

8.5.28.3 Freight Train Characteristics

The trains will be mixed designated trains operating between Waskaganish Yard and Matagami Yard and between Grevet marshalling yard and Chapais Yard. Trains on BDHR will be used to transport mining commodities related to lithium mining, and wood logs, some construction equipment and materials, consumer goods and Hydro-Québec equipment and materials. Trains on GCR will be used to transport mining ores, wood inputs and consumer goods.

A major expense in train operation is the locomotives. To maximize use of locomotives when determining train size, the number of cars on a given train are usually defined in incremental amounts that a locomotive can handle. The number of tonnes a locomotive can haul at an acceptable over the road time, to meet cycle time requirements, is determined by the track speed, type of locomotive and longitudinal profile of the proposed rail line. In train design, the power to weight ratio specification represents the relationship between the locomotive requirements (horsepower) and the tonnage limitations to ensure acceptable over the road time to meet the cycle requirement. A power to weight ratio target in the range of 0.60 is typical for this type of operation.

8.5.28.4 Train Consist

Train length has a very significant impact on the operating costs of a railroad. Train-kms generate expenses which can be easily quantified and then used as an important measurement of rail operating efficiency at various traffic levels. Basically, the more revenue tonnage a train handles, the more profitable a train becomes.

The train length determines the number of trains required to handle various traffic levels. The number of trains operated directly effects employee requirements, track infrastructure (sidings), number of meets on single track, operating schedule, track maintenance and opportunity for level crossing and trespasser accidents. In this study, two different trains will be operated on both railways: freight train and passenger train.

To develop an operating plan, traffic projections have been calculated to determine meaningful train designs for the BDHR and GCR that are consistent cycle times which are discussed in the following sections.

The net carrying capacity of each wagon type and associated commodity, combined with the pulling capacity of locomotives and maximum gradient of the line defines the maximum train length for required for operations. Since the preferred locomotives for heavy haul train operation in North America are the 4,000 to 4,400 HP diesel-electric traction units, two are needed per freight trip on both railways to haul the tonnages on a maximum gradient of up to 1.5%.

The tables below summarize the train consists and loadings for both railways.

Table 8.5–36: BDHR Train Consist

Commodity	Wagon Type	Number of Wagons	Loaded Yes/No	
			Southbound	Northbound
Logs	Bulkhead flat car	8	Yes	No
Containerised Spodumene in 20’ RTEUs	64’ flat car	19	Yes	No
Bulk Spodumene Concentrate	Covered hopper	36	Yes	No
Hydro Quebec equipment	64’ flat car	1	No	Yes
Construction equipment and materials	64’ flat car	1	No	Yes
Fuel in 20’ tank-tainers	64’ flat car	2	No	Yes
Goods Procurement	64’ flat car	8	No	Yes
Total number of cars per trip		**75**		

Table 8.5–37: GCR Train Consist

Commodity	Wagon Type	Loaded Yes/No	Number of Wagons	
			Westbound	Eastbound
Wood Chips & Biomass	Wood chip gondola	14	Yes	No
Bulk Copper Concentrate	Covered mill gondola	18	Yes	No
Bulk Spodumene Concentrate	Covered hopper	15	Yes	No
Goods Procurement	64’ flat car	1	Yes	No
Total number of cars per trip		**46**		

8.5.28.5 Operating Days per Year

An important planning element in determining the rolling stock, the train operation, employees, maintenance facilities and infrastructure requirements to handle a stipulated yearly tonnage, is the number of operating days specified per year. The rail operation for BDHR and GCR is a general process handling a specific traffic between the origin and the destination. It is not dependent on a single shipper but has a variety of customers and different commodities. Under a full traffic load, this railway would operate year-round, as most others do around the world.

To account for operational disruptions, unaccounted longer transit times and national holidays such as Christmas, an operating contingency is included in the calculations to determine train frequency and size, which directly impacts rolling stock and crew requirements. This contingency is normally provided for through a reduction in operating days per year. To reflect the impact that climate might have on the operations of these two railway lines, 350 operating days per year have been used to develop the operating plans.

8.5.28.6 Transit Times

The analysis of train transit times used the minimum transit times for the designed train consists modelled over the plan and profile developed for the railway lines. Minimum travel times on the lines were based on simulations carried out with the Railsim Train Performance Calculator (TPC) software. Multiple factors are considered for these calculations:

- the speed limits
- the train configuration and locomotive specifications
- the track geometry

The performance of the train as it travels on the railway is simulated, considering the power of the locomotives as well as factors like the air resistance, the track-wheel resistance and the gradients of the track. This makes it possible to determine how the train speed is affected by these factors. The figure below shows the results of one of the TPC simulations, for a freight train departing from Waskaganish and arriving at the timber siding located at KP 60.

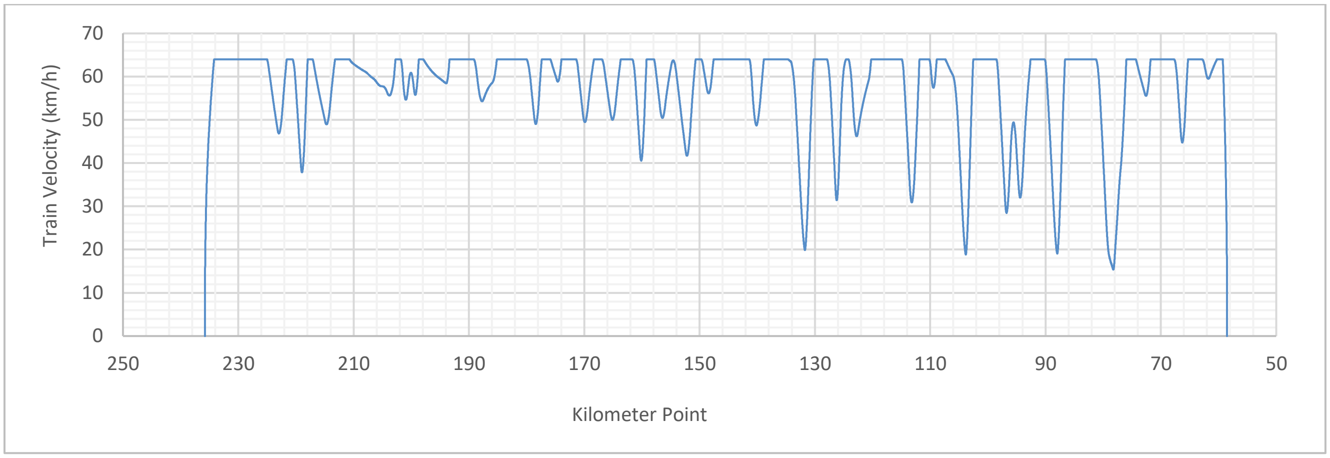


Figure 8.5-107: Train Speeds for a Freight Train Travelling from Waskaganish to the siding at KP 60

It is apparent that the resistances the train meets at certain points become significant, resulting in slowdowns.

These simulations make it possible to calculate the Minimum Running Time (MRT) on the line. This is not the real-world travel time, but a minimum theoretical travel time without considering factors like dwell time at stops, driver behaviour, time lost due to train meets, and other factors. The following table provides a summary of the travel times calculated:

Table 8.5–38: Summary of the Minimum Running Times Calculated for Each Train

Railway	Service	Traction	Speed Limit (mph)	Route	Minimum Running Time (h)
Billy Diamond Highway Railway	Freight	Diesel	40	Southbound Start KP 236 (Waskaganish) End KP 60 (Lumber Siding)	3.27
Billy Diamond Highway Railway	Freight	Diesel	40	Southbound Start KP 60 (Lumber Siding) End KP 0 (Matagami)	1.13
Billy Diamond Highway Railway	Freight	Diesel	40	Northbound Start KP 0 (Matagami) End KP 60 (Lumber Siding)	0.98
Billy Diamond Highway Railway	Freight	Diesel	40	Northbound Start KP 60 (Lumber Siding) End KP 236 (Waskganish)	2.80
Billy Diamond Highway Railway	Passenger	Diesel	60	Southbound Start KP 236 (Waskaganish) End KP 5 (Matagami)	2.42
Billy Diamond Highway Railway	Passenger	Diesel	60	Northbound Start KP 5 (Matagami) End KP 236 (Waskaganish)	2.43
Grevet Chapais	Freight	Diesel	40	Eastbound Start KP 123 (Grevet) End KP 278 (Chapais)	2.58
Grevet Chapais	Freight	Diesel	40	Westbound Start KP 278 (Chapais) End KP 123 (Grevet)	2.68

The achievable travel times on the line are developed by adding time allowance to the simulated MRT which account for operational requirements and practices, human behaviour and unanticipated delays, these are:

- Delays to permit the train to enter a siding and allow and opposing trains to pass on the main line (train meets).
- Adjustment for train driver behaviour.

8.5.28.7 Terminal Times

Terminal times are taken into consideration when developing a train's cycle time. The total terminal time is a function of loading/unloading time, which correlates to the number of cars handled by the train and the unloading/loading time for each car, the type of car and the commodity being unloaded. An operational allowance is added to this time to take into account activities such as shunting cars carrying different commodities into their appropriate unloading tracks, re-assembling the loaded cars into a train consist on the departure track and turning locomotives, etc.

8.5.28.8 Locomotive Fuelling

The fuel consumption of a train depends on gradients, maximum speed, load of wagons, distance, etc. The calculations of the fuel consumption were based on the results from simulations carried out with the Train Performance Calculator. The estimated fuel consumption per trip is summarized below:

- Waskaganish – Matagami (Southbound): 4 745 litres;
- Matagami – Waskaganish (Northbound): 2 257 litres;
- Grevet – Chapais (Eastbound): 865 litres;
- Chapais – Grevet (Westbound): 1 938 litres.

The recommended locomotives have a minimum fuel tank size of 16 000 litre and can make a 4 round trips on BDHR before refueling. To minimise the transportation distance and consequently its cost, it is recommended that fueling facilities be installed at Matagami Yard. A time allotment is provided in the schedule for locomotive fuelling at the Matagami Yard.

The recommended locomotives can make 11 round trips on GCR before needing refueling. It is recommended that fueling capability be installed at Chapais Yard. Since the Chapais locomotives only operate 3 days a week no specific allowance for fueling is required in their operating schedule.

The fueling station should allow for the parking of a fuel truck that can fuel a locomotive at a rate of 750 liters per minute per locomotive. Each fuel truck has a capacity of 18,000 litres. It is anticipated that two trucks may be necessary to supply the required volume of fuel for two locomotives on the BDHR (approximately 32,000 litres for the two locomotives) and to accelerate the fuelling process. The fuel truck will have an onboard metering system and a fuel ticket will be issued for each locomotive fuelled to provide records of each fuel transaction.

A spill collection system will be installed on the full length of the fueling platform and the spill will be directed toward an oil separator.

8.5.28.9 Train Inspections

The locomotive and car inspections needed as part of the rolling stock maintenance regime will also be carried out at the Matagami yard. Full standing train inspections and air brake tests will be carried out at the beginning of each trip in the Matagami, Waskaganish, and Chapais yards after assembly of the departing train consist. Automatic mechanical train inspections will also be performed by wayside detectors along the length of the line.

A walking inspection and brake test will also be carried out before the BDHR train leaves the timber loading siding after dropping of and picking up the bulkhead flats used in the timber service and on the GCR before the train leaves the marshalling yard at Grevet with the cars picked up in exchange from CN.

Locomotives will be sequentially changed out with the spare locomotive to permit the more rigorous inspections required under the locomotive maintenance strategy.

8.5.28.10 Cycle Time

Cycle time is the measurement of the time it takes the same set of rolling stock to reach the same status in successive trips. The most common measurement point is the available departure time from an originating terminal. The overall cycle time includes a combination of transit and various types of terminal times.

8.5.28.11 Cycle Time Considerations

A railway operating plan must incorporate realistic and reliable cycle times, as cycle time is a key parameter in determining rolling stock requirements and number of trains operated. Several different possible cycle times were examined, and in each scenario the level of service required was such that the service could be structured to avoid mainline operations during the night. This was approach was adopted since it was seen to be desirable for several reasons:

- From a safety point of view the railway will operate in a region where the population has no familiarity or experience with railways and has numerous grade crossings on the railway providing access for trapping, fishing, hunting and logging. Using grade crossings during the daylight hours increases visibility and enhances the user's awareness of the conditions.
- Daylight operations potentially reduce the risk of wildlife strikes on the mainline, since the hypnotic effect of the locomotive headlight, which often causes animals to "freeze", would not be in effect.
- Some of the routine track maintenance activities are site specific and benefit from a relative long period without the interruptions caused by the need to clear the track (leaving it safely operable) to allow a train to pass. The maintenance teams would be equipped with adequate lighting as a matter of routine, so night work is not a problem and providing uninterrupted track time significantly increases their efficiency and productivity.

The following table shows the cycle time adopted for the BDHR freight service.

Table 8.5–39: Sample Train Cycle Time on BDHR

Day	Time	Activity	Location
0	05:30	Train consists is assembled with loaded mineral cars and empty general freight wagons on the departure track	Waskaganish Yard
0	08:00	Train Crew performs a standing inspection and a brake test	Waskaganish Yard
0	09:00	Train departs Waskaganish	Waskaganish Yard
0	12:30	Train enters siding at the timber loading siding and loaded bulkhead flats are added to the train consist	Timber Loading Siding
0	13:30	Train Crew performs a walking inspection of the connection and added cars and performs a brake test	Timber Loading Siding
0	14:00	Train Departs Timber Loading Siding	Timber Loading Siding
0	15:00	Train arrives at Matagami Yard, and the freight cars are marshalled into the appropriate marshalling tracks.	Matagami Yard
0	20:00	Locomotives moved to the Matagami Rolling Stock Maintenance Shop	Matagami Yard
1	5:30	Train consists is assembled with loaded mineral cars and loaded general freight wagons on the departure track	Matagami Yard
1	08:00	Train Crew performs a standing inspection and a brake test	Matagami Yard
1	09:00	Train departs Matagami	Matagami Yard
1	9:30	Train enters siding at the timber loading siding and empty bulkhead flats are removed from the train consist	Timber Loading Siding
1	10:30	Train Crew performs a walking inspection of the end of train and performs a brake test	Timber Loading Siding
1	11:00	Train Departs Timber Loading Siding	Timber Loading Siding
1	13:30	Train arrives at Waskaganish Yard and the freight cars are marshalled into the marshalling tracks	Waskaganish Yard
1	15:00	Locomotives moved to their garaging track	Waskaganish Yard

The relatively short GCR allows the round trip to be completed on the same day.

Table 8.5–40 : Sample Train Cycle Time on GCR

Day	Time	Activity	Location
0	05:30	Train consists is assembled with loaded mineral cars and empty general freight wagons on the departure track	Chapais Yard
0	08:00	Train crew performs a standing inspection and a brake test	Chapais Yard
0	09:00	Train departs	Chapais Yard
0	11:30	Train enters arrival marshalling track, and the locomotives disconnect from the consist	Grevet Marshalling yard
0	12:00	Locomotives connect to the cars waiting in the exchange departure track – turning at the Grevet Wye if necessary	Grevet Marshalling yard
0	13:00	Train crew performs a standing inspection of the train and performs a brake test	Grevet Marshalling yard
0	14:30	Train departs	Grevet Marshalling yard
0	17:00	Train arrives at Chapais Yard and the freight cars are marshalled into the appropriate loading/unloading tracks.	Matagami Yard
0	19:30	Locomotives moved to their garaging track	Waskaganish Yard

8.5.28.12 Train Schedules

There is a difference between achievable travel times, and the travel times developed for an operating schedule or timetable. To ensure a robust and regularly repeatable service other factors which might slow down a train are also considered, and allowances are added to the travel time, these are:

- Temporary slow orders
- Operational inefficiencies
- A buffer to permit a system to re-establish its normal operating pattern after unanticipated events
- Specific to this proposed project, a buffer to the cycle time has been added to permit slow orders on specific bridges when requested by a land user

Based on the considerations described in the previous sections the proposed schedule for freight trains operating on the BDHR comprises three daily southbound trips a week and three northbound trips on each of the following days. An overnight stay in Waskaganish Yard provides adequate time for loading and unloading.

The proposed schedule for freight trains operating on the Grevet-Chapais includes a around trip shuttle service three times week, leaving cars at the Grevet Exchange Tracks for onward movement over the CN system and picking up cars to return to Chapais.

Table 8.5–41: Freight Train Schedules

	DIRECTION		KP	Station	Direction	
Billy Diamond	**Northbound: Days 1, 3, 5**				**Southbound, Days 2, 4, 6**	
	Dep	09:00	0	Matagami	Arr.	15:00
	Arr.	09:30	60	Timber Siding	Dep.	13:30
	Dep.	10:30	60	Timber Siding	Arr.	12:30
	Arr.	13:30	233	Waskaganish	Dep.	09:00
Grevet-Chapais	**Eastbound: Days 2, 5, 7**				**Westbound, Days 2, 5, 7**	
	Dep.	09:00	275	Chapais	Arr.	17:00
	Arr.	11:30	123	Grevet	Dep.	14:30

8.5.28.13 Operating Facilities

General

The staff identified in the Overall Staffing section of this report will report to work and perform many of their functions at railway-owned buildings. These building facilities will be newly constructed and can be broken down into several categories as set out below:

- Headquarters office in the Waskaganish community;
- Maintenance of Way Buildings located in Waskaganish, Matagami and Chapais yards;
- Workshop in Matagami Yard used for the maintenance of locomotives, wagons and MoW equipment;
- Other operational buildings for train control:
  - Yard Control Building
  - Bulk Warehouses
- Passenger facilities: buildings required for the transportation of passengers.

The particular locations of each of the types of facilities identified above are indicated in the table below.

Table 8.5–42: Location of Operating Buildings and Facilities

Department	Matagami	Waskaganish	Chapais	Waswanipi
Headquarters		X		
Maintenance of Way Buildings	X	X	X	
Rolling Stock Maintenance Shop	X			
Passenger Stations	X	X	X	X
Bulk Warehouses	X	X		

The remainder of this sub-section provides a further information regarding the particular type of building.

Headquarters

The office space required for the Headquarters could be located in the Waskaganish community and act as an Administration. The general requirements for the facility are defined in following table.

Table 8.5–43: Administrative Office Requirements

Area/Service	General Requirements
General Manager's Office	Closed offices, general office (cubicles) and boardroom.
Reception Area	Meeting/greeting/holding area for vendors, visitors, etc.
Engineering, HR, Finance, Accounting, IT, Transp. Management	Closed offices for upper management. Clerical support & desk-based administrative functions in flexible office cubicle configuration with meeting rooms. Floor/ceiling trunking for flexible phone, data, & power distribution.
Operations Control Center	Special desks w/ screens providing schematic view of line & train position along with radio communication with train crews.
Documentation Area	Design & maintenance manuals, design drawings, reference books, etc.
Computer Server/Telecom. Equipment Room	Secure location for storage of main servers for WAN system inventory, payroll and maintenance tracking systems.
Office Supplies Area	Stores for stationery, paper supplies, forms, etc.
Printing/Reproduction Area	Space for printing documents, compiling and binding reports, etc.
Employee Welfare Area	Male & female toilets, lunchroom w/ food prep. area & vending machines.

To achieve the efficiency required for the operation of both railways, the staff identified in the Railway Operations section need training once they are hired. Therefore, multifunctional training spaces can be rented in schools or community centers when needed.

MOW Maintenance Buildings

The management staff of the MOW Department will be located at the Headquarters facility in the Waskaganish community. However, some supervisors responsible for field operations such as track, bridges, work equipment, signals and telecommunications shall be located within their assigned yard.

It is proposed to use the maintenance-of-way facilities for minor repairs. Major repairs can be performed in Matagami Rolling Stock Maintenance Shop. Three (3) maintenance-of-way facilities are proposed in terms of small garage spaces, one to be located at Matagami Yard, another located at Waskaganish Yard and a third one located at Chapais Yard. It will be necessary for maintenance-of-way facilities to be provided at each of the three locations identified for the minor repairs. These maintenance facilities must accommodate all staffing and office work activities for a track segment i.e. track, welding, signal and communications, as well as any supervision. Suggested minimum requirements for a maintenance facility would be:

- Supervisor's office;
- Foreman's office;
- Lunchroom;
- Locker room / washroom;
- Storage room - small equipment;
- Storage room for track and signal materials requiring protection from the environment;
- Storage track for gang transporters and heavy track equipment (as required). It is recommended to provide garage-type parking for Gang Transport vehicles during winter months;
- Storage area for track materials and signals and telecommunications supplies.

Rolling Stock Maintenance Shop

The availability of a well-equipped shop will provide the operator the tools required to perform adequate rolling stock maintenance and ensure safe operations and maximize availability and reliability. One Rolling Stock Maintenance Shop is proposed in Matagami Yard for both railways.

Workshop Capacity

The workshops design is taking into account the size of the rolling stock fleet that will be required to haul 1.5 MTPA (for both railways combined) of different commodities and to provide the freight train service required to support this activity. Since maintenance facilities represent significant investments and are designed for a life expectancy of over 50 years, it is important to ensure they will be properly located and expandable, so that they can be adapted for the maintenance of a larger rolling stock fleet if needed. In that respect, the maintenance facilities will be designed to minimize the initial capital investment while providing the capability to maintain the 1.5 MTPA fleet of wagons and locomotives.

The anticipated fleet of wagons and locomotives for the 1.5 MTPA scenario is presented in the rolling stock section of this report.

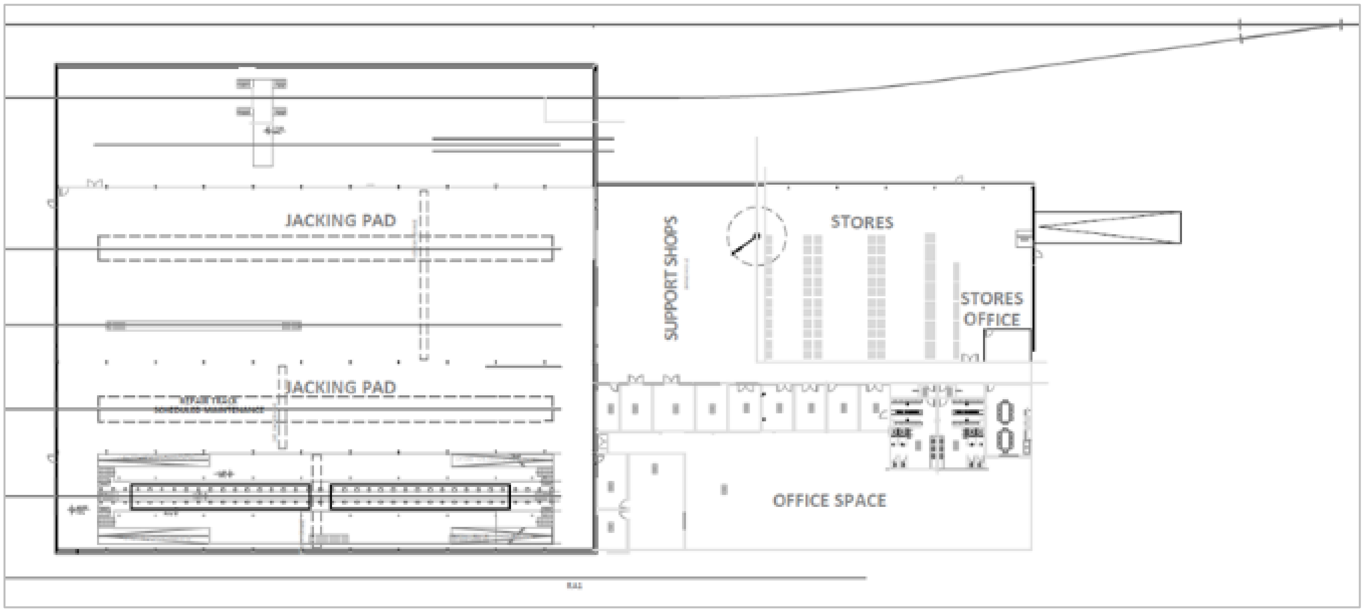


Figure 8.5-108: Rolling Stock Maintenance Shop Details

Workshop Characteristics

The workshop must be equipped to perform the maintenance recommended by their Original Equipment Manufacturer (OEM). This implies providing sufficient shop space to allow respecting the recommended maintenance intervals. This also includes the availability of workstations that are properly equipped so that efficient maintenance practices can be implemented. Space must be provided for the storage of tools, equipment and spare parts required for maintenance. Finally, circulation areas must be planned so that the movement of people and equipment can be achieved in a safe and efficient manner within the facilities.

The size of the wagon and locomotive fleets does not justify equipping the workshop to perform all maintenance and repair work. Only major repairs and maintenance will be performed at the workshop, using for the most part components that will have been overhauled by the Original Equipment Manufacturer (OEM). Maintenance strategy is defined in the Railway Operation section.

The shop staff was estimated in order to determine office requirements and to dimension accommodation for employees, such as locker rooms, toilet, canteens, and the shop. The anticipated staff level by category of employee is indicated in the rolling Stock Staffing section.

8.5.28.14 Yard Operational Facilities

These facilities are buildings located near loading tracks in Waskaganish and Chapais yards. They include warehouses for storage of certain commodities (i.e. Spodumene and copper concentrate) being shipped on a bulk basis that require handling from truck to rail and vice-versa.

Both spodumene and copper concentrate are fine powders, and both are reported to be free flowing. Moisture content affects the material properties. Therefore, it is important that the moisture content and thus, the material behaviour is known before making firm commitments on the material handling system.

For the purposes of this study, it is assumed that the material can be handled with belt conveyors and bins without issues. However, at the next stage of the study, it is important to get the stored materials samples tested to confirm the validity of the assumptions.

Enough space has been considered in the yards where a storage building is required for the spodumene and copper concentrate. One week's supply of material in each building is considered. Enough space at each end of the building is taken into consideration for equipment to operate, and for a truck to unload.

A schematic layout is shown in the two figures below. Trucks coming from the mines would back in the building, dump the material and then exit through the same door. A reclaim hopper to feed the rail car loading system would be at the opposite end of the building. This will require considerable shifting of the product inside the storage building. One loader should be able to service the rail loading as well as shift the material in the storage building.

Figure 8.5-109: Example of a Storage Warehouse – Schematic Layout

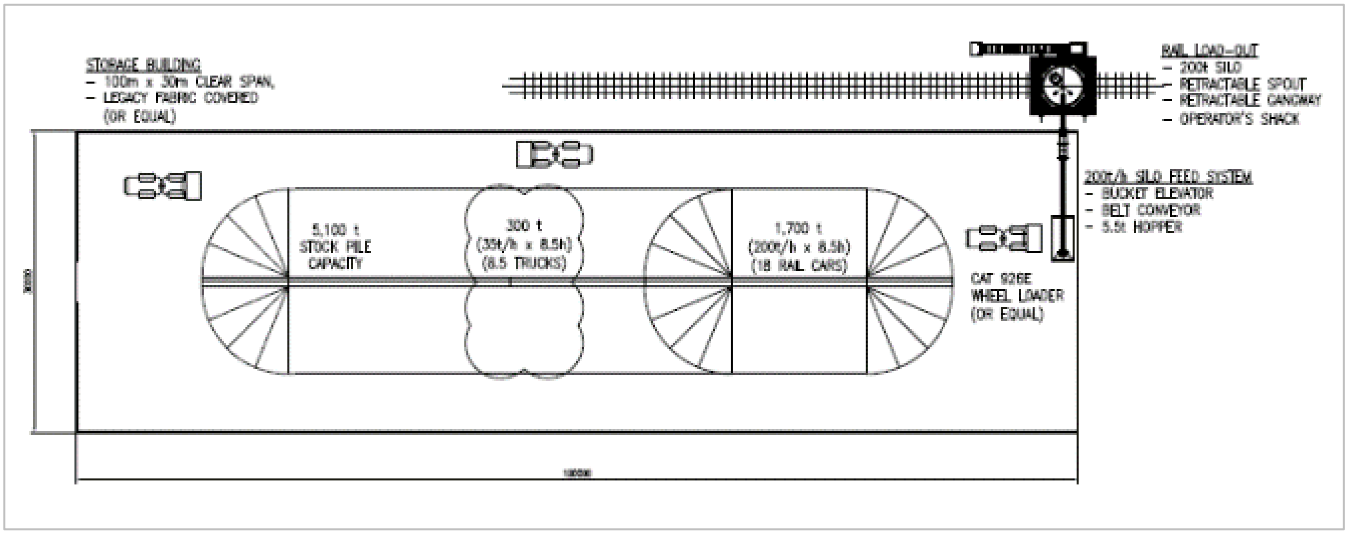


Figure 8.5-110: Storage and Rail Loadout – Schematic Layout (Estimated and Indicative)

Loading the rail cars in 8.5 hours is easily achievable with mobile equipment (front end loader) reclaim. The material will have to be elevated to the rail loading facility and stored in a surge bin prior to loading into the rail car. Elevating the concentrate can best be done with a bucket elevator or a high angle conveyor. The bin may need a vibrating discharger, depending on the flowability of the product. The silo should be designed to hold 200 tons of material, which gives a one-hour surge capacity.

8.5.29 Rolling Stock

Rolling stock includes all locomotives, freight cars ("wagons"), and passenger coaches that will run on the Billy Diamond Highway and Grevet-Chapais sections of the railway.

A common requirement for all rolling stock is that they must all be interoperable with railways in the rest of North America and therefore, all locomotives and wagons must be built to the standards and specifications of the American Association of Railroads (AAR), regardless of manufacturer and origin.

The following table summarizes the common requirements for all rolling stock:

Table 8.5–44: Rolling Stock Common Requirements

Characteristic	Particulars
Track gauge (mm)*	Standard gauge (1435)
Design maximum attainable speed (km/h)	110 (70 mph)
Minimum negotiable curve radius (m)	80
Maximum axle load (tonnes)	30
Rail wheels and axles*	Conventional railway wagon or locomotive type with outboard bearings
Wheel manufacturing standard*	As per AAR specification M-107/M-208, Class C, or equivalent.
Wheel rim hardness (BHN)*	• Minimum: 321 • Maximum: 363
Coupler type	AAR Type E Head
Braking system	Standard pneumatic as per AAR S-400
Braking ratios	As per AAR S-401 “Brake Design Requirements”, section 4.0.

8.5.29.1 Freight Car Requirements

Lithium Mining Products

The type of the Lithium Ore that is commonly found in Quebec is called Spodumene. Typically, Spodumene is processed at the mine site to concentrate the lithium content, and then shipped to a different facility for extraction of the lithium. Two different approaches to the transportation of the Spodumene Concentrate is being considered by the mining companies in Quebec.

One approach is to put the concentrate in containers at the mine site and road haul the containers to the nearest rail head where the containers are loaded onto rail flat cars for onward travel. This is referred to as Containerised Spodumene Concentrate.

The second approach is to load the concentrate into dump trucks, road haul it to the rail head, dump the concentrate in dedicated hangers, and load railcars from the hangers for onward travel by rail. This is referred to as Bulk Spodumene Concentrate.

The following are the freight car requirements.

Containerised Spodumene Concentrate

The concentrate will be transported in reinforced containers which are loaded, three at a time, onto 64’ flat cars(Figure 8.5-111). The reinforced containers, referred to as an REU, have the same footprint as a standard ISO 20 ft container and allows for direct “pit to ship” transportation. The reinforced containers are loaded and unloaded onto the flat cars using either cranes or container stackers (Figure 8.5-112:).

Figure 8.5-111: Reinforced Containers for the Transport of Spodumene

Reinforced container characteristics are as follows:

Table 8.5–45: REU characteristics

Characteristics	Value
External Length (mm)	6058
External Width (mm)	2438
External Height (mm)	1800
Max. Gross Weight (kg)	43,500
Tare Weight (kg)	3500
Max. Payload (kg)	40,000
Volumetric capacity (m^3)	19.6

Figure 8.5-112: Crane (left), Container Stacker (right)

For full flexibility, 64’ flat cars should be purchased that can transport REUs / regular ISO containers and cargo materials, therefore flat cars should be ordered with container twist locks located at 20’ intervals such that three 20’ containers or one 20’ and one 40’ container can be secured and be equipped with stake pockets and rachet tie downs to help secure bulky items. Container twist locks should be able to flip away such that they do not interfere with the loading of non-containerized equipment.

Such a flat car would not be able to transport containers longer than 40’ due to overhang.

