Appendix 5.3
Southern Lakes Enhanced Storage Concept Studies

2017 Integrated Resource Plan

Southern Lakes Enhanced Storage Concept

Planning Overview

FEBRUARY 2017

YUKON ENERGY

EXECUTIVE SUMMARY

PROJECT OVERVIEW & BACKGROUND

The Southern Lakes Enhanced Storage Concept (SLESC or the Concept) envisions increasing the licenced water storage range on the Southern Lakes (SL) in order to increase the production of winter energy at the Whitehorse Rapids Generating Station (WRGS).

No new infrastructure needs to be built to realize the Concept benefits, only a change to the allowable winter storage limits on the SL and the implementation/construction of mitigation measures.

BENEFITS

- The Concept represents a low cost source of winter renewable energy introduced by enhancing YEC's existing infrastructure. As such, the Concept is complementary to YEC's prior commitments and disclosures to the YUB and the Yukon Public – both of which emphasize maximizing the generation from YEC's existing assets.
- The Concept:
  - Provides a low cost source of firm winter energy of up to 9.9 GWh/year at a levelized cost of 9 cents/kWh;
  - Displaces nearly 5,100 tonnes of GHG emissions each year under average water conditions, assuming a split of 75% natural gas and 25% diesel generation;[1]
  - Maximizes production from existing assets and natural resources;
  - Can be implemented in near term (winter 2019 or 2020);
  - Provides a lasting benefit to some landowners who are already impacted by the effects of rising water levels in the Southern Lakes. Project mitigation would address existing problems with shoreline erosion and high groundwater; and,
  - Has a lower environmental impact than a greenfield hydroelectric project.

[1] Thermal equivalent of 9.9 GWh project power benefit at 75% natural gas (451 tonnes/GWh CO_2e) and 25% diesel (700 tonnes/GWh of GHGs) equates to nearly 5,100 tonnes CO_2e.

FEASIBILITY STUDY KEY FINDINGS/CONSIDERATIONS

- There are high human and environmental values contained in the Concept study area (Southern Lakes system). Some residents have concerns about, or have voiced opposition to the Concept. Others have indicated an interest in proceeding with a project.
- Baseline environmental and socio-economic studies, preliminary effects assessments, and conceptual mitigation designs for the Concept are complete.
- After 6+ years of study the character of the potential Concept effects is well understood. The likely effects are subtle, and are mostly additive to pre-existing effects of seasonal erosion and groundwater effects to low-lying properties that result from water levels on the system during the unregulated period (spring – fall). Technically and economically feasible mitigation options exist for identified adverse effects.
- No significant effects are predicted to accrue to valued aquatic or terrestrial habitats or species.

PROJECT STATUS

At this time baseline studies have been completed and a preliminary effects assessment has been conducted. Remaining work is mostly technical and involves the completion of a field level heritage resources impact assessment, the finalization of a detailed monitoring and adaptive management plan, with the associated stakeholder consultations. Discussions are ongoing with both Carcross/Tagish First Nation (C/TFN) and the Kwanlin Dun First Nation (KDFN) as potential YESAA decision bodies and with Ta'an Kwach'an Council (TKC) as the Concept study area includes their traditional territory as well. Yukon Energy is interested to know the perspectives of these first nations on the technical merits of the Concept before proceeding with further planning and assessment in 2017. Following these activities, YEC will have sufficient information to prepare a project proposal for assessment under the Yukon Environmental and Socio-economic Assessment Act (YESAA).

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1.0 INTRODUCTION

1.1 PROJECT OVERVIEW

In 2009, Yukon Energy restarted its examination of the Southern Lakes Enhanced Storage Project (the Project). The Project would increase winter generation at the existing Whitehorse Rapids Generating Station (WRGS) by increasing the amount of water available for power production in winter. The additional winter flow in the river will come from the proposed increase in the volume of water stored upstream in the southern lakes. This extra storage will then be available to augment flow in the Yukon River during the winter when the demand for electricity is greatest.

To achieve this, the Concept envisions expanding the storage range on the Southern Lakes by decreasing the licenced low supply level (LSL) by up to 10 cm, and by increasing the licenced full supply level (FSL) by up to 30 cm. No other operational changes are necessary to achieve the increased storage.

The only observable changes to lake levels during the regulated period (August to May) would be a slightly higher fall and early winter water level in the lakes, but no higher than what is often seen in the unregulated summer period. By winter there would be little difference in water levels as compared to present levels.

The expansion of the low supply level would mean that water levels in Marsh Lake in the spring would be up to 10 cm lower than historical/present. This difference would only be observed for a few weeks in late April and early May, and only observed on Marsh Lake, with little observable influence on Tagish Lake or Bennett Lake.

Figure 1 demonstrates how the change in the operational range can provide additional power generation at the Whitehorse station.

