JEAN MARIE RIVER BRIDGE REPLACEMENT
PERMANENT EROSION AND SEDIMENT CONTROL PLAN

Prepared for:
JACOBS AND THE GOVERNMENT OF THE NORTHWEST TERRITORIES

Prepared by:
MATRIX SOLUTIONS INC., A MONTROSE ENVIRONMENTAL COMPANY

Version 1.0
April 2024
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JEAN MARIE RIVER BRIDGE REPLACEMENT –

PERMANENT EROSION AND SEDIMENT CONTROL PLAN

Prepared for Jacobs and the Government of the Northwest Territories, April 2024

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CONTRIBUTORS

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VERSION CONTROL

Version	Date	Issue Type	Filename	Description
V0.1	15-Feb-2024	Draft	35370-522 PESC R 2024-02-21 draft V0.1.docx	Issued to client for review
V0.2	1-March-2024	Draft	35370-522 PESC R 2024-03-01 draft V0.2.docx	Issued to client for review
V0.3	5-March-2024	Draft	35370-522 PESC R 2024-03-01 draft V0.3.docx	Issued to client for review
V1.0	2-April-2024	Final	35370-522 PESC R 2024-04-02 final V1.0.docx	Issued to client as final

TABLE OF CONTENTS

IN-TEXT TABLES

FIGURE

APPENDICES

1 INTRODUCTION

Matrix Solutions Inc., a Montrose Environmental Company, prepared a permanent erosion and sediment control plan (PESC) for the Mackenzie Highway (Highway 1) bridge replacement project (project) over the Jean Marie River. The bridge is located approximately 65 km south of Fort Simpson, NWT, as measured along Highway 1, and is located immediately south of the junction with Highway 7 as shown on Figure 1. The purpose of the PESC Plan is to outline permanent erosion and sediment control measures to stabilize disturbed soils following completion of project construction activities and to minimize the risk of sediment-laden runoff from the project site entering adjacent watercourses.

Two types of erosion and sediment control measures will be installed for this project. Temporary erosion and sediment control (TESC) measures will be used to manage sediment during construction and will be removed upon construction completion. Permanent erosion and sediment control measures (PESC) will be installed for long-term ESC and will remain on-site upon construction completion. Preparation of the TESC plan is the responsibility of the contractor and information on TESC measures should be included with the contractor's environmental construction operations (ECO) plan. TESC best practices and recommendations for sensitive areas have been identified in Section 3.0 of this PESC plan. This information is being provided to facilitate discussions with the contractor. Site specific ESC measures may be modified based on field conditions present during construction.

This PESC plan was prepared in accordance with the Government of the Northwest Territories, Department of Transportation *Erosion and Sediment Control Manual* (GNWT 2016). Matrix has provided this report to the Government of the Northwest Territories (GNWT) and Jacobs Canada Inc. GNWT is the bridge owner and Jacobs is the overall bridge designer and prime consultant for the project.

1.1 Site Description

The Jean Marie River bridge location is shown on Figure 1. The bridge is on a North-South alignment with Fort Simpson to the North. The Jean Marie River flows west to east and is relatively straight at the bridge location. The existing bridge is a 35.4-m long clear-span bridge over the Jean Marie River. The bridge abutments are armoured with Class 2 rounded riprap, which has slumped in some locations beneath the abutments. The riverbank slopes at and near the bridge range from approximately 2H:1V directly underneath the bridge to as shallow as 4H:1V, with grasses and shrubs growing along the banks. A boat launch, accessed via a gravel driveway off the highway, is located on the southeast corner of the bridge.

Highway 1 at the Jean Marie River Bridge has a crowned asphalt surface, which directs road runoff to the east and west sides of the road. The road embankments are at 2H:1V slopes or flatter and are vegetated with grasses. These slopes convey surface water drainage into grassed ditches that run parallel to the road; drainage is directed into the Jean Marie River at the bridge. The area beside the road right-of-way is forested, except on the northeast side of the bridge where there is a gravelled parking lot with a residence and commercial lodging, the Checkpoint B&B.

The proposed replacement bridge will be constructed along the same alignment as the existing bridge, but at a higher elevation, which requires re-grading and raising of the bridge approaches. The proposed road side-slopes will vary from 3H:1V (without guardrails) to 2H:1V (with guardrails). The road side-slopes will be topsoiled and seeded. The boat launch location access from the highway will be shifted to the south by approximately 80 m due to the proposed guardrails Culverts will be installed across road turn-offs to maintain existing drainage pathways.

2 SITE ASSESSMENT

Matrix and Jacobs performed a pre-construction site visit in September 2023 to assess existing site conditions. Boreholes were drilled by Maskwa Engineering Ltd. (Maskwa) in March 2023 on the north and south bridge approaches. Surficial soils were noted to be silty sand. Desktop review of the borehole logs did not identify permafrost layers. Based on this information, it is assumed that the soil is erodible. Photographs of the existing soil and site conditions at various project areas are provided in Appendix A – Drawing 1.

Using the existing site contours provided by Jacobs, the project area was divided into four different drainage areas: the northeast, northwest, southeast, and southwest approaches of the bridge. These four different drainage areas collect water in the ditches along the highway and drain to the Jean Marie River at the bridge. The Revised Universal Soil Loss Equation (RUSLE) calculations were prepared for pre-construction and post-construction conditions in each of the four drainage areas. RUSLE calculations are included in Appendix B.

RUSLE calculations show that there is a low to moderate risk of soil loss in the areas immediately beside the bridge abutments for the pre-construction condition. This is because there are gaps in the riprap and bare soil is exposed. These risk condition in these areas will be lowered by the project due to the installation of riprap around the new bridge abutments, which will cover the embankment slope from the bridge abutments down to the river.

Areas of concern identified by Matrix during the site visit and from the RUSLE calculations are the south and north bridge approaches: Station 100+175 to Station 100+200 (south) and Station 100+240 to Station 100+265 (north). These areas are a concern due to their proximity to the water, steep slopes (2 to 3H:1V), and bare soil, resulting in a higher risk for soil loss.

The new (proposed) bridge is planned to be constructed on the same alignment and have a similar cross-fall and slope, which will result in little to no change to surface runoff expected from the site. Runoff from the bridge and within the project area will be primarily sheet flow. Due to the small drainage areas and cross-fall of the highway, minimal runoff is expected to be generated within the project boundary. Due to the cross-fall of the highway, there is little to no run-on that will be experienced by the highway and the raised approach to the bridge will result in little to no change. Establishment of vegetation along the road

embankment and along the temporary bridge approach will be critical to stabilization of surficial soils. Changes in site conditions between the proposed and existing bridge are described in Table 1.

TABLE 1 Site Conditions

Parameter	Existing Bridge	New (Proposed) Bridge
Clear Span Length (m)	35	37.4
Bridge Approach – North Embankment Side-slopes	Varies, 2H:1V or flatter	2H:1V or flatter
Bridge Approach – South Embankment Side-slopes	Varies, 2H:1V or flatter	2H:1V or flatter
Bridge Drainage	None – Drainage flows off bridge into river	Riprap lined drain troughs
Bridge Embankment Vegetation	Some riprap with sparse vegetation and exposed soils	Full riprap coverage

3 TEMPORARY EROSION AND SEDIMENT CONTROL MEASURES – SENSITIVE AREAS

The general construction sequence for the new bridge is described on Figure 1 of Appendix C. The contractor is responsible for providing a detailed TESC plan which will be a part of the ECO Plan. The TESC plan should follow Best Management Practices (BMPs) set out by the GNWT *Erosion and Sediment Control Manual* (GNWT 2016). Special consideration should be given in the TESC plan for work in high-risk areas, i.e., within the riparian zone by the bridge abutments. In these areas, it is recommended that the contractor's TESC plan include information on:

- Preventing unwanted runoff from entering the phase actively under construction. Temporary berm interceptors (BMP #3), diversion ditches (BMP #14), straw wattles (BMP #29), silt fences (BMP #1), and active management of construction scheduling should be considered to control and prevent additional run-on in these sensitive areas.

- Reducing the time that bare soil is exposed to erosive forces should be prioritized. During construction around the bridge embankments, placement of a root barrier membrane could be considered as a temporary cover material over bare soil, which can reduce the erosion risk during construction. Scheduling (BMP #25) should be referenced when developing the TESC plan.

TESC measures are recommended to be more protective for perimeter control, especially adjacent to sensitive undisturbed land (Jean Marie River), and to support sediment contamination avoidance versus sediment remediation.

A selection of recommended BMPs that should be considered for these high-risk areas are provided in Appendix E.

4 PERMANENT EROSION AND SEDIMENT CONTROL MEASURES

The new bridge and upgraded roads have been designed to maintain existing drainage pathways around the road and bridge. The following PESC measures were designed to mitigate erosion and sediment transport.

- Highway ditch seeding (Station 100+060 to Station 100+200 and Station 100+240 to Station 100+460)

  The ditches along the highway will be topsoiled (BMP #18) and seeded with the NWT's Native Seed Mix: General Reclamation (GNWT 2016) (BMP#15). A local seed supplier shall verify prior to placement of seed mix to verify that the mix recommended is appropriate given the site conditions. During construction, it is recommended that topsoil and low surface vegetation be stripped together for salvage and re-use on site. The minimum recommended topsoil depth within re-constructed ditch sections should be 0.10 m, imported topsoil should be placed as needed. After topsoil placement of areas with slopes steeper than 3H:1V, hydroseeding (BMP#17a) is recommended for to prevent loss of topsoil and seeds during vegetation establishment.

  A warranty and maintenance period of at least 2 years for seeded vegetation is recommended to ensure that grasses establish onsite given the harsh growing environment. Establishment of grasses to cover exposed soils is critical to preventing sediment transport. Topsoiling and seeding should be performed in the fall and should be watered regularly as per the landscape care and maintenance plan.

- Riprap drain troughs (Station 100+196)

  Drain trough design (by Others) was based on Alberta Transportation Bridge Structures Design Criteria v. 9.0 (AT 2022):

  > "At the ends of bridges, concrete drain trough collectors shall be used to channel water off the bridge and into concrete drain troughs. Drain troughs are required at the low corners of bridges."

  The bridge deck drain was based on deck runoff encroaching into the driving lanes calculation, based on Alberta Transportation Bridge Conceptual Design Guidelines (AT 2020). Based on the runoff volume calculated, no deck drain pipe is required.

  Class 1 Riprap will be installed at the foot of the concrete drain troughs to dissipate energy from runoff leaving the bridge. Runoff will pond in a riprap-lined depression allowing sediment to settle and runoff to be distributed when the pond overflows.

- Riprap bank armouring (Station 100+190 to Station 100+205 and Station 1+235 to Station 1+250)

  Riprap bank armouring was designed to protect the bridge abutments and slope from erosion due to flooding caused by the Jean Marie River and surface runoff down the riverbank slope. Minimum riprap

sizing was determined to be a Class 1 with a thickness of 0.6 m ($2 \times D_{50}$), as per Matrix's hydrotechnical report (Matrix 2024). If Class 2 is used it shall be a minimum 1.0 m thick ($2 \times D_{50}$). Riprap will be installed as per the IFC drawings.

Maintenance of each PESC measure should be performed as per the IFC drawings and specifications provided in Appendix D.

5 PERMANENT EROSION AND SEDIMENT CONTROL INSPECTIONS AND REPORTING

During the active construction phase, inspections of any installed PESC measures must be completed every 7 days and after every significant precipitation event (>12 mm in 24 hours). After construction completion, any installed PESC measures should be inspected prior to an interim construction completion inspection and signed off on by the engineer of record that they have been installed correctly. Subsequent inspections of PESC measures should be performed at minimum once during each spring and summer, and after a 1:2-year 24-hour rainfall event occurs until the end of the warranty period. Inspection of PESC measures should be performed as per the IFC drawings and specifications. PESC measures identified as deficient should be repaired or replaced as soon as practical. If implemented PESC controls are insufficient or not working as intended, changes to the PESC plan must be made to ensure continued compliance. Inspection, maintenance, and repair activities should be documented in the inspection reports. Inspection reports should be prepared and retained onsite during construction, along with the TESC and ECO plans. Reports are to be sent to the GNWT.

Table 2 details items to be examined during the inspection of each PESC item:

TABLE 2 Permanent Erosion and Sediment Control Inspection Checklist

Item	Inspection Checklist
Seeding	☐ Are there sparse or patches devoid of vegetation (> $1m^2$)? ☐ What is the percentage coverage? Minimum 80% coverage recommended. ☐ Do planted grasses meet GNWT Highway specifications for height? ☐ Is there rutting or rilling in the ditch? ☐ Is there gravel or debris preventing growth of grasses?
Riprap	☐ Is there consistent coverage of riprap (i.e., meets uniform thickness)? ☐ Has there been settling, slumping or displacement of the riprap? ☐ Are there visible voids or gaps in bank armouring? ☐ Is there large woody debris impinging or against the riprap? ☐ Is the bank or slope undercut?

6 SHUTDOWN AND EMERGENCY RESPONSE

In the event that the site is shutdown, e.g, construction work is halted for at least 7 days, inspections of any installed PESC and TESC measures should continue, stockpiles should be covered, and installed PESC

and TESC measures should be maintained and repaired during the shutdown to reduce the risk of sediment mobilization.

In the event of an emergency release during construction, the emergency response protocol in the ECO plan should be followed and the individuals listed in Table 3 should be contacted.

TABLE 3 Permanent Erosion and Sediment Control Plan Roles and Contact Information

Individual	Role	Responsibility	Contact Information
Chaudary Murtaza	Manager – Structures	Owner	867-767-9086 x 31127

7 REFERENCES

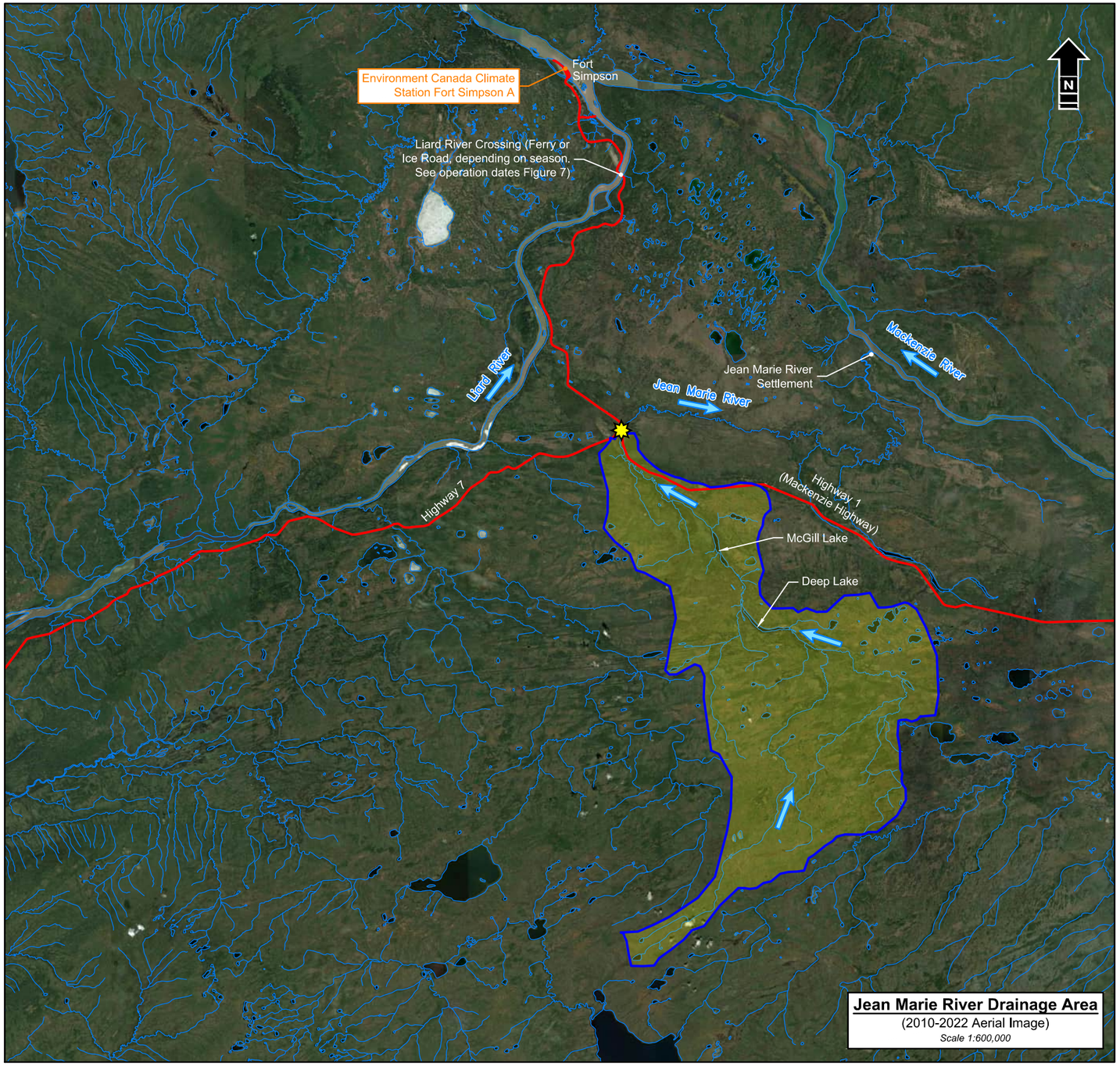
Alberta Transportation (AT). 2022. *Bridge Structures Design Criteria, Version 9.0*. ISBN 978-1-4601-5309-3. © 2022 Government of Alberta. January 2022.