Figure 8.5-113: 64’ Flat Car Transporting Three ISO containers (top), and Three REUs (bottom)

64’ flat car characteristics are as follows:

Table 8.5–46: 64’ Flat Car Characteristics

Characteristics	Particular
Number of axles	4
Maximum axle load (tonnes)	30
Maximum gross rail load (tonnes)	120
Tare weight (tonnes)	29
Maximum width and height (Loading gauge)	Meets AAR Standard S-2028-Plate C Equipment Diagram
Clear deck length (metres)	19.5
Length over couplers (metres)	21.1
End-of-wagon device	Standard (Non-Cushioned)
Type of bogies	Steerable AAR 3-piece, “70-ton”
Specialties	• Container twist locks located at 20’ intervals • Side stake pockets • Rachet tie downs

Bulk Spodumene Concentrate

Bulk Spodumene Concentrate will be transported in covered hoppers (see Figure 8.5-114) that protect the lading from the environment and are loaded through top hatches and unloaded through bottom gates.

Figure 8.5-114: Covered Hopper for the Transport of Bulk Spodumene

The covered hopper characteristics are as follows:

Table 8.5–47: Covered Hopper Characteristics

Characteristics	Particular
Number of axles	4
Maximum axle load (tonnes)	30
Maximum gross rail load (tonnes)	120
Tare weight (tonnes)	23.6
Maximum width and height (Loading gauge)	Meets AAR Standard S-2028-Plate C Equipment Diagram
Internal volume (cubic metres)	67
Length over couplers (metres)	12.79
End-of-wagon device	Standard (Non-Cushioned)
Type of bogies	Steerable AAR 3-piece, “70-ton”
Specialties	Top hatches, bottom gates

Logs

Logs will be transported on bulkhead flat cars (Figure 8.5-115). Bulkhead flat cars are flat cars with bulkheads at each end that impede the lading (in this case logs) from shifting longitudinally.

Figure 8.5-115 : Bulkhead Flat Car for the Transport of Logs

The bulkhead flat car characteristics are as follows:

Table 8.5–48: Bulkhead Flat Car Characteristics

Characteristics	Particular
Number of axles	4
Maximum axle load (tonnes)	30
Maximum gross rail load (tonnes)	120
Tare weight (tonnes)	37.9
Maximum width and height (Loading gauge)	Meets AAR Standard S-2028-Plate C Equipment Diagram
Clear deck length (metres)	18.9
Length over couplers (metres)	22.4
End-of-wagon device	Standard (Non-Cushioned)
Type of bogies	Steerable AAR 3-piece, “70-ton”

Wood Chips

Wood chips are transported in large open top cars with flat bottoms (Figure 8.5-116). They are loaded and unloaded with excavation buckets. Note: wood chip gondolas are part of the exchange traffic carried across the GCR so they will not be owned by the GCR railway but will be moved by it. They are shown here so that the information on the rolling stock carried by the railway and included in the composition of the train consist is complete.

Figure 8.5-116: Woodchip Gondola

Woodchip gondola characteristics are as follows (Note: A woodchip density of 480 kg/m^3 was used for the sizing the gondolas).

Table 8.5–49: Woodchip Gondola Characteristics

Characteristics	Particular
Number of axles	4
Maximum axle load (tonnes)	30
Maximum gross rail load (tonnes)	120
Tare weight (tonnes)	33.3
Maximum width and height (Loading gauge)	Meets AAR Standard S-2028-Plate C Equipment Diagram
Internal volume (cubic metres)	180
Length over couplers (metres)	20.4
End-of-wagon device	Standard (Non-Cushioned)
Type of bogies	Steerable AAR 3-piece, “70-ton”

Copper Concentrate

Copper concentrated will be transported in mill gondolas equipped with clamped-on plastic covers to protect the lading from the environment (Figure 8.5-117). Plastic covers are removed and replaced at the place of loading and unloading.

Figure 8.5-117: Mill Gondola with Plastic Cover

Mill gondola characteristics are as follows (a copper concentrate density of 2.25 t/m^3 was assumed for the sizing of the car):

Table 8.5–50 : Mill Gondola Characteristics

Characteristics	Particular
Number of axles	4
Maximum axle load (tonnes)	30
Maximum gross rail load (tonnes)	120
Tare weight (tonnes)	32.8
Maximum width and height (Loading gauge)	Meets AAR Standard S-2028-Plate C Equipment Diagram
Internal volume (cubic metres)	79 (car to be filled to 37.7 m3)
Length over couplers (metres)	17.61
Inside length (metres)	16
End-of-wagon device	Standard (Non-Cushioned)
Type of bogies	Steerable AAR 3-piece, “70-ton”
Specialties	Removable plastic cover

Hydro Quebec Equipment

Hydro Quebec heavy equipment that is loaded into standard ISO 20’ containers will be transported on the same 64’ flat cars described above.

Larger, non-containerized Hydro Quebec construction equipment will be transported on 64’ or 89’ flat cars.

Figure 8.5-118: 89’ Flat Car

Characteristics for the 89’ flat car is as follows:

Table 8.5–51: 89’ Flat Car Characteristics

Characteristics	Particular
Number of axles	4
Maximum axle load (tonnes)	30
Maximum gross rail load (tonnes)	120
Tare weight (tonnes)	37.65
Maximum width and height (Loading gauge)	Meets AAR Standard S-2028-Plate C Equipment Diagram
Clear deck length (metres)	27.22
Length over couplers (metres)	28.85
End-of-wagon device	Standard (Non-Cushioned)
Type of bogies	Steerable AAR 3-piece, “70-ton”
Specialties	Container twist locks located at 20’ intervals Side stake pockets Rachet tie downs

Fuel

Fuel will be transported in “tank-tainers” (Figure 8.5-119) that will be transported on the 64’ flat cars described above. Tank-tainers have the same external dimensions as 20’ ISO containers and are already transported by truck.

This option was selected for environmental considerations since it reduces the number of fuel transfer points (for example from rail car to storage facility and from storage facility to delivery truck). and therefor reduces the risk of fuel spills.

Figure 8.5-119: Typical Tank-tainer

Tank-tainer characteristics are as follows:

Table 8.5–52: Tank-tainer Characteristics

Characteristics	Particular
External Dimensions	Same as ISO 20’ container
Max. Gross Weight (kg)	43,500
Tare Weight (kg)	3800
Volumetric capacity (L)	17,500 to 26,000

On Company Service (OCS) Rolling Stock

OCS rolling stock primarily deals with track maintenance such as work trains, and the typical rolling stock consists of bottom dump and side dump ballast wagons, flat wagons, and box wagons.

Ballast Cars

Ballast is transported and dumped using two types of ballast car: bottom dump ballast cars that deposit track ballast on either side of the rails (Figure 8.5-120) with longitudinal gates, and side dump ballast cars that dump track ballast to either side of the right-of-way and are used for embankment widening (Figure 8.5-121).

Bottom dump ballast cars can be operated manually, pneumatically, or electronically, while side dump cars are controlled either pneumatically or hydraulically.

Figure 8.5-120: Bottom Dump Ballast Car

Figure 8.5-121: Side Dump Ballast Car

Typical characteristics for both types of ballast cars are as follows:

Table 8.5–53: Bottom Dump Ballast Car Characteristics

Characteristics	Particular
Number of axles	4
Maximum axle load (tonnes)	30
Maximum gross rail load (tonnes)	120
Tare weight (tonnes)	29.4
Maximum width and height (Loading gauge)	Meets AAR Standard S-2028-Plate C Equipment Diagram
Length over couplers (metres)	15
Internal volume (cubic metres)	77
End-of-wagon device	Standard (Non-Cushioned)
Type of bogies	Steerable AAR 3-piece, “70-ton”
Specialties	Longitudinal gates for depositing ballast to each side of rail, operated either manually, pneumatically, or electrically

Table 8.5–54: Side Dump Ballast Car Characteristics

Characteristics	Particular
Number of axles	4
Maximum axle load (tonnes)	30
Maximum gross rail load (tonnes)	120
Tare weight (tonnes)	40
Maximum width and height (Loading gauge)	Meets AAR Standard S-2028-Plate C Equipment Diagram
Length over couplers (metres)	16.74
Internal volume (cubic metres)	46.7
End-of-wagon device	Standard (Non-Cushioned)
Type of bogies	Steerable AAR 3-piece, “70-ton”
Specialties	Pneumatic or hydraulic dumping mechanism to deposit ballast to either side of right-of-way

8.5.29.2 Miscellaneous Supplies

Miscellaneous supplies such as tools are transported in box cars (Figure 8.5-122) while larger equipment, such as earth-moving equipment will be transported on 89’ flat cars.

Figure 8.5-122: Box Car

Typical box car characteristics:

Table 8.5–55: Typical Box Car Characteristics

Characteristics	Particular
Number of axles	4
Maximum axle load (tonnes)	30
Maximum gross rail load (tonnes)	120
Tare weight (tonnes)	33.1
Maximum width and height (Loading gauge)	Meets AAR Standard S-2028-Plate C Equipment Diagram
Length over couplers (metres)	17.7
Inside dimensions (metres)	15.4 (length) X 4 (height) X 2.9 (width)
End-of-wagon device	Standard (Non-Cushioned)
Type of bogies	Steerable AAR 3-piece, “70-ton”
Specialties	Pug doors

8.5.29.3 Locomotive Requirements

Locomotives represent a significant portion of capital and operating costs, so trains are designed around the capabilities of locomotives. The main factors to consider in determining the acceptable length and tonnage capacities of trains are grades, car types, weight, axle load, travel time, and the length of sidings.

Locomotives used for heavy haul operations require high horsepower and tractive effort to haul the tonnages commonly hauled by freight trains. For this purpose, the preferred locomotives for heavy haul train operation in North America are the 4,000 to 4,400 HP diesel-electric traction units which provide approximately 32% year-round traction and are equipped with alternating current (AC) traction. These locomotives have proven themselves in terms of high reliability, minimal maintenance requirements and fuel efficiency.

Figure 8.5-123: Typical High Horsepower Locomotives. Manufactured by Progress Rail (left) and Wabtec (right)

The following characteristics are for typical diesel-powered locomotives which represent the current industry standard and most cost-effective solution for traction. For a discussion on alternative motive power fuels and technologies, such as electrification and battery technologies, please see the report provided in appendix 6.18.

Table 8.5–56: Typical Locomotive Characteristics

Characteristics	Particular
Type of locomotive	Diesel-Electric Co-Co, Single Engine
Locomotive layout	Narrow long hood, single cab at one end
Type of traction	AC-AC (AC main generator, AC traction motors)
Max attainable speed (km/h)	120
Net Tractive power (hp)	4300 to 4400
Minimum continuous tractive effort at full horsepower (kN)	700
Minimum starting tractive effort (kN)	850
Minimum adhesion (% of locomotive weight)	32%
Maximum Weight-with full supplies (t)	194.4
Maximum axle load (t)	32.4
Length over coupling pulling faces (m)	22.0 to 23.5 (typical)
Maximum width and height	Must comply with a modified AAR Plate M
Braking system	Pneumatic (26-L), Dynamic Brakes, ECP Brakes not recommended
Minimum peak dynamic braking effort (kN)	470
Minimum Fuel tank size (Litres)	16,000
Bogie type	High adhesion, three axle, non-radial
Curve Negotiation (minimum radius curve) (m)	175
Coupler head type	AAR type F
Miscellaneous locomotive cab requirements	Toilet, refrigerator, microwave, air conditioning
Cab signalling	None
Emissions	EPA Tier IV

8.5.30 Rolling Stock Maintenance

The maintenance strategies for the rolling stock of BDHR and GCR and covers the following types of equipment:

- Locomotives
- Wagons
- Maintenance-of-Way Equipment

8.5.30.1 Locomotive Maintenance Strategy

The maintenance of a locomotive is a combination of preventative and corrective maintenance activities that are performed on an on-going basis. These are described further below.

Preventative (Scheduled) Maintenance

Preventative maintenance comprises a set of activities which are performed according to pre-established criteria to reduce the probability of equipment failure, which could lead to train delays and/or result in consequential damage requiring expensive repairs. These actions are carried out according to a program based on elapsed time, kilometres or condition of the locomotive, and are typically as recommended by the original equipment manufacturer (OEM). It is intended that condition monitoring equipment be used to enable maintenance frequencies to be optimized and to detect defects early enough so that they can be dealt with as preventative, rather than corrective maintenance.

The maintenance plan for locomotives is based on a cycle which includes three levels of preventative maintenance.

Table 8.5–57: Preventative Maintenance Approach for Locomotives

Level	Description
1	Daily Inspections
2	Scheduled Maintenance
3	Locomotive Overhauls

Daily inspections (Level 1 Maintenance) are visual inspections of different systems and components with the aim of detecting defects that might be developing in the locomotive. These visual inspections are usually performed before the locomotive departs on a train.

To maximize locomotive and train availability, locomotives will receive their daily inspection at the Matagami Maintenance Shop before being coupled to northbound trains. The daily inspection will be combined with the servicing of locomotives (adding fuel, oil, water, sand and cab cleaning). The combined daily inspection/servicing of locomotives will comprise the following activities:

- Fuelling;
- Adding sand, if required, to locomotive sand boxes;
- Verification of lubricant levels, and topping-up as required (diesel engine, air compressor, etc.);
- Verification of engine cooling water level and topping-up as required;
- Taking a sample of engine oil for analysis by the oil laboratory;
- Verification of any defect report (if applicable) issued by the train crew;
- Visual inspection of mechanical components such as the running gear (wheel, bogies, brake riggings, traction motor and gear cases), diesel engine, radiators and rotating equipment such as cooling fans, generator/alternator and pumps.);
- Visual inspection of electrical components (multiple unit cables, all external lights, electrical cabinet, meters, fault indicators, monitoring system);
- Engine load test (if required) and locomotive brake test;
- Cab and window cleaning; and
- Refilling of cab supplies (drinking water, first aid kit, toilet supplies, etc.).

If minor defects are found during fuelling, they will be recorded, and the locomotive will be directed to the Matagami Maintenance Shop for maintenance and repair.

Scheduled / On-Condition Maintenance

Level 2 Maintenance is performed on a 90-day schedule. These inspections are typically composed of a running gear inspection, checking air compressor, cleaning batteries, replacing fuel filters, lubricating oil if necessary and examining trucks (bogies), etc. In addition to the 90-day inspection, a 180-day inspection is performed on the locomotive, during which crankcase components are inspected; and radiator fan blades are cleaned and inspected, etc. Finally, in addition to the 90-day and 180-day inspections, a yearly inspection is performed, comprising cleaning of the compressor intercooler, checking the operation alarms and safety devices, inspecting cooling systems, lubricating alternator and radiator fan bearings, and draining and refilling traction motor gear cases, etc. The schematic figure below illustrates this concept.

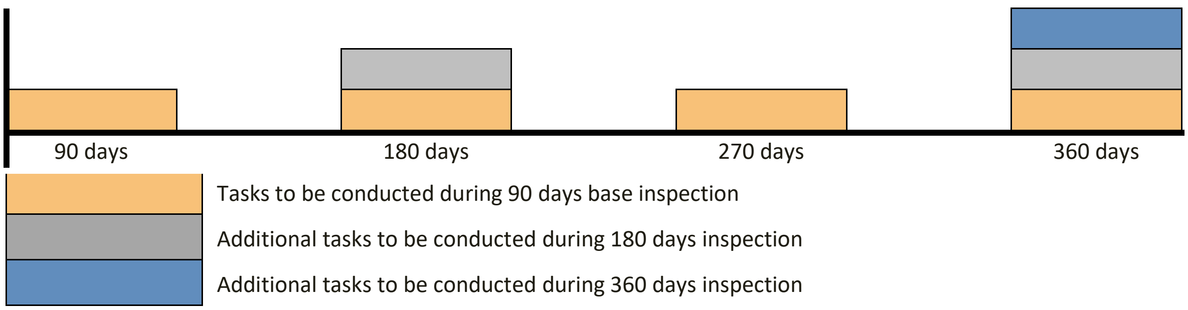


Figure 8.5-124: Scheduled Maintenance Distribution for Locomotives

The objective of these inspections is to ensure that the equipment and elements inspected will provide reliable service until the next inspection, and to ensure that the locomotive is safe for operation. If any of the checks reveal an unsatisfactory condition, then remedial action will be taken to rectify the situation. After the completion of each periodic inspection, a "Cab Card" is filled out and signed that indicates that the inspection was completed and when the next periodic inspection must take place.

Locomotive Overhaul

Level 3 Maintenance intervals can vary from 5 to 10 years, depending on locomotive utilisation. The appropriate interval will be determined once the locomotive anticipated workload has been assessed.

Two levels of overhaul (minor and major) are performed and alternate between each other. Both consist of the replacement of components (shown in the table below) by identical components which are new or reconditioned components (i.e.: overhauled components). During locomotive overhauls, minor components will be overhauled in-house while major ones will be contracted out to specialised companies since the shop the shop is not equipped for such overhauls.

Table 8.5–58: List of Major Locomotive Components to be Overhauled or Replaced

Component	Minor Overhaul	Major Overhaul
Diesel engine	Replace power assemblies and pumps only	Replace with an overhauled engine
Main alternator		Replace with an overhauled main alternator
Air compressor		Replace with an overhauled air compressor
Radiators and cooling fans	Replace	Replace
Bogies	Overhaul	Overhaul
Traction motors	Replace with overhauled traction motors – if necessary	Replace with overhauled traction motors – if necessary
Electronics		Replace
Air blowers	Overhaul	Overhaul
Brakes	Seals, gaskets replaced	Replace with overhauled component
Telecommunications/signalling equipment	Re-qualify (tested)	Replace and update
Cab items		Replace and update
Frame	Inspect for corrosion, local repairs and touch-up	Replace corroded elements
Couplers	Inspect, worn elements replaced	Replace

8.5.30.2 Corrective (Unscheduled) Maintenance

Corrective maintenance covers all troubleshooting and repair actions required to get a locomotive back into operating condition after a failure or an incident has altered or removed its ability to perform the required function. This maintenance is categorized as “unscheduled”. Potential defects are too numerous to be listed here. The following is a list of typical corrective maintenance actions:

- Replace a defective power assembly on the diesel engine,
- Replace or re-profile a wheel set,
- Repair leaks on the engine cooling or lubrication system,
- Diagnose a defect reported by the on-board computer,
- Replace an electrical component,
- Replace a turbo compressor,
- These defects are typically identified:
  - As the result of a trip inspection
  - As the result of a periodic inspection
  - By the locomotive driver or the on-board computer
  - As the result of a defect that occurred on the road

8.5.30.3 Locomotive Availability

An industry standard for locomotive availability is in the range of 90%, therefore an additional 10% of locomotives must be procured to ensure that there will be sufficient spare locomotives to support the train service while these locomotives are being maintained.

8.5.30.4 Wagon Maintenance Strategy

Freight wagons are subject to trip inspections, when defects are found, freight wagons are sent to the rolling stock maintenance building for servicing (colloquially known as being "shopped"), where they are subjected to a complete inspection prior to being released back into regular service.

Preventive Maintenance

Prior to any daily departure, the wagons in a train consist are visually inspected by a walk-by train inspection on both sides of the train, where defective parts are identified. These could include worn brake shoes, broken brake rigging, missing springs, excessively worn wheels, torn brake hoses, broken unloading gates, etc.

Small defects are fixed on the train in-situ, other defects are "tagged" for future repair. If not critical, the wagon will remain in service. Otherwise, the wagon is removed from the train for rerouting back to the maintenance workshop in Matagami for repair.

Bogie components such as side frames, bolsters, and wear liners wear out after a certain period, as do coupler components. The operator will establish a maintenance program where these components, as well as others, will be refurbished. A typical planned maintenance interval is every 700,000 km of accumulated service; however, this interval is highly dependent on operating conditions and can fluctuate greatly. An air brake system qualification is often performed at the same time.

As with locomotives, conditional maintenance consists of the replacement of components, on the condition that they are worn out, by new or refurbished components, however for wagons this is usually limited to the changing and re-profiling of wheels. It is anticipated that wheel life will be approximately 400,000 km. Wheels will be reprofiled two to three times during their life, at intervals depending on the depth/extent of the wheel wear or defect.

Corrective Maintenance

Corrective maintenance covers all troubleshooting and repair actions required to return a wagon to operating condition after a failure or incident. Often, these defects are found during the daily inspection, but can also be detected by wayside equipment such as "hot box" (overheated roller bearing) detectors or dragging equipment (such as broken brake rigging or dragging hoses) detectors. It is intended that hot box detectors and wheel impact load detectors be distributed on the network such that all trains pass at least one detector daily.

8.5.30.5 Allowance for Maintenance in Wagon Fleet Size

An industry standard for wagon availability is usually around 95%, therefore an additional 5% of wagons must be procured to ensure that that there will be a sufficient number of spare wagons to substitute for wagons being maintained or repaired.

8.5.31 MoW Equipment Maintenance Strategy

8.5.31.1 Rail-bound MoW Equipment Maintenance

Along with locomotives, freight wagons, and passenger coaches the railway will own some Maintenance-of-Way (MoW) equipment that will require regular maintenance. For this equipment, a cyclical maintenance approach is used. It should be noted that railcar movers are usually classified as MoW equipment with regards to maintenance.

A cyclical maintenance and repair program implies that MoW equipment is assigned a defined schedule for main shop overhaul. A cyclical maintenance program is most commonly based on work hours (engine), and/or kilometres travelled (measured by hub odometer readings) and/or regulatory requirements. As a rule of thumb, if not superseded by a regulatory requirement, a cyclical maintenance and repair program should be scheduled when one of the following parameters is reached; a) 2,500 engine hours, or b) 5,000 kilometres. When identified for the cyclical maintenance and repair, it is common practice for the unit to be sent to the workshop complete with its logbook and specific comments from the field supervisors/operators regarding the machine's condition. Once at the workshop, the shop mechanics will complete a stress analysis, ultrasonic testing and wear measurements of key components, structural members, axles and wheels of the unit. Also, a detailed visual inspection will be completed with identified defects noted. Necessary repairs will be completed as per company policy and regulatory requirements. The cyclical maintenance and repair program may differ significantly from the manufacturer's recommended service intervals program for the replacement of engine oils, filters and greasing of cylinders and bearings.

It is recommended that the machine operators accompany their machines to the main shop and be involved with the repairs. This will serve two purposes – the operators will be available to discuss the machines field performance with the shop mechanics and they will gain valuable knowledge and experience on machine maintenance. It should result in decreased downtime and increased productivity for the machine when reassigned to the field.

8.5.31.2 Road Vehicle Maintenance

The road vehicle fleet will include pickup trucks, SUVs, and larger trucks equipped with hi-rail gear for the MoW department and vans used by the transportation department.

Road vehicle maintenance usually consists of performing scheduled minor maintenance (such as oil changes, brake changes, etc.) and corrective repairs once a defect has been identified by the driver.

MoW equipment that is Hi-rail based can be maintained at the MoW equipment maintenance shop in Matagami, Waskaganish or Chapais yards, the Matagami Maintenance shop (space permitting) or outsourced to 3rd party maintenance repair garages, as the equipment can be readily taken to them. The specific rail-related components (e.g. steel railway wheels) however, must be serviced/maintained at the Matagami Maintenance shop.

8.5.32 Infrastructure Maintenance

The Infrastructure Department is responsible for track, earthworks, bridges drainage structures, buildings and railway signalling and telecommunications. The maintenance teams are organized on a territorial basis and different specialties share common locations and facilities in almost.

The Infrastructure Department is responsible for all activities associated with the day-to-day maintenance, capital replacement, design, and construction of the railway's fixed assets. This includes personnel involved in any of the duties related to the above activities such as managers, engineers, supervisors, foremen, qualified workers and operators, labourers and clerical staff.

Some non-specialist activities, such as vegetation control and building maintenance can be readily contracted out at lower cost than sending staff long distances to undertake minor works and it is assumed that this is the case for disciplines not specifically covered.

8.5.33 Maintenance-of-Way (MOW) Strategy

Track and ROW maintenance will be handled by four track gangs (a group of employees responsible for doing daily maintenance on the track, bridges, and signalling systems), based one each in Matagami and Chapais and two in Waskaganish. A heavy track team equipped for heavier track operations such as tie replacement, tamping and welding will support work on both the BDHR and GCR. It will be based in Waskaganish. Telecommunications and Signalling maintenance teams will be based in Waskaganish Matagami and Chapais.

Certain maintenance activities such as rail grinding, and electronic geometry inspections, require specialised equipment and operating crews. These activities will be contracted out to specialised companies who will also provide the necessary equipment.

A fleet of road and road/rail (hi-rail) vehicles provides the mobility needed to the maintenance teams.

Table 8.5–59: MOW Road and Road/Rail Vehicles

Item	Number
Pickup truck	5
Railroad truck	2
Hi-rail truck	5
Maintenance trolley	4
Railroad excavator	2
Ballast regulator	2

Figures below show recommended types of equipment.

Figure 8.5-125: Pickup Truck (Left), Railroad Truck (Right)

Figure 8.5-126: Hi-rail truck (left), Maintenance Trolley (Right)

Figure 8.5-127: Railroad Excavator Left), Ballast Regulator (Right)

MOW Maintenance Activities

A large part of the MOW workload is centred around regular inspections of different kinds. These are structured to identify defects before they could become a safety hazard so that the predominant maintenance activities are preventative and not reactive. Examples of some of the major inspection requirements are shown in the table below.

Table 8.5–60: Major Mainline Inspection Requirements

Category	Subsystem and/or Action Description
Mainline Track Inspection	Twice weekly by qualified gang member on foot or riding track mounted vehicle moving at walking pace
Mainline Track Inspection	Three times a year by the Track Maintenance Manger and Track Gang Foreman on foot or riding a track mounted vehicle moving at walking pace
Mainline Track Inspection	Every second year by the Track Maintenance Manger and Track Gang Foreman on foot
Mainline Track Inspection	Specific "on-demand" track inspection by gang foreman on foot or a riding track mounted vehicle
Seasonal Track Inspection	Performed by qualified gang member on foot or a riding track mounted vehicle moving at walking pace: • In Spring, or when triggered by weather conditions to monitor high water, spring run off, potential flooding • In extremely cold weather (below defined temperatures) to monitor CWR rail for breaks • In extremely hot weather (above defined temperatures) to monitor CWR rail for buckles • Twice a year before deciduous tree leaf out and before snow is on the ground to verify condition of: – the track surroundings – the subgrade conditions – subgrade transitions at bridges
Mainline Turnout Inspection	Routine visual inspection every time crossed by a MOW employee
Mainline Turnout Inspection	Monthly, by a qualified track gang member on foot, with a qualified S&C gang member
Mainline Turnout Inspection	Annually, by a qualified track gang member on foot, includes measurements to determine amount of wear

The results of each of the inspections are used to plan and prioritise maintenance examples of which are:

- Replacing timber ties that are split or have excessive tie plate cutting or plugging ties where the cut spikes no longer hold in the timber.
- Reconfiguring the ballast section with a ballast regulator.
- Tamping the ballast around loose ties.
- Tightening or replacing loose or missing bolts in the switch assemblies.
- Repair welding wearing surfaces in switches to prolong the useful life of the switch.
- Clearing blocked culverts to re-establish adequate flow through the culvert.
- Snow or ice removal in switches.

There are maintenance activities such as clearing brush and unwanted vegetation in the right of way and at level crossings which can be more economically dealt with by sub-contracting to local enterprises and that should be contracted out. There are other major maintenance activities that should also be contracted out due to the expertise or equipment needed. These are found in the following table.

Table 8.5–61: Major Maintenance Activities to be Contracted OUT

Category	Subsystem and/or Action Description
Track	Heavy mechanical tamping
Rail	Ultrasonic rail testing
Rail	Rail grinding (Curves)
Turnouts	Reinforced ultrasonic rail testing

Bridge and Structures Maintenance Strategy

Maintenance activities, including semi-annual and annual inspections, associated with bridges, culverts, and buildings should be contracted out to specialised companies who will provide the appropriate experience and equipment. The contracts should be managed and co-ordinated by Infrastructure Manager.

Signalling & Telecommunications (S&T) Maintenance Strategy

Railway signalling and telecommunication systems consist of integrated hardware and software from several technologies and various vendors. These systems are highly interdependent, and a single malfunction can critically impact the overall performances of the railway and cause economic loss.

Signalling and telecommunications systems operations and maintenance teams endeavor to minimize the occurrence of equipment failures and mitigate their impacts on the railway when failures do occur. These activities include:

- Corrective maintenance: Replacement of damaged or faulty boards and components.
- Preventive maintenance: Scheduled replacement of boards and components before a failure occurs, installation of hardware and software patches for updates or upgrades.
- Predictive maintenance: Identify and correct potential problems and failures based on regular monitoring of the system performances.

The S&T operations and maintenance teams should also develop and implement an action plan allowing them to provide a respond quick, efficient, and orderly response to systemic failures when they occur.

8.5.34 Staffing

The organisation of the railway will be based on functional lines of responsibility, with infrastructure, rolling stock and transportation departments reporting to a director of operations. The general organization of the railway is shown in the following figure.

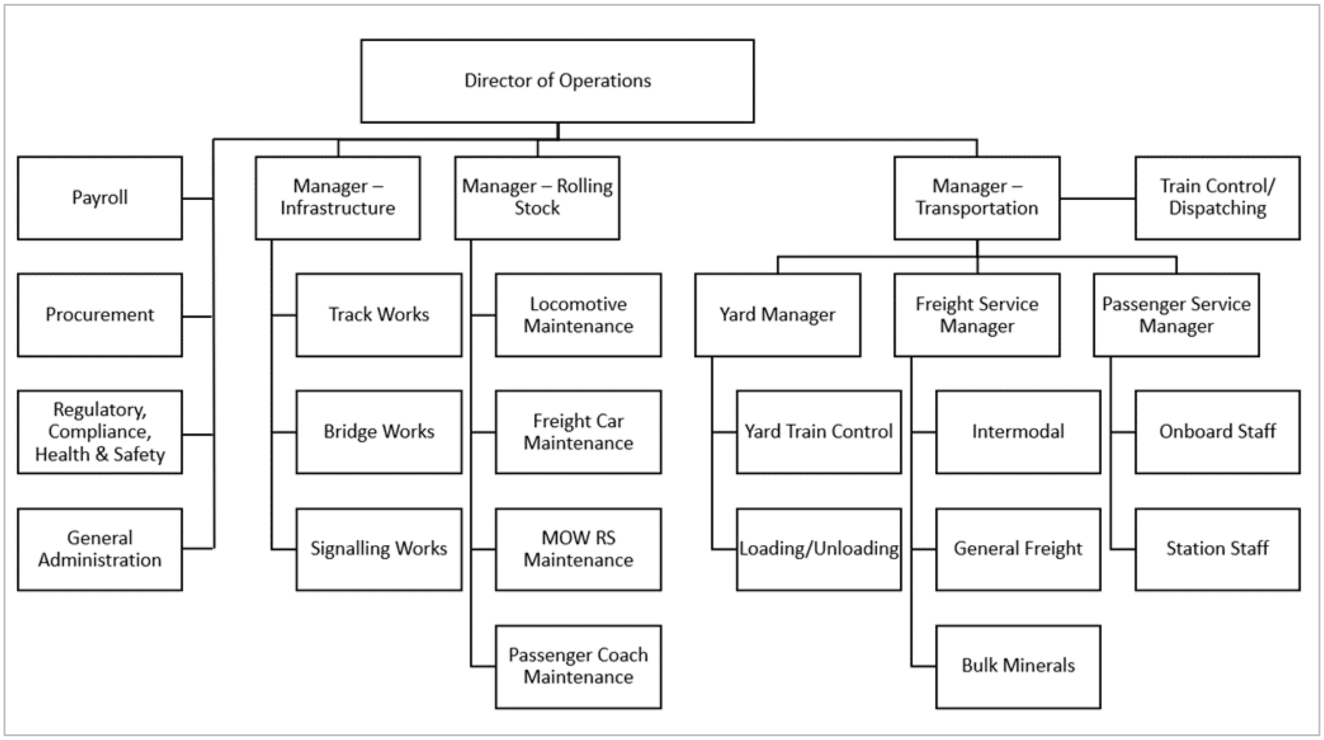


Figure 8.5-128: Railway Staff Organization Chart

8.5.34.1 Administration

The administration staff support the operation of the entire railway and provide the payroll, procurement, health & safety, human resources, environmental management, regulatory compliance and training functions. The 14 members of the Administration staff would be located in the System Headquarters at Waskaganish with the Director of Operations.

Table 8.5–62: Headquarters Administration Staff

Position	Matagami Yard	Waskaganish Community	Chapais Yard	Employees Required
Director of Operations		1		1
Secretary	1	2	1	4
Payroll Officer / Contract Administrator		2		2
Health & Safety		1		1
Storekeeper / Procurement Officer	1	1		2
Regulatory / Training		1		1
Admin Officer	1	1	1	3
			Total Employees	**14**

For the Rail Operations Staff for the Waskaganish Yard with consecutive daily shifts, would be provided with accommodation at the permanent camp at KP 257 of the Billy Diamond Highway, as would train crews starting or finishing an assignment that comprised a full shift.