Figure 1 Limitations of Existing Water Storage Range

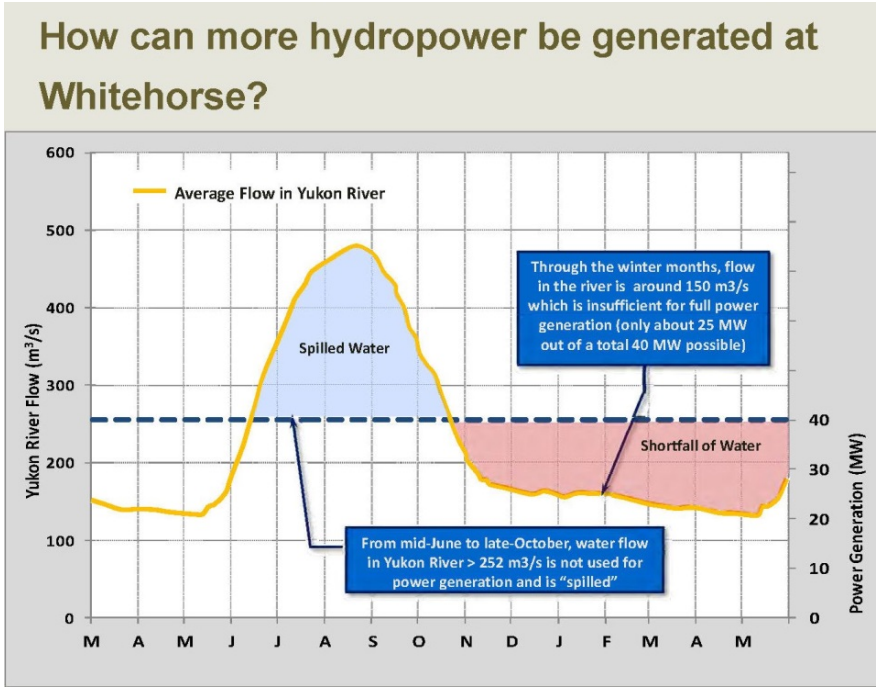
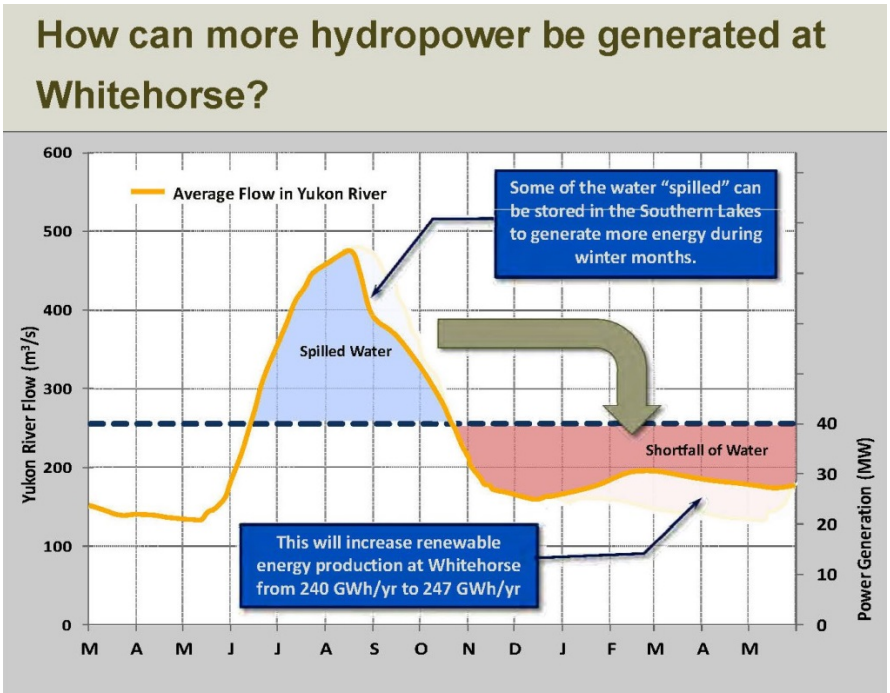


Figure 2 Effect of Increased Storage Range on Winter Energy Production



2.0 PLANNING ACTIVITY DETAILS

2.1 OVERVIEW OF RECENT PLANNING ACTIVITIES/OBJECTIVES

Work in recent years has been focused on narrowing down any remaining uncertainties regarding potential project effects, views/interests of potentially affected stakeholders, likely mitigation requirements and methods, and monitoring adaptive management plan requirements. Estimation of costs to implement mitigation and provide monitoring and adaptive management was also undertaken.