Alberta Transportation (AT). 2020. *Bridge Conceptual Design Guidelines, Version 3.0*. Technical Standards Branch, Alberta Transportation. © Copyright May 2020. The Crown in right of the Province of Alberta, as represented by the Minister of Transportation. May 2020.

Government of the Northwest Territories - Department of Transportation (GNWT). 2016. *Erosion and Sediment Control Manual*. March 2016.

Matrix Solutions Inc. (Matrix). 2024. *Hydrotechnical Design Report, Jean Marie River Bridge Replacement, Highway 1 (Mackenzie Highway)*. Version 3.0. Prepared for Jacobs and the Government of Northwest Territories. January 2024.

Plot 1:1 = Tabloid (L)



Jean Marie River Drainage Area
(2010-2022 Aerial Image)
Scale 1:600,000

Area Near Bridge
(2019-2022 Aerial Image)
Scale 1:15,000

Existing Jean Marie River Bridge (2023)

1 : 15,000 metres
150 0 150 300
UTM83-10

1 : 600,000 metres
6000 0 6000 12000
UTM83-10

Legend

- Jean Marie Bridge
- Flow Direction
- Jean Marie River Drainage Area (1310 km²)

References:
1. Roads and Hydrography obtained from GeoGratis © Department of Natural Resources Canada (all rights reserved) used under license.
2. Aerial imagery (2010-2022 and 2019-2022) obtained from ESRI Imagery © (2023) used under license.
3. Photograph by Matrix, September 28, 2023.

REVISION					
0	2024-04-02	Issued for Regulatory Review	TS	KC	GE
No.	**DATE**	**DESCRIPTION**	**BY**	**CHK.**	**DRN.**

Matrix Solutions Inc.
A Montrose Environmental Company

Government of the Northwest Territories and Jacobs
Jean Marie River Bridge Replacement - Highway 1 (Mackenzie Highway)

Location Plan and Drainage Area

Date: February 2024 | Project: 35370-522 | Submitter: T. Schaepsmeyer | Reviewer: K. Curtis

Figure 1

F:\35370\Drafting\CSD\2023 Jean Marie Bridge\Production\Figs\35370-LP.dwg - LP - March 1, 2024 11:01:45 AM - Gary Evenson

APPENDIX A
ESC Drawings

NOTES

1. ALL COORDINATES AND DISTANCES ARE BASED ON 3TM COORDINATE SYSTEM (NAD83).
2. AERIAL IMAGERY (AUGUST 2019 TO AUGUST 2022) OBTAINED FROM ESRI IMAGERY © (2023) USED UNDER LICENSE.
3. PHOTOGRAPHS TAKEN BY JACOBS AND MATRIX ON SEPTEMBER 27 AND 28, 2023.
4. BASE LINE WORK FROM JACOBS. GENERAL LAYOUT DRAWING (SC-INF01-6081-S001). DATED OCTOBER 6, 2023.

LEGEND

- CONSTRUCTION BOUNDARY
- EXISTING GROUND CONTOUR (MAJOR - 10 m INTERVAL)
- EXISTING GROUND CONTOUR (MINOR - 2 m INTERVAL)
- 2 PHOTOGRAPH
- ORDINARY HIGH-WATER MARK

NAD 83
COORDINATES

NO.	DESCRIPTION	DATE (YYYY-MM-DD)	BY	APPD
0	ISSUED FOR REVIEW	2024-02-15	TC	AYS

PERMIT

SEAL

	BY	DATE (YYYY-MM-DD)
DESIGNED	TS	
DRAWN	CGC	
CHECKED	AYS	

SCALE 1:1000 (0 20 40 m)

Jacobs

Matrix Solutions Inc. A Montrose Environmental Company

PROJECT

JEAN MARIE RIVER BRIDGE REPLACEMENT PERMANANT ESC

SEC: 29 - TWP: 24 - RGE: 10 - W 5th M

SHEET TITLE

EROSION & SEDIMENT CONTROL PLAN EXISTING SITE CONDITIONS PHOTOGRAPHS

FILE NO.	ENG DWG NO.
35370-ESC.dwg	
SHEET ID.	SHEET NO.
ESC_1	

	BY	DATE (YYYY-MM-DD)	PROFILE NO.
DRAWN	CGC	2024-02-15	

ISC: SHEET SIZE ANSI D 25 mm 0

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NOTES

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3. BASE LINE WORK FROM JACOBS. GENERAL LAYOUT DRAWING (SC-INF01-6081-S001). DATED OCTOBER 6, 2023.
4. DETAILED ESC MEASURES AND MAINTENANCE DURING CONSTRUCTION TO BE PROVIDED BY CONTRACTOR.

LEGEND

- DRAINAGE DIVIDE
- GRADING BOUNDARY
- RUSLE FAC SLOPE FACTOR VALUE
- A 0.00 — DRAINAGE DIVIDE LABEL DRAINAGE AREA IN HA
- EXISTING GROUND CONTOUR (MAJOR - 10 M INTERVAL)
- EXISTING GROUND CONTOUR (MINOR - 2 M INTERVAL)
- EXISTING VEGETATION
- EXISTING GRAVEL SURFACE
- EXISTING PAVEMENT SURFACE
- OVERLAND FLOW DIRECTION
- RUN-ON/RUN-OFF LOCATIONS
- CONSTRUCTION BOUNDARY

NAD 83
COORDINATES

NO.	DESCRIPTION	DATE (YYYY-MM-DD)	BY	APPD
0	ISSUED FOR REVIEW	2024-02-15	TC	AYS

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SCALE 1:1000 — 0 20 40 m

Jacobs

Matrix Solutions Inc. A Montrose Environmental Company

PROJECT

JEAN MARIE RIVER BRIDGE REPLACEMENT PERMANANT ESC

SEC: 29 - TWP: 24 - RGE: 10 - W 5th M

SHEET TITLE

EROSION & SEDIMENT CONTROL PLAN EXISTING SITE CONDITIONS ASSESSMENT

FILE NO.	ENG DWG NO.
35370-ESC.dwg	
SHEET ID.	SHEET NO.
ESC_2	

	BY	DATE (YYYY-MM-DD)	PROFILE NO.
DRAWN	CGC	2024-02-05	

ISC: SHEET SIZE ANSI D 25 mm 0

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NOTES

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4. BASE LINE WORK FROM JACOBS. GENERAL LAYOUT DRAWING (SC-INF01-6081-S001). DATED OCTOBER 6, 2023.

LEGEND

- DRAINAGE DIVIDE
- GRADING BOUNDARY
- RUSLE FAC SLOPE FACTOR VALUE
- A 0.00 — DRAINAGE DIVIDE LABEL DRAINAGE AREA IN HA
- EXISTING GROUND CONTOUR (MAJOR - 10 M INTERVAL)
- EXISTING GROUND CONTOUR (MINOR - 2 M INTERVAL)
- EXISTING VEGETATION
- PROPOSED VEGETATION
- PROPOSED GRAVEL SURFACE
- PROPOSED PAVEMENT SURFACE
- OVERLAND FLOW DIRECTION
- RUN-ON/RUN-OFF LOCATIONS
- CONSTRUCTION BOUNDARY

NAD 83
COORDINATES

NO.	DESCRIPTION	DATE (YYYY-MM-DD)	BY	APPD
0	ISSUED FOR REVIEW	2024-02-15	TC	AYS

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SCALE 1:1000 — 0 20 40 m

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Matrix Solutions Inc. A Montrose Environmental Company

PROJECT

JEAN MARIE RIVER BRIDGE REPLACEMENT PERMANANT ESC

SEC: 29 - TWP: 24 - RGE: 10 - W 5th M

SHEET TITLE

EROSION & SEDIMENT CONTROL PLAN DURING CONSTRUCTION

FILE NO.	ENG DWG NO.
35370-ESC.dwg	
SHEET ID.	SHEET NO.
ESC_3	

	BY	DATE (YYYY-MM-DD)	PROFILE NO.
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APPENDIX B
RUSLE Calculations

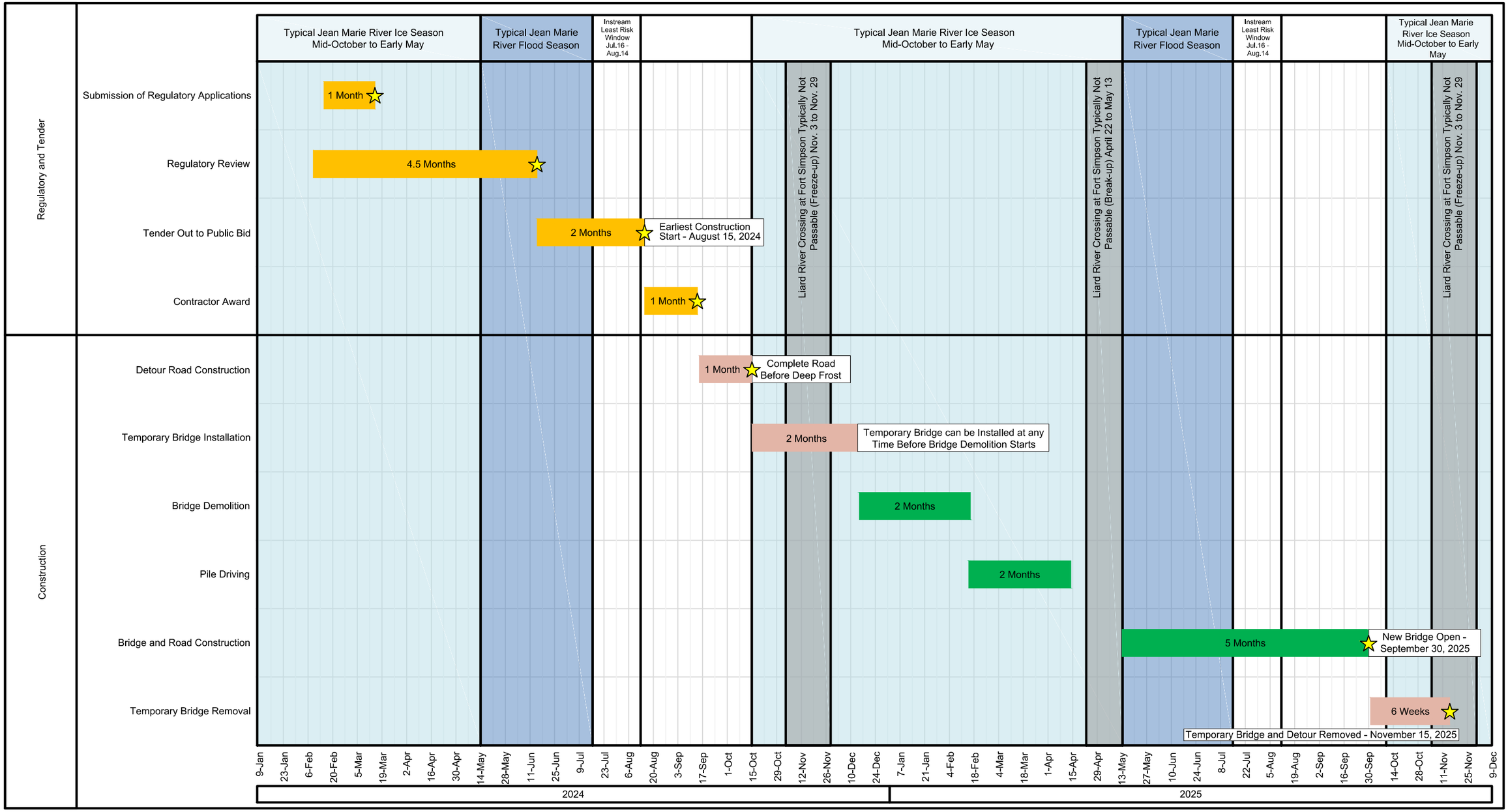
RUSLE Calculations - Existing Conditions

Location (referenced on Drawings)	Construction Stage	Slope and Slope Length (worst case LS Value for area)	R-Value	K-Value	Length	Slope	LS-Value	Description of Control Practices	C-Value	P-Value	A-Value (Tonnes/ha*yr)	ESC Hazard Class
A-LS1	Pre-Construction	25 m @ 2%	328	0.05	25.00	1.7%	0.22	C – half of the area ditch (grass 80% cover 0.01), half of the area tree canopy (80% cover broadleaf 0.04) ditch grass 80% cover 0.01 P – None	0.03	1.00	0.09	very low
A-LS2	Pre-Construction	20 m @ 16%	328	0.05	20.00	15.6%	1.94	C – Gravel cover over full road P – None	0.05	1.00	1.59	very low
A-LS3	Pre-Construction	15 m @ 37%	328	0.05	15.00	36.5%	3.84	C – Riprap and filter gravel layer with voids (0.05) and bare soil for 1/4 area P – None	0.28	1.00	17.64	moderate
B-LS4	Pre-Construction	20 m @ 1%	328	0.05	20.00	0.5%	0.08	C – half of the area ditch (grass 80% cover 0.01), half of the area tree canopy (80% cover broadleaf 0.04) ditch grass 80% cover 0.01 P – None	0.03	1.00	0.03	very low
B-LS5	Pre-Construction	8 m @ 27%	328	0.05	8.00	27.4%	1.77	C – Gravel cover over full road P – None	0.05	1.00	1.45	very low
B-LS6	Pre-Construction	15 m @ 24%	328	0.05	15.00	24.0%	2.53	C – Riprap and filter gravel layer with voids (0.05) and bare soil for 1/4 area P – None	0.28	1.00	11.61	moderate
C-LS7	Pre-Construction	20 m @ 21%	328	0.05	20.00	20.7%	2.69	C – Riprap and filter gravel layer with voids (0.05) and bare soil for 1/4 area P – None	0.28	1.00	12.35	moderate
C-LS8	Pre-Construction	8 m @ 8%	328	0.05	8.00	8.3%	0.46	C – Gravel cover over full road P – None	0.05	1.00	0.37	very low
C-LS9	Pre-Construction	20 m @ 1%	328	0.05	20.00	1.0%	0.13	C – half of the area ditch (grass 80% cover 0.01), half of the area tree canopy (80% cover broadleaf 0.04) ditch grass 80% cover 0.01 P – None	0.03	1.00	0.06	very low
D-LS10	Pre-Construction	20 m @ 15%	328	0.05	20.00	15.1%	1.86	C – Riprap and filter gravel layer with voids (0.05) and bare soil for 1/4 area P – None	0.28	1.00	8.56	low
D-LS11	Pre-Construction	8 m @ 10%	328	0.05	8.00	9.9%	0.58	C – Gravel cover over full road P – None	0.05	1.00	0.47	very low
D-LS12	Pre-Construction	20 m @ 1%	328	0.05	20.00	1.0%	0.13	C – ditch (grass 60% cover 0.04) P – None	0.04	1.00	0.09	very low

RUSLE Calculations - Post Development Conditions

Location (referenced on Drawings)	Construction Stage	Slope and Slope Length (worst case LS Value for area)	R-Value	K-Value	Length	Slope	LS-Value	Description of Control Practices	C-Value	P-Value	A-Value (Tonnes/ ha*yr)	ESC Hazard Class
A-LS1	Final Reclamation	25 m @ 1%	320	0.05	25.00	1.4%	0.19	C – half of the area seeded cover disturbed ditch (grass 80% cover 0.01), half of the area tree canopy (80% cover broadleaf 0.04) P – tackifier on slopes >3H:1V	0.04	**1.00**	0.12	very low
A-LS2	Final Reclamation	20 m @ 19%	320	0.05	20.00	18.6%	2.38	C – Asphalt overlay over full road P – None	0.00	**1.00**	0.00	very low
A-LS3	Final Reclamation	15 m @ 40%	320	0.05	15.00	40.4%	4.22	C – Riprap and filter gravel layer with voids (0.05) P – None	0.04	**0.70**	1.89	very low
B-LS4	Final Reclamation	20 m @ 8%	320	0.05	20.00	8.1%	0.80	C – half of the area seeded cover disturbed ditch (grass 80% cover 0.01), half of the area tree canopy (80% cover broadleaf 0.04) P – tackifier on slopes >3H:1V	0.04	**0.70**	0.36	very low
B-LS5	Final Reclamation	8 m @ 12%	320	0.05	8.00	12.3%	0.75	C – Asphalt overlay over full road P – None	0.00	**0.70**	0.00	very low
B-LS6	Final Reclamation	15 m @ 34%	320	0.05	15.00	33.7%	3.56	C – Riprap and filter gravel layer with voids (0.05) P – None	0.04	**0.70**	1.60	very low
C-LS7	Final Reclamation	20 m @ 14%	320	0.05	20.00	13.6%	1.64	C – Riprap and filter gravel layer with voids (0.05) P – None	0.04	**0.70**	0.73	very low
C-LS8	Final Reclamation	8 m @ 3%	320	0.05	8.00	3.4%	0.24	C – Asphalt overlay over full road P – None	0.00	**0.70**	0.00	very low
C-LS9	Final Reclamation	20 m @ 2%	320	0.05	20.00	1.9%	0.23	C – half of the area seeded cover disturbed ditch (grass 80% cover 0.01), half of the area tree canopy (80% cover broadleaf 0.04) P – tackifier on slopes >3H:1V	0.05	0.70	0.13	very low
D-LS10	Final Reclamation	20 m @ 7%	320	0.05	20.00	7.1%	0.75	C – Riprap and filter gravel layer with voids (0.05) P – None	0.04	**1.00**	0.48	very low
D-LS11	Final Reclamation	8 m @ 14%	320	0.05	8.00	14.0%	0.88	C – Asphalt overlay over full road P – None	0.00	**0.70**	0.00	very low
D-LS12	Final Reclamation	20 m @ 0%	320	0.05	20.00	0.3%	0.06	C – ditch (grass 60% cover 0.04) P – Tackifier on slopes >3H:1V	0.04	**0.70**	0.03	very low