8.5.34.2 Operations

Train Crews

All freight train crews will consist of a train driver and helper. The helper's position is considered an entry level position with progression to a train driver. If two qualified train drivers are on same crew, the driver with the most seniority will be the train driver with the junior being the helper.

The Transportation department is responsible for all activities associated with the movement of rail wagons. This includes personnel involved with the actual movement of a wagon such as yard and train crews, documentation involved in wagon movement (waybill, train journal, switch list) and the coordination of train movements, the function performed by train dispatchers.

Supervisory Staff

The Transportation Manager - will be located in Waskaganish. Reporting directly to him will be four Trainmasters who are located at key points in the railway network (Matagami, Waskaganish and Chapais yards) and control the movement of trains in and out of the yards and inside the yards. Centrally located are personnel involved in the documentation aspect and train coordination responsibilities.

Supervisor staff includes positions that are hourly rated and when required are relieved after their shift is over. The following table illustrates the supervisor positions by location.

Table 8.5–63: Supervisory Staff in Operations

Position	Matagami Yard	Waskaganish Yard	Chapais Yard	Employees Required
Superintendent - Transportation		1		1
Train master	1	2	1	4
Operations Coordinator		2		2
Yard Master	2	3	2	7
Intermodal Terminal Manager		2		2
			Total Employees	**16**

In total, it is estimated that BDHR and GCR will require 16 transportation supervisory employees, based on a 5-day work week.

Train Service Employees

Train Service Employees consist of crew engaged in train and yard service. Normally, a train crew will consist of two employees: in train service, a locomotive driver and an assistant driver and, in yard service, a locomotive driver and yard foreman. Since the yards are small and not complex, the Yard Master and/or the Yard Jockey allocate part of their shifts to drive locomotives or car movers in the yards. Permanent crew assignments are not set. Operating employees are be called on a "first-in, first-out" rotation basis with the two employees called for each train. In train service, the locomotive driver is in charge while the assistant driver performs the duties normally associated with a conductor. All Train and Yard Service employees should be qualified as a locomotive driver with the senior employee in the crew functioning as the locomotive driver. The locomotive driver's rate of pay should be slightly higher than the assistant driver.

Traditionally train crews are either paid by the mile or the hour or a combination. Yard crews are paid by the hour/shift.

Train service employees operate from a common pool at their home terminal and should be qualified to operate all train services assigned to that terminal. Yard service employees should be assigned regular hours while spare and relief assignments should use employees from the common pool at their home terminal or subsidiary terminal.

The following tables illustrate the train and yard service crew requirement for both BDHR and GCR. The information in the first table represents the total number of employees by each position. Only part of the hourly shifts will be allocated to the yard service depending on the need.

Table 8.5–64: Yard Crew Employees

	Matagami Yard	Waskaganish Yard	Chapais Yard	Total Equivalent Full Time Employees Required
Yard Master	2	3	2	7
Yard Jockey		2	1	3
			Total Employees	**10**

Some employee positions need a part time component to allow for the relative low train density, for example train marshalling activities in the three yards will predominantly take place only three times a week, as will timber loading at the timber siding. To allow for this factor employee numbers are reported as Total Equivalent Full Time Employees.

Table 8.5–65: Train Crew Employees

Position	Waskaganish	Chapais
Total Train Crew	4	2

Non-Operating Personnel

Non-Operating personnel (non-ops) are Transportation Department employees who do not work in Train or Yard service. Basically, there are two classifications, namely Inside and Outside Employees. The function of Inside Employees, for the most part, includes train coordination and documentation activities. Outside Employees perform duties in conjunction with Intermodal services.

Dispatchers

Train Dispatchers, located in the Control Centre at Waskaganish, are responsible for timely coordination and safe movement of trains outside of the yards. To properly perform their function, they must be familiar with the territory they control and applicable operating rules. To this extent, Train Dispatchers should periodically ride trains over their respective territories.

Carload Staff

Carload staff responsibility mainly involves the documentation required to move a rail wagon, record the movement, and ensure revenue generated is properly assessed and documented.

Carload staff personnel duties will be creating a stable carload staff. The volume of work will increase as traffic levels increase, but only a few positions will be volume related requiring additional staff.

The following activities will be the responsibility of the Carload staff personnel:

- Customer contact for rail activity such as rail car releases and placements.
- Preparing billing information for rail car movements.
- Car and Train Reporting.
- Preparing train journals and dangerous commodity documentation. Train journals will be sent to remote printers at the appropriate field locations where train crews report.
- Preparing switch lists for yard crews. Switch lists will be sent to remote printers at yard office locations where yard crews report.
- Coordinating with train dispatcher for required work enroute by train crews. Instructions to train crews will be sent to remote printers at the appropriate field locations where train crews report or via radio to trains enroute.

The following table illustrates the carload staff by position and location.

Table 8.5–66: Carload Staffing Total Equivalent Full Time Employees Required

Position	Matagami Yard	Waskaganish Yard	Chapais Yard	Total Equivalent Full Time Employees Required
Carload Manager		2		2
Carload Supervisor		1	1	2
Senior General Clerk		2		2
General Clerk	1		2	3
Intermodal Reporting Clerk		5		5
Timekeeper		5	5	10
Total Equivalent Full Time Employees				**24**

Intermodal Employees

Intermodal employee duties include off-loading containers from rail, staging for each, pickup or train loading, and gate attendants. In Waskaganish and Chapais yards, due to the large volume of truck traffic from mining sites, it is recommended that the gate operation be 24/7.

For the purpose of identifying the number of employees required, it is assumed that pickup and delivery of containers will be done by third party employees.

The following table illustrates the Intermodal staff by position and location:

Table 8.5–67: Intermodal Positions – Number of Employees

Position	Matagami Yard	Waskaganish Yard	Chapais Yard	Timber Siding	Total Equivalent Full Time Employees Required
Gateman/Agent	5	5	4		14
Yard Jockey		2	1		3
Loader Operator		5		5	10
Yardmen/Labourer	1	2	1		4
				Total Employees	**31**

Supplementary Staff

The Supplementary staff is responsible for all activities associated with bulk mineral in Waskaganish and Chapais yards. The staff personnel duties will be to unload the bulk mineral into the storage sheds and to load the stored bulk mineral into the hopper (part of the silo feed system). The following table illustrates the Supplementary Staff positions by location:

Table 8.5–68: Supplementary Staff

Position	Waskaganish Yard	Chapais Yard	Total Equivalent Full Time Employees Required
Bulk Mineral Loading	1	1	2
Bulk Mineral Handling in Storage Shed	5	5	10
		Total Employees	**12**

Summary – Transportation Department Staffing

The table below illustrates the transportation staffing requirements by location (Billy Diamond Highway and Grevet-Chapais railways).

Table 8.5–69: Total Transportation Department Staffing Requirements

Position	Matagami Yard	Waskaganish Yard	Chapais Yard	Timber Siding
Superintendent - Transportation		1		
Trainmaster	1	2	1	
Operations Coordinator		2		
Yard Master	2	3	2	
Intermodal Terminal Manager		2		
Train Dispatcher		3		
Gateman/Agent	5	5	4	
Loader Operator		5		5
Yardmen/Labourer	1	2	1	
Yard Jockey		2	1	
Carload Manager		2		
Carload Supervisor		1	1	
Senior General Clerk		2		
General Clerk	1		2	
Timekeeper		5	5	
Intermodal Reporting Clerk		5		
Bulk Mineral Loading		1	1	
Bulk Mineral Handling in Storage Hangar		5	5	
Train Crew Members		4	2	
Total Equivalent Full Time Employees Required	**10**	**52**	**25**	**5**

8.5.34.3 Rolling Stock Maintenance Staffing

This section covers the required staffing for the rolling stock maintenance of Billy Diamond and Grevet-Chapais railways and covers:

- Locomotives.
- Wagons.
- Maintenance of Way Equipment.

This department will require the staff indicated in the table below.

Table 8.5–70: Rolling Stock Maintenance Department Staffing

Position	Matagami Yard	Waskaganish Yard	Chapais Yard	Total Equivalent Full Time Employees Required
General Foreman	1			1
Foreman	3	2	2	7
Locomotive Maintenance	7			7
Maintainers (fueling/servicing and standing inspection)	3	1	1	5
Car Maintenance	18			18
Fabrication shop Helper	3			3
MoW Equipment	3			3
Shop Cleaning	1			1
Material Control	3			3
Admin	1			1
			Total Employees	**49**

Infrastructure Staffing

The Infrastructure Department, commonly referred to as the Maintenance of Way Department (MOW) will provide the required technical and maintenance support for the track, structures, signals, and telecommunications of the railway. It is responsible for planning, coordination, and execution of all activities associated with day-to-day maintenance, programmable maintenance, and capital renewal for track, structures, buildings, signals, and telecommunications.

The following positions are assigned to this department:

Infrastructure Manager

This position will have the responsibility of managing the department and implementing approved maintenance practices and procedures to ensure safety and satisfactory train performance over all tracks, bridges, and yard operations. This manager will report to the Director of Operations.

Track Maintenance Manager

The primary responsibility of the Track Maintenance Manager is to provide technical support to the track maintenance gangs and be directly responsible for field maintenance operations. They are also responsible for collecting field condition information of the track, right-of-way and yards for program development and implementation.

Track Gang Foreman

This staffing for track maintenance is divided into the two principal activities: routine and programmable maintenance. Typically, routine or day-to-day maintenance such as inspections and spot repairs, is organized on a regional or territorial basis and performed with Track Maintenance Gangs (TMGs). Conversely, programmable maintenance such as surfacing, and tie replacement is organized on a centralized basis and assigned to a single Heavy Track Maintenance Gang (HTMG). This separation of routine and programmable maintenance allows for the better utilization of personnel and specialized track maintenance equipment.

These activities will be led by a foreman who reports to the Maintenance Manager.

Maintenance Manager - Signals and Telecommunications

The Maintenance Manager of Signals and Telecommunications will be responsible for the management of work activities associated with the railway's signals and telecommunications systems. This position is located at the facilities in Matagami.

Senior Technician - Signals and Telecommunications

The senior technician will provide first level telecommunications support for all telecommunications technologies involved for railway operations. This position will be provided with a road and rail vehicle to carry out daily, weekly and monthly inspections.

Labourers

The labourers will be responsible for all activities associated with day-to-day scheduled maintenance of track and signalling system.

The table below provides a summary of the full-time personnel that will be required for the Infrastructure Department.

Table 8.5–71: Infrastructure Department Staffing

Position	Matagami Yard	Waskaganish Community	Waskaganish Yard	Chapais Yard	Employees Required
Manager Infrastructure		1			1
Maintenance Manager - Track		1			1
Maintenance Manager - SIG/TEL		1			1
Track Foreman	1		3	2	6
Foreman Heavy Track Gang			1		1
Senior Technicians - SIG/TEL	1			1	2
Senior Technicians' Mobile Team	2		2		4
Labourers - Track	4		6	6	16
Labourers Heavy Track Gang			4		4
Labourers - SIG/TEL	2			2	4
Labourers' Mobile Team			6		6
				Total Employees	**45**

8.5.34.4 Staffing Summary

The table below illustrates the staffing requirements by department and by location (BDHR and GCR), including the Passenger Services table, shown.

Table 8.5–72: Required Employees for Billy Diamond Highway and Grevet-Chapais Railways

Department	BDHR	Grevet-Chapais Railway
Headquarters	12	2
Operations	67	25
Rolling Stock Maintenance	47	2
Infrastructure	35	11
Passenger Services	10	3
Total employees	**171**	**43**

Railway staff would be based at the various locations as shown in the table below.

Table 8.5–73: Permanent Railway Staff by Function and Location

	Waskaganish Headquarters	Waskaganish-Yard	Waskaganish-Station	Timber Siding	Matagami Station	Matagami Yard	Waswanipi Station	Chapais Station	Chapais Yard
Administration	9					3			2
Main Line Operations	6								
Yard and Siding Operations		46		5		10			25
Rolling Stock Maintenance		4				42			3
Track and Signalling Maintenance	4		5		1		1	2	
Passenger Services	3	22				10			11
Total	**22**	**72**	**5**	**5**	**1**	**65**	**1**	**2**	**41**

Note that the training requirements of the above personnel are covered in Volume 5.

8.5.35 Passenger Services

8.5.35.1 Background

Passenger railways are important for long-distance mobility networks, providing commuter, regional and inter-city services across different regions of the world. There is currently no passenger train service in Nord-du-Quebec.

Via Rail operates a service between Montreal-Jonquière and Montreal-La Tuque-Senneterre. A single train departure from Montreal provides these two services. The train splits at Hervey Junction and the two sections head for their respective destinations. The return trips are scheduled to meet at Hervey and the recombined train returns to Montreal.

The Senneterre service operates over a 717 km route and takes approximately 14.5 hours. This route is mostly in a forest environment, serves 60 stations; more than 80 % of which are serviced when a passenger requests a stop to embark or disembark (so-called flag stops). The service is currently offered three times a week, departing Montreal on Mondays, Wednesdays and Fridays at 7:30 am and arriving in Senneterre at 21:02 pm. From Senneterre, the train departs on Tuesdays and Thursdays at 6:28 am to arrive at Montreal at 19:46 pm, and on Sundays departs at 9:00 am and arrives at 22:46 pm (VIA, February 2023). The area between La Tuque and Senneterre is not accessible by the public road network, only by forest resource roads.

The Jonquière service operates over a 511 km route (218 km of which is shared with the Senneterre service) and takes approximately 13.5 hours. This route serves 42 stations (11 of which are on the common route between Montreal and Hervey); more than 40 % of which are flag stops. The service is currently offered 3 times a week, departing Montreal on Mondays, Wednesdays, and Fridays at 7:30 am and arriving in Jonquière at 18:52 pm. From Jonquière, the train departs on Tuesdays and Thursdays at 8:28 am to arrive at Montreal at 19:46 pm, and on Sundays departs at 12:33 pm and arrives at 22:46 pm (VIA, February 2023).

Although the demand for long-distance passenger rail is low in Nord-du-Quebec, it is important to provide this service for the communities, the visitors and for the employees of the railways.

8.5.35.2 Passenger Traffic

Railway passenger traffic has been projected for the years 2021 to 2081 to account for the anticipated population growth in the Eeyou-Istchee and Bay-James area. Passenger train services are offered on the BDHR between the Waskaganish and Matagami stations and on GCR between Matagami and Chapais. Passenger service is expected to be extended to Senneterre and Jonquière, allowing passenger connections to other services in the East-West axis. Presents the anticipated ridership for the BDHR and the GCR. The total annual anticipated ridership is expected to grow from 6,100 in the first year of operation to 8,400 in 2080.

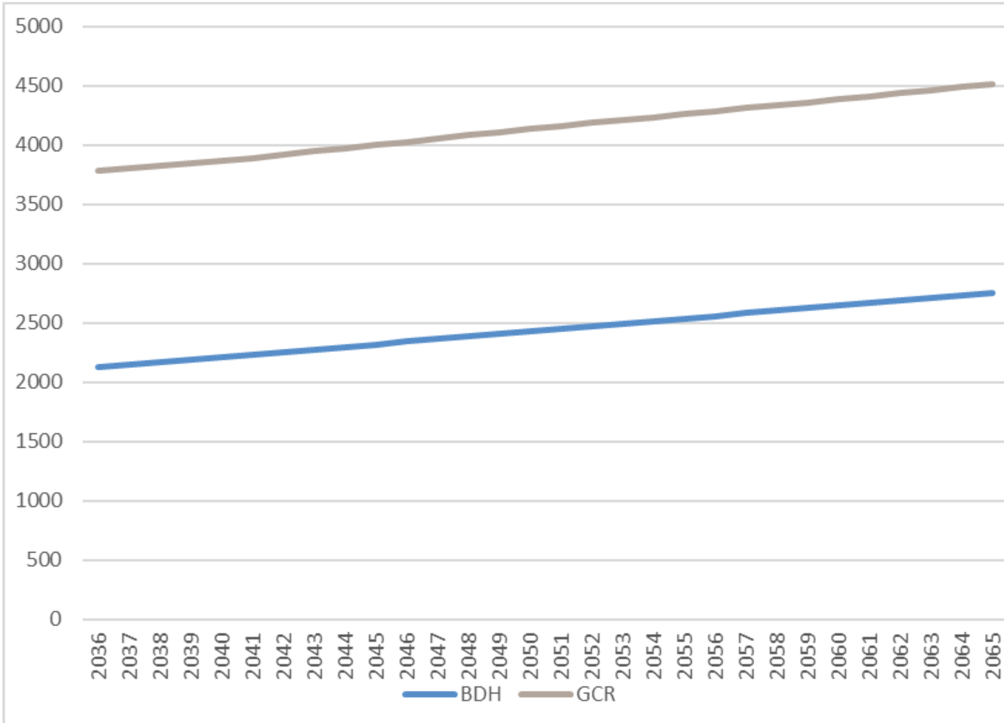


Figure 8.5-129: Projected Traffic Growth over Project Life

Passenger station locations were developed based on the projected traffic growth over the proposed project life and the proximity of the communities to the proposed railway lines. There are eight expected passenger stations, shown in the screenshot below:

1. Phase 1:
   a) Matagami
   b) Waskaganish
   c) Waswanipi
   d) Chapais
2. Phase 2
   a) Radisson
   b) Wemindji
   c) Eastmain
3. Phase 3:
   a) Whapmagoostui

More information about the passenger train operations (schedule, service, staffing etc.) can be found in the Rail Operations chapter.

Figure 8.5-130: Station Locations

8.5.35.3 Passenger Train Operations

Train Schedules

Two passenger trains a week serve Waskaganish and Matagami and continue on the CN Network to connect to VIA Rail Services, one at Senneterre and the other at Jonquière.

Train schedules have been developed by Train Performance Calculator software to establish the minimum running times (MRT) for passenger trains. Station times for existing stations are also included in the train schedule.

The following table provides an indicative schedule for passenger trains operating between Waskaganish station and either Jonquière or Senneterre.

Table 8.5–74: Passenger Schedules

Waskaganish/Jonquiere						Waskaganish/Senneterre					
Down Train Southbound Day: Mon (1)		KP	Station	Up Train Northbound Day: Tues (2)		Down Train Southbound Day: Sat(6)		KP	Station	Up Train Northbound Day: Sun(7)	
		0	Waskaganish	12:53	Arr.			0	Waskaganish	17:38	Arr.
Dep.	12:00			9:58	Dep.	Dep.	8:00			13:30	Dep.
Arr.	14:55	233	Matagami	9:48	Arr.	Arr.	12:08	233	Matagami	13:20	Arr.
Dep.	15:05			7:30	Dep.	Dep.	12:18			11:03	Dep.
Arr.	17:22	332	Franquet	7:20	Arr.	Arr.	14:35	332	Franquet	10:53	Arr.
Dep.	17:32		(Chapais Jct.)	6:48	Dep.	Dep.	14:45		(Chapais Jct.)	10:10	Dep.
Arr.	18:05	342	Grevet	6:38	Arr.	Arr.	15:27	358	Quévillon	10:00	Arr.
Dep.	18:15			6:02	Dep.	Dep.	15:37			7:54	Dep.
Arr.	18:51	385	Waswanipi	5:52	Arr.	Arr.	17:43	448	Barraute	7:44	Arr.
Dep.	19:01			4:27	Dep.	Dep.	17:53				
Arr.	20:26	507	Chapais	3:57	Arr.	Arr.	18:38	476	Senneterre	7:00	Dep.
Dep.	20:56			3:23	Dep.						
Arr.	21:29	529	Faribault Jct.	3:13	Arr.						
Dep.	21:39		(Chibougamau)	22:27	Dep.						
Arr.	2:26	748	Saint-Felicien	22:17	Arr.						
Dep.	2:36			21:09	Dep.						
Arr.	3:44	795	Chambord	20:59	Arr.						
Dep.	3:54										
Arr.	4:53	863	Jonquière	20:00	Dep.						

Passenger Train Characteristics

The schedule is based on operating passenger trains with characteristics similar to those in the table below.

Table 8.5–75: Passenger Train Characteristics

Criteria	Standard Gauge
Maximum Speed (km/h)	100
Locomotive Type	**SD70 or equivalent**
Locomotives/train	1
Coaches/train	3
Passenger trains/week (both directions)	4
Train Priority	Nil

The projected consist for the passenger train is set out in the table below. The right-hand columns indicate passenger capacity per coach and for the train overall.

Table 8.5–76: Passenger Train Consist

Equipment	Quantity	Seating per Coach	Seating per Train
Locomotive	1	-	-
Coaches	2	74	148
Genset Car	1	N/A	N/A
Total	3	N/A	148

Train and Trip Inspections

Trains will receive the necessary air brake test and inspections at Waskaganish and Chapais yards. At mainline crew change locations, the inbound crew will visually inspect both sides of the train as the train departs.

The locomotive for passengers’ train from Waskaganish to Jonquière will be inspected by the outgoing train crew at Waskaganish yard, locomotives will be changed out at Chapais yard and locomotive trip inspections will be performed at Chapais.

The locomotive for passengers’ train from Waskaganish to Senneterre will be inspected by the outgoing train crew at Waskaganish yard, locomotives will be changed out at Matagami yard and locomotive trip inspections will be performed at Matagami.

Locomotive Fueling

The fuel consumption that was calculated for the passenger services on BDHR using the Train Performance Calculator is summarized below:

- Waskaganish Station – Matagami Station (Southbound) service is estimated at 469 litres
- Matagami Station – Waskaganish Station (Northbound) service is estimated at 463 litres

One locomotive with a minimum fuel tank size of 16 000 litre can make a round trip without fueling enroute on BDHR. The locomotive can make 17 round trips on BDHR before refueling at Matagami Yard with the assumption that CN or VIA locomotives are used for the rest of the trip towards Senneterre or Jonquière. Therefore, the mainline fueling capability for the freight locomotives installed at Waskaganish Yard can be used for the passenger services. Alternatively, if the BDHR locomotive will be used for the rest of the trip towards Senneterre or Jonquière, it is safe to assume that the fueling station in Matagami Yard is sufficient.

Passenger Stations Operations

Waskaganish Passenger Station

The Waskaganish passenger station is located at the northern end of the BDHR near the T junction between Waskaganish road and Billy Diamond Highway. It provides an easy access for passengers from Waskaganish road. Two departures are planned every week, one to Jonquière and another to Senneterre. The passenger train accesses station on the BDHR main line that runs parallel to Billy Diamond Highway. The Waskaganish passenger station is in the vicinity of the Waskaganish yard.

One platform with the length of one locomotive and 3 coaches provides ample length to service the anticipated passenger train service. Once passengers have disembarked, the inbound train will remain on the station siding track to be inspected by the Passenger Operating Crew team. Train Servicing will be performed from the station platform and completed at least one hour prior to departure. Servicing will include coach cleaning. It is recommended that this service be contracted out to a third party.

The inbound locomotive will be turned on the Wye in the Waskaganish Yard and parked over night in the locomotive storage track. Prior to departure it will be returned to the passenger station track, coupled to the passenger cars and a brake test and outbound inspection will be performed on the passenger station siding track.

Matagami Passenger Station

The Matagami Station is located at the southern end of the BDHR before reaching Matagami yard. Four passenger service trips are planned to pass through the Matagami Station every week:

- Waskaganish to Jonquière
- Jonquière to Waskaganish
- Waskaganish to Senneterre
- Senneterre to Waskaganish

The passenger train continues on the CN Network and connects to VIA Rail Services, one at Senneterre and the other at Jonquière assuming that CN gives BDHR running rights for passenger services.

Waswanipi Passenger Station

The Waswanipi Station between Grevet and Chapais is the closest point to the railway, with a good road connection (Highway 113) to the community of Waswanipi. Two trips are planned every week through Waswanipi Station:

- Waskaganish to Jonquière
- Jonquière to Waskaganish

Chapais Passenger Station

The Chapais Passenger Station is located on Grevet-Chapais railway a little to the west of Chapais yard and south of Chapais itself. Two trips are planned every week through Chapais Station:

- Waskaganish to Jonquière
- Jonquière to Waskaganish

The passenger train access to all main line stations is from a siding off the main line. One platform with the length of one locomotive and three coaches provide ample length and number in providing the anticipated passenger train service.

8.5.35.4 Passenger Service Rolling Stock

Passenger Trains

Passengers will be transported in short, two-coach, passenger trains. Passenger coaches require electricity to power lighting, heating and air conditioning and are normally pulled by special passenger locomotives that are equipped to supply this electricity (called "head end power", or "HEP"). To reduce the number of different types of locomotives, provide a homogeneous fleet for a small railway passenger trains will be pulled by freight locomotives (see next section). The passenger train consist will include special "genset" car that provides the power need by the

Additionally, the railway may choose to add a baggage car to their trains to transport baggage and large objects such as Snow mobiles, ATVs, and canoes, however baggage cars have not been included in the present study.

Passenger Coaches

A typical single level passenger coach for long distance is shown Below. The coach should be economy class only with a maximum seating capacity of 74 people. All seats should be equipped with a USB plug and/or standard outlet. Coaches should be equipped with at least two bathrooms and a small gally area where a food service cart can be stored and equipped with two coffee pots to make coffee and tea, a microwave (if there is a hot food option), and a food storage area. If food is to be made available, a decision will need to be made whether there it is a cash only service, or if point-of-sale debit machines will be available to purchase food via credit or debit card. If a debit machine is available, the coaches will need to be equipped with internet connectivity and Wi-Fi which may be difficult in the remote location these trains will operate. If the coaches are equipped with Wi-Fi, the service can be sold as a service to individual passengers or included in the ticket price.

The current assumption is that all platforms on the BDHR and GCR will be low that these trains will serve will be low, so an elevator or high section platform will have to be used in conjunction with either a high loading door as shown on the right, or a regular door with a trap door that closes off the stairs, to accommodate passengers with disabilities (wheelchair). In the picture below the coach is equipped with doors for low platforms on the left and high platforms on the right

Figure 8.5-131: Typical Passenger Coach

The following are typical characteristics of a passenger coach.

Table 8.5–77: Typical Passenger Coach Characteristics

Characteristics	Particular
Number of axles	4
Maximum axle load (tonnes)	15
Tare weight (tonnes)	51
Maximum width and height (Loading gauge)	AAR Plate C
Length over couplers (metres)	26
Type of bogies	Passenger
No of seats	74
Specialties	• bathrooms • Galley area • Equipped with Wi-fi (optionally) • Equipped for passengers with disabilities (optionally)

Genset

A genset car is vehicle installed with a diesel generator-set (“genset”) that produces electricity for HEP power for coaches. The genset car is usually built from a surplus box car, or locomotive and includes one or two gensets (one acting as a back up), fuel tanks, cooling equipment, and electronic switch gear. Genset cars are not commercially available and would have to be designed and assembled for the railway by a third party.

Figure 8.5-132: Typical Genset Car

Characteristics of a genset car are not shown as they can vary greatly, however it is estimated that the genset car would have to produce about 300kW of power.

Locomotive Requirements

As mentioned earlier, passenger trains will be pulled by freight locomotives. The locomotive requirements for passenger trains are mentioned at page 132.

Maintenance Strategy

The maintenance philosophy adopted for passenger car maintenance is one that will result in a system that is safe, dependable, cost-effective, and attractive. As such, passenger car maintenance activities should be structured and scheduled so as to minimize operational disruptions and achieve the highest system availability and passenger acceptance.

Maintenance activities consist of: Servicing & Cleaning, Inspection, Preventive Maintenance, Corrective Maintenance and Overhauls.

- Servicing covers periodic replacement of consumables/expendables (e.g., filters, lubricating oils, light bulbs, toilet amenities) and adjustment of parts to their nominal position, required tolerance, setting, output, etc.;
- Cleaning covers interior and exterior cleaning of accumulated trash, dirt and grime as well as graffiti and other aesthetic nuisances.
- Inspection involves periodic inspection of parts and subsystems subject to deterioration and failure.
- Preventative Maintenance typically comprises inspections, servicing, adjustments tests, and scheduled replacement of components.
- Corrective Maintenance involves the repair or replacement of parts that have been damaged or failed while in service or storage.
- Overhaul comprises a variety of activities to restoring the equipment to like-new condition. To the maximum extent possible, LRU's (Line Replaceable Units) are exchanged with the removed unit being overhauled 'off-line'. This minimizes the time in which a vehicle or other subsystem is unavailable for service. However, large units such as car-bodies, which are unsuited to the LRU approach, will require vehicle removal out of service.

To ensure the efficient coordination and scheduling of the above tasks, passenger car cleaning, inspection, maintenance, and overhaul tasks are assigned to one of five inspection groups. The table below identifies these groups.

Table 8.5–78: Coach Maintenance and Overhaul Inspection Groups

Designator	Frequency	Typical Tasks
A	Trip	Emergency brake test, gathering of loose trash & removal of refuse, securement check of windows, doors, compartments, etc.
B	Daily	Replenishment of toilet & water supplies, wet mopping of floors, vacuuming of carpets, etc.
C	Monthly	Replenishment of lubricating fluids, filters, heavy cleaning of interiors & exteriors
D	Annual or Bi-annual	Brake seals, wheel profiling, shimming of couplers, bogie wear components, Heavy cleaning of air ducts, seats, etc.
E	Vehicle Half-life	Renewal of HVAC units, seats, carpets, windows, rebuilding of bogies, couplers, etc.

Passenger Coach Shop

Matagami Maintenance Shop for freight can be used to provide an adequate maintenance service for the proposed passenger fleet. This will allow sharing of the machinery and maintenance staff to service the freight wagons and passenger fleet.

8.5.35.5 MOW

Since the passenger train service is comprised of two weekly trains departing from Waskaganish, the incremental deterioration of the track structure that this cause is minimal. Track maintenance effort is typically a function of the number of gross tonnes of traffic operating over the line and the light axle loads and short train lengths compared to the freight trains translate into few gross tonnes for the number of trains.

In view of the above, it is considered that the amount of additional work for the MOW Department. resulting from the operation of these passenger trains will be insignificant and inseparable from the general maintenance required to support the freight operations.

8.5.35.6 Passenger Services Staffing

Management Staff

The head of Passenger Services reports to the transportation manager who in turn reports to the director of operations. The head of Passenger Services will have the following direct reports:

- Superintendent - Passenger Operations
- Train master - Passenger Operations
- Manager - Station Operations
- Manager - On-Board Services

The Superintendent - Passenger Operations position will have a dual reporting relationship with the head of Passenger Services and the Manager - Transportation. Reporting directly to the Superintendent of Passenger Operations will be one Passenger Train master who will be responsible for implementing adherence to the rule by passenger train crews. The Passenger Train master will be located at Waskaganish.

The Manager - Station Operations located in Waskaganish will be responsible for the station operations throughout Billy Diamond Highway and Grevet-Chapais railways.

The Manager of On-board Services will have On Board Service Staff reporting to him. The Manager of On-Board Services will also be responsible for contracting out train supplies and services.

The following table illustrates the supervisor positions for the passenger operations by passenger station location. These positions are a 5-day week in Waskaganish community and would not be replaced when the staff is on holiday.

Table 8.5–79: Supervisory Staff for Passenger Services Operations

Position	Matagami Station	Waskaganish Community	Waskaganish Station	Waswanipi Station	Chapais Station	Total Equivalent Full Time Employees Required
Superintendent - Passenger Operations		1				1
Trainmaster - Passenger Operations		1				1
Manager - Station Operations		1				1
Manager On-Board Services		1				1
					Total Equivalent Full Time Employees	**4**

Passenger Train Personnel

Passenger trains will have two classes of personnel on board. The Operating Crew responsible for the train operation and the On-Board Service personnel responsible for passenger services and revenue collection.

The Operating Crew on passenger trains will consist of a train driver and assistant. The train driver and assistant will only be responsible for adherence to operating rules and a safe train operation.

The On-board service personnel will be responsible for passenger care and safety. The On-board service personnel will be based in, Waskaganish and Chapais stations.

The following table illustrates the On-Board Service Personnel requirements by passenger station location.

Table 8.5–80: On-Board Service Staff

Position	Matagami Station	Waskaganish Station	Waswanipi Station	Chapais Station	Total Equivalent Full Time Employees Required
Passenger on-Board Staff		2		1	3
				Total Equivalent Full Time Employees	**3**

The total number of On-Board Service employees required is 3.

Station Staff

Due to the limited number of scheduled passenger trains, passenger stations need not be open 24 hours a day. The hours that the stations are open should correspond to the scheduled passenger train station times.