Key tasks included:

- *Erosion Program*
  - Complete erosion modelling.
  - Landowner contact and engagement for mitigation design.
  - Finalize mitigation options and forecast costs.
- *Groundwater Program*
  - Confirm specific properties potentially affected.
  - Land owner engagement for mitigation design.
  - Finalize mitigation options and forecast costs.
- *Monitoring and Adaptive Management Planning*
  - Determine key areas requiring pre-project effects prediction and post-project mitigation success confirmation.
  - Develop broad program requirements, frequency, and costs.
  - Develop draft cooperative/collaborative monitoring plan execution and reporting components (e.g., work with C/TFN, KDFN, TKC, regulators to draft plan tasks and review plan results).
- *Information Adequacy Program*
  - Update gap analysis and fill key info gaps.
  - Engage Regulators to confirm assessment approach and preliminary findings.
  - Discus draft mitigation, monitoring, and adaptive management plans.
- *Communications Program*
  - Targeted outreach to all stakeholders and Yukoners to relay key messages and develop better project understanding via house mailings.

- *FN Engagement & Consultation Program*
  - Consultation and engagement to develop common understating of potential project effects and mitigation.
  - Explore compensation requirements and benefit opportunities.
  - Seek to lever mutually beneficial renewable energy or other outcomes from engagement vis-à-vis the project Concept and other interests of Yukon Energy and/or FNs.
  - Seek acceptance of Concept 'in principle' and green light to proceed to the YESAA review stage.

2.2 PLANNING ACTIVITY RESULTS AND STATUS

All program activities, except for the First Nations engagement program, have been completed as of Q1 2017. Additional time is needed conclude the technical reviews with C/TFN, KDFN, and TKC for the Concept and the plan to proceed to assessment and permitting. It is expected that this work will be concluded by end of Q2 2017.

3.0 MITIGATION DESIGN & UPDATED COSTS

3.1 EROSION

The erosion program involved an intensive engagement and technical effort to identify, explore, and narrow down the optimal mitigation options for shoreline erosion protection in the areas potentially impacted by the Concept. A range of options are available for mitigation of erosion-related project effects, and 9 mitigation options were explored individually and with shoreline groups of potentially affected property owners.

The process of review and selection of an appropriate/acceptable mitigation solution was conducted in 2 rounds using a Structure Decision Making (SDM) process. In Round 1 Yukon Energy met with individual property owners to review the Concept and its potential effects, and to review various options to mitigate erosion effects. Round 2 included bringing together individuals from each discrete shoreline neighborhood together as a shoreline unit group to review and work toward consensus on a preferred mitigation option(s). Over 40 round-one meetings were held, with over 75% of landowners participating. Five round-two meetings were held with groups of residents from each potentially affected shoreline area. Over 85% of potentially affected property owners were engaged in at least one meeting to explore the Concept and potential mitigation options.

Mitigation in the form of engineered rip rap (hard, angular rock) was the dominant choice of homeowners who indicated a strong preference toward a solution that would be effective against erosion, durable, and low maintenance. One neighborhood indicated a preference for groins as a mitigation solution, although

the feasibility and acceptability of such a solution is not considered optimal and requires further discussions with subject area residents. A sample of mitigation options used in Round 1 consultations is presented in Appendix A.

Plate 1 Example of Shoreline Protection Using Rip Rap

YEC also instructed the project consultants (Hemmera) to review the work completed by the previous planning consultant (AECOM) regarding the assessment of areas recommended for erosion protection. All previously identified areas were confirmed, with some expansion to the overall length of required shoreline erosion protection in some areas (refer to the discussion below).

Updated erosion mitigation costs are estimated at $6.0M (feasibility or Conceptual-level estimate, with an associated accuracy of +/- 15% to 30%). This updated estimate is increased from the previous estimate of approximately $3.1M. The budget increase for erosion mitigation was a result of a number of changes:

Increase in construction costs: Updated engineering design work completed by Northwest Hydraulic Consultants (NHC) in 2015 has increased the length of shoreline requiring protection, and more conservative unit cost estimates for the shoreline mitigation have been used. The previous mitigation cost estimates completed by AECOM in 2012 utilized a value of $790 per metre of shoreline protected with rip rap. Northwest Hydraulic Consultants concluded that AECOM's cost estimates for construction were low, and revised the unit cost to $1,300 per metre. This updated unit cost was thought to be more realistic and was based on NHC's recent experience with similar projects. In addition, NHC's estimate of shoreline needing mitigation is 3,457 metres, an increase of 1,187 metres from the AECOM estimate of 2,270 m. The increase in shoreline length is partly related to the inclusion of beach features at the ends of each mitigation area, as opposed to prior calculations of required mitigation length based on property boundaries at the end of each beach section. In addition, NHC included a number of gaps in what is otherwise continuous shoreline armouring of Army Beach (e.g., mitigation will be needed at several sections of Army Beach with public access easements that adjacent property owners have not addressed).