APPENDIX C
Proposed Construction Schedule



Notes:

1. Regulatory review timeline depends on extend and nature of supplementary information requests from regulatory agencies.
2. Instream Least Risk Window from Dillon Consulting (October 2019).
3. Liard River Crossing dates from https://www.inf.gov.nt.ca/en/ferries.
4. Assume construction will rely on resources in Fort Simpson and will thus use the Liard River Crossing.
5. Assume heavy loads (crane, temp bridge, girders, etc.) will arrive from the south / east, and will not use the Liard Crossing.
6. Assume no instream work required for temporary bridge installation/removal or for demolition of old bridge / construction of new bridge. Contractor may work from the ice for demolition of old bridge (e.g., tarps/mats beneath the bridge and tracked equipment working from ice. Girders for new bridge can be installed without instream working platforms – contractor may use the temporary bridge to stage new girders and then lift with cranes working from the banks.
7. No instream work for riprap placement (i.e., no work below the wetted width at the time of construction). Riprap ideally placed after the new abutments are built and before the new girders are placed, but deviations to the sequencing may be required depending on the overall construction schedule. Riprap work in the "mid portion" (above the water level at the time of construction and below the 1:2-year water level) must be placed during low flow or frozen conditions.
8. Warranty Inspection period runs until December 31, 2026 (1 year after construction completion).

Legend

- Duration Dependent Regulatory Agency/Design Team
- Temporary Bridge - Installation and Removal
- Permanent Bridge - Demolition and Construction
- Critical Deliverable

REVISION					
0	2024-04-02	Issued for Regulatory Review	TS	KC	GE
No.	**DATE**	**DESCRIPTION**	**BY**	**CHK.**	**DRN.**

Matrix Solutions Inc.
A Montrose Environmental Company

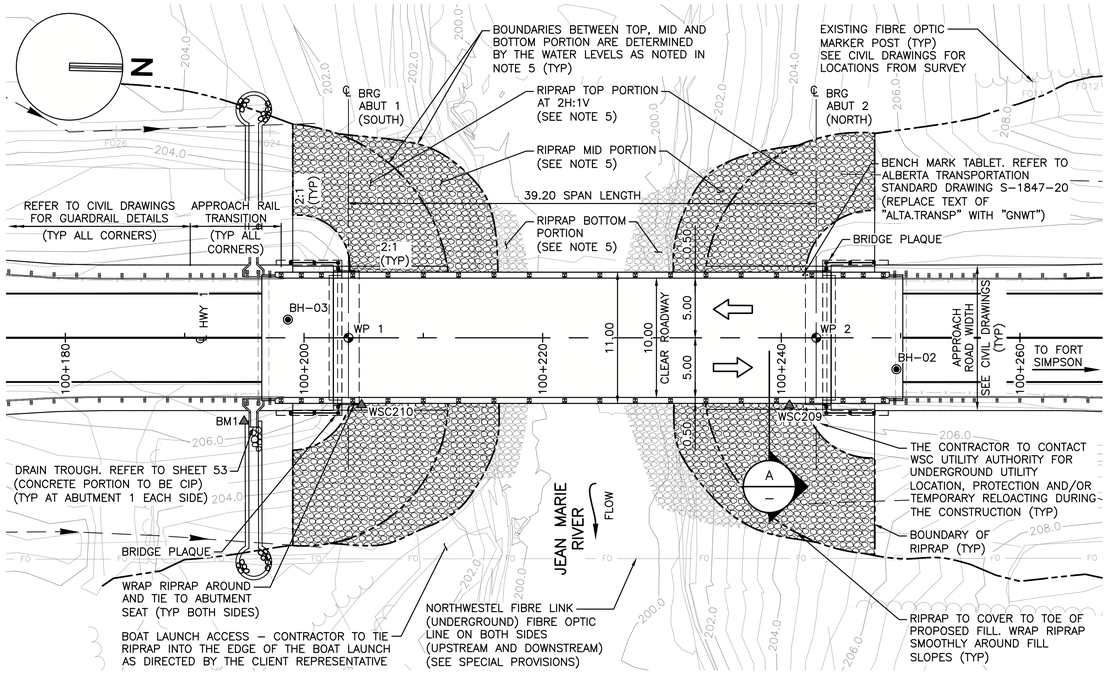
Government of the Northwest Territories and Jacobs
Jean Marie River Bridge Replacement - Highway 1 (Mackenzie Highway)

Project Construction Schedule

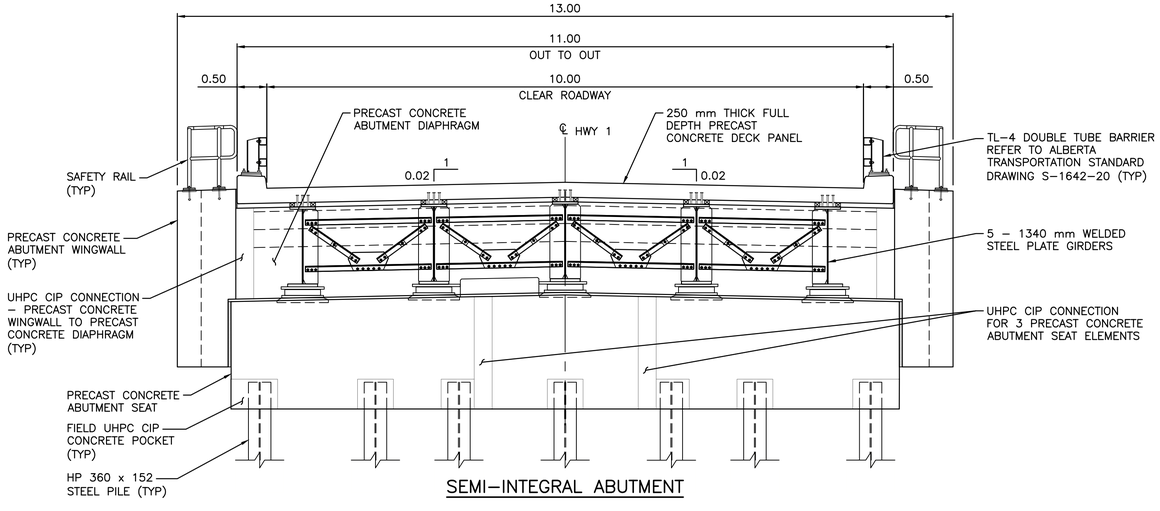
Date: February 2024 | Project: 35370-522 | Submitter: T. Schaepsmeyer | Reviewer: K. Curtis

Figure 7

APPENDIX D
Engineering Design and Specifications



PLAN
SCALE 1:250



SEMI-INTEGRAL ABUTMENT

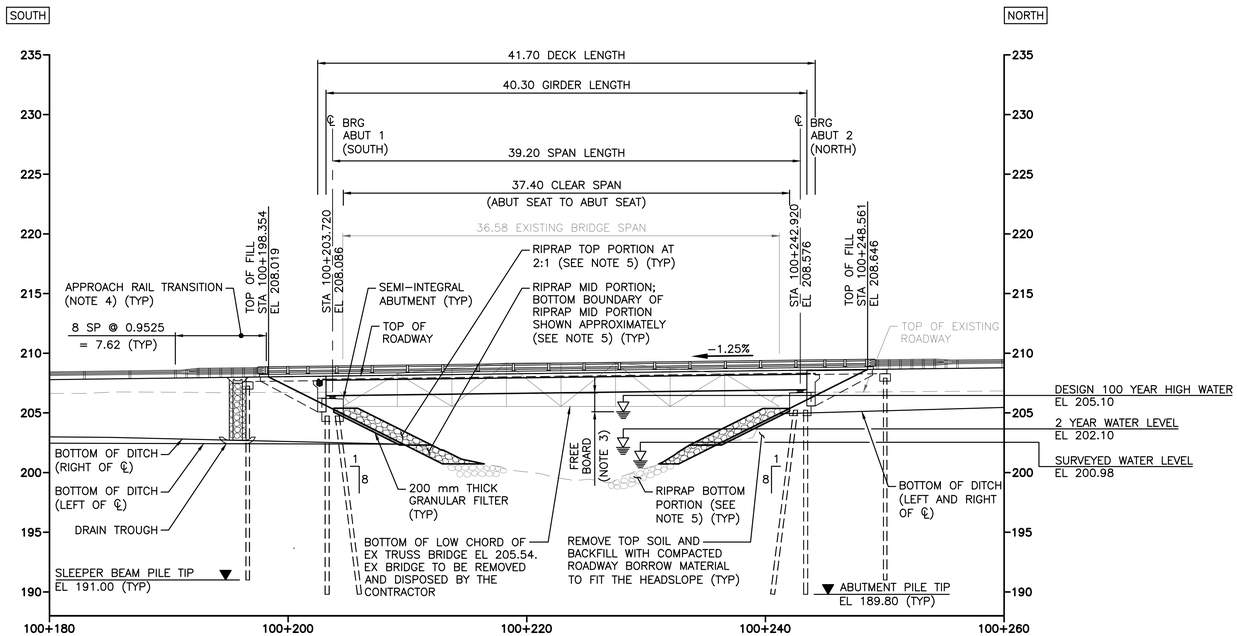
A – SECTION
SCALE 1:50

WORK POINT SCHEDULE

WORK POINT	NORTHING	EASTING	STATION	OFFSET	ELEVATION
WP 1	6813599.524	593974.476	100+203.720	0.00	208.086
WP 2	6813638.714	593973.606	100+242.920	0.00	208.576

BENCHMARK POINT TABLE

DESCRIPTION	NORTHING	EASTING	ELEVATION
BM1	6813590.94	593981.66	206.55
WSC 209	6813636.61	593979.31	205.21
WSC 210	6813600.75	593980.07	205.16



ELEVATION
SCALE 1:250

NOTES

1. DIMENSIONS ON THIS DRAWING ARE IN METRES UNLESS NOTED OTHERWISE.
2. ELEVATIONS ARE GIVEN TO THE TOP OF ROADWAY ALONG THE HIGHWAY 1 CONTROL LINE.
3. REQUIRED MINIMUM FREE BOARD = 1.20 m
   FREE BOARD PROVIDED AT ABUTMENT 1 = 1.20 m
   FREE BOARD PROVIDED AT ABUTMENT 2 = 1.67 m
   FREE BOARD PROVIDED AT MID-SPAN = 1.44 m
4. APPROACH RAIL TRANSITION: FIRST SIX SPACES AT 952.5 mm TO BE TWO LAYERS OF 2.7 mm THICK THRIE BEAM GUARDRAIL WITH TERMINAL CONNECTOR. LAST TWO SPACES AT 952.5 mm TO BE 2.7 mm THICK W-THRIE BEAM TRANSITION SECTION. REFER TO ALBERTA TRANSPORTATION STANDARD DRAWINGS S-1642-20, S-1643-20 AND SHEET 53 FOR DETAILS.
5. RIPRAP SHALL BE PLACED AS BELOW:

   TOP PORTION:
   (ABOVE THE 1:2-YEAR WATER LEVEL OF 202.10 m TO THE TOP OF RIPRAP ELEVATION OF 205.4 m FOR BOTH ABUTMENTS)
   USE A COMBINATION OF SALVAGED EXISTING RIPRAP AND IMPORTED RIPRAP UNDERLAIN BY 200 mm THICK GRANULAR FILTER BASE. IF CLASS 1 GRADATION IS USED, IT SHALL BE PREFERENTIALLY PLACED AT THE TOP OF THE RIPRAP REVETMENT (I.E., WHERE FLOW VELOCITY IS THE LOWEST). IF EXISTING RIPRAP IS SALVAGED, IT SHALL BE BLENDED WITH SMALLER RIPRAP, COBBLES, AND GRAVELS TO MEET THE FULL CLASS 2 GRADATION, TO THE SATISFACTION OF THE ENGINEER'S REPRESENTATIVE – HYDROTECHNICAL ENGINEER. GRANULAR FILTER BASE MATERIAL SHALL BE APPROVED EITHER AS WELL GRADED CRUSHED GRANULAR MATERIAL WITH D100 OF 100 TO 150 mm OR EQUIVALENT WELL GRADED UNCRUSHED BANK PITRUN GRAVEL. THE CONTRACTOR SHALL SUBMIT THE PROPOSED MATERIAL FOR APPROVAL BY THE HYDROTECHNICAL ENGINEER AT LEAST 2 WEEKS PRIOR TO THE WORKS.

   MID PORTION:
   (BELOW THE 1:2-YEAR WATER LEVEL OF 202.10 m AND ABOVE THE WATER LEVEL AT THE TIME OF THE RIPRAP PLACEMENT FOR THIS PORTION. RIPRAP FOR THIS PORTION SHALL BE PLACED DURING LOWER WATER LEVEL SEASON(S))
   ADD SMALLER PIECES OF RIPRAP, COBBLES, AND GRAVELS TO THE VOIDS OF THE EXISTING RIPRAP SURFACE TO APPROXIMATELY MEET THE CLASS 2 GRADATION, TO THE SATISFACTION OF THE HYDROTECHNICAL ENGINEER.

   BOTTOM PORTION:
   (EXISTING RIPRAP BELOW THE WATER LEVEL AT THE TIME OF PLACING MID PORTION RIPRAP DURING LOWER WATER LEVEL SEASON)
   NO NEW RIPRAP PLACEMENT BELOW THE WATER LEVEL. EXISTING RIPRAP BELOW THE WATER LEVEL SHALL REMAIN AND UNDISTURBED.
   (THIS PORTION OF RIPRAP SHOWN ON THE DRAWING IS SCHEMATIC)

   RIPRAP THICKNESS SHALL BE 0.6 m FOR CLASS 1 AND 1.0 m FOR CLASS 2, MEASURED PERPENDICULAR TO THE SLOPE,

PRELIMINARY – NOT FOR CONSTRUCTION

Government of Northwest Territories

Consultant Logo

Jacobs

Rev	Date	Description	Init
C	2024-03-25	ISSUED FOR 100% REVIEW	YL
B	2023-10-06	ISSUED FOR 80% REVIEW	YL
A	2023-06-19	ISSUED FOR 50% REVIEW	YL

REVISIONS

Government of Northwest Territories
HIGHWAY No. 1 (MACKENZIE HIGHWAY) km 411.2
JEAN MARIE RIVER BRIDGE
GENERAL LAYOUT