The recommended number of employees by station is as follows:

Table 8.5–81: Passenger Station Staff

Position	Matagami Station	Waskaganish Station	Waswanipi Station	Chapais Station	Total Equivalent Full Time Employees Required
Passenger Station Staff	1	1	1	1	4
				Total Equivalent Full Time Employees	**4**

Summary – Passenger Services Staffing

The following table summarises the staffing requirements for the Passenger Department.

Table 8.5–82: Passenger Service Staffing Summary

Position	Matagami Station	Waskaganish Community	Waskaganish Station	Waswanipi Station	Chapais Station	Total Equivalent Full Time Employees Required
Superintendent - Passenger Operations		1				1
Trainmaster - Passenger Operations		1				1
Manager - Station Operations		1				1
Manager On-Board Services		1				1
Passenger On-Board Staff			2		1	3
Passenger Station Staff	1		1	1	1	4
Train Crew Members			2			2
					Total Equivalent Full Time Employees	**13**

8.5.36 Construction Schedule

8.5.36.1 Access Points

Due to the geographical location of the railway, it will be necessary to construct access roads as proposed in the below table to allow for the mobilization of construction crews from locations that are not accessible under current conditions. Access roads will allow independent access during the construction of each section. Access roads will have to be maintained for several seasons during construction given the multi year construction schedule. After construction, these roads will be retained to allow access to the track for maintenance purposes.

Broadly speaking, the general strategy for access road location and construction is as follows:

1. Locate access points every 10-15 km along each future railway line (Billy Diamond Highway Railway, and Grevet-Chapais).
2. To reach these access points, preference has been given to existing forest roads to avoid costly new road construction. Where existing forest roads are used, two types of improvements will be made:
3. Minor improvement of an existing forest road - light road surfacing, some clearing.

4. Major improvement of existing forest road - Resurfacing of the road, extensive clearing, widening of the road by 3 to 5 metres.

Table 8.5–83: Temporary Access Road Categories

Category of Temporary Access Road	Description	BDHR Total Length	GCR Total Length
Construction of New Road	Construction of new road (greenfield)	0.3 km	0 km
Minor Upgrade of Existing Forestry Road	Light road surfacing, some brush cutting	3.0 km	57.7 km
Major Upgrade of Existing Forestry Road	Major brush cutting, Road Surfacing, road widening by 3-5m	0.2 km	58.9 km

Table 8.5–84: Temporary Access Road Number and Locations

	Billy Diamond Highway Railway	Grevet Chapais Railway
Number of Access Points	28	15
Access Point KPs	2.33 8.15 17.63 29.20 40.20 46.05 59.14 72.25 76.91 85.27 90.95 99.88 110.34 120.43 128.66 141.43 151.37 160.24 171.02 180.01 187.03 198.36 207.85 218.70 229.12 235.76 243.89 252.50	123.85 127.97 137.06 146.70 173.41 187.80 209.58 214.75 224.59 235.90 245.82 251.67 263.04 270.06 273.93

8.5.36.2 Labour Needs, Fluctuations, and Mobilization/Demobilization

The equipment required during the construction phase will be transported by road and rail to Matagami. Efforts will be made to procure as much labour from the surrounding Cree communities, and throughout Quebec. There will be many teams needed in the various stages of the proposed project, most notably for earthworks and bridge construction activities, due to the large volume of material needed to cut/fill, and the restricted environmental work windows at water crossings.

Fluctuations in labour requirements will be seasonal, as there will be minimal construction taking place throughout the winter but will quickly ramp up between April 1st and October 1st every year. Nonetheless, a portion of the labor will need to be retained, as certain construction activities, including bridge steel works both in the shop and onsite, can extend beyond October 1st. It is also anticipated that most of the contractor's equipment should remain on site throughout the winter to reduce mobilization/demobilization costs and time needed for these activities.

Although the number of personnel for each construction activity has not yet been confirmed, the list below is indicative of the various positions needed for construction of the proposed railway.

1. Project management, administration, and design team
2. Contractor:

   Clearing and grubbing

   a) surveyors
   b) bulldozer operators
   c) front end loader operators
   d) dump truck driver
   e) scraper operators
   f) Transport drivers

   Earthworks

   a) excavator operators
   b) front end loader operators
   c) bulldozer operators
   d) dump truck drivers
   e) grader operator
   f) roller operator
   g) Transport drivers
   h) track installation
   i) grader operators
   j) track laying machine operators
   k) Transport drivers
   l) Dump truck operators
   m) Front end loader operators
   n) culvert installation
   o) crane operators
   p) roller operators
   q) bridge construction

8.5.36.3 Potential Supply Chains and Strategy to Maximize Local Procurement

Maximizing local procurement of goods and services for construction should be a key element when evaluating bids. By utilizing existing capacities of local businesses, it will create an immediate positive impact on the communities and employees that work at these businesses, and also a longer lasting impact by giving these businesses the tools they need to grow. Typically, when choosing a supplier for a construction project, the lowest bidder will be chosen. However, it may be necessary in this situation to revise the procurement process, some changes may include:

- Adjusting the weighting in tender evaluation that provides points for local businesses.
- Modifying payment procedures to satisfy local business preferences.
- Restricting certain goods so that only local businesses may provide them.
- Cost allowance up to a certain percentage increase of a particular item should be provided by a local business.
- Creating smaller work packages so that they can be bid on by smaller local businesses with a smaller workforce.

8.5.36.4 Energy needs for Construction Phase

The continuous operation of construction crews depends on a continuous supply of fuel. Fuel will be supplied based on demand, ideally by a supplier in the region. The fuel will be stored in storage tanks located in the three areas around the proposed project, or in a location that will be deemed more appropriate and that will meet all environmental requirements. From this site, fuel trucks will need to be able to recharge and distribute fuel along construction sites.

On construction sites, most of the equipment will be powered by diesel fuel. Usually, fuel facilities are equipped to handle large quantities. Demands for regular gasoline are generally negligible, so it is common practice to leave the responsibility for storing gasoline to each contractor based on their needs.

8.5.36.5 Material Needs, Timelines, and Permitting (including remediation of sites at completion of work)

The equipment and materials required during the construction phase of the project will be transported by road and rail to Matagami. Although the majority of materials will be sourced from the province of Quebec, to minimize mobilization costs and delays, some long lead items such as rail will need to be sourced from the rest of Canada or the United States. Heavy equipment, such as excavators and bulldozers, as well as other small non-mobile equipment, will be transported to the construction site using flatbed trailers and a flatbed trucks. Mobile equipment, compliant with the Highway Safety Code, will be driven to the construction site. The mobilization period will be in accordance with the construction schedule.

8.5.36.6 Civil Engineering and Project Management Needs

Given the scope of the proposed project, there will be many engineering disciplines required before, during, and after construction. Prior to construction, during the design phase, there will be a need for civil engineers specializing in a wide variety of disciplines, most notably geotechnical, hydrological, structural, and environmental.

It has been anticipated there will be a need for an Owner's Engineer (OE), this role is of critical importance throughout the lifecycle of the proposed project as they will act as the representative of the owner for all construction related topics. In most cases, there is an OE representative onsite who follows the progress of a construction activity, monitoring the progress and providing daily/weekly updates to the owner. Based on these onsite OE engineers, the OE is then able to ensure that the contractor is remaining on budget and schedule and can raise any concerns they may have. Additionally, should there be any change orders requested by the contractor, the OE will evaluate the request, and either accept or decline it.

In addition to engineering needs, there will also be certain project management needs over the lifecycle of the proposed project. Regardless of discipline, each aspect of the proposed project will need to ensure the scope, and budget are respected. It will also be important that resources are managed correctly, especially during construction as there will be large fluctuations of labour needed depending on the season. Project managers for their various disciplines will also need to ensure any risks identified before or during construction are properly mitigated and managed. Finally, there will be a need for additional support across a wide variety of professions including accounting, finance, legal, regulatory, etc. Therefore, it will be critical that collaboration across these disciplines is maintained to minimize any delays that may occur.

8.5.36.7 Timelines, Schedules, and Key Benchmarks

When creating the construction schedule, 4 types of work schedule have been created as described below. During construction, it has been anticipated that work will be done seven days per week, and rotating crews will work two weeks on, two weeks off. Although many activities fall under multiple types of schedules, they will only be subjected to the most restrictive. In addition, all below schedules will respect the two Cree cultural activities where no work will take place;

Goose Break, 2 Weeks – End of April, beginning of May

Moose Break, 1 Week – Mid October

The 4 types of schedules are:

1. Activities limited by fish spawning season (Sept. 16-July 14):
    a) Bridge substructure works (earthworks, foundation (piles), abutments and piers concreting)
    b) Culverts
    c) 7-day workweek
2. Activities limited by nesting season for migratory birds (April 23 to August 15):
    a) Site clearing and grubbing (including wood cutting)
    b) Topsoil stripping
    c) 7-day workweek
3. Activities limited by winter (Oct 1 to April 1):
    a) Earthworks (excluding preloading)
    b) Culverts
    c) Trackworks
    d) 7-day workweek
4. Regular construction activities
    a) Bridge superstructure
    b) 7-day workweeks

The construction schedule also aligns itself with the economic model for all pre-construction activities, as presented in the below table:

Table 8.5–85: Schedule of Construction Activities

Activity	Length of Activity (months)
Construction of New Road	28
Activity	9
Feasibility study	32
Project review period / EIA procurement / Geotech / LIDAR	9
EIA Study / Agreements / Land acquisition	12
Project review period / DD procurement / PMO	12
Detailed design (DD)	5
Construction procurement "RFQ+RFP"	12
Communications	5

Constraints (Meteorological, Holidays, Cree Cultural Periods, Environmental)

Fish Spawning Season:

- Restricted period: 16 September to 14 July
- Work period: 15 July to 15 September

The fish spawning season in this region occurs between September 16 and July 14. Therefore, the allowable work period is between July 15 and 15 September. Bridge earthworks and culvert installation are affected by this period. This period is the most restrictive, as only two months of the year allow for direct water access, outside of this window no work in the water shall be permitted.

Migratory birds:

- Restrictive period: late April to mid-August
- Work period: mid-August to late April

This period restricts any tree cutting or tree harvesting, this mainly affects the early stages of the proposed project's construction period, where clearing and grubbing takes place for employee camps, access roads, and the future railway ROW. Although there is no restrictive period for work in woodland caribou habitat, the restrictive period for migratory birds includes the caribou calving period including the first two to four weeks of calf life (estimated to be between May 20 and June 30)

Winter Period:

- Restricted Period: 1 October to 1 April
- Work Period: 2 April to 30 September

The northern latitude of the region results in harsh climatic conditions during the winter season. Due to low temperatures and intense snowfall during the winter months, some construction activities exposed to the elements will not be able to continue throughout the winter. These weather conditions may impact the quality and efficiency of certain types of work, while other types of work will not be affected. For example, at these low temperatures, backfilling operations are almost impossible due to moisture inside the frozen ground, which prevents proper compaction.

Thus, the schedule includes a winter offseason for many construction activities between October 1 and April 1, until working conditions become more acceptable. On the other hand, work involving prefabricated materials such as rock excavation, backfilling and framing work will continue to advance, since it is not affected by the cold.

8.5.36.8 Construction Impact Mitigation Strategy

The construction plan for this proposed project was developed considering its environmental impacts. As such, it is important that all materials used and obtained throughout the construction process are disposed of or stored in a manner that minimizes or eliminates negative environmental impacts. This applies to all aspects and subsystems of the new railway.

Once all material needs have been met, excess excavated materials will be disposed of in an environmentally friendly manner.

As required by the Ministère des Forêts, de la Faune et des Parcs (MFFP), vegetation on construction sites will be restored, which will help prevent soil erosion. Thus, materials produced or obtained throughout construction periods will be disposed of and stored in a manner that minimizes or eliminates any possible negative effects on the environment.

In the construction plan and in the design of bridges and culverts, the recommendation to use prefabricated foundations and protected sheet piles will avoid disruption to water quality and the environment. In addition, the proposed sequence of earthworks particularly favours the reuse of excavated material in infill areas. In addition, the top layer of overburden that will be removed at the beginning and will be stored, treated, and reused as organic soil in any areas of disturbance.

For further details of construction impact mitigation strategies for specific aspects, such as flora, wildlife, wetlands, etc. see Appendix – 6.14 Environmental Protection Measures.

8.5.36.9 Consultation Framework and Monitoring

Consultations with the Cree community is of vital importance throughout the design and construction process. Similar to the regular occurring community consultations that have taken place throughout the feasibility study, consultations should continue during the proceeding stages of the proposed project. During the design phase, it may be required to have recurring meetings/calls with various stakeholders including the Cree communities, affected cities and municipalities, and the potential users of the railway.

Further, a plan should be created to monitor construction and provide Tallymen with a direct line of contact to the railway builder, to ensure their comments are addressed. This will be critical, as the owner, and the railway builder will be relying upon the Tallymen to ensure all environmental and social requirements are met.

8.5.36.10 Sale of Surplus Construction Assets to Local Stakeholders

There will many work fronts over a large area, needing a lot of equipment and machinery, along with the construction of certain infrastructure. Given the proposed project’s remote location, it is anticipated a significant percentage of this machinery, equipment, excess material and supporting infrastructure will be left onsite; if they can be used within the communities the railways will be built through, this will minimize transportation costs if returned to their original location. A few examples of these include

- Timber clearing equipment and the lumber that was cut down
- Worker camps at various locations
- Access roads
- Cast in place, and precast concrete plants
- Steel fabrication and assembly plants

8.5.36.11 Construction Schedule – Billy Diamond Highway Railway

This section provides the key dates of major construction activities of the Billy Diamond Highway Railway. For a more comprehensive description, see Appendix 6.13 - Detailed Construction Schedule

Table 8.5–86: Key construction activities and dates – Billy Diamond Highway Railway

Activity	Start Date	End Date
Submittal of Final Feasibility Report		February 2023
Review of Feasibility Study	February 2023	October 2023
Notice to Proceed (NTP)		October 2023
Owner's Procurement Activities	October 2023	March 2024
Procurement of Railway Builder	October 2023	November 2025
Detailed Design	August 2025	July 2027
Construction	July 2027	August 2034
Submittal of Final Feasibility Report		February 2023
Review of Feasibility Study	February 2023	October 2023

8.5.36.12 Construction Schedule – Grevet Chapais

This section provides the key dates of major construction activities of the Billy Diamond Highway Railway. For a more comprehensive description, see Appendix 6.13 - Detailed Construction Schedule.

Table 8.5–87: Key construction activities and dates – Grevet-Chapais Railway

Activity	Start Date	End Date
Submittal of Final Feasibility Report		February 2023
Review of Feasibility Study	February 2023	October 2023
Notice to Proceed (NTP)		October 2023
Submittal of Final Feasibility Report	August 2034	March 2035
Review of Feasibility Study		March 2035
Owner's Procurement Activities	October 2023	March 2024
Procurement of Railway Builder	October 2023	November 2025
Detailed Design	August 2025	July 2027
Construction	July 2027	August 2034

8.6 Cost Estimation

8.6.1 Capital Costs (CAPEX)

The purpose of this cost estimate is to provide information on the initial investment required for the construction of the Billy Diamond Highway Railway Phase 1 and Grevet-Chapais Railway. Following the Association for the advancement of Cost Engineering (AACE) International Recommended Practice No. 47R-11, and based on the engineering advancement of this study, this is a Class 3 cost estimate with an accuracy of +30% / -20% for the capital investment requirements (CAPEX).

8.6.1.1 Construction Cost Sectors

This section provides a description and the scope of each cost sector as part of the capital cost estimates:

- **Civil & Earthworks**: This category includes the cost of preparing the land for construction, such as clearing and grading the site, excavating, and filling, and installing drainage systems.
- **Structures**: This category includes the cost of building bridges, tunnels, retaining walls, and any other structures necessary for the railway to operate.
- **Drainage**: This category includes the cost of installing drainage systems, such as culverts and ditches, to manage water runoff and prevent erosion.
- **Trackworks**: This category includes the cost of materials and installation for tracks, ballast, and related components such as sleepers, fastenings and switches.
- **Level Crossings**: This category includes the cost of constructing level crossings at road, pedestrian or other level crossing points.
- **Signalling & Telecommunications**: This category includes the cost of installing signaling and communication systems, as required for the safe and efficient operation of trains on the railway.
- **Buildings & Passenger Stations**: This category includes the cost of building passenger stations, administrative facilities and other buildings necessary for the railway to operate.

- **Maintenance shops & Material Storage Areas**: This category includes the cost of building maintenance shops, warehouses, and storage areas for materials and equipment.
- **Environmental Protection**: This category includes the cost of protecting the environment, such as preserving wildlife habitats, reducing emissions, or addressing potential hazards.
- **Land costs**: This category includes the cost of acquiring land necessary for the construction of the railway.
- **EPCM Services:** EPCM stands for Engineering, Procurement, and Construction Management. This category includes the cost of hiring an EPCM firm to provide engineering, procurement, and project management services for the construction of the railway. These services can include project planning, design, procurement, construction management commissioning, and start-up services.
- **Indirect Construction Costs:** This category includes costs that are not directly related to the construction of the railway, such as project management, permits and approvals, insurance, and legal fees. These costs are necessary for the successful completion of the construction project.
- **Owner's Cost:** This category includes costs that are incurred by the railway owner, such as the cost of financing the project, contingency costs, and other costs associated with the ownership and operation of the railway. These costs are not directly related to the construction of the railway but are necessary for the railway to be operated and maintained once it is built.

8.6.1.2 Railway Construction Cost

The cost estimate includes the cost of railroad construction for a standard 56 ½" railroad track, designed based on AREMA recommendations, including the various subsystems that will be described in the following sections. The unit quantities and costs developed by the consultant represent the degree of accuracy required for the feasibility study. Table 8.6–1 and Table 8.6–2 below summarize the overall capital cost by sector. The base currency of the estimate is Canadian dollars, and all costs are in millions of 2022 dollars[10].

[10] Q4, 2022

Table 8.6–1: Capital Cost for the Construction of the BDHR Phase 1 B by Sector (in $M CAD)

Sector	Total Cost	Contingency	Sub-Total	Client Cost	Studies & permitting	Construction cost
Civil & Earthworks	$618	$103	$515	$17	$69	$429
Structures	$278	$46	$231	$8	$31	$193
Drainage	$91	$15	$76	$3	$10	$63
Trackworks	$1,085	$181	$905	$30	$121	$754
Level Crossings	$3	$0	$2	$0	$0	$2
Signalling & Telecommunications	$15	$2	$12	$0	$2	$10
Buildings & Passenger Stations	$39	$7	$33	$1	$4	$27
Maintenance Shops & Storage Areas	$62	$10	$52	$2	$7	$43
Environmental Protection	$6	$1	$5	$0	$1	$4
Rolling Stock	$54	$9	$45	$2		$43
Sub-total	**$2,251**	**$375**	**$1,876**	**$63**	**$244**	**$1,569**

Table 8.6–2: Capital Cost for the Construction of the Grevet-Chapais Railway by Sector.

Sector	Total Cost	Contingency	Sub-Total	Client Cost	Studies & permitting	Construction cost
Civil & Earthworks	$296	$49	$246	$8	$33	$205
Structures	$130	$22	$109	$4	$14	$91
Drainage	$26	$4	$22	$1	$3	$18
Trackworks	$704	$117	$586	$20	$78	$489
Level Crossing Surface	$1	$0	$1	$0	$0	$1
Signalling & Telecommunications	$16	$3	$13	$0	$2	$11
Buildings & Passenger Stations	$7	$1	$6	$0	$1	$5
Depots & Storage Areas	$27	$4	$22	$1	$3	$19
Environmental Protection	$0	$0	$0	$0	$0	$0
Rolling Stock	$24	$4	$20	$1		$19
Sub-total	**$1,231**	**$205**	**$1,026**	**$34**	**$134**	**$857**

8.6.1.3 Relocation of Existing Roads and Construction of Access Roads

The tables below provide the cost of construction of various community access roads and the Route du Nord, which will be required with the construction of the Billy Diamond Highway and Grevet-Chapais railways.

Table 8.6–3: Capital Cost for the Construction of All Four Community Access Roads by Sector

Sector	Total Cost	Contingency	Sub-Total	Client Cost	Studies & permitting	Construction Cost
Site organisation:	$164	$27	$137	$5	$16	$116
Earthworks:	$69	$11	$57	$2	$7	$49
Roadway and pavement:	$357	$60	$298	$10	$35	$252
Drainage and engineering structures:	$69	$12	$58	$2	$7	$49
Signposting:	$5	$1	$4	$0	$0	$3
Miscellaneous works:	$26	$4	$21	$1	$3	$18
Landscaping:	$1	$0	$1	$0	$0	$1
Environmental protection:	$2	$0	$1	$0	$0	$1
Sub-total	**$691**	**$115**	**$576**	**$20**	**$68**	**$488**

Table 8.6–4: Capital Cost for the Route du Nord by Sector.

Sector	Total Cost	Contingency	Sub-Total	Client Cost	Studies & permitting	Construction Cost
Site organisation:	$190	$32	$158	$5	$19	$134
Earthworks:	$61	$10	$51	$2	$6	$43
Roadway and pavement:	$511	$85	$426	$14	$50	$361
Drainage and engineering structures:	$114	$19	$95	$3	$11	$81
Signposting:	$5	$1	$5	$0	$1	$4
Miscellaneous works:	$43	$7	$36	$1	$4	$30
Landscaping:	$0	$0	$0	$0	$0	$0
Environmental protection:	$3	$0	$2	$0	$0	$2
Sub-total	**$927**	**$155**	**$773**	**$26**	**$92**	**$655**

8.6.2 Sustaining Capital

Sustaining capital includes the ongoing costs associated with maintaining and upgrading existing infrastructure and equipment for a railway company. These costs are necessary to keep the railway in safe, reliable, and efficient operation, and includes expenses such as:

- Rehabilitation of existing equipment: This includes upgrading or replacing old equipment as it reaches the end of its useful life.
- Rehabilitation of existing infrastructure: This can include maintaining tracks, bridges, and stations, as well as upgrading signaling systems and other safety equipment.
- Upgrades to improve safety, efficiency, and capacity: This can include investments to improve the safety, efficiency and capacity of the railway, such as upgrading signaling systems, adding new tracks, or expanding stations to accommodate more passengers.

The base currency of the sustaining capital estimate is Canadian dollars, and all costs are in 2022 dollars.

8.6.2.1 BDHR

Table 8.6–5: below provides a summary of the Sustaining Capital per cost sector over a 30-year horizon for the BDHR.

Table 8.6–5: BDHR sustaining capital cost, in million CAD.

Sector	2044	2049	2054	2059
Civil & Earthworks	- $	- $	26.22 $	- $
Level Crossings	- $	- $	- $	2.90 $
Signalling & Telecommunications	- $	14.96 $	- $	- $
Buildings & Passenger Stations	0.14 $	- $	0.14 $	12.55 $
Maintenance Shops & Storage Areas	0.04 $	- $	0.04 $	22.63 $
Total	**0.18 $**	**14.96 $**	**26.38 $**	**38.08 $**

As can be observed in the table above, there is no sustaining capital projected for trackworks and rolling stock. Indeed, the traffic anticipated does not justify the replacement of track components or rolling stock before 2064. The regular maintenance costs for these items are included in the OPEX.

8.6.2.2 Grevet-Chapais Railway

Table 8.6–6: below provides a summary of the sustaining capital per cost sector over a 30-year horizon for the Grevet-Chapais Railway.

Table 8.6–6: Grevet-Chapais Railway sustaining capital cost. All costs in millions CAD.

Sector	2044	2049	2054	2059
Civil & Earthworks	-	-	-	-
Level Crossings	-	-	-	-
Signalling & Telecommunications	-	-	1.49	-
Buildings & Passenger Stations	-	15.58	-	-
Maintenance Shops & Storage Areas	0.04	-	0.64	11.89
Total	**0.04 $**	**15.58$**	**2.13 $**	**11.89 $**

8.6.2.3 Community Access Roads and Route du Nord

Table 8.6–7 provides a summary of the sustaining capital per cost sector over a 30-year horizon for the community access roads as well as the Route du Nord.

Table 8.6–7 Community access roads sustaining capital cost.

Sector	2044	2049	2054	2059
Roadway and Pavement	0,82 $	0,06 $	32,90 $	0,06 $
Landscaping	3,35 $	--	3,35 $	--
Total	**4,17 $**	**0,06 $**	**36,25 $**	**0,06 $**

Table 8.6–8 Route du Nord sustaining capital cost.

Sector	2044	2049	2055	2059
Roadway and Pavement	1.20	0.08	48.03	0.08
Landscaping	4.88		4.88	
Total	**6.08 $**	**0.08 $**	**52.91$**	**0.08$**

8.6.3 Operating Expenses (OPEX)

The railway operating cost can be broken down into four key categories:

1. Infrastructure maintenance costs: This includes the cost of ongoing maintenance for tracks, stations, structures, and other infrastructure necessary for the railway to operate.
2. Equipment maintenance costs: This includes the cost of maintenance of locomotives, railcars, and other railway equipment.
3. Staffing costs: This includes the cost of hiring and training new employees, as well as ongoing labor costs such as salaries and benefits.
4. Energy costs: This includes the cost of fuel and electricity needed to operate the railway.

8.6.3.1 Track and Infrastructure Maintenance

The annual operating costs for track are those associated with inspections, specifically track geometry cars and ultrasonic test vehicles, as well as rail grinding and ballast maintenance. The acquisition of a track geometry car and a rail flaw detection (ultrasonic) car has been considered, but their purchase is not recommended. These machines are specialized equipment requiring skilled operators assigned to specialized track maintenance work. Therefore, these two activities will be contracted out.

In addition, bridges and culverts will require a cursory inspection to be carried out annually, as well as a detailed inspection which will be carried out every 5 years. This has also been contracted out.

Most of the ongoing maintenance activities will be carried out by the permanent maintenance staff of the railway. These activities will include track inspection and assorted items related to minor corrective maintenance, such as spot tamping and surfacing, and general maintenance of the ROW vegetation. These details of these activities are discussed in Section 8.5.24.

The following figure the variation of the OPEX cash flows for track and infrastructure maintenance, including staff salaries, as well as subcontracted activities.

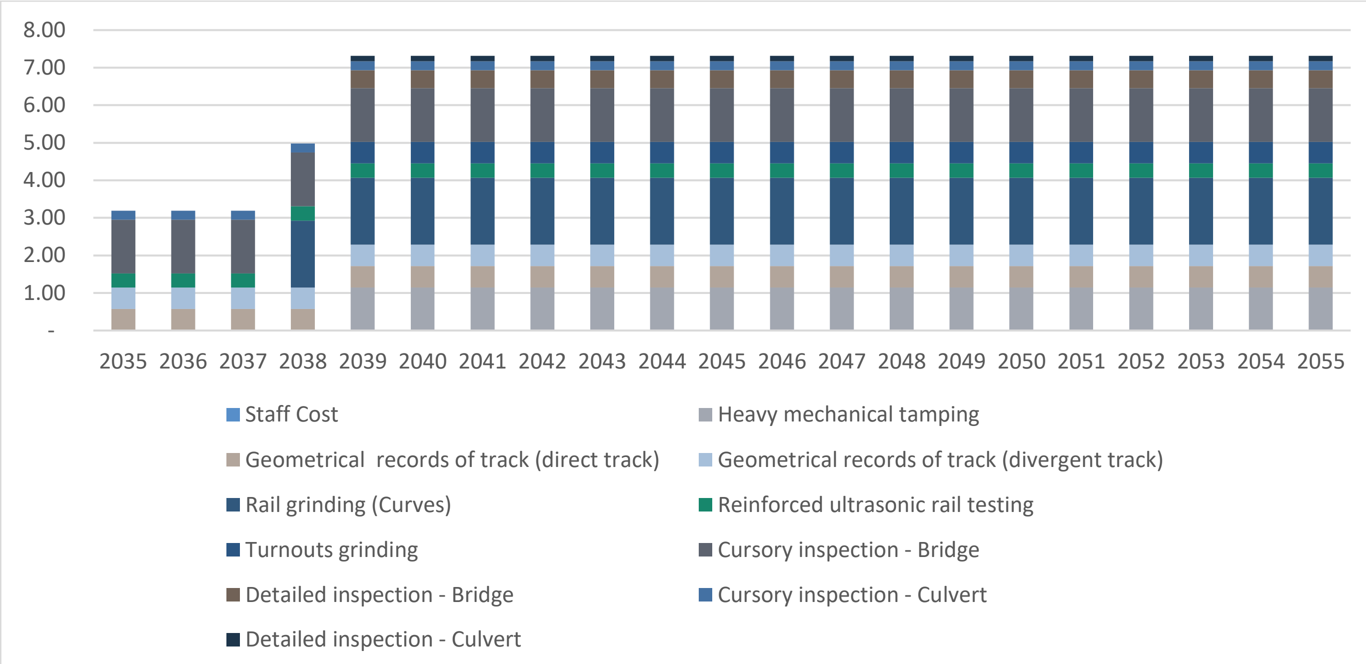


Figure 8.6-1: Track and infrastructure OPEX, 2022M$

The total estimated annual cost amounts are summarized in the table below.

Table 8.6–9: Track and infrastructure OPEX

Years of Operation	Annual Cost (CAD)
1 - 4	$ 3.19 million
5 - 30	$ 7.31 million

8.6.3.2 Rolling Stock Maintenance

Figure 8.6-2 below provides a summary of the cash flows related to rolling stock maintenance. While annual maintenance costs are expected to remain mostly constant, every 6- and 12-years locomotives will require a minor and a major overhaul, which is why the cost for these years will be higher.

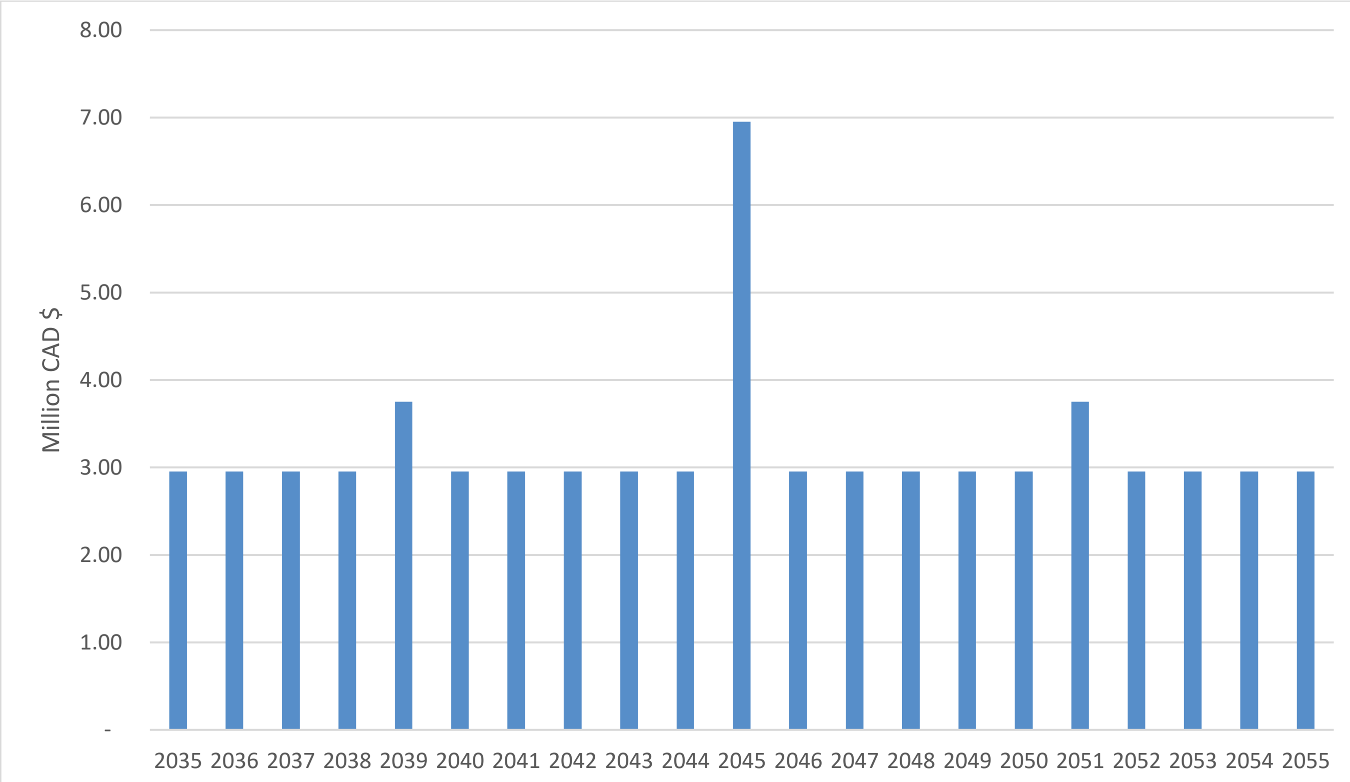


Figure 8.6-2: Rolling Stock Maintenance Costs

8.6.4 Construction Cost Cash Flows

Project construction activities will begin in 2030 and will be carried out during a 5-year period, with the last activities expected to be completed by 2034.