Increase in in contingency: The previous estimate of $3.1M included a 20% contingency. However, NHC has increased the contingency allowance to 30% to more appropriately account for the current level of engineering definition of the mitigation designs.

The cost and design definition will be updated at the preliminary design phase, which in scheduled for 2018 as part of preparations for permitting. A further round of detailed design will be completed in 2019 following permitting, and will consider any regulatory requirements coming out of the assessment and permitting processes. Detailed design will generate design specifications to be used as inputs for the construction tendering stage.

3.2 GROUNDWATER

Preliminary groundwater surveying work completed in 2010-2014 estimated that somewhere between 75 and 100 properties might be affected by the Concept. Intensive survey work completed in 2015 confirmed that only 53 properties would need mitigation for project-related groundwater effects.

Required mitigation will take the form of raised septic fields, septic tank replacement and/or anchoring, installation or enhancement of basement/crawlspace sump pumps. A single property will require some foundation insulation. In many cases the effects of unregulated high summer water levels already impact these properties. With the Concept the duration of such impacts would increase and therefore Yukon Energy would address these effects. In addition to construction and installation of physical mitigation infrastructure as outlined above, one time compensation payments will be calculated and paid to some affected land owners for costs associated with increased wear and tear on equipment and increased electricity costs associated with some installations (e.g., increased annual duration of sump pump operation). These costs are factored into the mitigation cost estimate below.

Estimated groundwater mitigation costs are approximately $1.2M, reduced from an earlier estimate of $1.35M. The decrease in the estimated costs was caused by the decrease in the number of properties that would be impacted. These cost estimates are considered to have an expected precision variance of +/- 15% to 30%.

4.0 COMMUNITY ENGAGEMENT AND HOME-OWNER SUPPORT

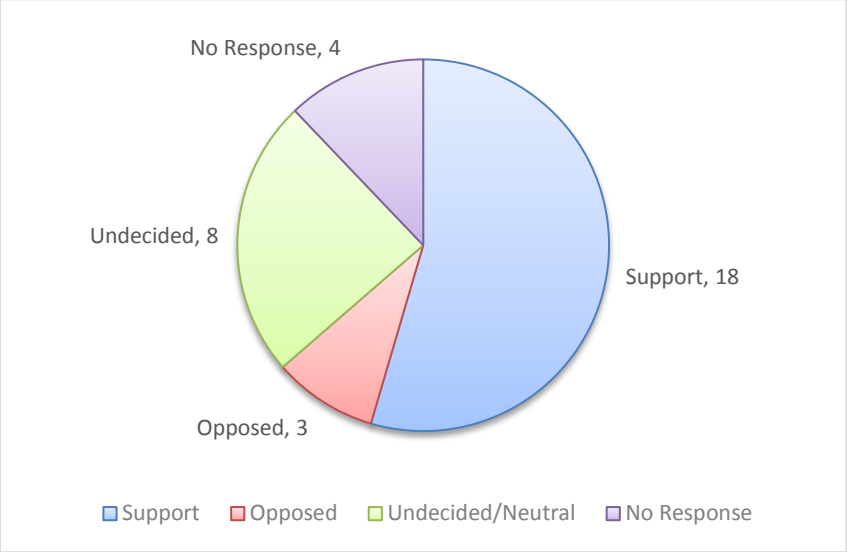
YEC has completed an extensive program of community engagement on the Southern Lakes ESP since 2010, including numerous public meetings, workshops, and an outreach and public education program.

4.1 EROSION

General attitudes towards the project Concept were surveyed as part of the engagement on erosion mitigation designs with property owners potentially impacted by the Concept. The results of this survey

are presented in Figure 3. Of those property owners who participated in the group mitigation evaluation meetings 55% (18 individuals) indicated support for the mitigation and the project. Of the remaining participants, 9% (3 individuals) were not in favor of the project, with 24% (8 individuals) indicated they were undecided, and 12% (4 individuals) did not respond. Only 1 respondent indicated they couldn't accept the mitigation if the project were to proceed (i.e., of the 3 respondents opposed to the project, only one was opposed to the mitigation if the project did in fact proceed). In most cases the mitigation would be installed on Crown Land (i.e. below the ordinary high-water mark, which is owned by the Crown in most cases).