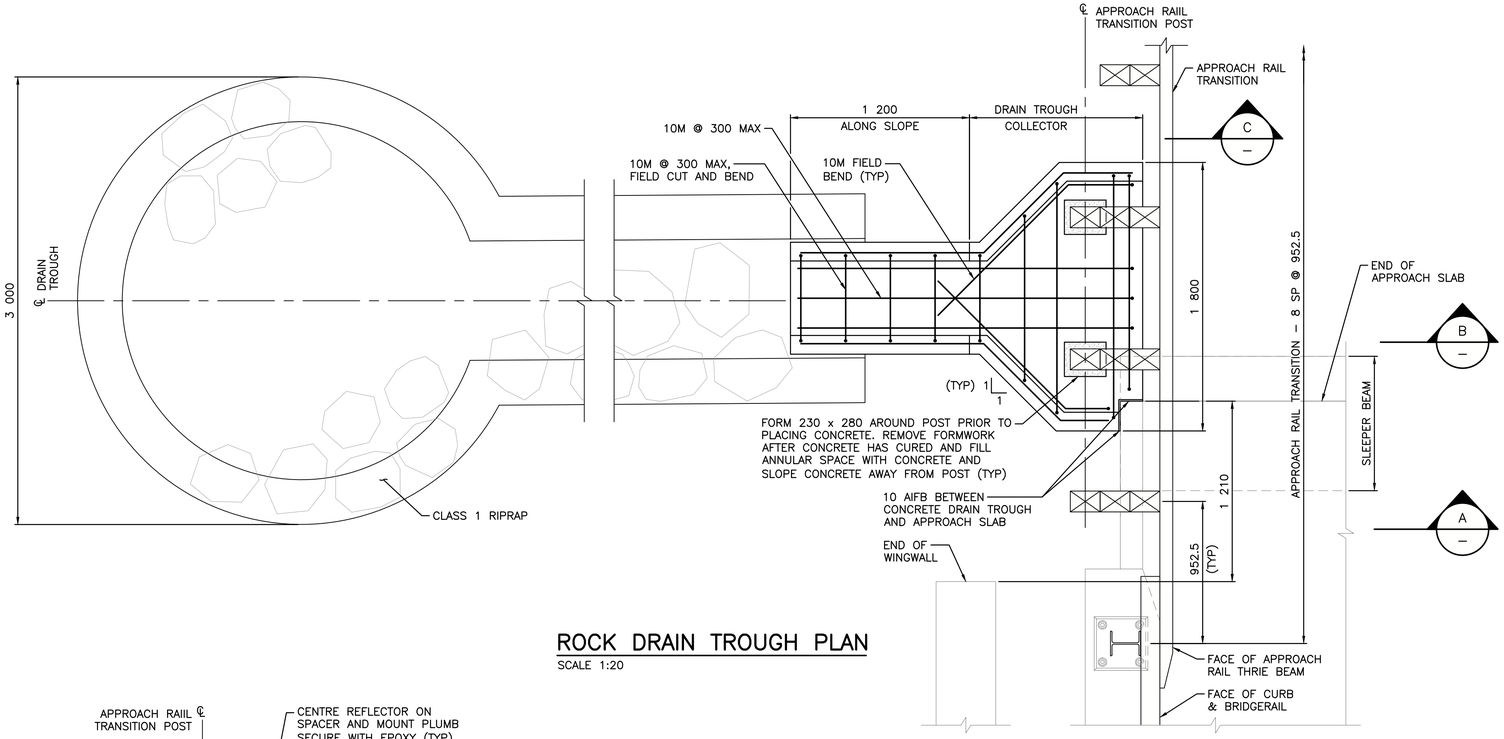
DESIGNED	YL	DATE	2024-03-25
CHECKED	JZ	DATE	2024-03-25
DRAWN	KK	DATE	2024-03-25
SCALE	AS SHOWN		

PREPARED UNDER THE DIRECTION OF

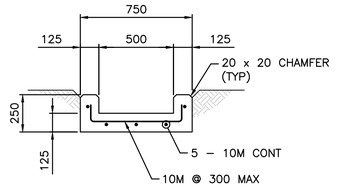
YING YI LI, P.ENG.
ENGINEER OF RECORD
DATE 2024-03-25

PROJECT No.	SHEET No.	DRAWING No.
CE857700	23 OF 55	SC-INF01-6081-S001 C

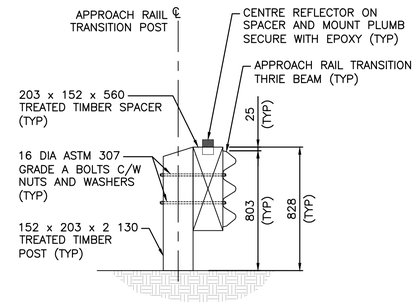
FILE: C:\pw_workdir\jacobs-us-vs-pw-02\dms92401\S001.dwg
PLOTTED : Monday, March 25, 2024



ROCK DRAIN TROUGH PLAN
SCALE 1:20



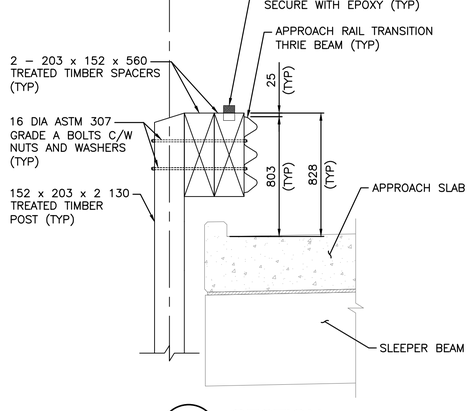
D – SECTION
SCALE 1:20



C – SECTION
SCALE 1:20

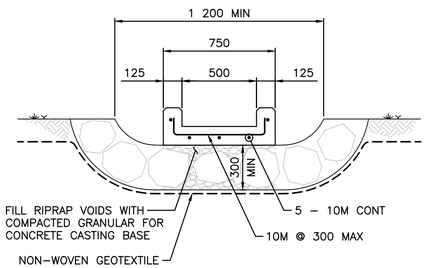
NOTES

1. ALL MATERIAL SHALL BE SUPPLIED IN ACCORDANCE WITH THE STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION.
2. CAST IN PLACE CONCRETE SHALL BE CLASS C WITH CLASS 1 FINISH IN ACCORDANCE WITH THE STANDARD SPECIFICATIONS FOR BRIDGE CONSTRUCTION SECTION 4.
3. SUPPLY AND PLACEMENT OF NON–WOVEN GEOTEXTILE FILTER FABRIC SHALL BE IN ACCORDANCE WITH THE STANDARD SPECIFICATION FOR BRIDGE CONSTRUCTION SECTION 10. NON–WOVEN GEOTEXTILE FILTER FABRIC SHALL BE KEYED 300 INTO THE SUB–GRADE ALL AROUND BENEATH THE ROCK RIPRAP IN ORDER TO ANCHOR THE FABRIC.
4. ASPHALT IMPREGNATED FIBRE BOARD (AIFB) SHALL MEET THE REQUIREMENTS OF ASTM D1751.
5. CLOSED CELL FOAM SHALL BE SIKA EMSEAL OR AN EQUIVALENT APPROVED BY THE DEPARTMENT.
6. APPROACH RAIL TRANSITION DETAILS NOT SHOWN ON THIS DRAWING REFER TO ALBERTA TRANSPORTATION STANDARD DRAWING S–1642–20 AND S–1643–20.

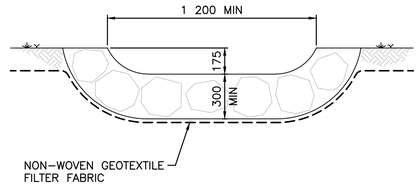


A – SECTION
SCALE 1:20

B – SECTION
SCALE 1:20



E – SECTION
SCALE 1:20



F – SECTION
SCALE 1:20

PRELIMINARY – NOT FOR CONSTRUCTION

Government of Northwest Territories

Consultant Logo

Jacobs

Rev	Date	Description	Init
B	2024–03–25	ISSUED FOR 100% REVIEW	YL
A	2023–10–06	ISSUED FOR 80% REVIEW	YL

REVISIONS

Government of Northwest Territories
HIGHWAY No. 1 (MACKENZIE HIGHWAY) km 411.2
JEAN MARIE RIVER BRIDGE
DRAIN TROUGH AND APPROACH RAIL TRANSITION DETAILS

DESIGNED	YL	DATE	2024–03–25
CHECKED	JZ	DATE	2024–03–25
DRAWN	KK	DATE	2024–03–25
SCALE	AS SHOWN		

PREPARED UNDER THE DIRECTION OF

YING YI LI, P.ENG.
ENGINEER OF RECORD
DATE 2024–03–25

PROJECT No.	SHEET No.	DRAWING No.
CE857700	53 OF 55	SC–INF01–6081–S031 B

APPENDIX E
BMPs

Berm Interceptor Erosion Control	B.M.P. #3

Description and Purpose

- Earth dike barrier constructed of compacted soil to intercept and divert flow of runoff water away from erodible slopes, sensitive areas or water bodies
- A spillway outlet of erosion-resistant granular material constructed to allow exit of diverted water to less sensitive areas

Applications

- Primarily used as an erosion control by diverting water away from the work site. May be used in sediment control by being used for sediment pond construction or directing sediment laden water to sediment ponds.
- Temporary or permanent measure
- Used instead of, or in conjunction with, diversion ditches
- Perimeter control
- Placed along contours and/or at toe of slope to divert run-off from sensitive areas
- Used to divert water to sediment control structures

Advantages

- Easy to construct
- Can utilize on site soil material with a protective lining (e.g., poly sheeting or geotextile fabric)
- Can be converted to sedimentation/impoundment pond with the design of a permeable filter berm at the exit spillway area (see BMP #13)

Limitations

- Earth dike barriers may be require design by a qualified person may be required for earthen barriers in accordance with dam design guidelines and regulatory requirements. The consequences of failure will influence the level of design and construction requirements

Construction

- Construct barrier from bottom up by placing and compacting subsequent lifts of soil
- Degree of compaction of each lift to be specified by the design engineer based on consequences of failure

Berm Interceptor Erosion Control	B.M.P. #3

Construction Considerations

- The barrier should be trapezoidal in cross-section
- When using soils a protective liner should be used
- Low barriers should have the slopes suited to the construction material used
  - 1.5H:1V for granular soils
  - 2H:1V or flatter for compacted mixed or fine-grained soils

Inspection and Maintenance

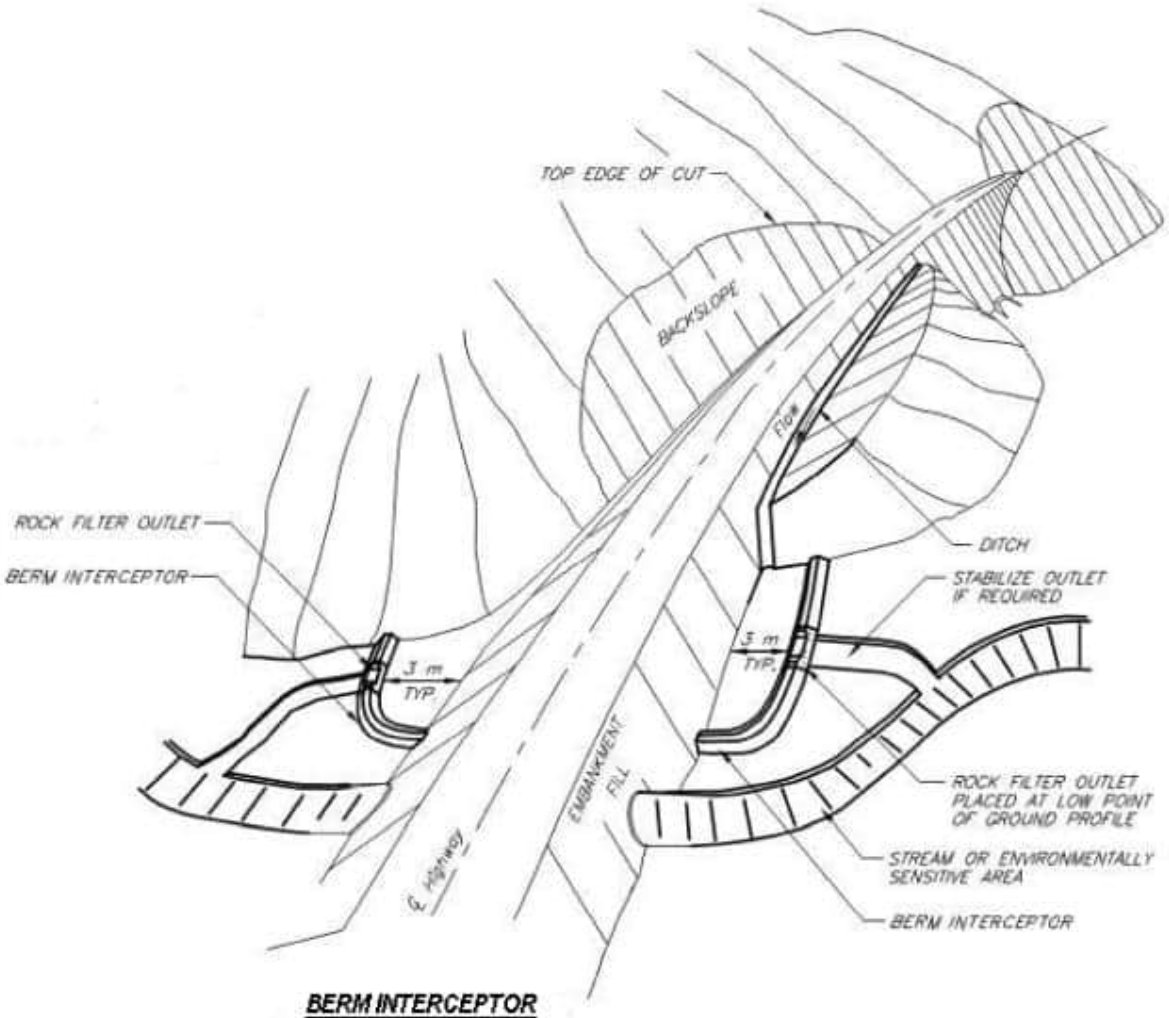
- The degree and extent of inspection and maintenance performed on an earth dike barrier is directly related to the consequences of failure. An engineer experienced in embankment design and inspection may be required for design, inspection, design of remedial measures, and supervision of their implementation
- Inspection frequency should be in accordance with the PESC and TESC Plans
- Piping failures may be remedied, under the guidance of the qualified person, by replacing saturated soils with drier compacted soil and/or by placement of geotextile over the failed area and placing a stabilizing toe berm constructed of granular materials
- Inspect a minimum of once per week and remove sediment when depths reach approximately one-half the barrier height, unless instructed otherwise by the designer.
- Deactivate and remove barrier once slope soils have been stabilized and return berm to an acceptable free-draining and stable condition

Similar Measures

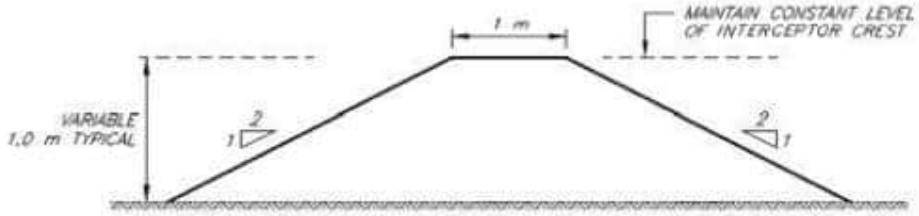
- Berms
- Sand/Gravel Bag Barriers

Design Considerations

- Qualified person design may be required for barriers constructed to hold back water (dike).



BERM INTERCEPTOR
TYPICAL LOCATION



TYPICAL SECTION
BERM INTERCEPTOR

NOTES:
1. SILT ACCUMULATION TO BE REMOVED WHEN HALF BERM INTERCEPTOR HEIGHT COVERED.
2. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

BERM INTERCEPTOR

Rolled Erosion Control Products (RECP) a) Channel Installation b) Slope Installation c) Straw or Coconut Fiber Rolls Erosion Control	B.M.P. #8

Description and Purpose

- Biodegradable or synthetic fabricated soil coverings used for temporary protection of disturbed soils on slopes and drainages until vegetation can be established
- Natural fibrous organic material (sod) stripped from the site may be utilized to protect soils from erosion if carefully removed and stored. This material may require staking or staked netting to hold it in place
- Categories of rolled erosion control products (RECP) can be:
  - Erosion control blankets (ECB) (generally biodegradable and temporary)
  - Turf reinforcement mats (TRM)
  - Composite turf reinforcement mats (C-TRM)
- RECP may be manufactured of organic material, synthetic material, or as a composite of organic and synthetic materials. There are many different products available with varying qualities, durability and lifespan (e.g. Curlex – wood product; expands to conform to the surface; filters; and is lighter in color to reduce heat).
- RECPs protect disturbed soils from raindrop impact and surface runoff erosion, increase water infiltration into soil, retain soil moisture and decrease evaporation loss
- Protect seeds from raindrop impact, runoff, and birds/animals
- Stabilize soil temperature and increase soil moisture to promote seed germination and enhance vegetation growth

Applications

- Temporary or permanent erosion control measure
- May be used to protect disturbed, exposed soils for cut or fill slopes at gradients of 2.5H:1V or steeper
- May be used on slopes where erosion potential is high
- May be used on slopes where vegetation is likely to be slow to develop
- May be used to protect disturbed exposed soils in ditches and channels (with high flow velocities) by providing additional protective cover while allowing successful high density vegetative growth to become established

Rolled Erosion Control Products (RECP) a) Channel Installation b) Slope Installation c) Straw Rolls Erosion Control	B.M.P. #8

Advantages

- Erosion protection is higher, more uniform, and longer lasting than sprayed-on products (e.g., mulches)
- Wide range of commercially available temporary (biodegradable) or permanent products