The methodology for developing the net cash flows was to correlate the construction schedule with the cost estimate made, to provide the net cash flows over the construction period. The series of activities were grouped to increase construction efficiency and to complete the proposed project in the shortest possible time frame so that operations could begin. Resource leveling and time-cost analysis was performed by moving non-critical schedule activities within their margin of flexibility so that a better resource profile was achieved to meet specific milestones at the lowest cost. The net cash flows are those used in the financial model to calculate the various economic parameters in relation to the overall project feasibility.

The cash flow distributions associated with the BDHR, the Grevet-Chapais Railway, the community access roads and the Route du Nord during the construction period are shown in the figures below.

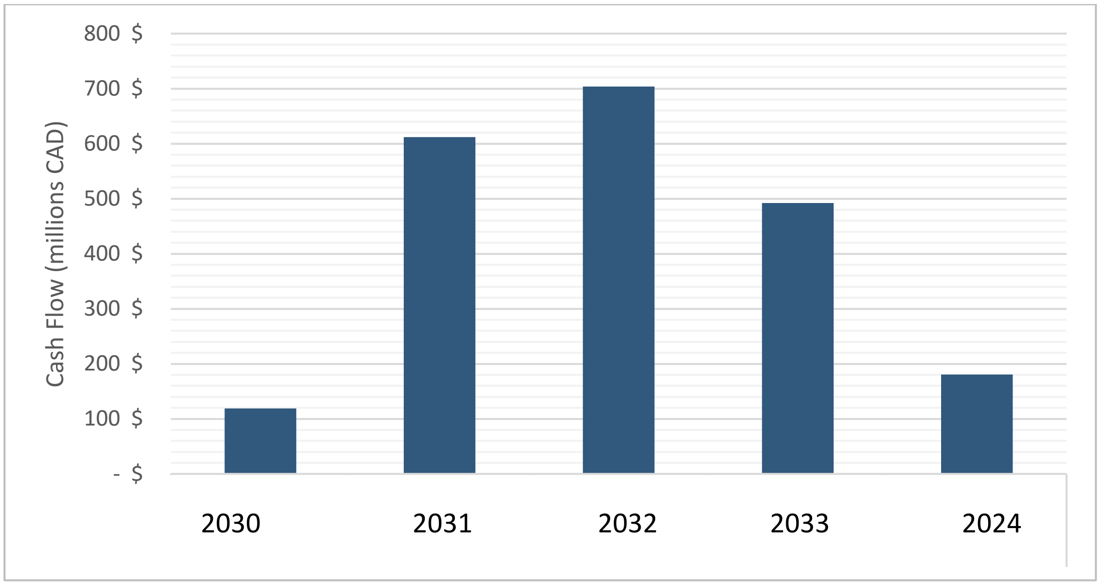


Figure 8.6-3: Cash flow for the construction of the BDHR. All costs in millions CAD.

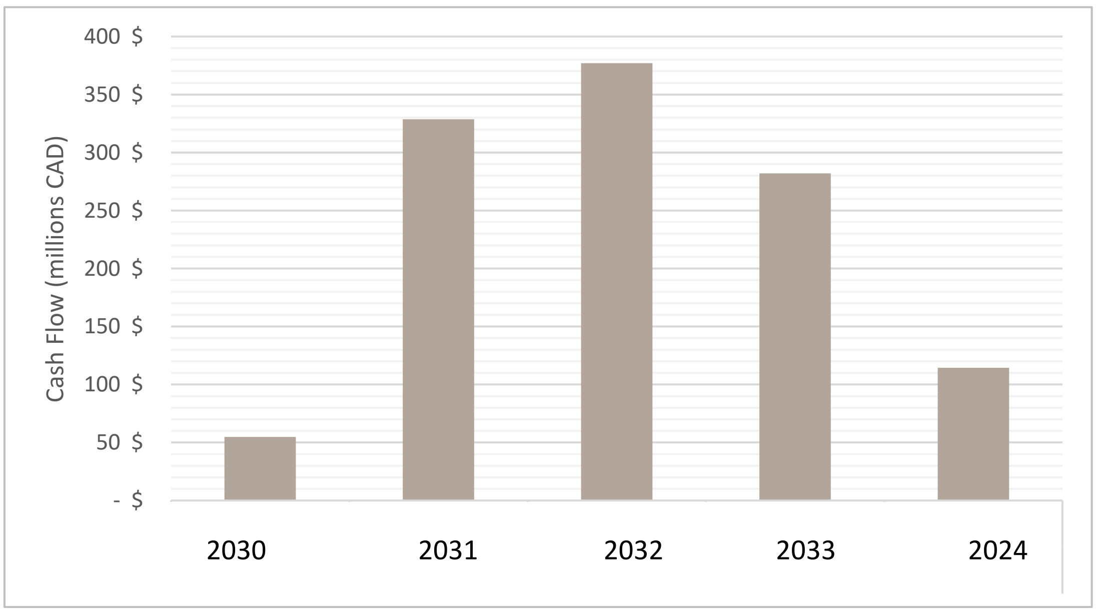


Figure 8.6-4: Cash flow for the construction of the Grevet-Chapais Railway
All costs in millions CAD

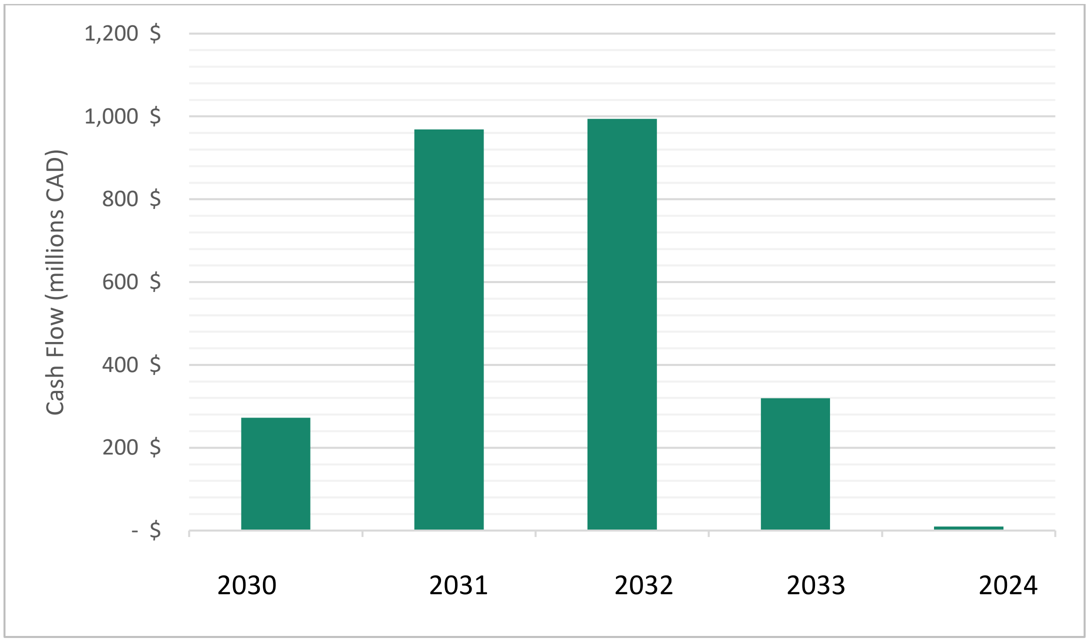


Figure 8.6-5: Cash flow for the community access roads and the Route du Nord. All costs in millions CAD.

8.7 COMMUNITY ACCESS ROADS

8.7.1 Introduction

The existing road network (728 km) covered by this study consists of five access roads. The three first links the Billy Diamond Highway to the communities of Waskaganish, Eastmain and Wemindji, the fourth is the Route du Nord which links route 167 to Billy Diamond Highway and lastly, the access road which connects the community of Nemaska to the Route du Nord.

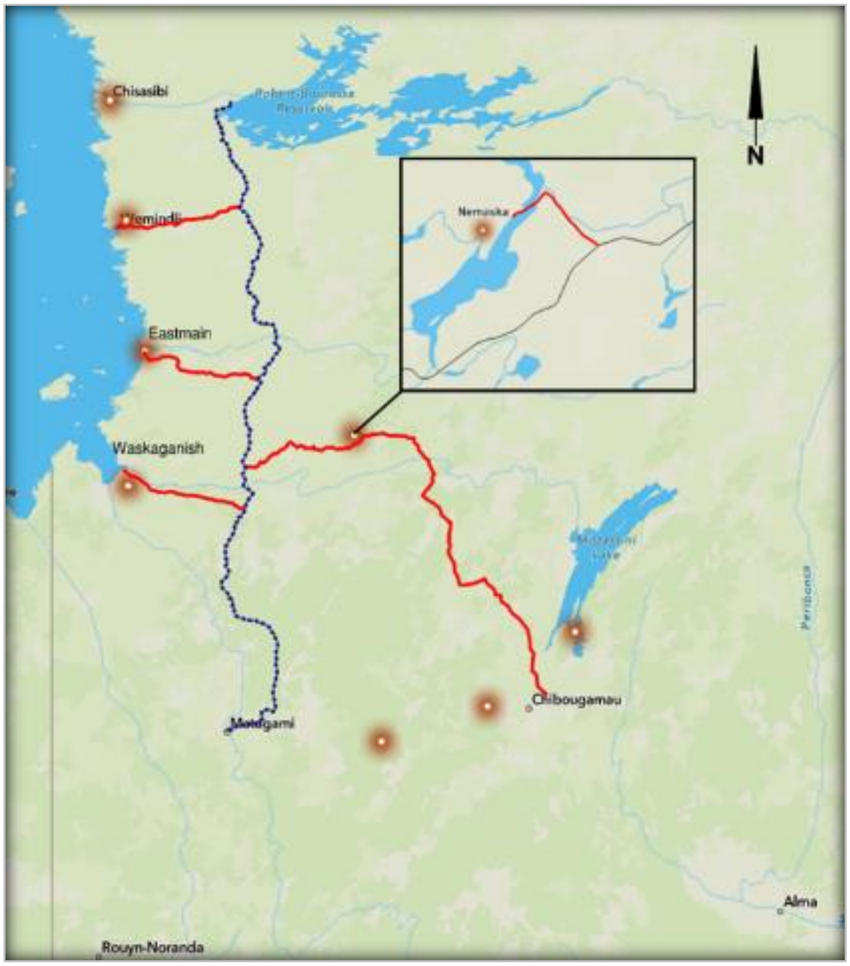


Figure 8.7-1: Community Access Road Location Plan

The Waskaganish access road (102 km) connects to kilometre marker 237 of the James Bay Road Billy Diamond Highway. Only 22.3 km located at the west end are paved on category 1 lands.

The Eastmain access road (104 km) connects to kilometre marker 350 of the James Bay Road. Only 30 km located at the west end are paved on category 1 lands.

The Wemindji access road (98 km) connects to kilometre marker 518 of James Bay Road and was built in the 1990s. Only 22,6 km located at the west end of the road are paved on category 1 lands.

The Nemaska access road (10 km) connects to kilometre marker 296 of the Route du Nord. Only 4 km located at the north end of the road are paved.

The Route du Nord is a 407-kilometre, gravel road connecting Chibougamau to the James-Bay Road. The road has opened access to the Nemaska community and the forestry industry.

The purpose of this report is to establish the characteristics of the existing access roads to determine possible improvement works according to today’s geometric design standards, while improving quality of life for local residents and identify requirements for paving. The mandate includes the paving of all roads, excluding portions of roads already paved.

8.7.2 Design Parameters

The following table presents the design parameters retained for the analysis of the existing roadway in order to establish the recommended improvement works.

Table 8.7–1: Design parameters

	Parameter	Value	Reference
Generals	Functional classification	Resource access network	-
	AADT (vehicles/day)	220 (2021)	Route du Nord, km 108, MTMD
	Heavy vehicles (%)	33%	Route du Nord, km 108, MTMD
	Posted speed (km/h)	70	Existing
	Design speed (km/h)	80 km/h (70 km/h for low-volume roads)	Section 1.4.4, Tome I, MTMD
Cross section	Lane width (m)	3.50	
	Number of lanes	2	
	Shoulder width (m)	1.00	
	Shoulder rounding (m)	0.60	
	Minimum slope of embankments	1V : 2H	
	Minimum width of ditches (m)	1.00	
Plan, profile and sight distance	Minimum horizontal curve radius (m)	255	Table 6.3-4, Tome I, MTMD
	Design vehicle	WB-20	Section 8.7.3, Tome I, MTMD
	Maximum superelevation (%)	6.0	Section 6.3.3, Tome I, MTMD
	Decision sight distance (m)	160	Table 7.9-1, Tome I, MTMD
	Object height for sight distance (m)	1.15	Table 7.5-1, Tome I, MTMD
	Driver’s eye height for sight distance (m)	1.08	Section 7.6, Tome I, MTMD
	Minimum K factor for crest vertical curve	26	Section 6.4.3, Tome I, MTMD
	Minimum K factor for sag vertical curve	30	Section 6.4.3, Tome I, MTMD
	Minimum vertical curve length (m)	70	Table 6.4-3, Tome I, MTMD
	Maximum slope (%)	10	Table 6.4-2, Tome I, MTMD

8.7.3 Scope and Objective

To improve the access roads to the communities and the Route du Nord, a technical assessment, based on the existing plans, of the different characteristics of the existing roadway was carried out to determine its deficiencies. The problems raised by the stakeholders and the road users of the area were considered in the establishment of corrective measures. Without limitation, the following elements were analyzed:

- Horizontal geometry and superelevation
- Vertical profile
- Cross section
- Culverts
- Issues raised by the community
- Public services
- Safety barrier

8.7.4 Analytical Approach for Existing Roads

The geometry of the segments of the road corridor, located upstream and downstream of the point of analysis have been considered to maintain coherence with the geometry of the overall corridor, since a one-time change to the geometry of the road without considering the rest of the corridor risks compromising safety if no other improvements are planned. Therefore, specific interventions must be consistent with the whole sector to avoid sudden changes in the road environment, modifying the driver's perception and expectations. The cross section, the operating speed and the driver's effort are the main elements considered in this analysis. The following four principles should be considered in assessing the consistency of a layout:

- the homogeneity of the cross section
- the uniformity of driver operating speeds
- consistency with the environment crossed
- crash history.

The analysis on the access roads was carried out using Lidar data which are summarized in the following table:

Table 8.7–2: Lidar data

Roads	Source	Accuracy (mm)	Zones
Wemindji	Geoposition 2015	± 100	9-10
Eastmain	Geoposition	± 100	9
Waskaganish	Geoposition 2015	± 100	9-10
Nemaska	Groupe PHB	± 100	8-9
Route du Nord	Groupe PHB	± 100	8-9

8.7.5 Community Access Roads and Route du Nord

8.7.5.1 Horizontal Geometry

An analysis of the horizontal alignment of the access roads was carried out to validate the operating speed at which users can safely navigate existing horizontal curves. The following table presents the result of this analysis.

Table 8.7–3: Horizontal Curves and Exiting Permissible Speeds

Roads	Curves speed				
	Total	More than 80 km/h	70-79 km/h	60-69 km/h	Less than 60 km/h
Wemindji	78	66	9	3	0
Eastmain	106	94	12	0	0
Waskaganish	62	62	0	0	0
Nemaska	24	12	7	4	1
Route du Nord	376	327	35	12	2
Total	**646**	**561**	**63**	**19**	**3**
		☑	☑		☒

☑ Compliant ☒ Non-compliant

For low volume roads with less than 400 vehicles per day, the design speed is the same as the posted speed.

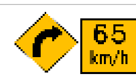
Based on this analysis:

- 624 horizontal curves do not require intervention for operating speeds greater than 70 km/h;
- For horizontal curves corresponding to an operating speed of 60 km/h, the installation of horizontal curve signs (D-110) with a recommended speed sign (D-110-P-2) of 55 km/h is required;
- For horizontal curves representing operating speeds lower than 60 km/h, improving the horizontal curve radius is recommended.

Tables of the horizontal geometry of each of the access roads are presented in the Appendix 6.21.

The following table lists the curves on which interventions are recommended:

Table 8.7–4 : Horizontal curves requiring interventions

Roads	Station	Curve speed (km/h)	Interventions
Wemindji	68+300	66	
	68+524	65	
	75+544	68	
Eastmain	11+288	68	
Waskaganish	Not applicable		
Nemaska	0+080	65	
	0+822	67	
	4+598	52	Curve correction
	5+457	68	
	10+251	69	
Route du Nord	45+400	69	
	56+418	66	
	66+983	60	
	68+893	47	Curve correction
	72+612	66	
	75+959	63	
	82+664	57	Curve correction
	84+002	69	
	89+922	67	
	230+954	60	

Roads	Station	Curve speed (km/h)	Interventions
	236+781	66	
	239+285	60	
	241+841	67	
	343+544	66	

The following figures shows an example of a curve at kilometer 69 (Route du Nord) that needs to be corrected.

Figure 8.7-2: Street View July 2022 - Curve with radius too small at kilometer 69 (Route du Nord)

The following figure shows an example of a curve where danger signs should be installed (kilometer 242, Route du Nord).

Figure 8.7-3 : Street View July 2022 - Curve at kilometer 242 (Route du Nord)

In a horizontal curve, roadside elements must be located far enough to allow the required sight distance. Furthermore, the area inside the curve must be free of any sufficiently large obstacles that could interfere with the perception of an object on the roadway. In the case of the access roads, the vegetation growing on the edge of the roadway hinders the visibility of drivers. Therefore, it is recommended to trim the vegetation on the road embankments.

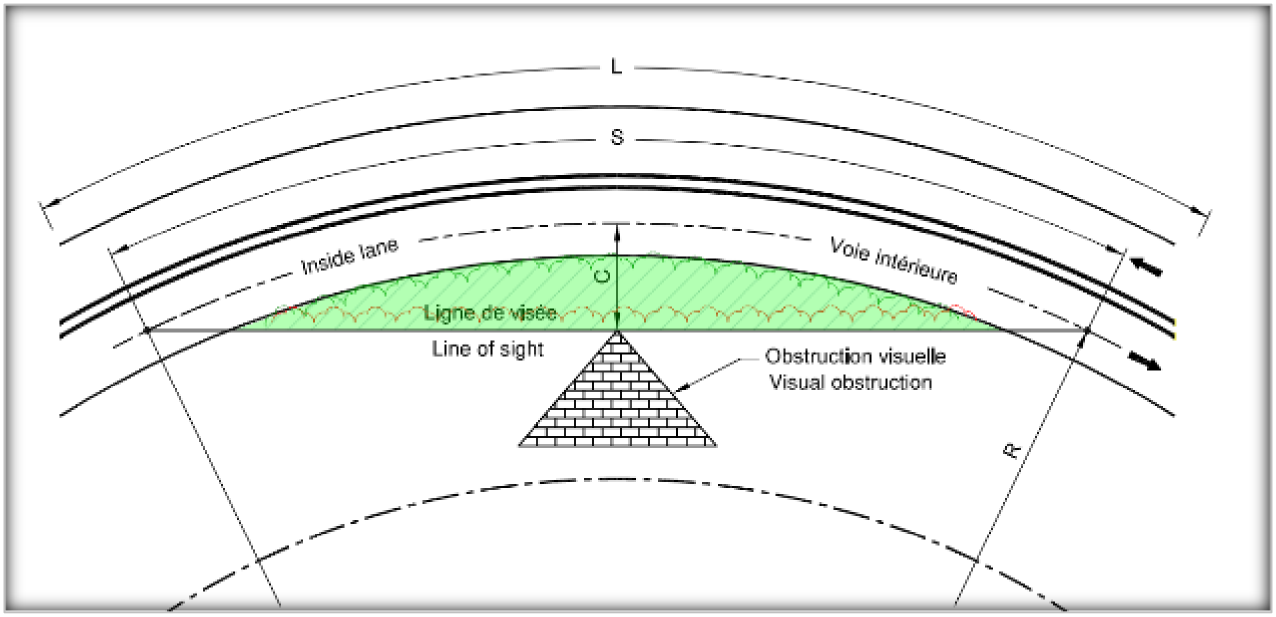


Figure 8.7-4: Line of sight inside a curve

8.7.6 Superelevation

When the horizontal alignment is in a straight line, the roadway has a normal crown with cross slopes of 2%. In horizontal curves, a superelevation varying according to the radius of curvature and the design speed is required. An analysis of the existing superelevation in the existing horizontal curves has been carried out and the non-conforming horizontal curves will be corrected by regrading with additional granular material (80 % of curves to be corrected for superelevation).

8.7.7 Vertical Profile

The maximum slope is generally determined by the terrain and the design speed. Steep grades can reduce construction costs but can significantly impact operating conditions (snow, frost). According to the design guidelines, slopes greater than 10% could be problematic, as higher downslopes increase breaking distance, while higher upslopes reduce operating speeds, especially those of heavy vehicles.

The following table presents the list of sectors where the slopes are greater than 10%.

Table 8.7–5: Slopes greater than 10%

Roads	Station	Slope (%)	Slope length (m)
Wemindji	-	-	-
Eastmain	-	-	-
Waskaganish	-	-	-
Nemaska	-	-	-
Route du Nord	106+703 to 106+763	10,40	60
	114+016 to 114+068	10,36	52
	150+350 to 150+536	10,67	186
	193+664 to 193+859	11,09	195
	227+630 to 227+660	10,43	30
	229+273 to 229+431	11,02	158
	229+725 to 229+944	11,20	219
	232+851 to 232+907	10,03	56
	236+671 to 236+715	10,51	44
	240+498 to 240+743	10,68	245
	241+571 to 241+585	11,51	14
	242+476 to 242+512	12,84	36
	249+544 to 249+588	10,87	44
	250+890 to 250+921	11,59	31
	257+237 to 257+312	10,66	75

Considering that it is an existing road with low traffic flow, that the majority of the slopes are close to the 10% limit and that they have a short length (between 14 and 245m), slopes slightly higher than those recommended for other roads are acceptable in this case. In addition, a slight slope correction would have little impact on the heavy vehicle operating speeds. Therefore, it is not required to correct these profiles.

The following figure shows an example of the vertical profile between stations 240+498 to 240+743.

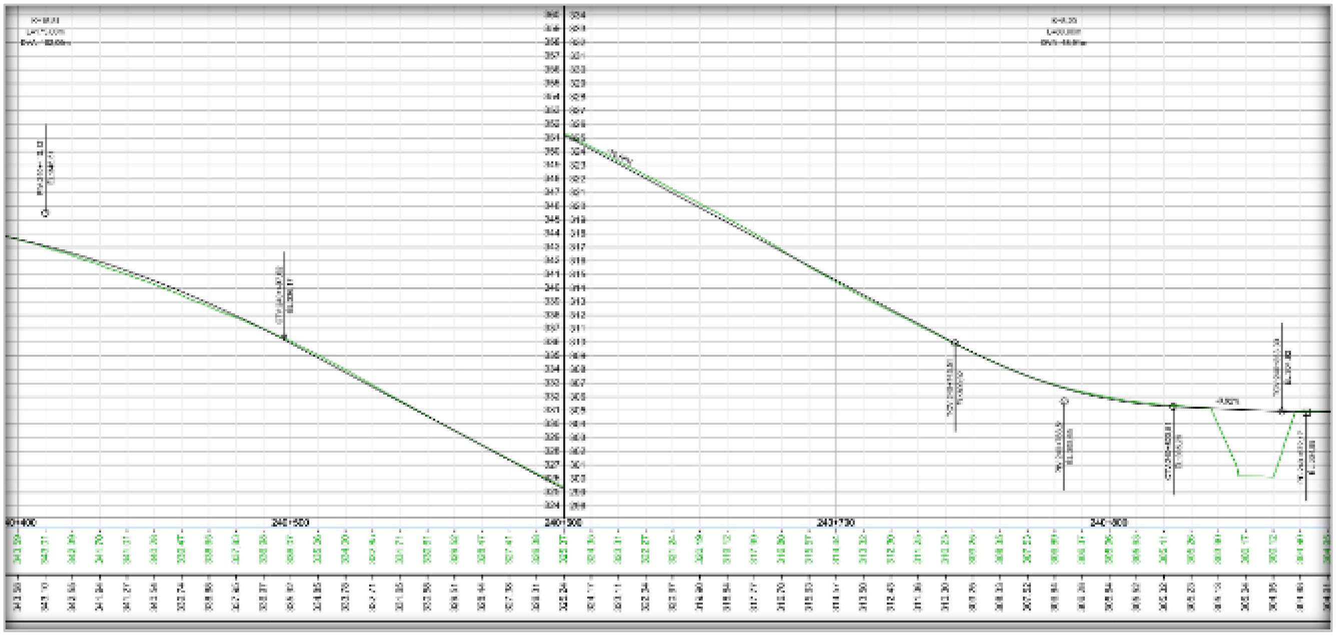


Figure 8.7-5: Example of profile between stations 240+498 to 240+743

An analysis of the existing sag and crest vertical curves was also carried out to validate whether they allow for sufficient sight distance and are sufficiently long for the design speed. The purpose of these curves is to bring a gradual change from slope to slope. Their shape is parabolic, thus allowing to have a constant change in slope all along the curve. A crest curve is calculated using the required sight distance, the height of driver's eye and the height of the object that they want to see on the road. A sag curve is calculated by setting a headlight height of 0.6m and an angle of the light beam 1° upwards.

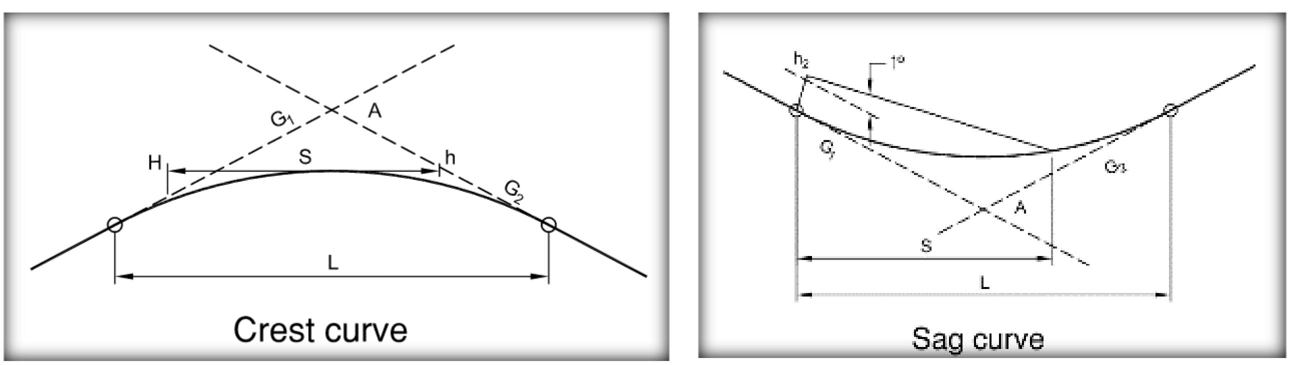


Figure 8.7-6: Vertical curves

Table 8.7–6 : Vertical Curves and Exiting permissible Speeds

Vertical curves speed														
Roads	**Total**		**80 km/h**		**70 km/h**		**60 km/h**		**50 km/h**		**40 km/h**		**<40 km/h**	
	Crest	Sag	Crest	Sag	Crest	Sag	Crest	Sag	Crest	Sag	Crest	Sag	Crest	Sag
Wemindji	193	373	175	331	12	17	5	11	1	10		4		
Eastmain	275	299	259	249	11	27	4	15	1	7				1
Waskaganish	183	189	183	185		2		2						
Nemaska	29	29	27	26			2	2						
Route du Nord	899	984	631	537	156	99	101	137	10	132	1	74		5
Subtotal	1579	1874	1275	1328	179	145	112	167	12	150	1	78		6
			☑		☑			☑		☑	☒	☑	-	-
Total	**3453**		**2603**		**324**		**279**		**162**		**79**		**6**	

☑ Compliant ☒ Non-compliant

Due to the large number of non-compliant vertical curves and the very low traffic flow observed, it is suggested not to correct sag curves that would have only a limited effect on user safety. However, and in order to limit construction costs, it is recommended to install restricted visibility signs in crest curves for speeds of 50 and 60 km/h (124 vertical curves). For speed below 40 km/h, it is desirable to carry out repair work (2 vertical curves). Tables of the vertical curve for each of the access roads are presented in the appendix 6.21.

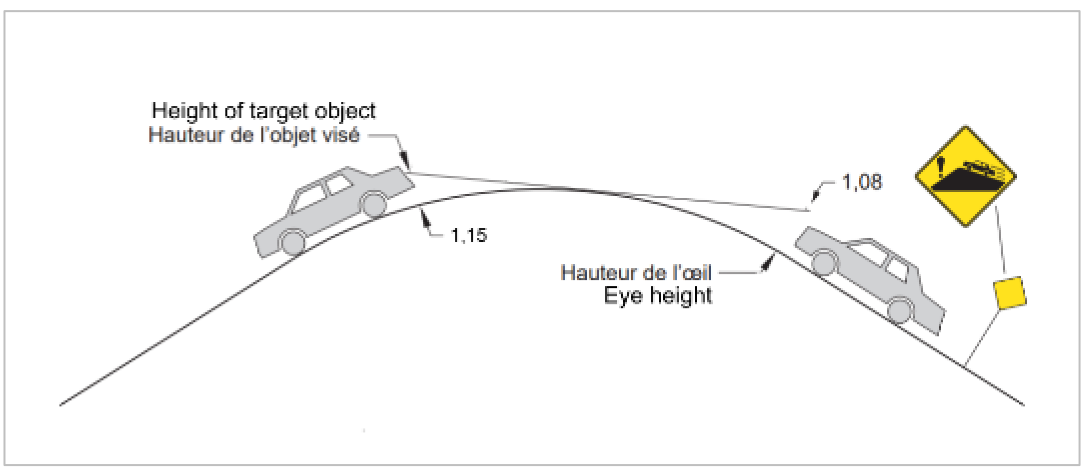


Figure 8.7-7 Visibility in a vertical crest curve

8.7.8 Cross Section

Based on the comments of community stakeholders, the current paved surfaces are too narrow, and road users typically drive in the center of the roadway (risk of frontal collision or leaving the road). Also, the existing shoulders are unstable and do not allow vehicles to park alongside the road to access nearby resources or in case of emergency. Using an inventory of the existing roadway widths, an assessment of the space available for the future development of the road lanes, shoulders and eventual lifting of the roadway with additional granular material and pavement was made. This assessment assumed the road would remain on the existing platform to limit additional encroachments in wetlands and minimize impacts on watercourses at the culverts, while salvaging the existing roadway as a sub-base. To increase visibility and improve the drainage of the side ditches, clearing of the roadside and cleaning of the side ditches is suggested using the lower third method.

It is also recommended that the access roads be paved, it reduces fine dust particles that can have an impact on the respiratory tract, reduces the frequency of crashes due to loss of visibility and reduced traction on a gravel road, minimizes impacts of dust on the environment (vegetation and water) and reduce damage to vehicles.