Figure 3 General Attitudes of Erosion Landowners Who Attended Group Engagement (Round 2) Meetings (n = 33)



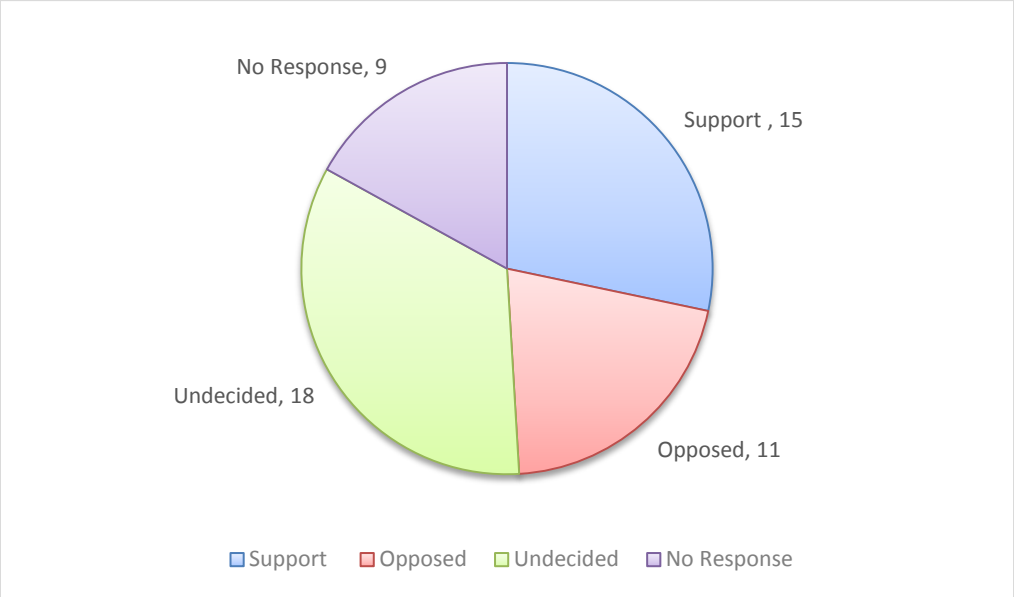
4.2 GROUNDWATER

General attitudes towards the project Concept were also surveyed as part of the engagement on groundwater mitigation designs with property owners potentially impacted by the Concept. The results of this survey are presented in Figure 4. The groundwater program involved engagement with 153 properties that were assessed to be within the zone of influence of the Concept. Of those, 53 properties were confirmed to be likely to need mitigation if the Concept were to proceed.

- In all, 157 telephone conversations and formal meetings were held with potentially affected property owners regarding groundwater.
- 71 properties were physically surveyed to confirm infrastructure elevations and 12 "complex" properties were evaluated by an engineer for geotechnical/structural potential effects.
- At only one of the 12 complex properties assessed was it determined that mitigation would be required to address the potential effects of the project.

Of those property owners who participated in the initial assessment and follow-up mitigation meetings, 28% (15 individuals) explicitly indicated support for the mitigation and the project. Of the remaining participants, 21% (11 individuals) were not in favor of the project, with 34% (18 individuals) indicated they were undecided, and 17% (9 individuals) either did not respond or could not be contacted. Some property owners in the 'undecided' category stated that they would reserve their final acceptance or refusal of Yukon Energy's offer to provide mitigation to a point in time where they would be engaged for discussions regarding the detailed mitigation work/construction plan following the YESAA assessment. Other stakeholders in the 'undecided' or 'neutral' category were otherwise indifferent to the project and/or the proposed mitigation.

Figure 4 Groundwater Impacted Landowner Project Acceptance (n=53)



All stakeholders will have an opportunity to provide input and information to the regulators during both the YESAA assessment process and the water board licencing process.

5.0 MONITORING & ADAPTIVE MANAGEMENT PLAN

5.1 OVERVIEW

A detailed monitoring and adaptive management program will form an integral part of the implementation of the Southern Lakes ESP, and the mitigation of risk post-implementation. While draft components have been prepared, a final detailed monitoring and adaptive management program requires input from stakeholders and as yet has not been completed. Work is planned in 2017 to complete a plan

suitable for assessment under YESAA in collaboration from key stakeholders. An overview of the scope of this plan, and the general principles that will be applied in the development of the plan are outlined in sections 5.1 and 5.2, below.

5.2 MONITORING PROGRAM

The monitoring program will include elements that allow Yukon Energy to assess two things:

1. The observed effects on fish, wildlife and wetland environments, compared to the predicted effects made during the assessment.
2. The effectiveness of implemented erosion and groundwater mitigation measures.

Consequently, monitoring is proposed in the following key areas:

- Heritage Resources
- Erosion Mitigation Effectiveness (incl. sites with mitigation and unmitigated control sites)
- Groundwater Mitigation Effectiveness (incl. sites with mitigation and unmitigated control sites)
- Fish and Wildlife
- Wetlands

The following principles will be followed in the development of a detailed monitoring program:

a) The monitoring program will be sensitive and provide timely results for decision-making. YEC will collaborate directly with affected first nations and others to carry out the monitoring plan and to jointly review the results of the annual reporting.
b) Monitoring will also include the use of control sites to ensure Yukon Energy and others are able to discern effects that may be caused by the project or effects that are caused by factors other than those influenced by the project (e.g., erosion caused by peak summer water levels above the Concept full supply level).