Limitations

- Poor performance of RECP may result from the following:
  - Low density vegetation growth (beneath RECP) due to non-favourable weather and growth conditions (i.e., soil type, moisture, storm events at critical times). The effectiveness of RECP, especially along channels, is very dependent on success of vegetation growth on site. It is important that the designer assess the effectiveness of RECP in accordance with site, soil, terrain and vegetation growth conditions
  - Heaving (lifting) of RECP and the erosion of underlying soils (undermining) can occur under rapid snow melt conditions when melt water gets underneath the RECP or when high flow velocity is created in a narrow channel. This situation can occur along steep channels interlaced with drop structures where the RECP is installed between the check structures. Undermining can occur along un-anchored edges of RECP at upper edges of ditch when snow melt or overland flow occurs at tops of ditch and gets beneath the RECP. This is especially critical when underlying soil is easily erodible (e.g., fine-grained non-cohesive silty soils). It is important to trench-in and anchor the edges of the RECP installations and install anchor pins (staples) at sufficient density intervals (refer to BMP #8 Figures)
  - Ice build-up from groundwater seepage sources can uplift and dislocate the RECP which may cause flow to pass beneath the RECP to erode the substrate soils. Winter ice accumulation may be related to the groundwater regime frozen soils (permafrost or ground ice). Investigative design on subsurface drainage by a geotechnical engineer may be required in these areas.
- Can be labour intensive to install
- Must be installed on unfrozen flat ground
- Temporary blankets may be used for erosion control and require removal before implementation of the permanent measures
- Rolled erosion control products (RECP) are not suitable for rocky sites

- Proper surface preparation is required to ensure direct contact between blanket and soil
- Polyethylene sheeting (poly) can be used on sensitive slopes with precautions:
  - Poly sheeting RECP product can be easily damaged, ripped or cut, is non-biodegradable, and proper disposal is required
  - Poly sheeting product results in 100% runoff, thus increasing erosion potential in downslope areas receiving the increased flow volumes
  - Poly sheeting may increase flow velocity and should be used in conjunction with check dam structures on long slopes
  - Poly sheeting should be limited to a temporary covering for sensitive soil stockpiles or small critical unstable slope areas

Construction (Slopes)

The following is a general installation method for RECP on slopes:

- Prepare soil surface to make smooth and place topsoil and seed
- Surface must be smooth and free of large rocks, debris, or other deleterious materials. This is a critical step to get the RECP to stay in contact with the soils at all times
- RECP is to be securely anchored at top of slope in a minimum 0.15 m by 0.15 m trench for the entire width of the blanket

  The blanket should be rolled out downslope and anchors (pegs) should be placed along central portion of blanket spaced at 4 anchors per m^2 minimum (0.5 m spacing) for slopes steeper than 2H:1V and 1/m² (1 m spacing) for slopes flatter than 2H:1V
  - (1) Where the blanket roll is not long enough to cover the entire length of the slope, a minimum 0.15 m by 0.15 m anchor trench should be excavated at the location of the lap, and the downslope segment of the blanket anchored in the trench, similar to the method used for the top of the slope, or
  - (2) When blankets must be spliced down the slope, place blanket end over end (shingle style with approximately 0.10 m overlap). Staple through overlapped area at 0.3 m intervals.
  - The upslope portion of blanket should overlap the downslope portion of blanket, shingle style, at least 0.15 m with staple anchors placed a maximum 0.3 m apart
  - Adjacent rolls of blanket should overlap a minimum 0.1 m

- Anchors along overlap between adjacent rolls should be placed 0.5 m apart

Construction (Channels)

- A RECP should be installed in accordance with the manufacturer's directions where available

The following is a general installation method for channels:

- Prepare the surface and place topsoil and seed
  - Surface must be smooth and free of large rocks, debris, or other deleterious materials
- Begin by excavating a minimum 0.15 m deep and 0.15 m wide trench at the upstream end of channel and place end of RECP into the trench
  - Use a double row of staggered anchors ('U' shaped pegs) approximately 0.1 m apart (i.e., 0.2 m linear spacing) to secure RECP to soil in the base of trench
  - Backfill and compact soil over RECP in trench
- Roll the centre RECP in direction of water flow on base of channel
- Place further rolls of RECP, starting with the upstream RECP over top of the downslope section (shingle style).A minimum 0.15 m overlap of the upper roll over the top of the downslope section is required.
  - Use a double row of staggered anchors approximately 0.1 m apart to secure the RECP to soil
  - Use an anchor channel (excavated trench as above) for the second row of RECP where high flows may be anticipated, ensuring good overlap with upslope RECP section
- Full length (side) edge of RECP at top of sideslopes must be anchored in a minimum 0.15 m deep and 0.15 m wide trench
  - Use a double row of staggered staple anchors a maximum of 0.1 m apart (i.e., 0.2 m linear spacing) to secure RECP to soil in base of trench
  - Backfill and compact soil over RECP in anchor trench
- Overlap RECP on sideslopes (shingle style down channel) and a minimum of 0.1 m over the centre RECP and secure the RECP to soil with anchors spaced a maximum of 0.2 m apart

- In high flow channels, an anchor trench across the width of the channel is recommended at a maximum spacing of 10 m to anchor the ends of the RECP to the underlying soil
  - Use a double row of staggered anchors ('U'-shaped pegs) a maximum of 0.1 m apart (0.2 m linear spacing) to secure the RECP to the soil in the base of the trench
  - Backfill and compact soil over the RECP in the anchor trench
- Anchor terminal ends of the RECP in a minimum 0.15 m deep and 0.15 m wide anchor trench
  - Use a double row of staggered anchors a maximum of 0.1 m apart (i.e., 0.2 m linear spacing) to secure the RECP to the soil in the base of anchor trench
  - Backfill and compact soil over the RECP in anchor trench

Construction Considerations

- Slopes should be topsoiled and seeded prior to placing RECP
- Ensure blanket is in direct contact with the soil by properly grading soil, removing rocks or deleterious materials, prior to placing blanket. This is critical to the success of the installation.
- In channels, RECPs should extend above the anticipated high flow height, with a minimum 0.5 m of free board (extra room)
- For turf reinforcement mat (TRM), RECP should be placed immediately after topsoiling
- RECP should be anchored by using wire staples, metal geotextile stake pins, or triangular wooden stakes
  - All anchors should be a minimum of 0.15 to 0.2 m in length
  - For loose or saturated soils, use longer anchors
- RECPs must be placed to run with the direction of flow, without stretching the fabric and maintaining direct contact with underlying soil
- It is essential to understand product specifications and follow manufacturer's instructions on installation methods. These are available from suppliers, and on the Internet. The BMP #8 Figures offer guidance.

Product Quality Assurance/Quality Control (QA/QC) Certification

RECPs should be certified by the supplier/manufacturer to ensure product performance and compliance with specified property requirements. A certificate for QA/QC testing of manufactured products is required. The performance and QA/QC testing should be carried out by reputable laboratories to ensure a commonly acceptable QA/QC standard. Dependent on product type and intended performance, the product information certificate should be provided by the product supplier/manufacturer to include the following: Manufacturer's Certificate on:

- Performance specification
  - Permissible Tractive Resistance (include testing methods and vegetative growth conditions)
  - Permissible Flow Velocity (if available)
  - Longevity (for biodegradable or non-biodegradable products)
- Minimum Average Roll Values (MARVs) along with specified testing methods for
  - Physical properties
    - Mass per unit area
    - Thickness
    - Tensile strength
    - UV Resistance
  - Other physical properties (for non-woven below Erosion Mat (if specified)
    - Grab tensile strength
    - Grab elongation
    - Puncture strength
    - Trapezoidal tear
    - UV Resistance

Inspection and Maintenance

- Areas covered with RECPs should be inspected regularly and repaired as required and in accordance with the PESC and TESC Plans. After periods of heavy rainfall or storm events check for RECP for separation or damage
- Any damaged or poorly performing areas should be repaired immediately. Regrading of the slope by hand methods may be required in the event of erosion.

- Inspection and maintenance should continue until dense vegetation is established
- Seeded areas should be monitored and areas with low vegetation density should be reseeded
- After approximately one year, a top dressing of fertilizer may be applied to improve vegetation cover and assist degradation of temporary blankets
- Some RECPs contain and embedded seed mix which may be suitable for use. Discuss the seed contained in the product to ensure compliance with GNWT requirements for seeding and invasive species.

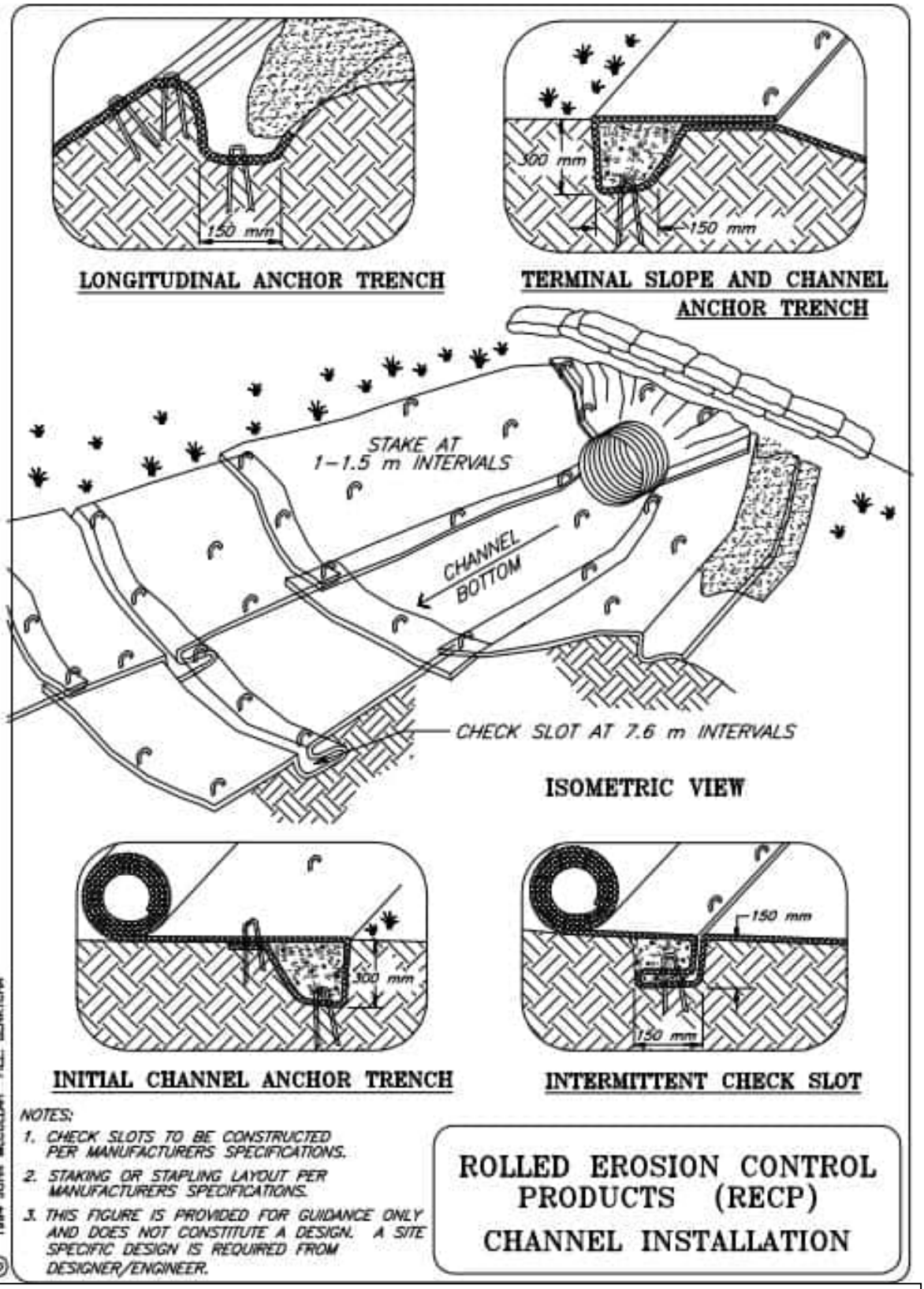
Similar Measures

- Re-spreading of natural fibrous organic material (Sodding)
- Mulching (for slopes only)
- Riprap (primarily in channels)
- Gabion mattresses (primarily in channels)

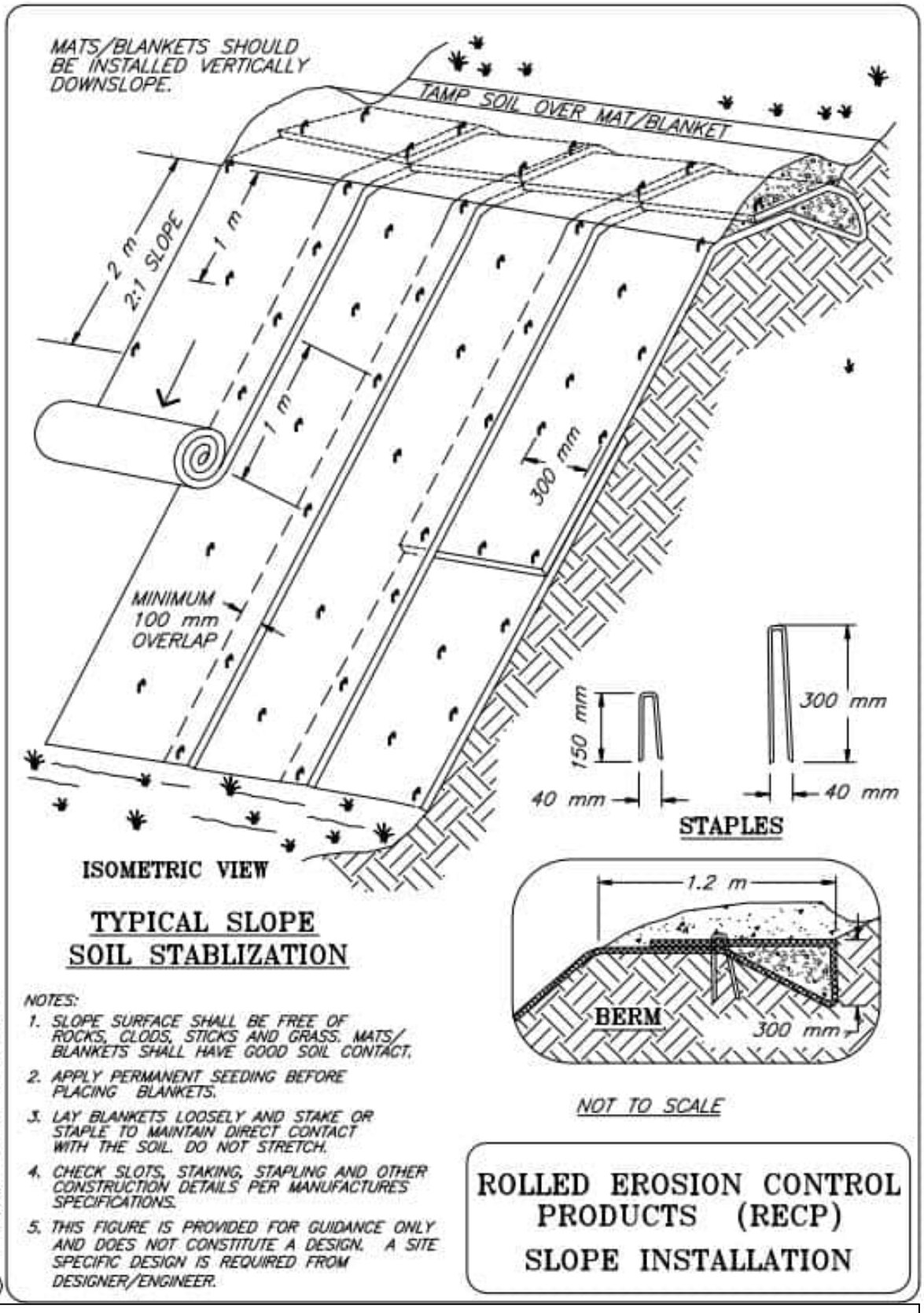
Design Considerations

- Assess hydraulic (water) flow conditions and tractive stress on channel
- In areas which are anticipated to have slow vegetation return (northern areas with short growing seasons and permafrost zones), consideration should be given to covering the site with a layer of dense fibrous organic material, where available
- Assess local soil, weather and growth conditions for revegetation (within 3 to 12 months of the project) to determine if the use of RECP as a protective measure is suitable. If the revegetation conditions are assessed as favourable, the use of RECP can be considered

Discuss the suitability of the RECP product for use on the site with your supplier. Suppliers are key information sources and can provide detailed recommendations suitable to the specific location or site conditions.