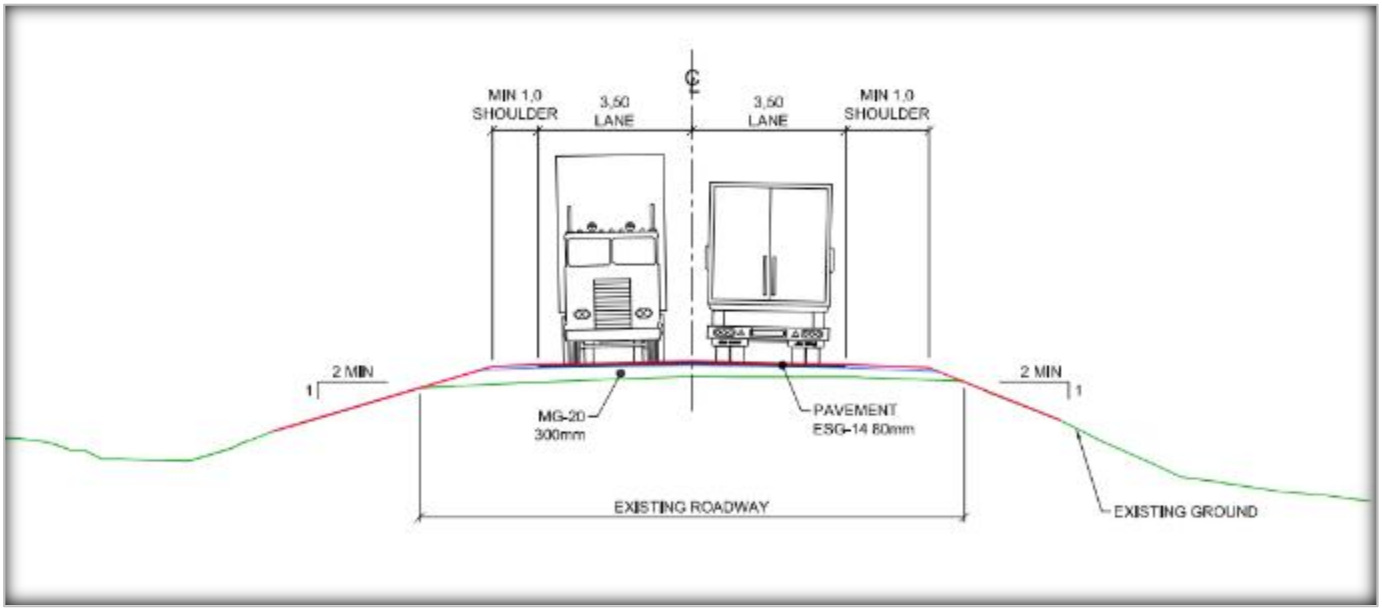


Figure 8.7-8: Roadway cross section

Based on this analysis, an E type cross section is proposed with some modifications but maintaining the total width:

- 3.5 m lanes to facilitate trucking;
- gravel shoulders of 1 m minimum;
- maintaining of existing embankment slopes (2H:1V min.).

The proposed roadway structure above the existing road is as follows, backed by geotechnical analysis and recommendations:

- 300 mm granular resurfacing with MG 20;
- 80 mm paved surface with ESG 14 asphalt.

8.7.9 Access

According to other comments from community stakeholders, it is difficult to park on the side of the road because of the very narrow shoulders. To allow for safe parking of vehicles along the roadway and to provide access to hunting areas and resources, it is suggested, in the next stages, to make an inventory of existing accesses and, if necessary, to develop new parking areas along the road according to the needs of the community.

8.7.10 Culverts

The assessment of the condition of the existing culverts, consisting mainly of corrugated steel pipe, was based on data provided by Ministère des Transports et de la Mobilité Durable (MTMD) and site visits. The below table presents the condition classes according to the condition index of the culvert. It should be noted that the complete inventory of culverts was not available.

The inspection of 54 culverts was carried out in the summer of 2022 and confirmed the results obtained from the MTMD.

Table 8.7–7 : Culvert Condition Classes

Condition Class	Definition
A	Culverts free from defects or having negligible defects requiring no intervention
B	Culverts with slight defects requiring no major intervention in the short term.
C	Culverts with significant defects requiring no major short-term intervention. Minor interventions may be required to extend the life of the culverts.
D	Culverts in poor condition requiring minor or major interventions in the short term.
E	Culverts in very poor condition requiring minor or major interventions in the short term.

For this study, condition class C, D and E culverts are replaced. Table 8.7–8 presents the summary of the condition of the culverts available.

Table 8.7–8: Distribution and Conditions of Culverts (MTMD)

	Km	Condition Class A or B	Condition Class C or D or E	Total Culverts Inspected
Wemindji	17-98	100	19	119
Eastmain	9-104	Not inspected	Not inspected	Not inspected
Waskaganish	24-102	135	7	142
Route du Nord et Nemaska	0-304	415	209	624
Total		**650**	**235**	**885**

The existing corrugated steel culverts are already over thirty years old. Assuming that the new roads will be paved, it is recommended that all the culverts be replaced to avoid any excavation of the newly paved surface in the short-term future. The use of a longitudinal transition of 20H-1V during the excavation is desirable to avoid differential settlement of the road under the effect of frost. Hydraulic studies, environmental inventories, including presence of fish species, will be necessary prior to culvert replacement.

Figure 8.7-9: Inspected culverts on the Route du Nord

8.7.11 Crash Barriers on Access Roads

A summary inventory of the existing crash barriers at the culverts was carried out. This assessment found that there is a significant lack of crash barriers. An extra 1.2 m shoulder width is required for their installation and proper use. Table 8.7–9 provides a summary of the inventory of these devices.

Table 8.7–9 : Crash Barrier Work Requirements

	Existing to be Replaced	New Sites	Sites with Devices Not Required	Total Sites Analyzed
Wemindji	1	143	0	144
Eastmain	8	132	0	140
Waskaganish	2	144	7	153
Route du Nord et Nemaska	40	557	40	637
Total	**51**	**976**	**47**	**1074**

Figure 8.7-10: Site with a lack of crash barrier for a culvert

8.7.12 Signage and Markings

To improve road safety, it is desirable to carry out pavement markings and to review the road signage according to current standards. Thus, the pictograms and markings on the road must always be the same to convey the same message. Also, homogeneity requires that, under identical conditions, the road user encounters messages of the same value, of the same scope and implemented according to the same rules.

The purpose of road signs is to make road traffic safer, to point out dangers and to provide indications or useful information to road users. In order to be effective, it must be uniform and homogeneous, attract attention, be perfectly visible and readable from a distance, be easy to understand and be well adapted to the dangers and particularities to be reported.

The communities have also requested the addition of signage indicating the numbering of traplines, camps, moose crossings, etc.

Figure 8.7-11: Example of sign for presence of moose

8.7.13 Multipurpose Trails Near Communities

According to the findings obtained by community stakeholders, the roads are too narrow near the communities and are used by pedestrians and hunters. To improve the safety of these vulnerable users, it is proposed, in subsequent stages, to develop a multifunctional path near the communities that is separated from the road to protect them from automobile and truck traffic.

8.7.14 Traffic Maintenance

During the work, it will not be possible to divert traffic to other secondary roads. Therefore, the traffic will have to be carried out alternately using traffic lights or traffic control barriers. It should be noted that the use of a road flagman is only permitted for posted speeds of 70 km/h or less.

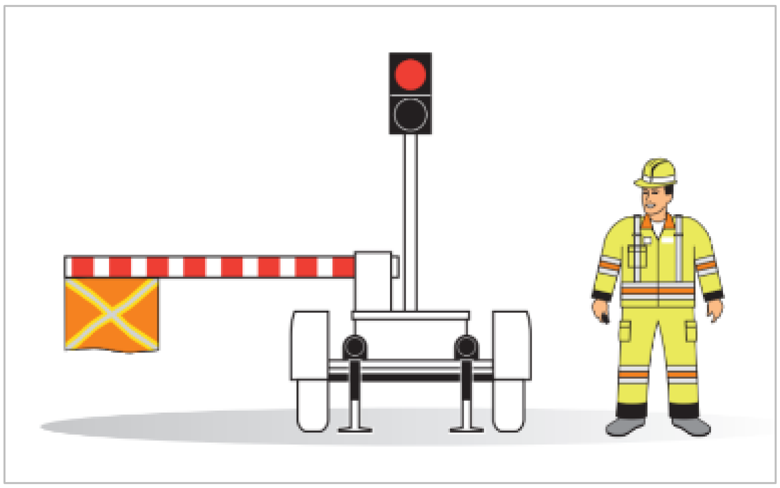


Figure 8.7-12: Traffic control barrier for works

8.7.15 Winds and Snow

Direction and strength of the wind in the area have been analyzed from data ranging from 2017 to 2022 from the Eastmain River airport. During winter, winds mainly come from the West North-West at speeds of 13 km/h on average with gusts of wind with speeds of up to 43 km/h. During summer, winds blow at speeds of 13 km/h and gusts are less frequent. These gusts blow at speeds of 41 km/h on average.

The following graph shows the direction and speeds of winds at Eastmain River airport.

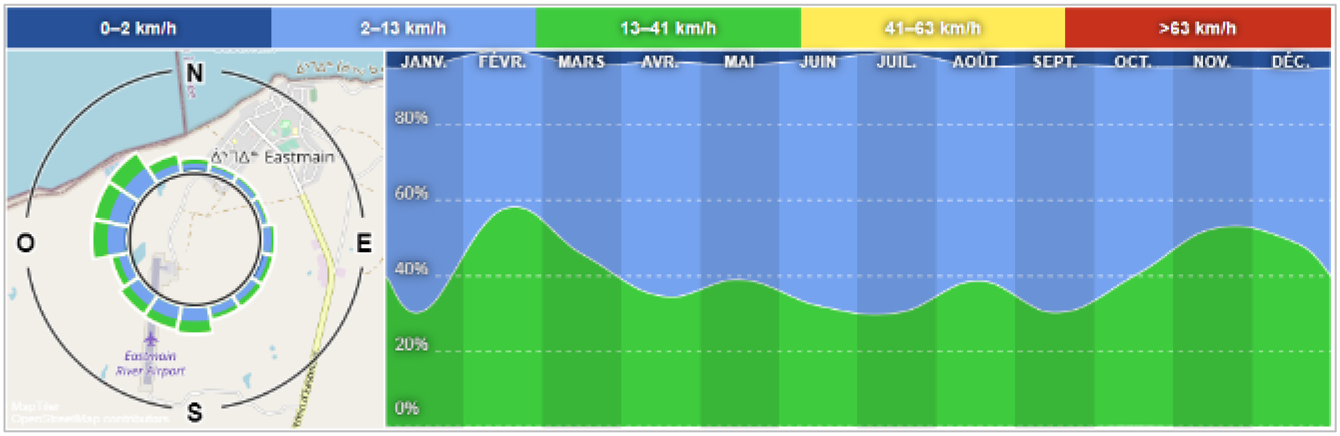


Figure 8.7-13: Statistiques de vent et météo Eastmain River Airport - Windfinder

For the Route du Nord, according to the Chapais-Chibougamau Airport station, wind blows in general from West or West Southwest at speeds between 14 and 18 km/h with gusts between 35 and 37 km/h.

The following graph shows the direction and speeds of winds at Eastmain River airport.

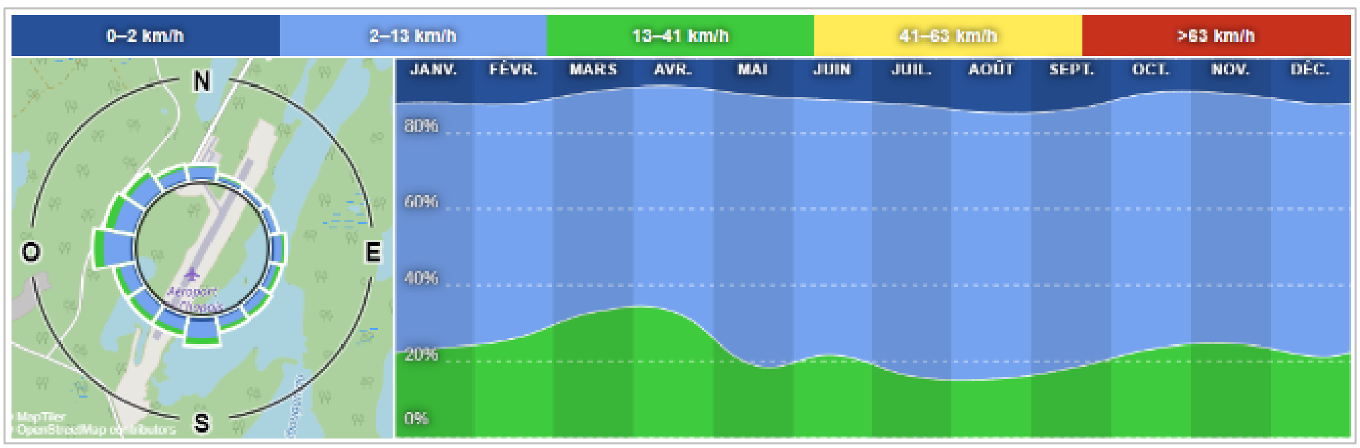


Figure 8.7-14: Statistiques de vent et météo Aéroport de Chibougamau/Chapais - Windfinder

According to the climate normals from the Chapais 2 station monitored by the Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs which is the closest to the site of study, the region receives approximately 303 cm of snow yearly.

By looking at the geometry of the different roads concerned by this study and the directions of the winds, we can see that the risk of snow blades forming on the different access road to Wemindji, Eastmain, Waskaganish and the northern part of the Route du Nord is rather minimal due to their parallel axis with the winds. In the case of the southern part of the Route du Nord, this roadway runs on a Northwest-Southeast axis while the wind comes from the West. This accentuates the risk of snow blades forming on the roadway.

The level of service in terms of network maintenance in the winter period is determined according to the average daily winter traffic and the functional classification of the road. For this study, a flow of less than 500 vehicles per day and the road is classified for access to resources. The level of service corresponds to a roadway on hardened snow.

8.7.16 Maintenance work

Maintenance work on the access roads must be carried out to ensure the safety of road users as well as the sustainability of the infrastructure.

The following table presents an overview of the interventions that take place annually, according to needs.

Table 8.7–10: Maintenance work

Description	Calendar
Maintenance of small roadside signage	Operation that takes place throughout the year
Longitudinal pavement marking maintenance	This operation is generally carried out between mid-April and the end of October.
Maintenance of semi-rigid guard rails	This operation is generally carried out between the months of May and November.
Sweeping and picking up debris from traffic lanes	The collection operation is carried out throughout the year and the sweeping operation in the spring, summer and as needed.
Shaping of shoulders in granular materials	Operation that is generally carried out outside the freezing and thawing periods.
Patching or resurfacing of shoulders with granular materials	Operation that is generally carried out outside the freezing and thawing periods.
Foundation maintenance	Operation that is generally carried out outside the freezing and thawing periods.
Manual road patching with asphalt	Operation that is carried out all year round.
Mechanized patching of pavements with asphalt	Operation that is generally carried out between the end of the thaw period and the time when conditions no longer allow it.
Crack sealing in flexible and mixed pavements	Operation that is generally carried out between the end of the thaw period and October 15.
Cleaning and digging of side ditches and culvert discharges	The cleaning and digging of side ditches and culvert discharges is generally carried out between the end of the thaw period and the time when conditions no longer permit it.
Maintenance of erosion protection of ditches and ponds	Operation which is generally carried out outside the freezing period.
Culvert cleaning	Culvert cleaning is generally carried out outside of the frost period.
Culvert repair	Culvert repairs are generally carried out outside of the frost period.
Clearing, felling and pruning of trees	Brush clearing is usually done in August and September.

8.7.17 Integration of Cree Perspective and Knowledge

The principal community concerns raised by stakeholders and proposed solutions are tabulated below.

Table 8.7–11: Issues raised and proposed solutions

Issues raised	Suggested solutions
Roadway too narrow when passing vehicles	Revision of the cross-section of the road
Narrow and unstable shoulders	
Difficulty parking on the side of the road	Development of access, parking areas and turning areas along the road corridor
Road too narrow near communities and used by pedestrians and hunters	Development of multipurpose trails near communities
Lack of signage (numbers of traplines, camps, moose, etc.)	Complete overhaul of signage
Various overflowing culverts and presence of beavers	Replacement of culverts and installation of beaver barriers
Dangerous curves and slopes	Dangerous curves and slopes will be improved, addition of danger signage
Rock near the roadway	The rock located inside the lateral clearance of users will be excavated.
Loss of visibility due to roadside vegetation	Roadside vegetation trimming
Roadway erosion	Stone embankment stabilization
Dust	Asphalt pavement surfacing

8.7.18 Public services

The roads are crossed by Hydro-Québec transmission and distribution lines. Due to the proposed improvements, the roadway will be lifted. Consequently, the vertical clearances under the power line conductors need to be validated to ensure that Hydro-Québec standards are met in this regard. Table 8.7–12 details the number of overhead line crossings for the different roads.

Table 8.7–12: Power Line Crossings

Access Road	Number of Crossings of Hydro-Québec Lines
Wemindji	0
Eastmain	12
Waskaganish	2
Route du Nord et Nemaska	39
Total	**53**

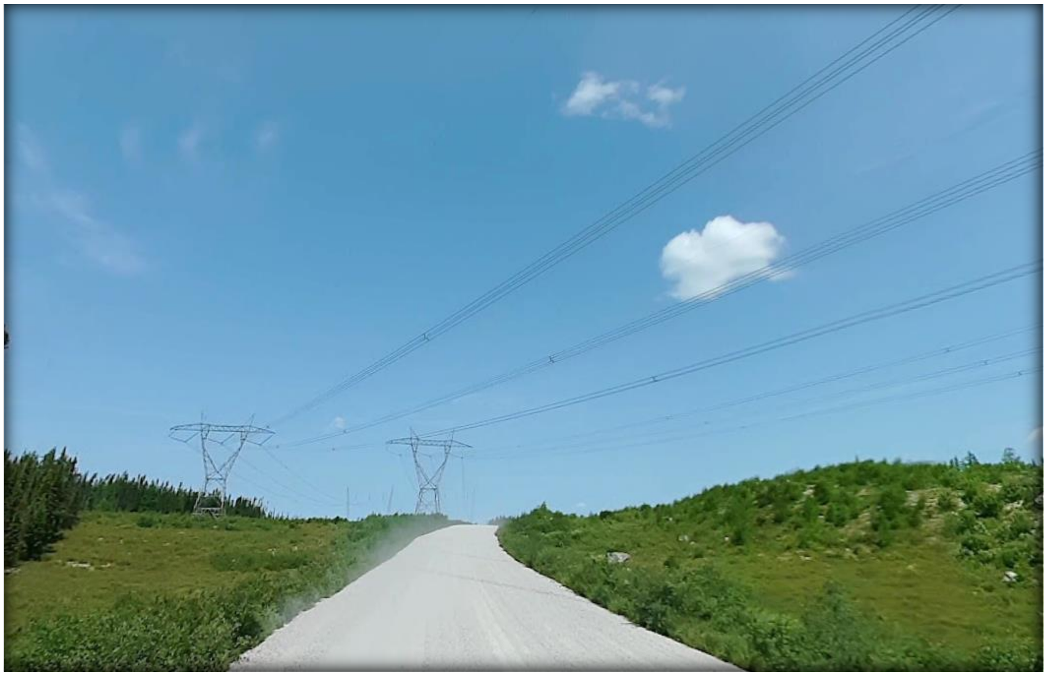


Figure 8.7-15: High voltage line on Route du Nord

Additionally, some sections of these roads have underground fiber optic cables. Cable locations need to be validated for each section of road, to ensure that they are protected during culvert replacement work.

8.7.19 Work and Cost Estimate

To improve the safety and condition of the existing roads, several interventions are recommended. The following list presents the main roadway corrective works:

- Corrections of horizontal and vertical curves.
- Trimming of roadside vegetation.
- Ditch cleaning.
- Decontamination of the existing road.
- Granular resurfacing with MG 20.
- Pavement ESG 14.
- Development of multifunctional trails near communities.
- Replacement of culverts.
- Improving pavement markings and signage.
- Development and replacement of crash barriers.
- Landscaping.
- Environmental protection measures.

The following table presents a summary of the work costs for each of the access roads.

Table 8.7–13: Cost estimate

Description	Route du Nord	Wemindji	Eastmain	Waskaganish	Nemaska	Total
Site organization	116.60	26.96	26.65	29.53	5.00	204.73
Earthwork	37.66	8.69	8.39	11.52	0.94	67.19
Pavement and surfacing	313.62	58.29	59.07	68.26	6.57	505.80
Drainage	70.02	13.88	10.33	14.79	1.14	110.16
Signage	3.36	0.79	0.85	0.62	0.09	5.71
Various works	26.43	4.37	4.03	5.68	0.54	41.05
Landscaping	0.24	0.12	0.12	0.12	-	0.60
Environmental protection	1.60	0.28	0.33	0.28	0.07	2.56
Administration and profits (15%)	85.43	17.01	16.47	19.62	2.15	140.67
Total (M$)	654.98	130.37	126.23	150.42	16.49	1,078.49

The detailed estimate of the cost of road works for the access roads is presented in the appendix 6.19 to this report.

8.8 MISTISSINI SECONDARY ACCESS ROAD – TECHNICAL ASPECTS

The community of Mistissini has voiced their need for a second access road du ime to safety issues, such as an infrastructure failure or a natural disaster on the current single access road. The Grande Alliance included the identification and cost estimate for the establishment of this second access road in Vision Eeyou Istchee mandate.

8.8.1 Background Research

In order to carry out the work concerning the various technical aspects of the implementation of a second access road to the community of Mistissini and to carry out an analysis that is as accurate as possible, we recovered all the information that was available and that could be of interest in the analysis to be carried out. In particular, we retrieved the data made available by the various government agencies concerning the territory. In order to make a precise planning of the route, we also acquired aerial photographs of the territory in order to make a three-dimensional analysis.

8.8.2 Data Retrieved through the Various Ministers

LIDAR digital terrain model

The Gouvernement du Québec, through the Ministère des Ressources Naturelles et des Forêts (MRNF), has captured this data by LIDAR on a province-wide scale. Since the Mistissini sector is included in this data, we used it as an input in the planning and evaluation of the technical feasibility of the implementation of a second access road to Mistissini. The digital terrain model produced has a resolution of 1 m, which is more than sufficient for our work. This data is disseminated by map sheets at a 1:20,000 scale in the NAD83 CSRS MTM geodesic reference system and its height reference system is CGVD28 (hybrid model HTv2.0 1997).

Surface Deposit Layer

We first used the surface deposit layers published by the MRNF, which were interpreted as part of the ecoforestry photo interpretation and validated by the ecoforestry inventory direction. This information, which is already available, will serve as a basis for more precise soil identification.

Wetland Layer

We used the cartography of potential wetlands in Quebec (CMHPQ) 2019 published by the *Direction de la connaissance écologique* to be able to evaluate the environmental impact of the road construction and specially to compare the alignments according to this criterion, that is to say to compare the impact of one alignment versus another. This layer is available via the free data published by the Ministère de l'Environnement, de la Lutte contre les Changements climatiques, Faune et Parcs.

Boundaries of Parks and Biological Refuges

We used the park and biological refuge layers to verify their location to avoid creating new roads in parks and to respect biological refuges during the planning. The layers were again retrieved from the free data site of the MRNF. The limits of the structured wildlife territories appear on the different maps presented. It is unavoidable to cross a wildlife reserve to reach the northern road. As for the biological refuges, no particular constraint has been observed.

Existing Road Network

The territory under study is covered by a network of forest roads that are more or less practicable depending on their class and current condition. We obtained a portrait of these roads via the AQ Réseau + database. This database provides information on the type of road and the organization responsible for its management. The information is presented in the map of existing roads in Appendix 6.22 and allows us to see that, with respect to the boundaries of Category 1 lands in the community of Mistissini, the territory is covered by 155 km of forestry roads divided into different classes. This distribution is presented in Table 8.8–1 below.

Table 8.8–1: Road Lengths per Class on Category 1 Lands

Categories	Length (km)	Proportion (%)
Class 02	11	7,1%
Class 03	14	8,9%
Class 04	13	8,2%
Winter roads	40	26,0%
Unknown	77	49,8%
Total	**155**	**100,0%**

Aerial photos

The aerial photos acquired are infrared photos from 2012 and 2013. They were acquired with the orientation parameters required to allow the interpretation of the territory in three dimensions. They were acquired on the Geoselec site which is a partner of the Gouvernement du Québec in the distribution of their aerial images. These photos were initially acquired through the MRNF's ecoforestry mapping program. They were the most recent available at the time of the study. Map 2 in appendix 6.23 presents the photos acquired for the study.

8.8.3 Data from the Ministère des Transports Regarding Traffic on the Territory

On the free data site of the Ministère des Transports, it is possible to consult the traffic flows for specific roads. We were able to retrieve 2020 traffic data for a portion of the Route du Nord, from Route 167 to the intersection of the existing access road to the community of Mistissini and the beginning of the existing access road to Mistissini. The data recovered is presented in Table 8.8–2 below. We were surprised to find that the traffic flow of the Mistissini community access road is higher than that of Route 167 and the Route du Nord. This leads us to believe that there is an error in the published data for the Mistissini access road. Based on the data presented in the Table 8.8–2, we believe it is fair to hypothesize that the second Mistissini access road may have an average daily traffic flow of less than 100, and therefore a relatively low traffic flow.

Table 8.8–2: Average Daily Traffic on Existing Roads Around Mistissini

Roads	AADT
Route du Nord	250
Route 167	70
Mistissini Road	1120

*AADT: Annual average daily traffic

Figure 8.8-1: Interactive Map Excerpt Showing Traffic Flows

8.8.4 Published Documents Considered in the Study

In carrying out the study, we also considered the guidelines set out in "ON THE ROAD NETWORK" prepared by the Eeyou Planning Commission. The main guidelines that we retained for the technical component are as follows:

- Prioritize the use of existing forestry roads before building new ones.
- Taking account, the safety of all users in the design parameter (avoid blind hills, dangerous curves, narrow road).

- The road design should consider the cohabitation of heavy trucks with smaller vehicles and recreational vehicles like ATVs and snowmobile.

We also considered the "Sustainable Snowmobile Circuits" study (see Appendix 6.17) on the implementation of a 150 km snowmobile circuit that would link the communities of Oujé-Bougoumou, Mistissini, Waswanipi and the town of Chibougamau. The trail network suggested in this study proposes a trail in the study area for a second access road to Mistissini. The snowmobile trail alignment concerned is presented in the following Figure 8.8-2.

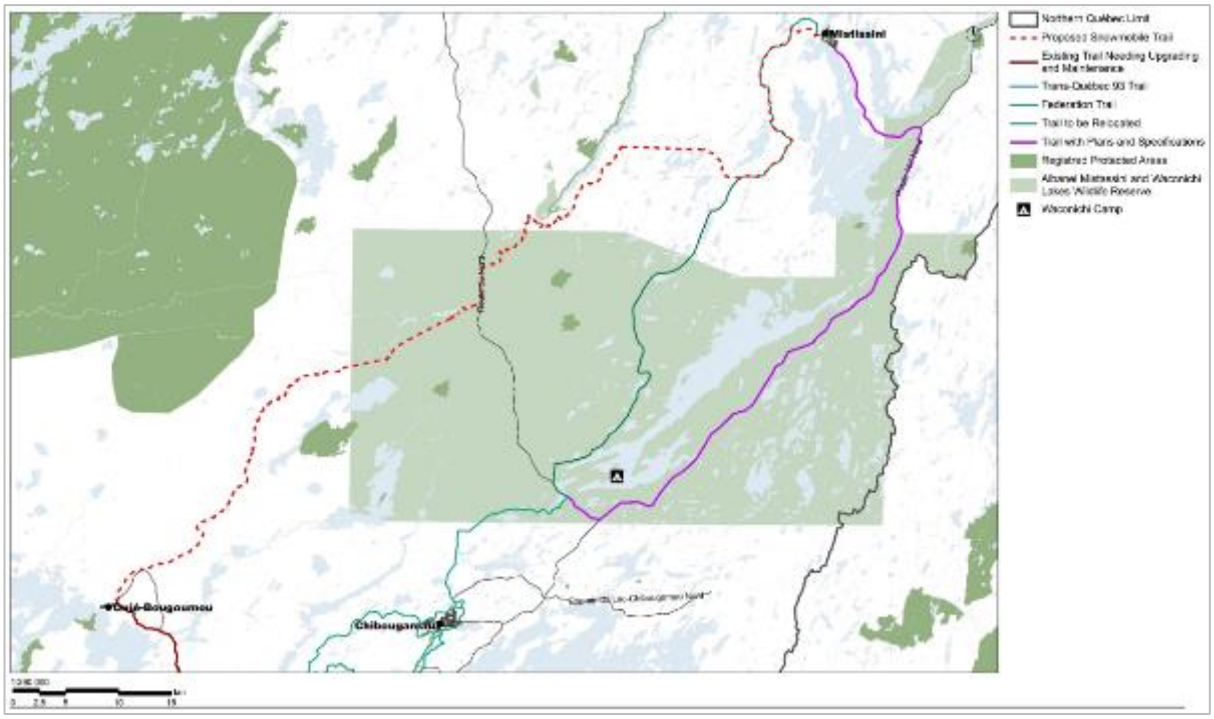


Figure 8.8-2: Map of the Sustainable Snowmobile Circuits

8.8.5 Inputs and Design Recommendation

The design parameters that have been used are similar to those for the other community access roads, i.e., the modified Type E, to have a running surface of 7 m instead of 6 m (see original type E in Appendix 6.17). However, since there is forestry activity on the Mistissini territory and particularly in the sector studied, we suggest considering a standard road section that is 2 m wider than the road section used in the rest of the La Grande Alliance study, but unpaved. This proposed cross-section is based on a Class 1 road according to the RADF (see Figure 8.8-3**Erreur ! Source du renvoi introuvable.**) and the typical cross-section is shown in Appendix 6.17. The MRNF is the organization responsible for the majority of the existing roads in the study area. This proposal meets the local communities' desire to have wider roads for safety. Being unpaved allows for forestry activity without the pavement being damaged by oversized trucks. Until comments are received from the community on this proposal, the parameters initially proposed in the Grande Alliance will be used in the design and for the cost estimated.

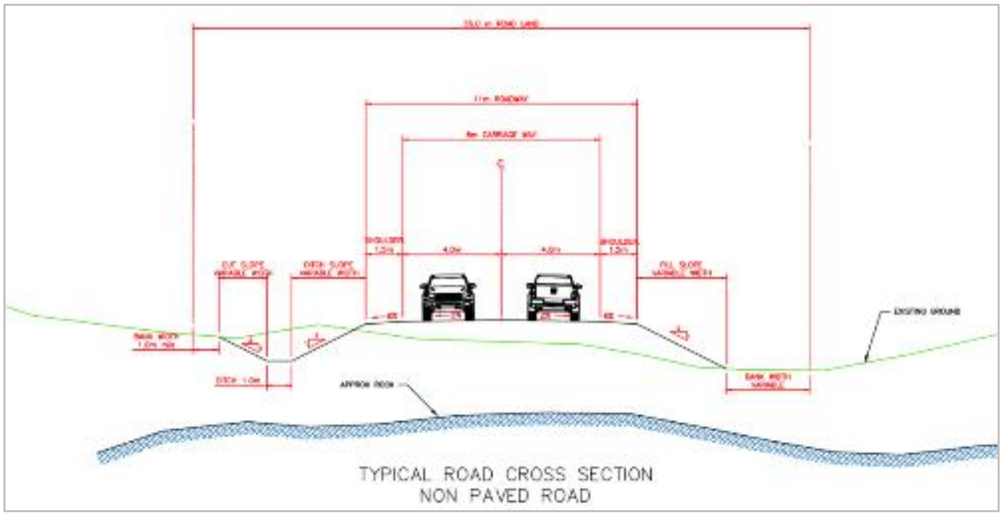


Figure 8.8-3: Suggested Mistissini Road Section

Table 8.8–3: Design criteria

Design criteria	Original design	Proposed design
Design speed (km/h)	70	70
Lane width (m)	**3.50**	**4.00**
Shoulder width(m)	1.0	1.5
Ditch width (m)	1.0	1.0
Cross section minimum slope 2nd class and (Rock)	2H:1V (1H: 10V for Rock)	2H:1V (1H: 10V for Rock)
Minimum horizontal curve radius (m)	255	255
Minimum K factor for crest	26	26
Minimum K factor for sag	30	30
Maximum slope %	10	10
Rolling surface	**Asphalt**	**MG-20**

8.8.6 Photo-interpretation

Photo-interpretation allowed us to establish the routes according to different criteria such as surface deposits, wetlands and slopes. This work allowed us to validate, on the one hand, if the reuse of existing roads was possible to transform it into a higher-class road requiring combinations of less pronounced slopes and curves. On the other hand, this work was necessary to establish the best corridor for the new portions of the path.

In a second step, photo-interpretation allowed us to correlate and validate the surface deposits to take into account the possible superposition of deposit layers and to assign a larger dimension to the potential depth of the unconsolidated deposits that could be used for construction. The results can be viewed on the map in Appendix 6.23.

Finally, the photo-interpretation allowed us to target potential borrow sites. To this end, we targeted two types of borrow sites, namely gravel pits/sand pits to obtain MG-112 and other granular materials as well as quarry sites for the production of various aggregates such as MG-20, MG-56 and aggregates required for paving. The results can also be seen on the deposits map in Appendix 6.23 and the location of sites in the following Table 8.8–4.