The estimated monitoring program costs are as follows:

- Years 1-3 = $167,000/year
- Years 4-5 = $120,000/year
- Years 6-10 = $70,000/year
- Years 10+ = $40,000/year

5.3 ADAPTIVE MANAGEMENT PROGRAM

The adaptive management program will define the steps or measures that YEC will take in response to unexpected negative outcomes in the key areas covered by the monitoring program (e.g., if the actual effects predictions on fish/wildlife/wetland environments are worse than predicted, or if the erosion and groundwater mitigation measures are not fully effective).

The adaptive management program will define both the specific actions (to the extent possible) and the financial commitment that YEC will make in response to any negative impacts, up to an including reversal of the project (i.e., reversion to the current storage range on the Southern Lakes system).

The following general principles will be followed in the development of the detailed adaptive management plan:

a) YEC will consult with key stakeholders (FN's, Environmental NGO's, homeowners) on the development of the adaptive management plan. It is important that these stakeholders have a clear understanding of the way the monitoring will be undertaken and what the results will direct Yukon Energy to do in response.
b) The adaptive management plan will be as specific as possible, defining clear responses to specific outcomes. As such, the plan will attempt to limit YEC's financial risk by defining the scope and value of additional actions, and associated expenditures, that the corporation will incur in response to defined negative outcomes.
c) In addition, the total (cumulative) financial commitment to cover potential adaptive management responses will be capped at a fixed amount, where after a reversion to the previous storage range, or something in between, would be the remaining option to address any unexpected impacts (i.e., reverse the effects).
d) YEC will consider creating a multi-stakeholder committee, or use some form of independent oversight mechanism to evaluate unsolicited complaints from the public regarding perceived project impacts. It will be critical that the process to evaluate such complaints and administer any resulting mitigation be transparent, fact-based, and unbiased.

For the purposes of financial modeling of the overall project, Yukon Energy has assumed a worst case financial commitment of $3.3M ($2016) to cover potential adaptive management responses. A break-down of the $3.3M budget allocation for adaptive management is provided in Table 1:

Table 1 Estimated costs for Adaptive Management Program (2016$)

Item	Estimated Costs (2016$)	Assumptions
Adaptive management costs for groundwater mitigation	$0.05M	Percentage of installed systems require replacement/maintenance (5%-25% depending on the type of mitigation installed)
Adaptive management responses for erosion	$2.67M	10% of initial costs to repair installed mitigation after a 1 in 50+ year storm event Up to one third of the non-mitigated erosion sites being monitored to require mitigation within a few years post-implementation
Lake trout and/or other wildlife species habitat enhancements and studies	$0.60M	
	$3.32M	

The forecast cost of the adaptive management responses will be reviewed as part of the development of the detailed adaptive management program and as part of Yukon Energy's stagegate project review process.

6.0 PROJECT ECONOMICS

6.1 PROJECT COSTS

A summary of the total upfront costs of the project are presented below in Table 2.

Table 2 Southern Lakes ESP Project Development Costs

Item	Total Costs (2016$)	Notes
Planning, Assessment & Permitting – Committed to date	$6.50M	
Planning, Assessment, Permitting & Preliminary/Detailed Engineering– Future	$1.75M	
Project Implementation – Erosion Mitigation	$6.00M	1, 2
Project Implementation – Groundwater Mitigation	$1.00M	1, 2

Subtotal – Capital Cost	$15.25M	
Post-Implementation Adaptive Management	$3.32M	3, 4
Total	$18.57 M	

Notes:
1. Compensation to FN's for increased duration of inundation of settlement land included.
2. Cost areas will be for design and construction of erosion and groundwater effect mitigation.
3. These costs for cover potential adaptive management responses will be incurred over time, but are expressed as 2016$.
4. Post-Implementation adaptive management responses have been estimated based on professional judgement of potential unexpected effects and/or rates of mitigation failure. While erosion, fish and wildlife, heritage resources, and groundwater adaptive management responses are included in the estimates, the erosion component represents over 75% of the dollars assigned here.

6.2 Operating Costs

Operating costs include monitoring, land use fees associated with FN land inundation, and any other project costs such as benefit payments. These costs are estimated to range from $50,000 per year in later years and up to $270,000 in the early years post-implementation.

6.3 Concept Renewable Energy Value & Levelized cost of Energy

The Concept delivers incremental winter renewable energy, which displaces more costly thermal energy. Power benefit calculations estimate that 9.9 GWh per year of thermal energy under the High Industrial Activity Scenario from the 20-Year Load and Peak Demand Forecast presented in the 2016 Resource Plan be displaced by the project under average water conditions.