Government of the Northwest Territories – Transportation



Government of the Northwest Territories – Transportation

Diversion Ditch (Intercept Ditch) Erosion Control	B.M.P. #14

Description and Purpose

- Channels or swales constructed along the crest of slopes to intercept and prevent overland flows from entering areas with bare soil slopes. This diversion will convey runoff away from the slope or construction area and minimize erosion and downslope sediment delivery from overland sheet flow
- Can be used to direct runoff to slope drains (or downdrains) which carry water from higher to lower slope elevations

Applications

- Permanent or temporary measure
- Effective method of intercepting overland flows to avoid flow over exposed slopes and resulting erosion, especially on cut slopes in highly erodible soils (sand and silt)
- Can be used in conjunction with an existing slope drain which was installed down a steep slope
- May be lined with vegetation, riprap, erosion control blankets, or some other erosion protection measure in order to divert clean water, protect the ditchline base from erosion, and to protect highly sensitive and high risk environmental areas downslope
- Can be used in conjunction with erosion or sediment control measures, such as check dam structures, diversion into vegetated areas, or permeable synthetic barriers as part of permanent channel design to protect highly sensitive and high risk environmental areas

Limitations

- Ditch may require design by qualified personnel if flow velocities and/or volumes are large, or if the ditch crosses areas with soil stability conditions
- Ditch may require lining with riprap, RECP or non-woven geotextile fabric to minimize soil erosion from the concentrated flow
- Ditch must be graded to maintain adequate depth, and positive drainage to avoid ponding and breaching of channel sides, which may lead to overtopping of the channel and result in downslope erosion
- Removal of sediment build-up and other ditch maintenance works may be difficult due to limited access in some areas (crest of slopes)
- Ditch may require removal or infilling for reclamation activities on the work site

Diversion Ditch (Intercept Ditch) Erosion Control	B.M.P. #14

Construction

- Excavate the diversion ditch a minimum setback distance of 2 m from the crest of the slope. The ditch ex cavation material can be used to prepare a berm on the downslope side but this must not load the top of slope or add soil to the slope. This may require design by a geotechnical engineer
  - Place and compact excavated soil to form a berm between the crest of slope and the diversion ditch to provide adequate depth (up to 1 m) for the ditch
    - The potential for failure and the consequence of a failure of this berm will determine the level of compaction effort required
  - Sideslopes of the ditch should not be steeper than 2H:1V (depending upon material type)
  - Depth of ditch (from base of ditch to top of berm) should be a maximum of 1 m in depth; width of ditch should be 1 m maximum. If a l arger ditch is required, then alternate drainage control measures should be explored
  - Ditch grade should be a minimum of 1% to promote positive drainage and prevent ponding and saturation of soils

Construction Considerations

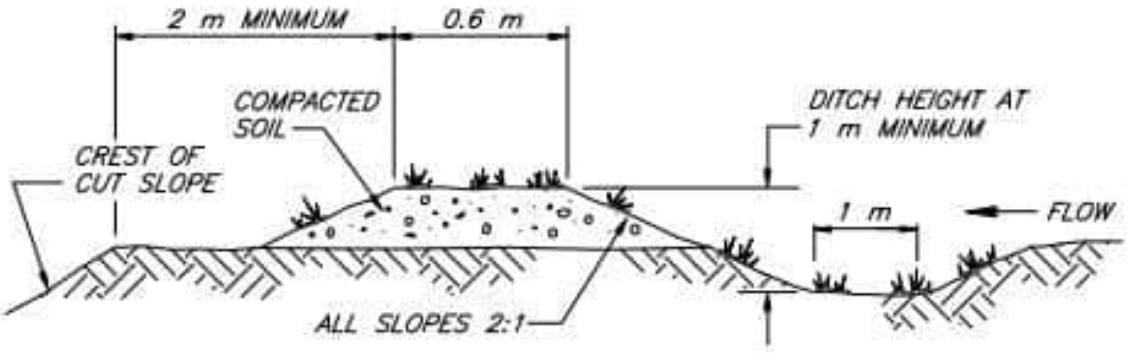
- Channel should be graded towards nearest natural draw or drainage pipe

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Repair any damage or erosion to the ditch base or berm immediately

Similar Measures

- Berms
- Barriers



TYPICAL DIVERSION DITCH

NOTES:

1. THE DITCH BEHIND THE DYKE SHALL HAVE POSITIVE GRADE TO A STABILIZED OUTLET.
2. THE DYKE SHALL BE ADEQUATELY COMPACTED TO PREVENT FAILURE.
3. FOR SENSITIVE HIGH RISK AREAS, THE DITCH SHALL BE STABILIZED WITH TEMPORARY OR PERMANENT SEEDING OR RIPRAP.
4. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

DIVERSION (INTERCEPT) DITCH

FILE: TEMPDIKE

Seeding Erosion Control	B.M.P. #15

Description and Purpose

- The planting or placing of seed mixes into soils for revegetation of a disturbed site before or after a layer of topsoil is spread over the slope
- Promotes faster revegetation of the area and increased erosion protection through development of a root and leaf structures from plant growth
- Established vegetation reduces available space for the growth of invasive species.

Applications

- Permanent measure
- Permanent seeding may be applied to exposed bare mineral soil areas which have been graded to final contours
- Permanent seeding may be applied to landscape corridors, cut slopes and road shoulders by broadcasting, furrowing or spraying on. A protective mulch & tackifier may be recommended dependant on the site conditions.
- Seeding should be applied and protected by RECP in channels where there may be erosion of soil and seed
- The establishment of vegetation by seeding methods in some areas may not be feasible due to climatic conditions or may be very slow in recovery. Seek advice from seed suppliers with northern expertise when selecting seed or other appropriate vegetation specific to the site
- Fertilizers should be avoided unless recommended specifically for the site by the seed supplier, as fertilizer tends to promote top growth over root growth. Root growth is extremely important for plant survival in the northern climates
- The seed mix should be approved by the GNWT-DOT and not include palatable grass or plant species, in order to avoid attracting larger wildlife or domestic animals. This will minimize vehicle-animal collisions. The vegetation may provide some minor habitat for wildlife after vegetation establishment
- Seed growth can be enhanced with a protective layer of topsoil, mulch or rolled erosion control product (RECP) to improve germination and growth environment

Advantages

- Enhances terrestrial and aquatic habitat with vegetation growth re-establishment and reduction of surface erosion
- Aesthetically pleasing with established vegetation cover
- Grows stronger with time as root structure develops

- Generates vegetation which enhances infiltration of runoff and transpiration of groundwater
- Seeding with a suitable mixture of grasses and herbaceous legumes in disturbed areas is an inexpensive method of stabilizing the soil, particularly if the area is flat to gently sloping and has suitable soils
- Cost of seeding disturbed areas is relatively low and its effectiveness on a long-term basis is relatively high

Limitations

- Invasive species should be avoided when choosing seed mixtures. Information about species to avoid can be located on the GNWT-ENR website
- Uncut dry grass may present a fire hazard
- Seeding of long steep slopes may be difficult without using measures such as RECP's or hydroseeding-hydromulching-tackifier methods
- Seasonal windows on planting are very short may not coincide favourably with the construction schedule
- Areas that have not been covered with seed and topsoil or a layer of organic material are susceptible to erosion until vegetation is established. Use of topsoil and mulch can supply necessary nutrients, moisture control and reduce rain drop erosion potential during germination and until vegetation is established
- Additional erosion control measures, such as RECPs, may be required for steep slopes and channels
- Reseeding may be required in areas of limited plant growth
- Time to establish root structure may be unacceptable for some high risk areas; rolled erosion control products or spreading of reserved organic fibrous mat should be considered for these areas

Construction

- Preserving fibrous mats (sod) during stripping operations may be beneficial as these mats may contain native seed. Avoid areas with invasive species when stockpiling sod.
- The site should be prepared prior to seeding. Most seed of northern species require mineral soil contact to root successfully
- Surface should be graded to design grades and then have topsoil added
- Seedbed should be 10-40 mm deep, with the top 10 mm consisting of topsoil which is free of large chunky material or stones

- Seed should be applied immediately after seedbed preparation using broadcast seed spreaders, cyclone (broadcast) spreaders, or hydroseeding to ensure uniformity of application
- Seedbed may be harrowed, raked, or chain-dragged to ensure proper seed-soil contact based on the conditions of the site
- Fertilization for plant development in northern climates is not recommended as fertilizer tends to promote top growth rather than root growth in the plants. Root growth is critical to plant survival in northern climates. Time released fertilizer, if recommended by the seed supplier, should be applied unless the site drains immediately to streams or water bodies

Construction Considerations

- Seeding rate for all mixes should be 20 kg/ha minimum or adjusted to the local rate as determined through previous project experience
- Fall rye may be added to each mix, with approval from the GNWT-DOT, to provide early growth and protection from soil erosion. Fall rye seeding rate is 5 kg/ha
- Selection of proper vegetation seed mix depends on soil conditions, climate, topography, land use, and site location
- Planting of seeds by hydroseeding and mulching techniques should be considered for slopes steeper than 3H:1V where seedbed preparation is difficult, or where application of seed, mulch, and fertilizer in one continuous operation is desirable
- Grass sod may be installed for faster results around community developments in southern locations within the NWT, however it is very costly and may be limited by ground conditions and supply. If mulch is placed as a germination medium for seeds, the mulch layer may be further protected with a biodegradable matting (jute burlap) to prevent mulch from being washed or blown away

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Freshly seeded areas should be inspected frequently to ensure growth is progressing, erosion is controlled and invasive species have not colonized the site
- Additional stormwater control measures should be considered for areas damaged by runoff erosion
- Re-seeding may be required after initial seeding to get suitable density of plants
- Cutting or mowing thin grasses will encourage the establishment and spread of the grass roots

Similar Measures

- Hydraulic seeding (hydroseeding) and mulching

Design Considerations

- Seed application rate of 20 kg/ha may be used; if fall rye is to be added, it should have an application rate of 5 kg/ha
- Bacterial inoculants should be used when seeding with legumes. This is normally applied to the seed in accordance with the supplier's recommendations before it is shipped. Fertilizer use should be limited to slow release (2 year) types and shall be carefully controlled as too much nitrogen may increase nutrient loading to receiving streams and fertilizer can promote top growth instead of root growth.
- Seeding can occur during any period when germination can be successful and plants have sufficient time to become established before the end of the growing season. Seeding should occur in spring or in fall for optimum results. Seeding conducted in the fall or on up to 0 .15 m of snow will overwinter and germinate the following spring. Seeding periods will vary dependant on specific seed type and mix ratio which is developed for the site. Seed mixes, application rates, and application schedule should follow the seed suppliers recommendation for best results
- Mulch is recommended when broadcast seeding. For specific needs of local growth environment, specific design and advice from local seed supplier may be required

The GNWT Department of Transportation has adopted the following general seed mixes for use on transportation projects in the Northwest Territories. Seed mix success is dependent on the site location, soil types and ground conditions, and the care taken in application.

Seeding Erosion Control	B.M.P. #15

Government of the Northwest Territories - Department of Transportation
Grass Seed Mixtures for use on Transportation Projects

The following seed mixes are provided as a guideline by the GNWT–DOT for *"Seeding".* A qualified person must perform the vegeta tion assessment and the soil testing for fertilizer (if required) as part of the design work.

The following seed mixes are very general and are standard mixes and each region of the NWT would vary. A knowledgeable seed supplier should be contact ed for site specific seed mix recommendations. Seeding application rates are 20kg/ha unless otherwise specified.

Seed Mix 1 - Native Seed Mix: General Reclamation

General Reclamation Mix		**% by Dry Weight**
Common Name	**Latin Name**	
Slender Wheat Grass	*Agropyron trachycaulum*	25%
Violet Wheatgrass	*Agropyron violaceum*	25%
Tufted Hairgrass	*Deschampsia cespitosa*	20%
Alpine Bluegrass	*Poa alpina*	20%
Tickle Grass	*Agrostis scabra*	5%
Fowl Bluegrass	*Poa palustris*	5%

(Arctic Alpine Seed Ltd – www.aaseed.com - Custom Mix for General Reclamation, 2012)

Seed Mix 2 – Custom Native Reclamation Mix (Kakisa)

Custom Native Reclamation Mix (Kakisa)		
Common Name	**Latin Name**	**% by Dry Weight**
AEC Hillcrest Awned Slender Wheatgrass	*Agropyron trachycaulum*	42%
Violet Wheatgrass	*Agropyron violaceum*	29%
Rocky Mountain Fescue	*Festuca saximontana*	17%
Boreal Creeping Red Fescue	*Festuca Rubra var. rubra*	7%
Alpine Bluegrass	*Poa alpina*	5%

(Arctic Rim Distributors – Brett Young: Custom Native Reclamation Mix #LEL-BLND-07-001351, 2008)

Seed Mix 3 – Silt-Clay Cut Slopes

Silt-Clay Cut Slope Mix		**% by Dry Weight**
Common Name	**Latin Name**	
Violet Wheatgrass	Agropyron violaceum	50%
Sheep Fescue	*Festuca ovina*	40%
Northern Fescue	*Festuca saximontana*	10%

(Arctic Alpine Seed Ltd - www.aaseed.com - Silt-Clay Cut Slope Mix, 2012)

Seed Mix 4 – Sand or Gravel Cut Slopes

Sand or Gravel Cut Slope Mix		% by Dry Weight
Common Name	**Latin Name**	
Violet Wheatgrass	*Agropyron violaceum*	50%
Northern Fescue	*Festuca saximontana*	25%
Tufted Hairgrass	*Deschampsia cespitosa*	25%

(Arctic Alpine Seed Ltd – www.aaseed.com - Sand or Gravel Cut Slope Mix, 2012)

Seed Mix 5 – Sandy Soil Mix

Sandy Soil Mix		% by Dry Weight
Common Name	**Latin Name**	
Violet Wheatgrass	*Agropyron violaceum*	50%
Northern Fescue	*Festuca saximontana*	30%
Sheep Fescue	*Festuca ovina*	20%

(Arctic Alpine Seed Ltd – www.aaseed.com - Sandy Soil Mix, 2012)

Seed Mix 6 – Saline Soil Mix

Saline Soil Mix		% by Dry Weight
Common Name	**Latin Name**	
Violet Wheatgrass	*Agropyron violaceum*	40%
Northern Fescue	*Festuca saximontana*	20%
Alkaligrass	*Puccinellia nuttalliana*	10%

(Arctic Alpine Seed Ltd – www.aaseed.com - Saline Soil Mix, 2012)

Seed Mix 7– Sub Alpine Environments

Sub Alpine Environments Mix		% by Dry Weight
Common Name	**Latin Name**	
Violet Wheatgrass	*Agropyron violaceum*	50%
Tufted Hairgrass	*Deschampsia cespitosa*	25%
Northern Fescue	*Festuca saximontana*	20%
Tickle Grass	*Agrostis scabra*	5%

(Arctic Alpine Seed Ltd – www.aaseed.com - Sub Alpine Environments, 2012)

Seed Mix 8 –Alpine Environments

Alpine Environments Mix		**% by Dry Weight**
Common Name	**Latin Name**	
Alpine Bluegrass	*Poa alpina*	40%
Violet Wheatgrass	*Agropyron violaceum*	20%
Northern Fescue	*Festuca saximontana*	20%
Tickle Grass	*Agrostis scabra*	10%
Tufted Hairgrass	*Deschampsia cespitosa*	10%

(Arctic Alpine Seed Ltd – www.aaseed.com – Alpine Environments, 2012)

Hydroseeding Erosion Control	B.M.P. #17a

Description and Purpose

- Hydroseeding is the spraying-on of a slurry to a slope to provide a layer of seed and growth medium
- The slurry consists of a combination of seed, mulch, tackifier, and possibly fertilizer with a colouring agent and water which are mixed together in a tank. The seed and fertilizer choice will be individually determined for the site specific conditions
- When sprayed on the soil, the slurry forms a continuous seed blanket and protects the soil from wind and water erosion and raindrop impact by binding (or adhering) the seeds in place
- The hydroseeded layer reduces soil moisture evaporation, and decreases soil surface crusting due to evaporation or drying of soil
- Enables revegetation of steep or long slopes where revegetation by any other method would be very difficult or unsafe; re-seeding and special mix design may be required. Slopes with bedrock outcrop or large gravel are not generally favourable for hydroseeding

Applications

- Temporary or Permanent measure
- Slurry is held in suspension through constant agitation and is sprayed onto disturbed areas by hose using high pressure pumps mounted on trucks. Coloring of the slurry is used to determine coverage and density
- Can be used for spray-on seeding covering large areas efficiently after placement of topsoil or organic material
- Can be used to provide temporary and permanent surface erosion control prior to establishment of permanent native vegetation
- May be used to provide soil stabilization for seeding disturbed soil areas
- Can be used with higher efficiency and cover large areas with advantages over conventional methods (broadcast seeders)
- Can be used in areas where little topsoil is available

Limitations

- Site must be accessible to hydroseeding equipment
  - Tanks and pumps mounted on trucks which use roads or flat areas
  - Maximum hose and spray range of approximately 30 m to 50m

- May require subsequent spraying to reseed bare spots or cover areas with low growth
- Requires significant amount of a local water source

Construction

- Prepare soil surface by removing large rocks or other deleterious materials
- Apply topsoil or organic materials if available
- Apply hydroseed-mulch as per supplier's recommendations

Construction Considerations

- Seed
  - Seed selection should be made in accordance with Government of the Northwest Territories (GNWT) approved seed mixes for ecological zones
  - GNWT – Department of Transportation has approved seed mixes, specific to supplier recommendations, for transportation construction projects depending on site location (see BMP #22 Seeding)
  - Seed mixes have been developed based on historic performance results on other northern Canadian sites

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Areas damaged by runoff may need to be repaired and/or protected from further erosion before hydroseeding
- Site may need to be reseeded to achieve required densities

Similar Measures

- Seeding
- Mulching
- Rolled Erosion Control Products (RECP)