Table 8.8–4: Location of Borrow Sites

Section	Type
13+000	Quarry
15+000	Gravel pit/Sand pit
20+000	Gravel pit/Sand pit
29+500	Quarry
39+000 à 41+000	Gravel pit/Sand pit
43+500	Gravel pit/Sand pit

8.8.7 Alignments

With all the data that was available, two route options were established with two variants. The proposed routes connect the community of Mistissini to km 32.5 of the Route du Nord. The following Figure 8.8-4 presents the routes and locates them in the region. This information is also available on the map "Route Locations" in Appendix 6.17.

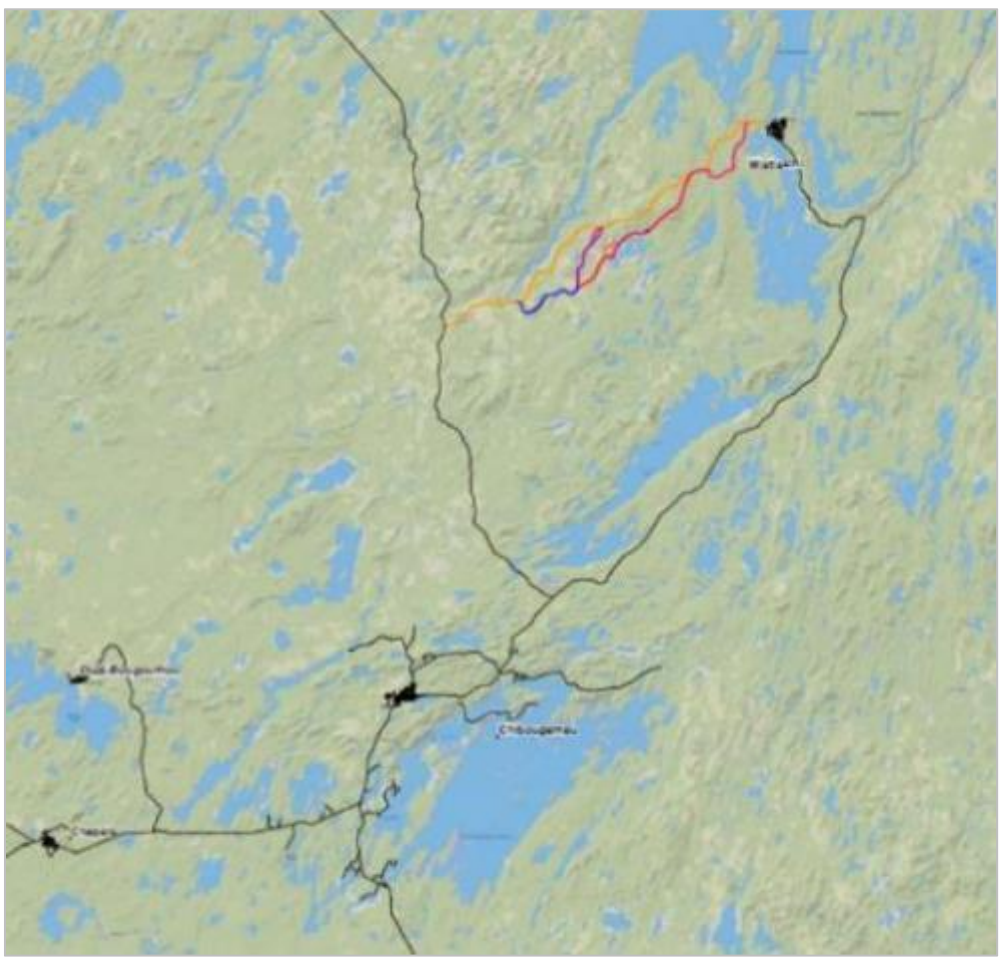


Figure 8.8-4: Location of Proposed Options

The proposed corridors were initially chosen with the strategy of reusing existing road corridors as much as was reasonably possible due to concerns about further dividing the territory raised by the Eeyou Planning Commission. Subsequently, the physical aspects of the environment such as surface deposits, wetlands and watercourses were used to determine the final selection of routes.

The two proposed alignments, without taking into account the variants, totalled 42.3 km for Option 1, and 45.0 km for Option 2. Option 1 uses approximately 14.2 km of existing road corridors, and Option 2 uses 25.8 km. The characteristics of the alignments are presented in Table 8.8–5 below.

8.8.7.1 Length

The road total length criterion is only used to compare the corridor possible total lengths. Length is an important parameter, and the shortest corridor possible should be chosen when considering construction costs and maintenance costs. Option 1 below totalizes 42+258 m compared to 45+029m for Option 2. Option 1 is the shortest.

Option 1 - 42+258m	**Option 2 - 45+029 m**

8.8.7.2 Length in existing corridors

One of the preoccupations mentioned by the client was to avoid creating new road corridors and favour existing corridors. To this effect, the two proposed options are based on the use of the existing corridor. Option 1 uses 14+208m of the existing corridor and Option 2, 25+820m.

Use of existing corridor criteria:

Option 1 - 14+208m	**Option 2 - 25+820m**

The type of deposits is an important element to consider since the construction cost can be affected by the nature of the surface deposits. We therefore defined 3 classes of deposits: very good, good and restrictive.

8.8.7.3 Very good deposits

Very good surface deposits are those with a good borrow pit potential for road construction, such as glaciofluvial, drumlinized and drumlinoids as well as existing gravel pits. These deposit types will lower the costs, increase their quality and reduce the environmental impacts. Option 1 includes 22+081m of these deposit types and Option 2 has 14+170m.

8.8.7.4 Good deposits

Good surface deposits are made of till and sand, and they can include some loam. Option 1 includes 15+041m of these deposit types and Option 2 has 23+929.

8.8.7.5 Restrictive deposits

Restrictive surface deposits are those that present constraints to road construction, including technical and environmental constraints. For example: thin and very thin till deposits, rock and organic deposits. Option 1 includes 5+136m of these deposit types and Option 2 has 6+930m.

Option 1 – Quality of deposits - Better	**Option 2 – Quality of deposits - Good**

8.8.7.6 *Water Course Crossings*

The amount of water course crossings is divided in two categories: intermittent streams and permanent streams. Permanent water courses include a subclass of very wide courses, which will require important crossing structure. Option 2 has 11 fewer streams than Option 1.

Option 1 – More	**Option 2 - Less**

8.8.7.7 *Potential Wetland*

Potential wetlands are environments where road shouldn't be built because of the complexity of the construction parameters and environmental constraints. These wetlands were, however, identified as "potential," and the information will therefore need to be validated on site. Option 2 has fewer wetlands than Option 1. However, the quantities are similar so both options are on the same level.

Option 1 – 5+393m	**Option 2 – 4+855m**

8.8.7.8 *Recreation and Touristic Conflict*

In parallel with our study, the « Sustainable Snowmobile Circuit Report » study on the future snowmobile trail between Mistissini and Oujé-Bougoumou was done by BC2. Both options are located in the same corridor as the snowmobile trail. This issue will need to be taken into account for the land harmonization measures. Proportions are as follows.

Option 1 – 18+046m	**Option 2 – 3+849m**

Looking at the overall characteristics of the two scenarios analyzed in the following matrix, Option 2 has a greater number of characteristics favourable to the establishment of a second access road.

Table 8.8–5: Characteristics of Proposed Routes

Criteria	Option 1	Option 2
Total length	42.3 km	45.0 km
Length in existing corridor	14.2 km	25.8 km
Deposit quality	Better	Good
Number of streams crossing	More	Less
Length in potential wetland	5.4 km	4.9 km
Possible recreational conflict	18.1 km	3.8 km

8.8.8 Preliminary Road Construction Design

The two alignments and their variants were presented in the community during a workshop and the people met were in favour of option 2.

The Option 2 alignment has been optimized and a preliminary road design completed on the sections of roads to be built to provide a cost estimate. The optimized Alignment 2 uses 29 km of existing road corridor and 12 km of new roads and 4.5 km of road that has already been built. The location of the different sections can be visualized on the typical map of works according to the option chosen in Appendix 6.17. The sections to be built are located between kilometres 27+000 to 35+000 and 37+000 to 41+000, and we made preliminary plans and profiles to ensure the technical feasibility and to estimate the construction costs. A total of 31 stream crossing culverts were identified. These are new culverts or existing culverts that will need to be replaced. The preliminary plans and profiles of the new sections to be built can be consulted in Appendix 6.17.

8.8.9 Water Crossings and Drainage

The location of water crossings can be separated into two categories: on the one hand, there are existing water crossings on existing road sections that will need to be upgraded. There are also new stream crossings to be installed on new road sections (Flow calculations were performed in order to have a relatively accurate picture of the culverts to be installed in the selected option 2. The results of the calculations can be found in Appendix 6.17. The calculated diameters are presented in the column "Diameter". It should be noted that no bank surveys were conducted to confirm the accuracy of the dimensions. This sizing will be used for construction estimation purposes only. Field surveys will be required to validate these assumptions in future studies. The installation slopes were also estimated, but not validated. This estimate allowed us to assess a proportion of culverts requiring weirs to maintain free fish passage. The estimated length of culverts was estimated from the preliminary plans and profiles.

Table 8.8–6: Existing Culverts to Be Replaced and Prescribed Diameter

KM Location	Name	Diameter (mm)	Details	Length (m)
0+375	MISS001	800		27
4+809	MISS002	2400		30
6+150	MISS030	800		24
10+471	MISS003	1400	weirs	51
13+207	MISS004	1400		30
13+823	MISS005	1200	weirs	30
14+698	MISS006	800		18
15+284	MISS007	1400		39
15+677	MISS008	1400	weirs	21
16+599	MISS009	1000		18
17+097	MISS010	1000		21
18+012	MISS031	800		15
20+241	MISS011	800		21
20+665	MISS012	1400	weirs	21
22+132	MISS013	1400		18
24+101	MISS014	1400	weirs	15
24+287	MISS015	800		18
26+000	MISS016	NA	Bridge 20 m	20
35+636	MISS022	1800	weirs	36
36+245	MISS023	800		18
36+550	MISS024	2x2400		27

KM Location	Name	Diameter (mm)	Details	Length (m)
36+874	MISS025	1400	weirs	54

Table 8.8–7: New Culverts to Be Installed

KM Location	Name	Diameter (mm)	Details	Length (m)
28+848	MISS017	800		18
29+218	MISS018	1200	weirs	30
31+063	MISS019	800		33
33+708	MISS020	1600		45
34+518	MISS021	1600		27
38+111	MISS026	800		21

In addition to watercourses, it is our duty to ensure that we maintain adequate drainage of the infrastructure and therefore provide the necessary drainage culverts. Without doing a design to position each drainage to calculate the number and length required, we estimated a minimum number per km of road. The goal was to have the amounts planned for the cost estimate. We therefore estimated 3 drainage culverts per km of road, for both the sections under rehabilitation and the sections under construction, resulting in a total of 123 drainage culverts being deemed necessary, 87 for the sections under rehabilitation and 36 for the new sections of road. For the length, we estimated that the drainage culverts should vary between 12 m and 18 m.

8.8.10 Estimation of Quantities (Earthworks)

Reconstruction Sections

For the sections of road being rehabilitated, assumptions had to be made to allow us to estimate the construction costs for the 29 kilometres of roads being rehabilitated. The work takes into account the fact that it is very likely that the existing infrastructure does not meet the criteria necessary for the application of paving as a running surface. It is possible that the existing infrastructure contains organic soil and even stumps or plant debris, as this practice is common to the construction of forest harvesting roads of Class 4 and below according to the RADF. Considering that large portions of the roads being rehabilitated are on sand deposits - and for the sake of the estimation exercise - we have made the assumption that for half of the roads being rehabilitated, the subgrade will need to be excavated and replaced with MG-112. The assumptions can be found in the following Table 8.8–8.

Table 8.8–8: Assumed Works on Reconstruction Sections

Type of Works	Length
4 m brush cutting on each side of the road for visibility Grubbing (4 m-wide)	29 km
Widening on 4 m and corrections Reprofiling of ditches	14,5 km
Excavation of the infrastructure of 1 m deep and filling with MG-112	14,5 km

Sections under Construction

For the sections under construction, the preliminary plans and profiles that we produced allowed us to estimate the volumes of earthworks associated with the construction of a new access road. With the current scenario, there are two sections of road under construction: sections 27+00 to 35+000 (see Table 8.8–9 and sections 37+000 to 41+000 (Table 8.8–10).

Table 8.8–9: Earthworks Quantities - Section 27+000 à 35+000

From	To	Cutting Class 2 (m³)	Filling Class 1 (m³)	Total Cutting (m³)	Total Filling (m³)	Borrow Material (m³)
27+000	28+000	1 959	259	2 219	2 294	75
28+000	29+000	3 084	148	3 232	4 740	1 508
29+000	30+000	3 561	2 432	5 993	8 982	2 989
30+000	31+000	3 063	201	3 264	5 108	1 844
31+000	32+000	1 428	9	1 437	2 798	1 362
32+000	33+000	1 765	16	1 781	2 567	786
33+000	34+000	6 436	6 909	13 345	14 366	1 022
34+000	35+000	5 305	9 152	14 456	19 408	4 952
	Total:	**26 600**	**19 125**	**45 725**	**60 263**	**14 537**

Table 8.8–10: Earthworks Quantities - Section 37+000 à 41+000

From	To	Cutting Class 2 (m³)	Filling Class 1 (m³)	Total Cutting (m³)	Total Filling (m³)	Borrow Material (m³)
37+000	38+000	2 559	556	3 115	4 932	1 817
38+000	39+000	17 368	4 332	21 699	33 209	11 510
39+000	40+000	9 817	-	9 817	13 612	3 795
40+000	41+000	7 772	-	7 772	10 680	2 908
	Total:	**37 517**	**4 887**	**42 404**	**62 433**	**20 029**

8.8.11 Cost Estimation

Based on quantities estimate in the previous section, here is a summary of the construction costs for the second access road to Mistissini (Table 8.8–11). The detailed costs of the estimate are presented in Appendix 6.17, including direct construction costs plus the contractor's profit and administration percentage. It is important to note that the costs presented in the following section include the contractor's profit and administration but not the owner's costs. These construction costs include all materials, equipment and labour to complete the work. The costs include all existing roadway rehabilitation work required to pave the road, including excavation and replacement of existing infrastructure.

Table 8.8–11: Construction Costs

Steps	Costs
Organization	12,500,000 $
Earthwork	12,667,407 $
Roadway and paving	27,090,945 $
Culvert and drainage	2,291,340 $
Signage	502,500 $
Various works	1,110,000 $
Landscaping	100,000 $
Administration and Profits 15%	8,439,328 $
Total:	64,701,520 $

Figure 8.8-5 below shows the percentage distribution of construction costs for the second Mistissini road. It is important to pay particular attention to the proportion of the total cost allocated to the pavement, i.e., 42% in construction costs. This cost includes the granular materials of the sub-base and foundation as well as the paving.

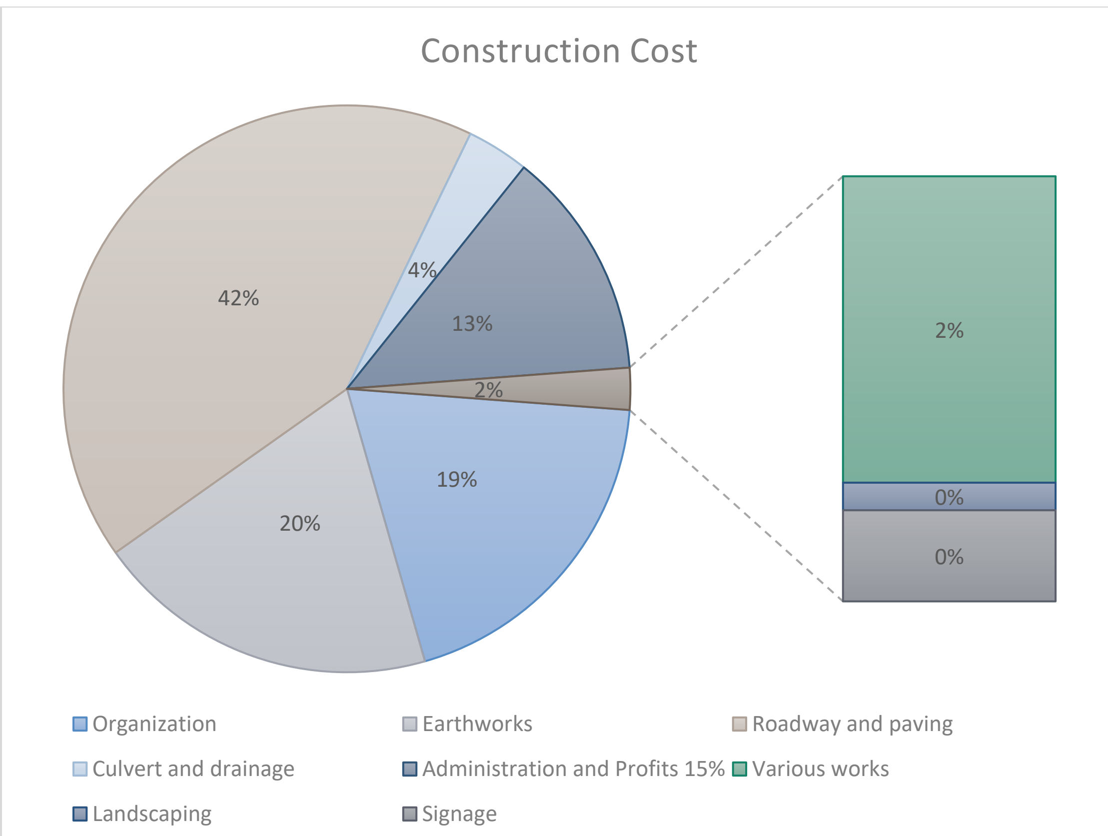


Figure 8.8-5: Distribution of Construction Costs

A closer look at the costs for the pavement and surfacing portion (see Figure 8.8-6) shows that paving accounts for a very large proportion of the roadway costs, at 64%.

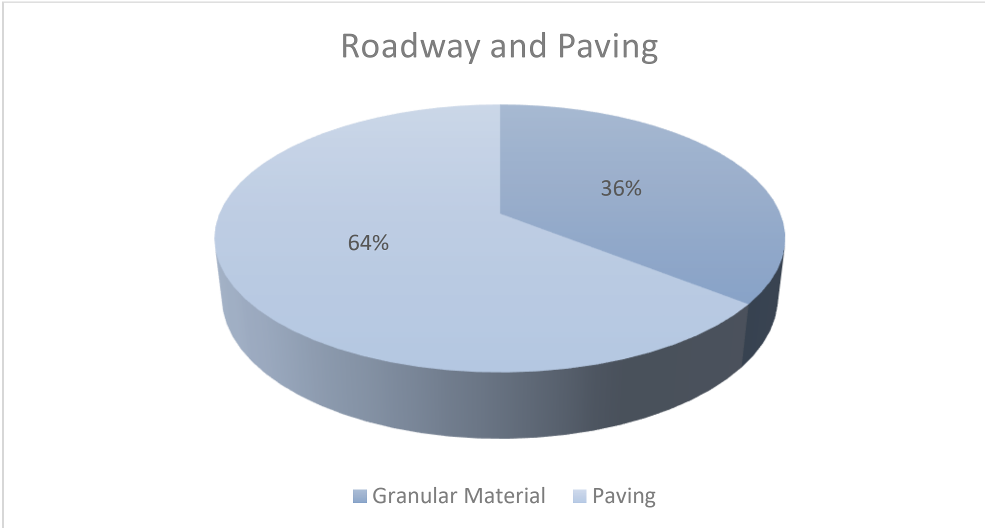


Figure 8.8-6: Distribution of Roadway Cost

8.8.12 Conclusion and Recommendations

From a technical point of view, the study shows that there are no major constraints to the establishment of a second access road to Mistissini, which would connect the community directly to the Route du Nord. The road would be approximately 45 km long. The territory already has several forestry roads that have allowed for the exploitation of certain volumes of wood on the territory. This fact also proves that there are no major constraints to the establishment of an access road in this sector. It is also possible to reuse some of the existing roads and upgrade them so as not to further fracture the territory. To build this second access road, including paving, the cost of the work including administration and profits is estimated at $64.7 millions.

We recommend that the community reflect on the real need to apply asphalt on this road as a running surface. On the one hand, the cost of paving is to be considered given the average daily traffic flow which will probably be below 100. We must also take into account the presence of the forestry industry on the territory, the Eenatuk Forestry Corporation holding a wood harvesting permit for the purpose of supplying a wood processing plant (PRAU) of approximately 125,000 m^3 annually. The weight of the trucks used by the forest industry could prematurely degrade this pavement layer. The costs that could be saved by choosing an unpaved road are in the order of nearly $20 million in direct costs.

8.9 Additional Technical Studies

8.9.1 CN Track Assessment and Estimate of Rehabilitation Costs

8.9.1.1 Condition of Surrounding Track

In the region, the following operating sections of railway lines are present, all operated and owned by CN and all Class 2.

CN Matagami Subdivision: 25 mph, (61 miles) 98 km long

CN Chapais Subdivision: 25 mph, (92 miles) 148 km long

CN Cran Subdivision: 25 mph, (133 miles) 214 km long – excluded from the study

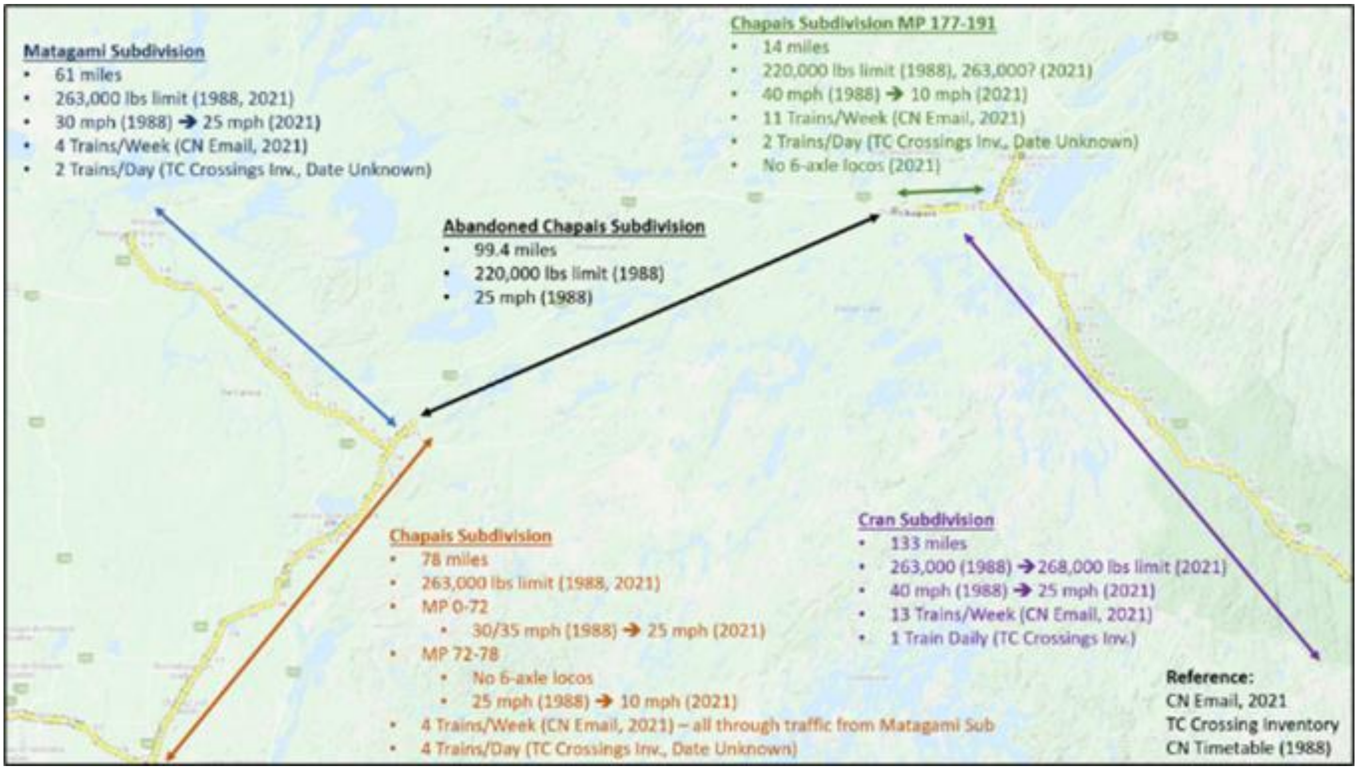


Figure 8.9-1: Overview of the CN Subdivisions

Currently, the Matagami Subdivision and the Chapais Subdivision have a 25-mph speed limit making them both Class 2.

The study team performed a desktop, high level cost estimate of what was required to bring these two subdivisions to a Class 3 level meeting Transport Canada standards to permit speeds of 40 mph so that they are in line with the speeds proposed for the BDHR and GC railways. The proposed speed increase would reduce the travel time by one to two hours in each direction for the rolling stock travelling on the two subdivisions.

Only the track on the Matagami and Chapais Subdivisions was considered for upgrading; upgrading the bridges was considered too costly so the trains would have to drop their speed to 25 mph to cross them.

Using Google imagery between Matagami and Barraute, the following railway infrastructure items were listed bellow. The lengths are approximate, they are indicated only for information purposes.

Table 8.9–1: Summary of existing infrastructures of CN subdivisions

Matagami Subdivision							
Type	**Quantity**	**River Bridge**	**Length (m)**	**Siding**	**Length (m)**	**Yard**	**Length (m)**
Turnout	28	1	45	1	825	1	1550
Bridge	7	2	40			2	5000
Crossing	13	3	45			3	3950
		4	50				
		5	60				
		6	287				
		7	47				
Chapais Subdivision							
Type	**Quantity**	**River Bridge**	**Length (m)**	**Siding**	**Length (m)**	**Yard**	**Length (m)**
Turnout	30	1	125	1	1240	1	8700
Bridge	2	2	80	2	5300		
Crossing	22						

8.9.1.2 Rehabilitation Estimate

Using parametric estimates gained from experience with track rehabilitation, the VEI team estimated the cost to upgrade the ties, rail and ballast for the existing tracks to a Class 3 estimate.

Overall, it was determined that 30% of the track would require replacement of ties, rail and ballast; this represented the sections in tangent that could permit 40 mph speeds, not in close proximity to bridges and/or in curves that would be subject to speed restrictions. The quantity of track components that could not be re-used was also accounted for.

Figure 8.9-2: Crossing on Matagami Sub (25 mph Speed Limit)

8.9.1.3 Ownership

It is important to note that in their most recent Three-Year Rail Network Plan[11] (2019), CN has indicated their plans to discontinue the operations of the Chapais and Matagami lines, due in part to the reduced traffic on the line. The presence of the lithium mines opening in the Cree territory suggests that the economics of owning and operating these lines may now be more viable. At this junction, CN's 3-year plan for 2022, has not been made public.

[11] https://www.cn.ca/-/media/Files/About-CN/Company-Information/three-year-plan-en.pdf?la=en&hash=757E78FBABC46810EDFEF99BC7ACE66BC4C17BC6

CN Three-Year Rail Network Plan

Canadian Network

Revised July 4, 2019

Province	Line	Milepost From	Milepost To	Milepost Total	Status
Quebec	Alexandria	0.00	12.00	12.00	Discontinue B
Quebec	Becancour	0.00	24.60	24.60	Retain
Quebec	Bridge	0.00	15.70	15.70	Retain
Quebec	Chapais	0.00	78.10	78.10	Discontinue
Quebec	Chapais	169.40	200.20	30.80	Retain
Quebec	Cran	0.00	133.20	133.20	Retain
Quebec	Lac St Jean	0.00	204.40	204.40	Retain
Quebec	Levis	0.00	15.00	15.00	Retain
Quebec	Matagami	0.00	61.10	61.10	Discontinue
Quebec	Matane	0.00	34.40	34.40	Retain

Figure 8.9-3: CN Three-Year Rail Network Plan

Current Train Frequencies

1. Matagami Subdivision: 2 trains daily
   a) Scheduled Monday/Thursday: L5812 (Senneterre – Matagami)
   b) Scheduled Tuesday/Friday: L5802 (Matagami – Senneterre)
2. Chapais Subdivision MP 0-72: 4 trains daily
   c) Scheduled Monday/Thursday: L5812 (Senneterre – Matagami)
   d) Scheduled Tuesday/Friday: L5802 (Matagami – Senneterre)
3. Chapais East end (Chibougamau sector):
   e) Schedule Tue/Thur/Sun: L5622 (Chambord – Chibougamau)
   f) Scheduled Mon/Wed/Fri: L5632 (Chibougamau – Chambord)
   g) Scheduled Mon/Tue/Wed/Thu/Fri: L5682 (Chibougamau – Chapais – Chibougamau)
4. Cran subdivision: 1 train daily
   h) Scheduled Tue/Thur/Sun: L5622 (Chambord – Chibougamau)
   i) Scheduled Mon/Wed/Fri: L5632 (Chibougamau – Chambord)
   j) Scheduled 7days: L5312 (Chambord – Dolbeau - La Dore – Chambord)

8.9.1.4 Rehabilitation Estimate

Using parametric estimates gained from experience with track rehabilitation, the VEI team estimated the cost to upgrade the ties, rail and ballast for the existing tracks to a Class 3 estimate. The results are below.

Table 8.9–2: Cost Summary

Description	Chapais Sub	Matagami Sub	Total
L (km) - Total length	125.5	98	
30% of L - Assumption	37.65	29.4	
Cost based on $ 2.0 M/km	$ 75.3M	$58.8M	$134.1M

The above estimate will be used as a risk/opportunity in the financial analysis since the expenditure is not a requirement to permit the proposed operations but may be advantageous should the decrease in travel time provide a better overall performance.

8.9.2 Battery and Electric Train Propulsion Technologies Study

The purpose of the study was to provide a discussion and validation of the feasibility of using alternative train propulsion modes for Phase 1 of the BDHR, with the aim of reducing the lifecycle greenhouse gas emissions of the proposed project. This will include the study of:

- Battery-powered trains;
- Electric trains powered by overhead catenary;
- Hybrid trains, which will include a combination of battery and diesel propulsion.

This section of the final technical report for Phase 1 provides an overview of the alternative propulsion technologies considered, as well as a discussion of the results. The technical details of a traditional electrified railway and the state of advancement of battery technologies as applicable to railway propulsion are addressed in detail in the full Battery and Electric Train Propulsion report in Appendix 6.15.

Rail transport accounts for approximately 1% of the total transportation emissions in the world. Recent developments in railway rolling stock have shown numerous applications of so-called “zero or low emission trains” relying on innovative technologies. While so far these have been mainly limited to urban transit, alternative propulsion modes are starting to emerge as a promising way to sustain growth in conventional rail transportation as well.

Although there are not a lot of technical obstacles for electrifying a railway line with catenary infrastructure, the associated construction cost can be significant. It is also important to consider how the energy is supplied as methods for electricity production can vary considerably from one country to the next, or even within the same country. In the European Union (EU), approximately 60% of the railway network is electrified and carries approximately 80% of all railway traffic in this region. At the same time, all current railway freight operations in North America are using diesel-based propulsion.

In recent developments, some American Class 1 railways have begun testing alternative technologies with the aim of minimizing or eliminating diesel-based propulsion altogether. Battery-powered trains are the latest evolution of electric trains, with an onboard energy storage allowing them to run where there is no catenary. This technology aims to employ the advantages of electric trains without the high cost of electrifying a railway line.

While the technology is still in early development, there are multiple battery-electric locomotives currently being developed and tested for North American use. Some examples are the “FLXdrive” being developed by Wabtec, and the EMD Joule developed by Progress Rail. Some of the major railways around the world have already placed orders for such locomotives or are even already testing them in operation – Roy Hill, Canadian National, Rio Tinto, BHP, Union Pacific, Vale and FMG.

8.9.2.1 Challenges

Battery technologies still have many limitations which means that they are not yet suitable for all types of railway operations. The following challenges related to using both battery-powered and catenary locomotives should be taken into consideration when implementing this technology:

- One of the main issues related to implementing catenary locomotives for the proposed project is that there are currently no electric freight locomotives being manufactured and sold in North America and importing locomotives from outside the continent poses significant challenges due to the mismatch in locomotive standards.
- The cost of building the infrastructure for full catenary-electrification is significant.
- The local climate of the proposed project involves harsh winter months when the low temperatures will have a significant negative impact on the ability of the batteries to provide the necessary tractive energy.
- Due to the significant distance that trains cover between the terminals of Matagami and Waskaganish, battery tenders may be required to supplement the onboard batteries of the locomotives and provide sufficient energy for the trip.
- To limit battery wear and the impact on the available battery capacity, battery-powered locomotives may need to be parked inside the maintenance shops during the cold winter nights.
- Fast charging the batteries will increase the rate of wear and reduce their lifespan, and thus should be kept to a minimum. In addition, if fast charging is used, the batteries cannot be charged above 95%.
- To limit battery wear and ensure that batteries reach their full lifespan, these should not be discharged below 20%, as this reduces the usable battery charge of the trains.
- It is well understood with the current state of technology that battery capacity will reduce over time due to wear. This effect is estimated to amount to about a 25% loss of charge over a period of 10 years. This loss was considered in the present analysis to ensure that, even with only 75% of its charge available, trains will be able to complete their trip.
- Considering the significant time, it may take to recharge the batteries, this may result in a need for multiple charging stations at each terminal to recharge the locomotives in parallel.