Estimates of the costs and benefits, and the resulting levelized cost of energy of the Concept are presented in Table 4.

Table 3 Summary of Economic Analysis - Southern Lakes ESP

Present Value of Costs 2016 $000's	$23,126
Present Value of Benefits 2016 $000's	$30,020
Project Real LCOE at $2016 /kW.h	$0.09
Benefit/Cost Ratio	1.3

Notes:
1. Values are real LCOE numbers (inflation free).
2. Assumes 2% inflation rate
3. Economic life of the project set to 34 years
4. Assumes real discount rate of 3.38%, nominal 5.45%,
5. Assumes 8.25% nominal return rate and Debt/Equity ratio of 60%/40%
6. Energy benefit assumed constant at 9.9 GWh/yr fully utilized

7. Based on 20-yr load forecast for the High Industrial Activity Scenario. This load forecast was also used for Mayo Lake Enhanced Storage Project.

In the case modelled, the levelized cost of energy represents the lowest costs renewable energy option currently available to Yukon Energy, and compares favourably to LNG at 17.4 c/kW.h. The Concept also has the added benefit of avoiding nearly 5,100 tonnes of thermal GHG emissions each year, which would otherwise be emitted with equivalent thermal energy.[2]

7.0 FN ENGAGEMENT

All first nations whose traditional territory and/or settlement lands fall within the regional study area have been engaged periodically since the studies began in 2009. This includes the Kwanlin Dun First Nation, (KDFN), Carcross/Tagish First Nation (C/TFN), Ta'an Kwach'an Council (TKC), and the Taku River Tlingit (TRT). Efforts have been made to share information regarding the purpose and need for the project, the baseline studies and preliminary impact assessments, proposed mitigation, monitoring, and adaptive management commitments, and to identify and understand interests and concerns of the FNs.

First Nations engagement has been focused primarily with C/TFN and KDFN, as no significant adverse effects have been identified to the interests of the TKC or the TRT. C/TFN and KDFN will also likely be Decision Bodies under the YESAA assessment, along with other governments (e.g., YG, DFO).

Engagement activities to date have identified several key issues for FNs related to the Concept including:

- Shoreline erosion and related effects on private property and settlement lands, water quality, riparian and nearshore aquatic habitats for such valued components as moose, caribou, and aquatic furbearers.
- Shoreline heritage resources located in zone of influence of existing/potential erosion.
- Inundation of low lying shoreline areas on settlement land or otherwise:
    - A draft compensation framework based on a 'land rental value' has been shared with C/TFN and KDFN, but more work is needed to negotiate an agreement in this regard.
    - Approximately 7 hectares of additional KDFN settlement land would see an increased duration of wetting in the fall of each year.
    - Approximately 45 hectares of additional C/TFN settlement land would see an increased duration of wetting in the fall of each year.

[2] Thermal equivalent of 9.9 GWh project power benefit at 75% natural gas (451 tonnes/GWh CO_2e) and 25% diesel (700 tonnes/GWh of GHGs) equates to nearly 5,081 tonnes CO_2e.

- No new/additional settlement land parcels would be wetted, i.e., only parcels wetted under the existing FSL would be wetted longer under the Concept FSL.
- The additional period of wetting of settlement lands is on average about 93 days per year and occurring in the late summer and fall.
- Inundated areas have only been mapped for Marsh Lake as the steep topography of the shorelines at Tagish Lake and Bennett Lake indicates that only very minimal increases in shoreline inundation will occur there.

At this point in the planning Yukon Energy has been able to provide technical responses to previously identified interests and concerns with the Concept. The key steps now are to respond to follow up questions and concerns and seek feedback from the FNs on whether they would consider Yukon Energy has exercised sufficient due diligence and has done enough work to move to the YESAA assessment stage.

8.0 PROJECT TIMELINE

If a decision were made to proceed with the Project at the next stagegate (tentatively scheduled for Q2 2017), a submission could be made to the YESAAA Whitehorse Designated Office by the end 2017. Following a 6-8-month assessment process an application to the Yukon Water Board would be made with the potential to have an amended licence by the end of 2018. Work could then begin to tender and undertake the physical mitigation construction in 2018 and 2019. Construction of shoreline protection would need to be undertaken in the later winter and early spring so that the work could be done during dry conditions from the lake side of the shore as opposed to the land side. This will minimize disturbance to the shoreline and private property. Use of the additional storage would then be feasible for the fall of 2019 or 2020.