Hydromulching Erosion Control	B.M.P. #17b

Description and Purpose

- The spraying-on of a slurry to a slope to provide a layer of growing medium
- Seed must be in contact with mineral soils to take root. This consideration is especially important for successful revegetation in northern areas.
- The slurry consists of seed, mulch and may contain time released fertilizer, and water which are mixed together in a tank. Tackifiers (natural or synthetic material used to stick fibers together (e.g. cornstarch)) may be added dependent upon site conditions and location
- The slurry reduces soil moisture evaporation, reduces raindrop erosion and decreases soil surface crusting due to evaporation or drying of soil

Applications

- Temporary or Permanent measure
- Can be used in areas where little topsoil is available
- Used where soil amendments (fertilizer or fibers) may be required
- Usually used in conjunction with hydroseeding

Advantages

- Relatively efficient spraying method of promoting plant growth as well as applying erosion protection
- Allows spray-on seed application on steep slopes where conventional re-vegetation methods are very difficult
- Minimizes effort required to re-vegetate disturbed areas as hydromulching usually only requires one spray-on application in comparison with hand seeding methods
- Relatively efficient operation for high coverage rates
- Provides protection from wind erosion when tackifiers are added

Limitations

- Site must be accessible by hydromulching equipment
  - Usually mounted on trucks
  - Maximum hose range of approximately 30 m to 50 m
  - Requires significant supply of local water

Hydromulching Erosion Control	B.M.P. #17b

Construction

- Prepare soil surface by removing large rocks or other deleterious materials
- Apply topsoil if available
- Spray on hydromulch as per supplier's recommendations

Construction Considerations

- Hydraulic Mulches
  - Cellulose
    - Comprised of recycled paper from newspapers, magazines, or other paper sources
    - Rapid method for applying seed, fertilizer, mulch, and water in almost any disturbed area
    - Usually installed without tackifier in slurry
    - Short fibre lengths and lack of tackifier limits water erosion control effectiveness and does little to control moisture content and temperature within the soil
    - Residual inks within the recycled paper may leach into soil, potential problem on environmentally sensitive areas
    - Longevity significantly shorter than for wood fibre mulches or bonded fibre matrices (BFM)
    - Cheaper than wood fibre mulches and bonded fibre matrices (BFM)
  - Wood Fibre
    - Comprised of whole wood chips
    - Industry standard, provides quick and uniform method and medium for re-vegetating large areas quickly and economically
    - Longer fibre lengths than for cellulose mulches
    - Longer lasting and has better wet-dry characteristics than cellulose mulches
    - Provides limited erosion control even when sprayed on with tackifiers
    - Provides limited control of soil moisture content and temperature when applied at higher rates
    - Less expensive than BFM, however, less effective than BFM
    - More expensive than cellulose mulches, however, more effective than cellulose mulches

- Bonded Fibre Matrices (BFM)
  - Slurry comprised of either cellulose mulch, wood fibre mulch, or a combination of the two
  - Mulches are bound together using chemical bond, mechanical bond, or a combination of the two
  - All fibres and binding agents are premixed by manufacturer, ensuring uniformity and consistency throughout the application
  - Well suited for sites with existing desirable vegetation and where worker safety and minimal ground disturbance are desired
  - Degree of protection similar to that obtained from rolled erosion control products (RECP)
  - Quicker installation/application than for RECP
  - Chemically bonded BFM may require a 'set-up' or curing/drying period
    - Application must be limited to periods where there is no threat of rain during curing period
    - Mechanically bonded BFM have no curing time and are effective immediately after application
  - Application on dry soils is not recommended
  - More expensive than cellulose and wood fibre mulches
  - More effective than cellulose or wood fibre mulches
- Tackifiers
  - May include chemical or other substances mixed with water
  - Natural component tackifiers (cornstarch based) are available

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Areas damaged by runoff may need to be repaired and/or protected from further erosion.

Similar Measures

- Seeding
- Mulching
- Rolled Erosion Control Products (RECP)

Topsoiling Erosion Control	B.M.P. #18

Description and Purpose

- The covering of exposed mineral soils with soils of high organic content to minimize raindrop erosion potential
- May be used to provide some thermal insulation for underlying permafrost
- Provides a medium for vegetation to grow

Applications

- Usually a Permanent measure
- May be used to provide bedding medium for seed germination and a cover and nutrients to exposed nutrient poor soil that is not suitable for vegetation growth. Seed within northern climates requires mineral soil contact to root efficiently. This should be considered during application of topsoil and seed may need to be applied first in some areas
- May be used on slopes with a maximum gradient of 2H:1V
- Normally topsoil is placed prior to seeding, mulching, hydroseeding-hydromulching, and installing rolled erosion control products (RECP), or planting of trees/shrubs

Advantages

- Placing topsoil provides organic medium for vegetation, and promotes root structure growth
- Topsoil organic content provides nutrients to promote plant growth
- Absorbs raindrop energy to reduce erosion
- May provide some thermal insulation for permafrost

Limitations

- Not appropriate for slopes steeper than 2H:1V
- Placing and grading topsoil can be time consuming and expensive
- Long steep slopes may not be accessible for topsoil spreading
- Dry topsoil may be eroded by blowing wind, sheet flow or concentrated flows
- Topsoil may not be readily available in some areas

Construction

- Prepare ground surface to final grade by removing large rocks or other deleterious materials

- Apply topsoil with a bulldozer or light track equipment to design thickness
- Track walk upslope or downslope (do not overcompact topsoil by heavy equipment; only track walk one pass) to provide a contour of roughness of topsoil to further minimize erosion

Construction Considerations

- Topsoil should be free of weeds which may inhibit re-vegetation of desirable plants (i.e., grass and native species)
- Subgrade should be roughened (by track walking up/down the slope prior to topsoiling) to promote adherence of topsoil to subgrade. Topsoil should be moistened regularly prior to vegetation establishment during periods of hot dry weather to minimize wind erosion
  - Hydroseeding-hydromulching with tackifier application will minimize wind erosion of topsoil

Design Considerations

- Perform pre and post disturbance survey
- Consider use of a soil amendments (fiber and fertilizer additives) in areas with little topsoil or topsoil with poor growth nutrients
- Perform a pre-construction topsoil assessment to determine topsoil thickness hence design thickness

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Areas damaged by erosion (rilling or gulleying) should be regraded and topsoiled immediately. Erosion controls should be added such as sedim ent fencing, wattles and/or RECPs

Similar Measures

- Hydroseeding-Hydromulching
- Mulching
- Rolled Erosion Control Products (RECP)

Scheduling Sediment Control and Erosion Control	B.M.P. #25

Description and Purpose

- Schedule the sequence and timing of construction activities in order to:
  - Efficiently maximize the amount of erosion protection installed (such as topsoiling and seeding) as soon as a portion of grade construction is completed, and
  - Limit the portion of land disturbance from construction compatible with the efficient and achievable rate of erosion control measures constructed Incorporate erosion and sedimentation control concerns during the scheduling phase which will minimize the amount and duration of bare soil exposure to erosion elements and ensure erosion and sedimentation control measures are implemented at an appropriate time
- An operational schedule may be designed during planning stages by the contractor and altered during actual construction to suit variable conditions as these are encountered

Applications

- Temporary measure

Advantages

- Ensures erosion and sedimentation control issues are identified during the planning stage by the contractor
- Promotes timely implementation of erosion and sediment control practices
- Planning for activities to be completed during dry seasons to reduce erosion due to rainfall and sediment transport due to excessive overland flows (avoid flooding periods)
- Planning may avoid fish and wildlife sensitive periods (spawning and nesting)
- Planning to ensure timely mobilization of equipment and labour
- Plan to have all needed ESC materials on hand when required
- May be used to minimize bare soil exposure and erosion hazards
- Promotes efficient utilization of equipment where needed for erosion and sedimentation control on construction projects
- Promotes the installation of permanent erosion control measures (such as topsoiling and seeding) immediately after completion of each phase to get vegetation establishment underway

- Avoids the cost of costly remobilization if equipment is moved off site and is then required for implementing an erosion control measure.
- Finishes the project as it progresses rather than leaving all of the finish work until the end. Promotes good will, allows erosion and sediment controls to be removed and reduces liability while the labour is on site to do the work. No re-deployment required.
- Promotes good housekeeping

Limitations

- May not have been accounted for in the bidding and contract finalization or planning stages

Implementation

- Incorporate a schedule for erosion control and protection structures as part of the overall construction plan
- Determine sequencing and timetable for the start and end of each item, such as clearing, grubbing, stripping, etc., as part of the construction schedule
- Incorporate installation of appropriate erosion and/or sediment control measures in the construction schedule
- Allow sufficient time before construction operations and seasonal rainfall periods to install erosion and/or sediment control measures
- Whenever possible, schedule work to minimize the extent of site disturbance (soil exposure) at any one time
- Incorporate staged topsoiling and revegetation of graded slopes as work progresses
  - Don't leave all topsoiling and revegetation until the very end of the project
  - Remove un-necessary ESC controls as and when they are no longer needed

Inspection and Maintenance

- Routinely verify that construction activities and the installation of erosion and sediment control measures are progressing in accordance with the approved schedule
  - If progress deviates from schedule, take corrective action
  - An ESC Plan is a living document and is expected to be updated as required.
- When changes to the project schedule are unavoidable, alter the schedule as soon as practical to maintain control of erosion

- If previously unidentified erosion issues occur, install control measures to correct the problem and, if significant, add to the inspection plan and amend the Erosion and Sediment Control Plan.

Compost Blanket Erosion Control	B.M.P. #28

Description and Purpose

- Compost is the product resulting from the controlled biological decomposition of organic material, occurring under aerobic conditions
- Compost has been sanitized through the generation of heat and biologically stabilized to the point that it is appropriate for its particular application
- Active composting is typically characterized by a high temperature phase that sanitizes the product and allows a high rate of decomposition
- It is followed by a lower temperature phase that allows the product to stabilize while still decomposing at a slower rate
- Compost should possess no objectionable odours, chemical characteristics (high biological oxygen demand) or substances toxic to plants
- Compost contains plant nutrients but is typically not characterized as a fertilizer
- May derive from agricultural, forestry, food or industrial residues, bio-solids, leaf and yard trimmings, manure, or tree wood

Applications

- Compost blankets are commonly used for permanent erosion control (does not require removal)
- The technique is appropriate for slopes up to 2H:1V grade and on level surfaces
- Only used in areas t hat have low sheet flow drainage patterns (not for areas that receive concentrated flows)
- Compost used on GNWT-DOT projects must meet Canadian Council of Ministers of the Environment (CCME) Guidelines for Compost Quality (trace elements, maturity/stability, pathogens), which are adopted by the Government of the Northwest Territories – Department of Transportation.

Advantages

- Relatively cheap method of promoting plant growth and slope protection if available in the area
- Reasonably cost effective if material availability allows compost to be made on or near the site

Limitations

- May require approval from the GNWT Environment and Natural Resources
- May not be readily available therefore may be expensive

- Application of compost may be difficult on steep slopes
- May require spray-on method to apply compost to steep slopes
- Requires specialized blower truck, hose and attachments for blanket installation

Installation

- Slightly roughen (scarify) slopes and remove large clods, rocks, stumps, roots larger than 50 mm in diameter and debris on slopes where vegetation is to be established
- Apply compost at the rates as follows:

Annual Rainfall/Flow Rate	Total Precipitation	Application Rate for Vegetated Compost Surface	Application Rate for Unvegetated Compost Surface
Low	25 mm – 635 mm	12.5 mm – 19 mm	25 mm – 37 mm
Medium	635 mm – 1270 mm	19 mm – 25 mm	37 mm – 50 mm
High	>1270 mm	25 mm – 50 mm	50 mm – 100 mm

- Compost shall be uniformly applied using an approved spreader, (e.g., bulldozer, discharge spreaders)
- A pneumatic blower unit propels the compost directly at the soil surface, thereby preventing water from moving between the soil-compost interface
- Seeding can be incorporated during the compost application

Construction Considerations

- Use higher blanket application rates in area with high rates of precipitation and rainfall intensity, and snow melt
- Tackifier may be used in conjunction with a compost blanket, especially in regions with spring melt, and sites with severe grades and long slopes
- In areas subjected to wind erosion, a coarser compost product or higher blanket application rate is preferred
- Use lower blanket application rate in areas with lower precipitation rates and rainfall intensities

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Areas damaged by erosion (washout or rilling) should be regraded, if necessary, and re-covered with compost immediately. Action should also be taken to mitigate the cause of the erosion

Compost Blanket Erosion Control	B.M.P. #28

Similar Measures

- Rolled Erosion Control Products (RECP)
- Hydroseeding
- Hydromulching

Rolls
a) Coir Roll
b) Fibre Roll
Streambank Stabilization Techniques and Erosion Control

B.M.P. #29

Description and Purpose

- Coir rolls are long cylindrical tubes that are composed of interwoven coconut fibres which are bound together with durable coir netting. Coir rolls are particularly applicable for wetland, streambank, and shoreline projects. Coir rolls are most commonly available in 0.3 m diameters and 6 m lengths. These rolls can be linked together to form longer tubes, and are often used in combination with other biotechnical techniques, such as brush layering or live siltation methods or branch staking. Coir logs encourage siltation and wetland/floodplain maintenance
- Fibre rolls are installed along slope contours as a grade break to reduce erosion potential by reducing overland flow velocities
- Straw rolls consist of bundled straw (or natural fibre) wrapped in photo-degradable open-weave plastic or natural fiber netting staked into the soil along slope contours as a grade break to reduce erosion potential
- Live stakes or branches can be installed to anchor the fibre rolls to provide deep rooted vegetation with potential favourable moisture retention provided by fibre roll
- Fibre rolls may capture sediment, organic matter, and seeds carried by runoff

Applications

- The tough, long-lasting coconut fibres make coir rolls appropriate for wetland, streambank, and shoreline applications. Coir rolls work well when immediate erosion control is needed. Brush layers work well with coir roll applications, adding further stabilization with a live root system , while also providing excellent habitat features. The coir roll provides a base for the brush layer cuttings to be laid upon at an appropriate angle which benefits the growth of cuttings. The cuttings provide further protection from breaking waves and high flows
- Fibre rolls may be used on slopes stable enough to support vegetation (steep, confined slopes and channel banks with gradients greater than 1H:1V may have low success potential)
- Fibre rolls may be used on long slopes as a grade break to shorten the length of slope between other slope retention features
- Fibre rolls may be used as grade breaks, where slopes transition from flatter to steeper gradients

Advantages

- The coir material is natural and long lasting (5 to 7 years), and has high tensile strength

- The coir rolls and fibre rolls accumulate sediment while the plant roots develop. Eventually the coir material biodegrades and the cohesive strength of the root systems and flexible nature of the roots become the primary stabilizing element
- The coir roll/brush layering combination provides immediate shoreline and streambank protection, with additional benefits of riparian enhancement when the cuttings become established
- Coir rolls address ecological concerns by encouraging vegetation and small wildlife habitat, and are an alternative to stone revetments or other structural measures
- The high tensile strength coconut fibres, the fibre netting and the wooden stakes used to anchor the material make up the initial structural components of the system, while plant root and top growth increase the strength and water velocity reduction and sediment capture effects of the structure
- Fibre rolls can be used on slopes too steep for sediment fences or straw bale sediment barriers
- In time, the plastic netting will degrade due to the sunlight and straw will degrade and be incorporated into the soil. Natural fiber netting (Bionet^{TM}) is also available
- The primary purpose of fibre rolls is erosion control, however fibre rolls do provide a small amount of sediment control as a secondary benefit.