8.9.2.2 Analysis and Results

The following scenarios were studied:

- Alternative A: Full railway electrification with catenary-electric locomotives;
- Alternative B: Battery-powered trains:
  - Scenario B1: Charging the locomotives at Waskaganish and Matagami;
  - Scenario B2: Charging the locomotives at Waskaganish, Matagami and recharging at a boost station at the midway point (KP 118);
  - Scenario B3: Charging the locomotives at Waskaganish and Matagami, and swapping the battery tenders at the midway point (KP 118);
  - Scenario B4: Running a hybrid train with two diesel and one battery locomotive and recharging the locomotive at Waskaganish and Matagami.

Energy modelling was carried out using static calculations to determine the battery capacity requirements and the impact of the time required for recharging battery locomotives. These calculations were based on the results from simulations carried out with the Train Performance Calculator and took the challenges described above into account. At the core of this analysis is estimating the energy required for traction versus the energy capacity of the batteries.

To provide robustness to the results additional energy calculations were carried out for the worst-case scenario, which considers a reduced battery capacity due the cold weather conditions and battery wear.

The table below provides a summary of rolling stock requirements for all battery scenarios.

Table 8.9–3: Summary of the Rolling Stock Requirements for Each Scenario

Scenario	Type	SD70 / Passenger loco (Diesel locomotive)	Option 1		Option 2		Option 3	
			Wabtec FLXdrive		Progress Rail Battery Loco Type 1		Progress Rail Battery Loco Type 2	
			Locomotives	Battery tenders	Locomotives	Battery tenders	Locomotives	Battery tenders
B1 (Charging at terminals)	In-operation	0	Not applicable, as the Wabtec FLXdrive was not designed to operate without the assistance of diesel locomotives.		2	8	2	6
	Spare	0			1	1	1	1
	Total	**0**			**3**	**9**	**3**	**7**
B2 (Charge at Boost Station)	In-operation	0			2	3	2	1
	Spare	0			1	1	1	1
	Total	**0**			**3**	**4**	**3**	**2**
B3 (Swap battery tenders)	In-operation	0			2	8	2	6
	Spare	0			1	1	1	1
	Total	**0**			**3**	**9**	**3**	**7**
B4 (Hybrid)	In-operation	2	1	0	1	0	1	0
	Spare	1	0	0	0	0	0	0
	Total	**1**	**1**	**0**	**1**	**0**	**1**	**0**
B1 (Passenger)	In-operation	0	Not applicable, as the Wabtec FLXdrive was not designed to operate without the assistance of diesel locomotives.		1	0	1	0
	Spare	0			0	0	0	0
	Total	**0**			**1**	**0**	**1**	**0**
B4 (Passenger)	In-operation	1	1	0	1	0	1	0
	Spare	0	0	0	0	0	0	0
	Total	**1**	**1**	**0**	**1**	**0**	**1**	**0**

Table 8.9–4 below provides a summary of the energy consumed for recharging the locomotives for each scenario. A charging-to-traction efficiency of 55% was estimated during the winter months of operations, and a corresponding efficiency of 85% was estimated for the summer months.

Table 8.9–4: Summary of the Energy Consumption for each Scenario

Scenario	Locomotive Configuration	Season	Energy consumed for charging (MWh)		Fuel Consumed (L)	
			Southbound	Northbound	Southbound	Northbound
Diesel	2 x SD70	Any	0	0	4745	2257
A (Catenary-electric)	2 x Catenary-electric Locomotives	Any	25.1	13.8	0	0
B1 (Charging at terminals)	2 x Progress Rail Battery Loco Type 1	Winter	38.8	20.7	No diesel fuel consumed.	
		Summer	25.2	13.5		
	2 x Progress Rail Battery Loco Type 2	Winter	40.5	20.5		
		Summer	26.3	13.3		
B2 (Charge at Boost Station)	2 x Progress Rail Battery Loco Type 1	Winter	37.0	17.2		
		Summer	24.1	11.2		
	2 x Progress Rail Battery Loco Type 2	Winter	38.5	16.7		
		Summer	25.0	10.8		
B3 (Swap battery tenders)	2 x Progress Rail Battery Loco Type 1	Winter	37.5	17.8		
		Summer	24.3	11.6		
	2 x Progress Rail Battery Loco Type 2	Winter	39.5	17.9		
		Summer	25.6	11.6		
B4 (Hybrid)	2 x SD70 1 x Wabtec FLXdrive	Winter	4.9	4.9	4278	1809
		Summer	3.2	3.2		
	2 x SD70 1 x Progress Rail Battery Loco Type 1	Winter	5.6	5.6	4126	1625
		Summer	3.7	3.7		
	2 x SD70 1 x Progress Rail Battery Loco Type 2	Winter	10.2	8.6	3460	1121
		Summer	6.7	5.6		
Diesel (Passenger)	1 x Passenger Locomotive	Any	0	0	469	463

Scenario	Locomotive Configuration	Season	Energy consumed for charging (MWh)		Fuel Consumed (L)	
			Southbound	Northbound	Southbound	Northbound
B1 (Passenger)	1 x Progress Rail Battery Loco Type 1	Winter	4.4	4.4	No diesel fuel consumed.	
		Summer	2.9	2.9		
	1 x Progress Rail Battery Loco Type 2	Winter	5.2	5.1		
		Summer	3.4	3.3		
B4 (Passenger)	1 x Passenger Loco (Diesel) 1 x Wabtec FLXdrive	Winter	4.4	4.4		
		Summer	2.9	2.9		
	1 x Passenger Loco (Diesel) 1 x Progress Rail Battery Loco Type 1	Winter	4.4	4.4		
		Summer	2.9	2.9		
	1 x Passenger Loco (Diesel) 1 x Progress Rail Battery Loco Type 2	Winter	5.2	5.1		
		Summer	3.4	3.3		

Table 8.9–5 provides a comparison of the infrastructure and other requirements for each scenario:

Table 8.9–5: Comparison of Infrastructure and other Requirements for Each Scenario, and the Impact on Operations

	Alternative A: Full electrification	Scenario B1: Charging at the terminals	Scenario B2: Charging at terminals and at the midway boost station	Scenario B3: Battery tender swapping	Scenario B4: Hybrid trains
Infrastructure	Requires the full electrification of the railway with catenary infrastructure, as well as the necessary electric equipment (such as substations) to deliver electric power along the line.	A battery charging station at Waskaganish (2 x 1.2 MW charging stations) A battery charging station at Matagami (3 x 1.2 MW charging stations)	A battery charging station at Waskaganish (2 x 1.2 MW charging stations) A battery charging station at Matagami (3 x 1.2 MW charging stations) A battery charging station at the halfway point (KP 118) which also includes a siding track such that the mainline can remain unobstructed during charging (3 x 1.2 MW charging stations)	A battery charging station at Waskaganish (1 x 1.2 MW charging stations) A battery charging station at Matagami (2 x 1.2 MW charging stations) A battery charging station at the halfway point (KP 118) which also includes a siding track such that the mainline can remain unobstructed during charging, as well as a backtrack to store the spare battery tender wagons. (1 x 1.2 MW charging stations)	A battery charging station at Waskaganish (1 x 1.2 MW charging stations) A battery charging station at Matagami (1 x 1.2 MW charging stations)
Rolling stock	4 catenary electric locomotives instead of the diesel locomotives	4 battery-electric locomotives instead of the diesel locomotives 9 battery tender wagons	4 battery-electric locomotives instead of the diesel locomotives 4 battery tender wagons	4 battery-electric locomotives instead of the diesel locomotives 9 battery tender wagons	2 battery-electric locomotives in addition to 4 SD70 locomotives (diesel)
Impact on operations	No impact is anticipated with the current assumptions	No impact is anticipated with the current assumptions	Will increase travel time in the southbound direction by approximately 5 hours Will require an additional crew due to the additional time required for charging before arrival at Matagami	No impact is anticipated with the current assumptions	No impact is anticipated with the current assumptions

8.9.2.3 *Investment Comparison and Discussion*

In terms of capital investment requirements, the catenary electrification scenario is the least desirable by a significant margin (see Table 8.9–6 below).

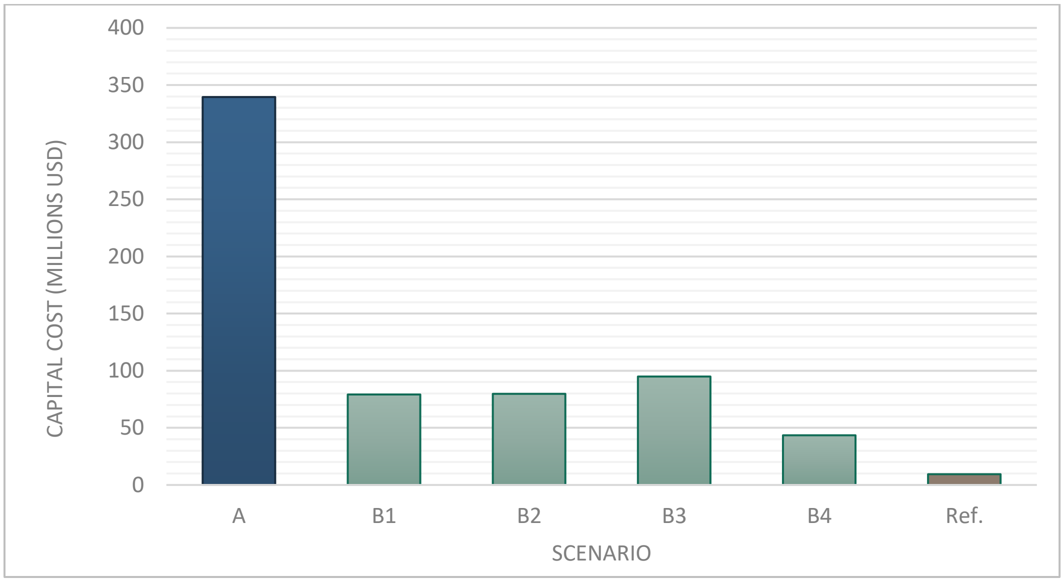


Table 8.9–6: Comparison of the Total Capital Cost of all Scenarios

When we consider the operating cost and the annualized average sustaining capital cost together, scenario B4 results in the smallest combined annual cost of all alternative propulsion modes.

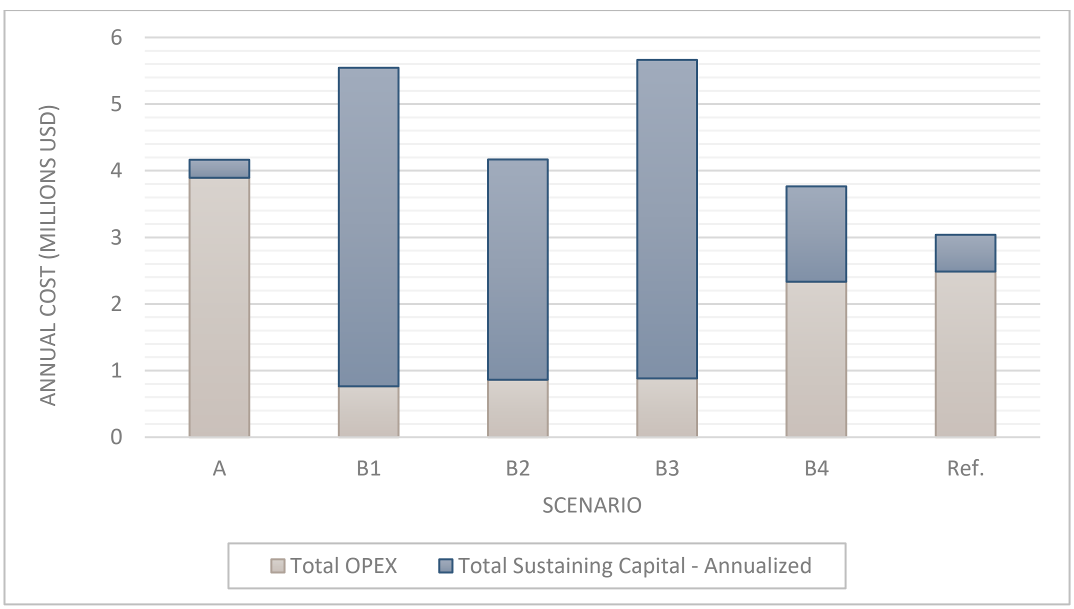


Table 8.9–7: OPEX and Sustaining Capital Comparison for All Scenarios

As shown in Table 8.9–7, all scenarios have a higher combined annual cost when compared to the reference diesel-locomotive scenario.

It’s important to consider that GHG emissions, as well as the emission of other harmful by-products by the diesel combustion engines, will be reduced significantly for all scenarios when compared to the diesel-only reference case. The table below provides a summary of the annual emission reduction for train operations for each scenario.

Table 8.9–8: Summary of the Annual Fuel and Emission Reduction

Scenario	A	B1	B2	B3	B4	Ref. Diesel
Annual diesel fuel consumption (L)	0	0	0	0	949,653	1,189,240
Annual electricity consumption (MWh)	6,576	8,418	7,740	7,872	2,030	0
Reduction in fuel consumption and emissions	100%	100%	100%	100%	20%[12]	-

Battery-powered locomotives are still in early development and testing has not yet been carried out over a long enough period such that conclusions can be drawn with respect to the reliability and suitability of this technology for railway operations. The associated risks cannot be ignored and thus a full dependence on battery locomotives for the railway operations cannot be recommended at the current time. This includes scenarios B1, B2 and B3.

Looking at the catenary-electric scenario, since there are no freight catenary-electric locomotives currently being manufactured and used in North America, there may be supply and operational risks to consider.

Considering all the challenges and risks mentioned above, the recommended approach is a staged one – where only the battery hybrid scenario B4 is implemented at an initial stage. This will make it possible to test the battery technology without having a full reliance on it. Risks will be greatly mitigated due to the redundance provided by diesel locomotives. In addition, the battery-powered locomotives will still provide a significant reduction in GHG emissions. This scenario also has the advantage of having the smallest capital cost and the lowest combined OPEX and Sustaining Capital annual costs of all alternative propulsion mode scenarios.

A feasible approach for the staged implementation can be as follows:

- **Stage 1:** Implementation of battery-hybrid operations for passenger trains only (B4 passenger + diesel freight)
- **Stage 2**: Hybrid operations for both freight and passenger operations (B4 passenger and freight)
- **Stage 3**: Incremental replacement of the diesel locomotives with battery locomotives over time
- **Stage 4**: Full transition to battery-powered trains

8.9.2.4 Recommendations

There are significant challenges and costs related to full catenary railway electrification. The quantity of traffic, which would justify the level of investment needed, can only be achieved when the proposed full project, namely Phases 1, 2 and 3, are complete. Investing in full electrification infrastructure in Phase 1 risks that technology being out of date by the time Phase 3 is completed.

Currently the advancement of battery technologies is not sufficient to provide the power needed by long distance freight trains. The recommended approach would be to initially implement a hybrid scenario – where battery

[12] The use of a Wabtec FLXdrive locomotive was considered. The emission reduction increases to 25% if the Progress Rail Type 1 battery locomotive is considered instead.

locomotives are used in combination with diesel locomotives. This would provide a significant reduction of the GHG emissions and enable operators to gain experience and test the robustness and viability of battery-powered locomotives. Over time, as the technology matures, it will be possible to transition to fully battery-powered operations.

8.9.3 Grevet-Chapais Replacement Trail Study

8.9.3.1 Grevet-Chapais Replacement Trail

The reactivation of the Grevet-Chapais rail line could create a conflict of use with the current users of the corridor, 93 km of which is currently used by snowmobile associations as a trail (see map in Appendix 6.16) and 84 km by the forest industry as a major logging road (see map in Appendix 6.16). The relocation of these two trails is an integral part of reactivating the Grevet-Chapais rail corridor, and the feasibility and the necessary costs will be estimated.

8.9.3.2 Consultation with Grevet-Chapais Users

Considering the important impact that the reopening of the Grevet Chapais railway line could have on snowmobilers and the forestry industry, we contacted them to obtain information and discuss their perceptions of the project.

8.9.3.3 Consultation with FQCM and Concerned Snowmobile Clubs

First, we had a first contact with the Chapais snowmobile club, more precisely with Mr. Martin Blanchet, President of the Club. At first, Mr. Blanchet mentioned that he was not against regional development but that the reopening of the Grevet-Chapais section would mean the loss of 70% of the Trans-Québec 93 trail between Grevet and Chapais, which he could not accept. For the Chapais Club, the development of the Grevet-Chapais rail line must take into consideration the existing infrastructure, i.e., the Trans-Québec 93 trail, and offer an alternative solution to the snowmobile industry. They mentioned that with the help of the FCMQ, they have analyzed an alternative scenario and evaluated the cost of reconstruction at $3M.

We therefore contacted Mr. Yannick Claveau, liaison agent for the Saguenay - Lac St-Jean and North Shore regions of the FCMQ, in order to learn about the assumptions that dictated this alternative scenario. Mr. Claveau sent us a map and shapefiles to explain the process. In order to do a quick exercise, they assumed that the trail could be relocated along Route 113. The details of the cost assumptions are based on their experience and were not explained to us.

We then organized a meeting by videoconference with the presidents of the Chapais and Quévillon snowmobile clubs as well as the FCMQ liaison officers of the two regions concerned. The purpose of this meeting was to understand their concerns and needs. The Quévillon club was not aware of the Chapais club's approach to propose an alternative trail and they would have liked to be informed beforehand. The Quévillon club also wants to make sure that it is part of the stakeholders in the discussions surrounding the TransQuebec 93. One of the important points raised by the Quévillon club concerning the technical aspect was the importance of keeping access to Desmaraisville as a refueling point for snowmobiles. Various technical aspects were also discussed such as the importance of not having too many curves in the development of an alternative route.

8.9.3.4 *Consultation with Barette-Chapais*

We contacted Mr. Denis Chiasson of Barette-Chapais to discuss the company's perception of the potential impacts of the Grevet-Chapais section reopening. For Barette-Chapais, this logging road is a major axis for the harvesting of wood. They have invested significant amounts of money in it, notably by adding steel-wood bridges and improving the road to maintain this road. They don't want to lose their investment and they don't want to lose this road which allows the transportation with big "planetary" off-road trucks. Barette-Chapais is not against the development, but they question the reactivation of this railroad corridor when, according to them, the railroad axis between Chapais and the Chibougamau-Chambord line needs a major repair.

Figure 8.9-4: Bridge Site and Road Pictures by VEI

These two groups of users have communicated that they have invested significant amounts of money over the last few years to ensure the sustainability of their activities. The two groups therefore consider that if the rail line is reopened, they must be compensated both in terms of maintaining their activity in the sector and in monetary terms to ensure the maintenance of comparable infrastructure. These compensations must be aimed at maintaining their activities according to the same quality and safety standards.

8.9.3.5 *Relocation Study*

It could be a challenge to accommodate the railroad, a forest road and a snowmobile trail in the same corridor, given the different physical constraints and safety issues. Table 8.9–9 below presents the length of the affected sections, the distance in conflict with the forest road and the snowmobile trail as well as the estimated relocation distance.

Table 8.9–9 : Description of Routes in Conflict

Description of Routes	Snowmobile Trail (km)	Forest Road (km)
Length of problematic Section	155	84
Distance in conflict superposition with the railroad	92	75
Distance needed to be relocated (assumption)	105 to 195	82

After discussions with the snowmobile clubs, the possibility of relocating the snowmobile trail in the Route 113 corridor seems plausible. The trail would follow the axis of Route 113, but far enough away to keep the trail in the forest, thus maintaining the recreational aspect. It would occasionally be returning close to the road to provide access for emergency interventions and user safety. However, this option is the longest and most expensive. We also evaluated the possibility of relocating the trail in the axis of the rail corridor using the existing network of forest roads and taking care not to use the same axis as for the relocation of the forest road to be relocated. The disadvantage of this option is the number of road crossings and the railroad which creates safety issues, but it has the advantage of being the least expensive and shortest.

Table 8.9–10: Snowmobile Trail Relocation works assumptions

Type of works	Grevet-Chapais Corridor	Rte 113 Corridor
Bruch clearing 2m (km)	60	0.0
Bruch clearing 10m (km)	22.5	0.0
Bruch clearing (km)	22.5	195.0
Rough formatting (km)	33.6	195.2
Seeding (km)	33.6	195.2
Culvert 450mm (unit)	10	20
Culvert 600mm (unit)	5	15
Culvert 800mm (unit)	3	10
Culvert 1000mm (unit)	2	8
Drainage 300mm (unit)	102	80
Bridges (unit)	2	6
Rail Crossing (unit)	13	2
Road Crossing (unit)	2	0

The major logging road could be relocated by using existing forest roads in the current corridor and by adding new roads sections to connect them. We used this base to estimate the distance to be relocated. This scenario needs 87 km of forest roads to be built or repaired. As was done for the snowmobile trail, the number of watercourses was evaluated by a geomatic analysis, no field survey was performed. The assumptions for the relocation of the forest road are presented in the following Table 8.9–11.

Table 8.9–11: Forest Road Relocation works assumptions

Type of works	Quantity
Clearing 35m de large (km)	40.20
Grubbing kp 6 to kp 10	46.40
Road Construction (km)	40.20
Light road repair (km)	9.50
Medium road repair (km)	23.00
Heavy road repairs (km)	14.00
Culvert 800mm (unit)	15.00
Culvert 1200mm (unit)	5.00
Culvert2000mm (unit)	5.00
Drainage 600mm (unit)	162.00
Bridges (unit)	4.00
Crossings (unit)	7.00

8.9.3.6 Cost Estimate

The costs presented in the following tables and charts are based on assumptions only. The intent is to provide a range of costs to be considered within the overall costs of reactivating the Grevet-Chapais rail line. Table 8.9–12 below presents the direct cost for the snowmobile trail and the direct cost for the forest road.

Table 8.9–12: Snowmobile and forest road relocation costs

Items	Costs
Snowmobile trail relocation cost	14,002,981 $
Forest road relocation cost	70,181,867 $

8.9.3.7 Final Recommendation

In addition to the feasibility and financial aspects of relocating the trail, we emphasize the importance of conducting more detailed consultations with the various stakeholders in the subsequent studies. The relocation of the trail may generate impacts on several industries, including outfitters and hunting and fishing activities in general. The location of future forest cut territories could also have an impact on the forest road location.

With respect to the technical aspects of relocating the forest road and the snowmobile trail, there are no major constraints. On the one hand, the relocation of the forest road along the Grevet-Chapais railway axis would have the advantage of also serving as a strategic access for the construction of the railway. For the snowmobile trail, we consider that it is possible to relocate it also along the current railroad axis and it is the most economical scenario. However, for safety reasons concerning the proximity of the railroad axis and the forest road to be relocated as well as the number of crossings that will be associated with them, it would be preferable to consider a relocation along the axis of Route 113. Subsequent consultations will allow us to obtain the perception of all the stakeholders on these issues.

As for the monetary aspects, the amounts may be surprising, but it must be considered that the relocation of the forest road avoids the need to build new roads and repair others for construction. As for the snowmobile trail, the scenario takes into account best practices and offers a high level of safety. It is also important to take the time to put these figures in perspective as they represent 8% and 2% of the overall costs of re-commissioning the Grevet-Chapais section as shown in the following Figure 8.9-5. Subsequent studies will also provide a more accurate picture of the real costs.

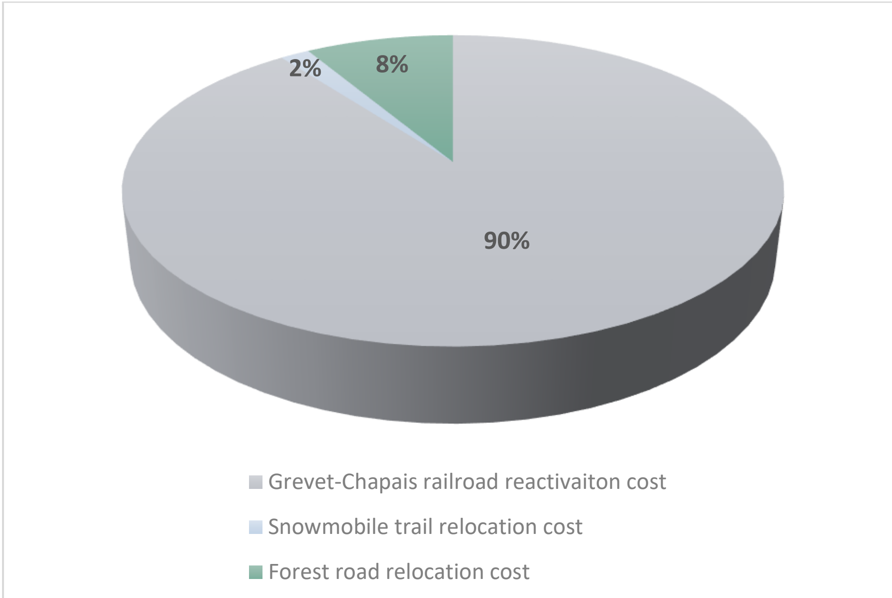


Figure 8.9-5: Proportion of the forest road and snowmobile trail relocation cost on the overall project costs

8.10 CONCLUSION

The transportation sector is one of the most important levers in national efforts for social and economic development. Among all modes of transportation, including maritime, air, and road, rail transportation is one of the four major modes of transportation and plays a significant role in multi-sectoral development. The Grande Alliance railway line possesses all the attributes of a structuring project, as it not only aims for growth but also acts as a development multiplier in the northern regions.

The section of the La Grand Alliance railway line between Matagami and Rupert River is characterized by a moderately hilly terrain, crossing predominantly clayey soils and peatlands. In addition to these unique features, technical solutions have been proposed such as pre-loading embankments to accelerate settlement or excavating compressible soils. However, the greatest challenge was designing a route within a 200 m corridor, dotted with protected and sensitive areas, including a roadway centered on this corridor with a 42 m wide footprint. Deviation from this footprint could not be avoided everywhere, given the size of the curve radii and vertical slopes required by railway standards, in contrast to those of a road.

The section of the railway line between Grevet and Chapais does not present significant difficulties, as some of the railway infrastructure already exists, although it has degraded in some places over time. In this regard, the engineer of this section has worked to align the new railway line with the existing infrastructure, both in terms of plan and profile, to avoid unjustified additional costs.

Results Obtained

This report has reviewed the technical disciplines impacted by the chosen alignment, including rail, earthworks, structures, hydraulic and drainage works, roads, environment, and various constraints, as well as mitigation measures, transshipment areas, stations, and rolling stock.

To limit construction costs and reduce construction time of large excavations and embankments while also ensuring an acceptable level of functionality and operability, the engineer has designed and estimated maintenance costs to Class 3 as per Transport Canada's classification. As a result, the speed is set to 65 km/h (40 mph) for freight and 100 km/h (60 mph) for passenger.

Despite the track class, the total alignment between Matagami and Rupert River is 41% in curves, and 59% of the total length in tangents. This ratio between these lengths confirms the nature of the terrain and its qualification as moderately hilly.

The route from Grevet to Chapais has 26% of its total length in curves, and 74% of the total length in tangents.

The following graphs present the weight of construction cost for each discipline for each railway alignment.

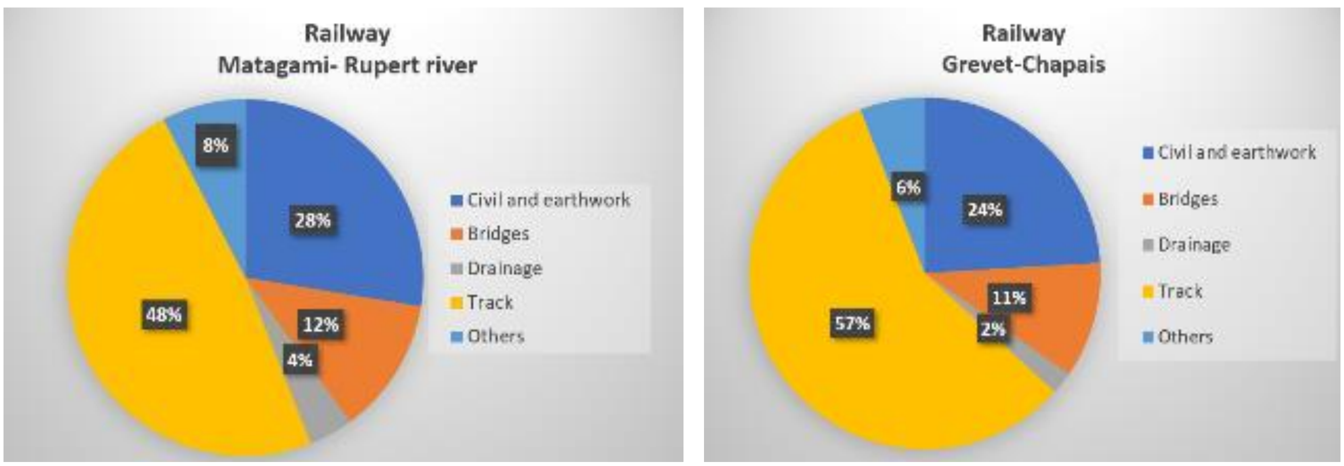


Figure 8.10-1: Division of Capital Cost for Railways

For roads, the following graph summarizes the weight of each of them in terms of construction costs.

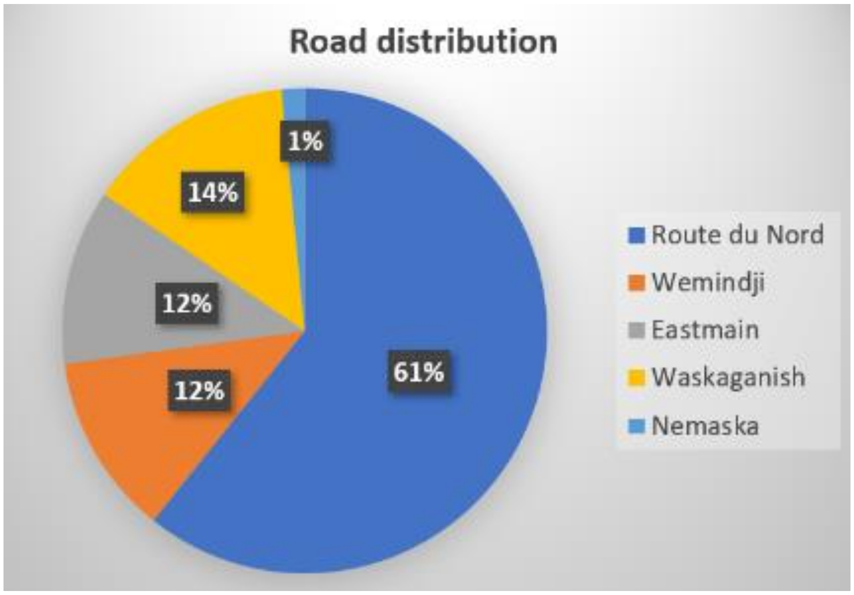


Figure 8.10-2: Division of Capital Cost for Roads

Recommendations

The analyses carried out in the context of this stage of the project have led to the feasibility study, which is intended to be a reference for subsequent studies. This achievement was made possible, among other things, by geotechnical investigations along the route, the search for borrow and quarry materials, LIDAR surveys covering the crossed areas, various on-site consultations, and the search for data and numerous variants and sub-variants of the alignment.

However, in subsequent stages, a more detailed level of design will be sought, and to that end, the following actions will need to be taken to improve, complete, or modify certain parts of the study, if necessary:

- Additional geotechnical investigations, as well as tests to characterize all sites crossed by the route, for a better understanding of the environment.
- Surveying in specific locations such as culverts, structures, and others. LIDAR alone is not sufficient.
- Comprehensive consultations with residents, Cree communities, and others.
- Supplementary environmental studies and proposals for mitigation or attenuation measures.
- Conducting detailed analyses and studies according to the desired level of design.
- Hold workshops with government officials and all stakeholders for the validation or removal of road, forestry, and other level crossings, and even the rerouting of certain road sections.
- Conduct a safety study and detailed assessment of the selected crossings and evaluate, if necessary, the installation of barriers.

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