Limitations

- This technique should be implemented during the dormancy period of the cuttings used for brush layering and staking
- Coir rolls are relatively expensive
- Fibre rolls are designed for low sheet flow velocities
- Fibre rolls are designed for short slopes with a maximum gradient of 1H:1V
- Fibre rolls may be labour intensive to install
- Straw rolls have a shorter life span due to natural degradation
  - Usually only functional for two seasons
  - Susceptible to undermining and failure if not properly keyed into the soil
- Labour intensive maintenance may be required to ensure rolls are in continuous contact with the soil, especially when used on steep slopes or sandy soils

Construction

- Determine the annual maximum water elevation
- Mark the water level on a stake driven into the substrate, 0.3 or 0.6 m offshore. Installing the materials and plants at the correct elevation is the most important aspect to assure success of the installation. Determine, on site, where the installation will begin and end
- Determine soil level by laying a straight cutting on the coir roll with approximately 20% of the cutting sticking out past the roll, and with the basal ends dipping down into the soil
- Begin installation at the downstream end (if using in a streambank project)
- Prepare the site for installation of coir rolls by removing any large rocks, obstructions or material that may prevent the coir from making direct and firm contact with the soil. Coir rolls must be level, installed along a horizontal contour. Place coir rolls parallel to the stream bank or shoreline. It is very important to key the ends of the coir rolls firmly into the shoreline or stream bank, so waves and flows will not scour behind the rolls and compromise the integrity of the structure
- Install the coir roll such that 0.05 m of the roll extends above the annual water elevation
- Adjacent rolls shall be laced together, end-to-end, tightly and securely
- If using brush layer cuttings, prepare the soil bed behind the installed coir rolls for brush laying. It is important that the bud ends of the live cuttings angle up to some degree from the basal ends. Lay cuttings in this fashion, slightly crisscrossed for additional strength
- Next, backfill over the cuttings with soil, covering the lower 80% of the branches. At this time, the soil can be levelled and prepared for a soil wrap for additional height and soil stability
- If simply covering the cuttings with soil, compact slightly and grade slope to appropriate angle. Use water to wash soil in between branch layers
- If using plant materials, such as container-grown, pre-rooted plant plugs or willow stakes, they should be planted into the coir rolls and through the coir mats and netting
- To install plant plugs and willow stakes into the coir roll, use a planting iron or pilot bar into the roll and wedge it back and forth to create a hole for the plant. It is extremely important that the root system of the plant be placed below the water

table for certain species. All plants shall be checked to ensure that they have been firmly installed through the fibre material, into the soil

- Mulch and seed exposed areas with native species
- Prepare the slope face and remove large rocks or other deleterious materials
- Excavate small trenches a minimum of 0.15 m deep and 0.15 m wide across the width of the slope, perpendicular to the slope direction, starting at the toe of the slope and working upwards towards the crest of slope
- Space trenches a maximum of 3 to 8 m apart along the slope incline, with steeper slopes having trenches spaced closer together
- Place fibre rolls into the trenches, ensuring continuous contact between the fibre roll and the soil surface
- Butt-joint adjacent fibre roll segments tightly against one another and lace together
- Use a metal bar to make a pilot hole through middle of the fibre roll a minimum depth of 0.3 m into underlying soil
- Pilot holes should be spaced a maximum of 1 m apart
- Secure fibre roll to soil using wooden stake or other appropriate anchor. Live stakes may be used as alternate anchors
- Place soil excavated from the trench on the upslope side of fibre roll Seed the soil along the upslope and downslope sides of the fibre roll to promote vegetation growth
- Compact the soil upslope of the fibre roll to minimize undermining by runoff

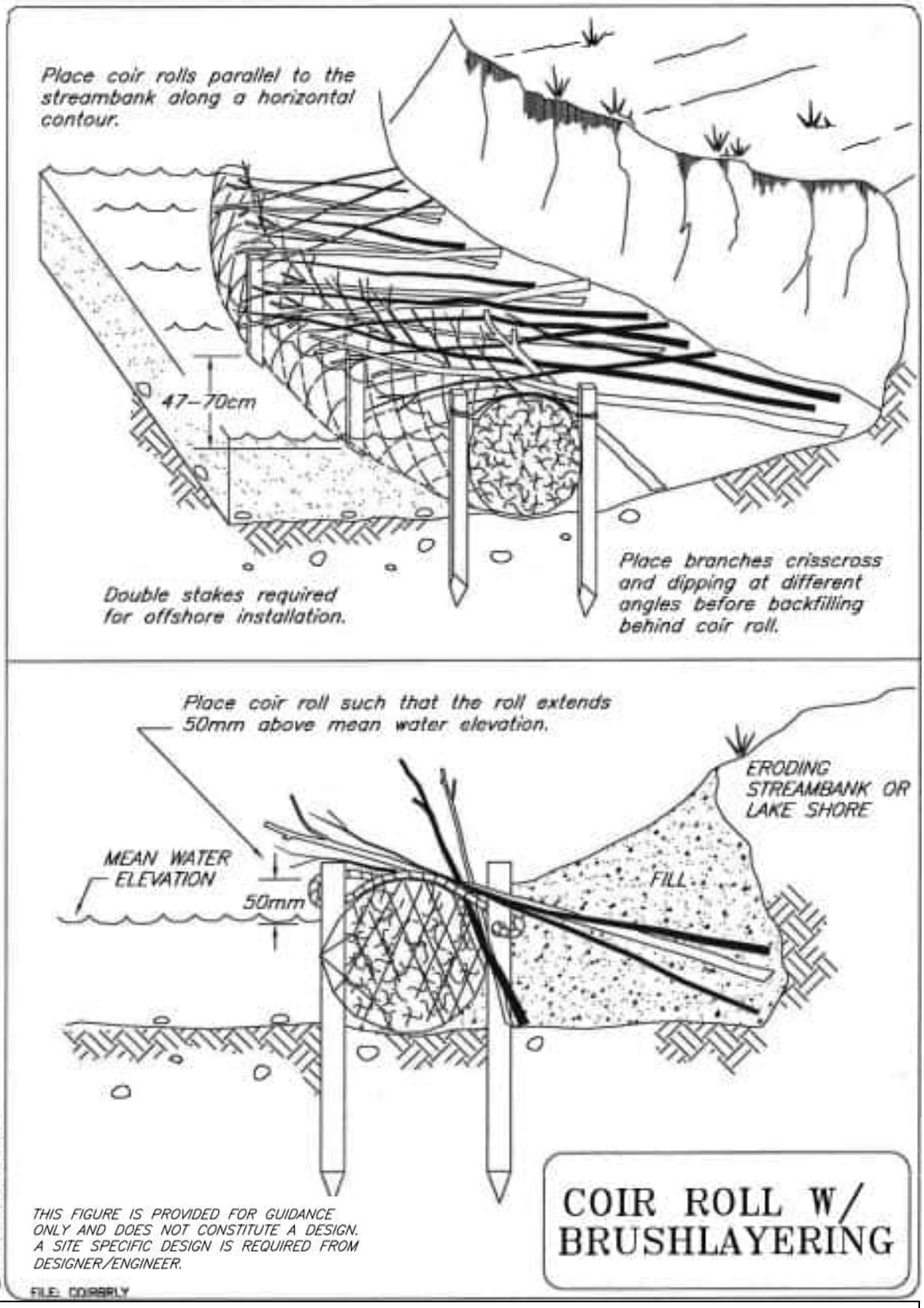
Construction Considerations

- All work site disturbance should be minimized. Protect any existing plants, when possible, and avoid additional disturbance that can lead to erosion and sedimentation
- Install additional erosion and sediment control measures such as temporary diversion dikes, sediment fences and continuous berms, as needed, before beginning work
- Coir rolls can be used in the stream as a sediment barrier, silt curtain, and/or coffer dam to control sediment while work is being done in the water
- Topsoil should be saved, if possible, and replaced once the subsoil has been removed or regraded. Soil shall be stored away from the water's edge and it shall be moved to its final location and stabilized as quickly as possible

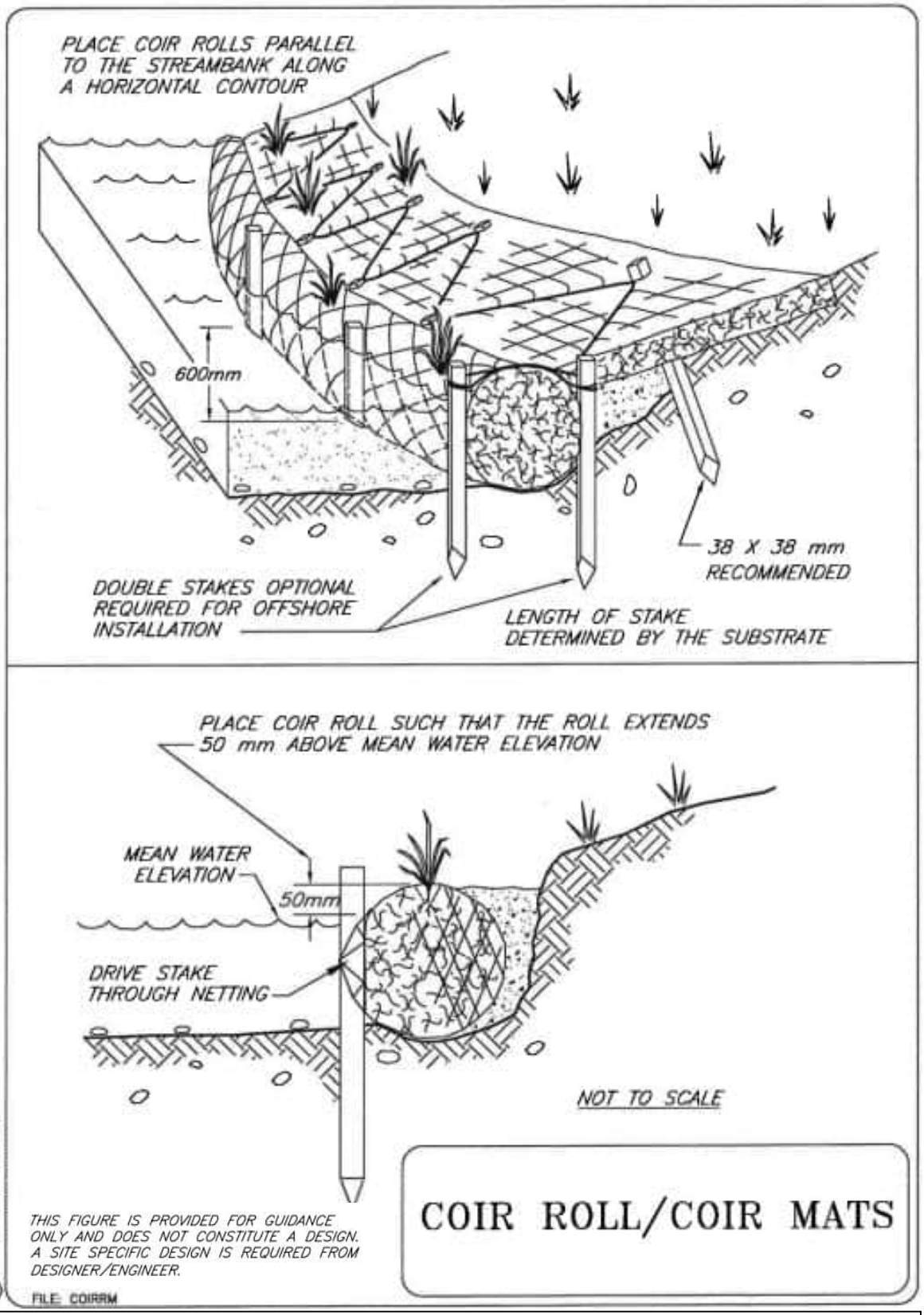
- For typical applications at the water's edge, coir rolls are held in place with a single row of stakes, spaced 0.3 m apart. Stakes may be driven through the netting on the outer edge of the roll. It is very difficult to drive stakes through the high-density rolls, however, a stake can be driven with the help of a pilot hole through the low density part of the coir rolls
- Lacing among the stakes is recommended for coir mats exposed to extreme conditions such as ice, waves, or flooding
- Coir rolls shall be placed along streambanks or shorelines at a height sufficient to protect the bank from flows or waves. Additional coir rolls may be placed above the lower rolls, in a tile-like fashion, to protect the upper shore or stream bank
- Use live stakes in place of wooden stakes for streambank coil rolls
- If the slope soil is loose and uncompacted, excavate a trench to a minimum depth of 2/3 of the diameter of the coir roll
- For steep slopes, additional anchors placed on the downslope side of the coir roll may be required

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Check plants to ensure that they have been firmly installed into the soil below the fibre material
- Water plants, if necessary, during the establishment phase
- Check all materials periodically or after major storms to ensure they remain properly secured. Make necessary repairs promptly
- All temporary and permanent erosion control measures shall be maintained and repaired as needed to ensure continued performance of their intended use
- Areas damaged by washout (rilling or gulleying) should be repaired immediately
- Additional stormwater control measures should be considered for erosion (rilling or gulleying) areas damaged by runoff



Government of the Northwest Territories – Transportation


PLACE COIR ROLLS PARALLEL TO THE STREAMBANK ALONG A HORIZONTAL CONTOUR
600mm
38 X 38 mm RECOMMENDED
DOUBLE STAKES OPTIONAL REQUIRED FOR OFFSHORE INSTALLATION
LENGTH OF STAKE DETERMINED BY THE SUBSTRATE
PLACE COIR ROLL SUCH THAT THE ROLL EXTENDS 50 mm ABOVE MEAN WATER ELEVATION
MEAN WATER ELEVATION
50mm
DRIVE STAKE THROUGH NETTING
NOT TO SCALE
THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.
FILE: COIRRM
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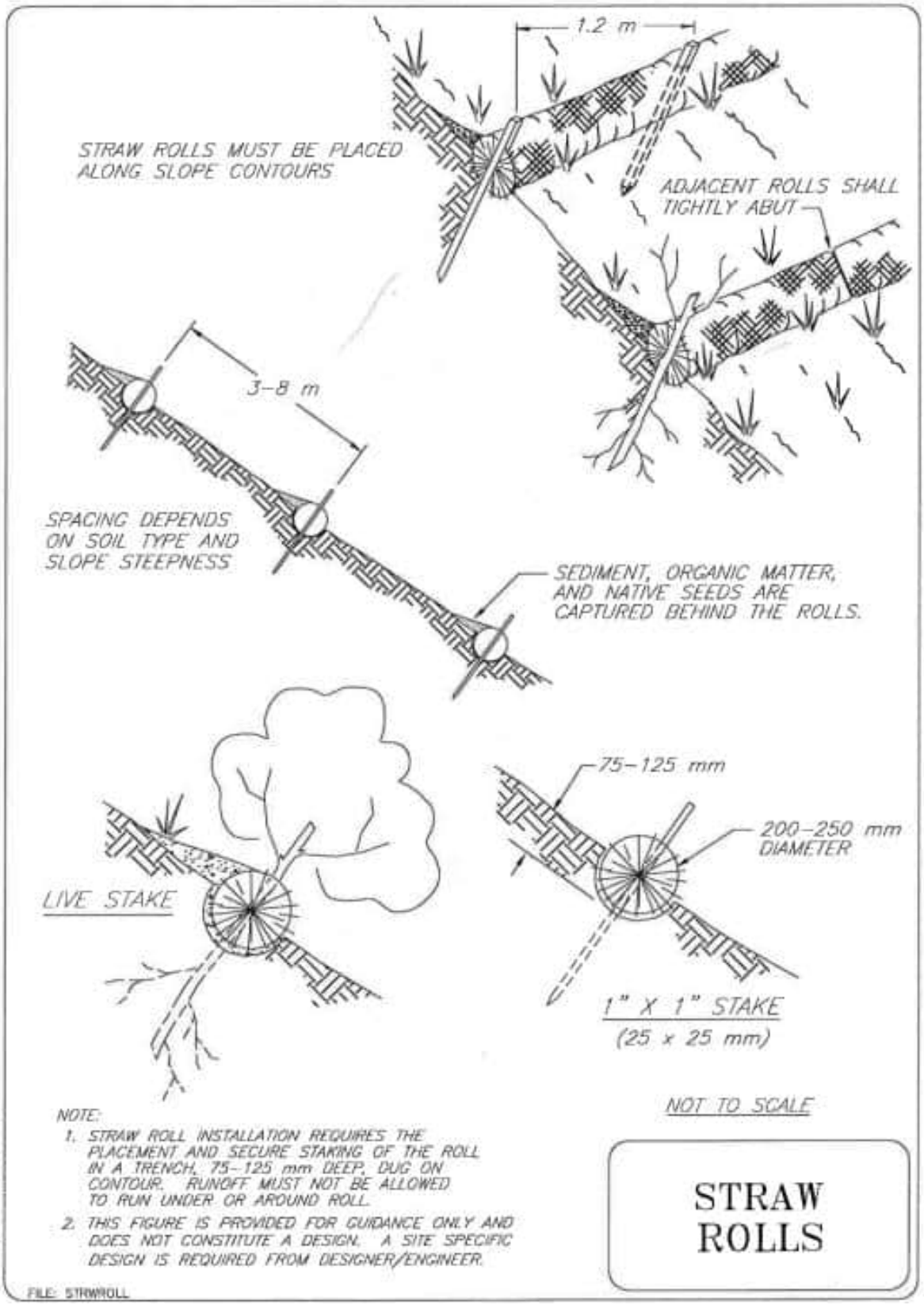
COIR ROLL/COIR MATS


1.2 m
STRAW ROLLS MUST BE PLACED ALONG SLOPE CONTOURS
ADJACENT ROLLS SHALL TIGHTLY ABUT
3-8 m
SPACING DEPENDS ON SOIL TYPE AND SLOPE STEEPNESS
SEDIMENT, ORGANIC MATTER, AND NATIVE SEEDS ARE CAPTURED BEHIND THE ROLLS.
75-125 mm
200-250 mm DIAMETER
LIVE STAKE
1" X 1" STAKE
(25 x 25 mm)
NOT TO SCALE
NOTE:
1. STRAW ROLL INSTALLATION REQUIRES THE PLACEMENT AND SECURE STAKING OF THE ROLL IN A TRENCH, 75-125 mm DEEP, DUG ON CONTOUR. RUNOFF MUST NOT BE ALLOWED TO RUN UNDER OR AROUND ROLL.
2. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.
STRAW ROLLS
From: Soils-Applied Earthcare - EROSION DRAW 3.0
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FILE: STRWROLL