APPENDIX A

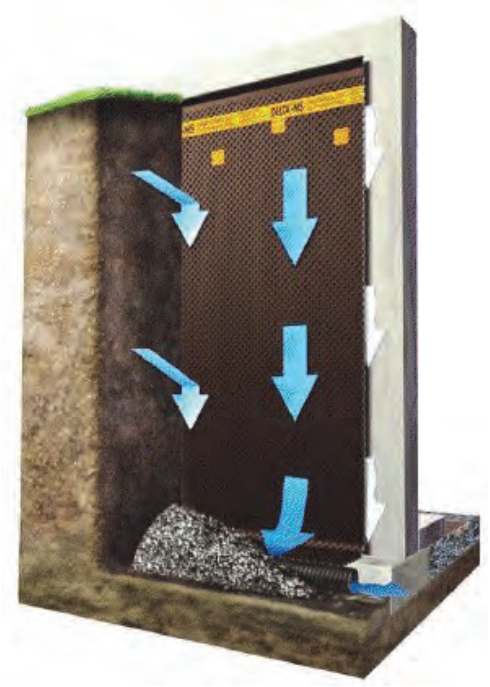
EROSION & GROUNDWATER ENGAGEMENT INFORMATION PACKAGES

Basement/Crawlspace Waterproofing

SOUTHERN LAKES ENHANCED STORAGE CONCEPT • FACT SHEET 5

How could groundwater rise affect my home?

The proposed concept would involve holding back (storing) more water in the Southern Lakes during the fall, which may result in a slightly longer duration of seasonal high groundwater levels in some areas around the lakes. On some properties this could exacerbate flooding or dampness already experienced in some basements/crawlspaces during seasonal high water levels, or it could cause flooding or dampness in a few basements/crawlspaces that have not previously experienced such groundwater effects.



Typical basement/crawlspace waterproofing installation

Mitigation Solution – Basement/Crawlspace Waterproofing

Basement and crawlspace waterproofing is a mitigation option to manage the potential impacts of groundwater rise, such as flooding and dampness. A typical waterproofing installation involves excavating down to the foundation around the perimeter of the home, cleaning and repairing cracks in the foundation walls, and installing a waterproofing membrane, a weeping tile and drainage gravel.

Benefits

Increased property value though improvements (up to $21,000)

Reduces damage to property (e.g. flood damage)

Discourages mold in basements/crawlspaces

Drawback

Requires access around building foundation (e.g., tree removal)

Significant temporary modification to property during installation

Will basement/crawlspace waterproofing work for you and your property?

Can it be installed around your basement/ crawlspace?

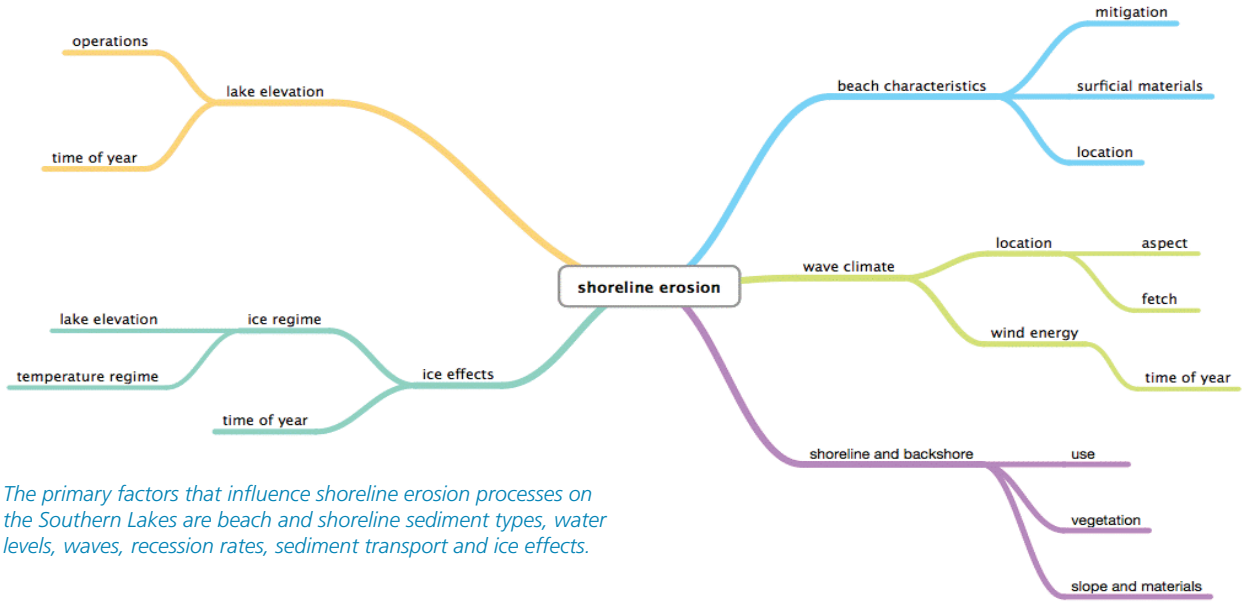
Is there good access?

Is the site accessible with conventional excavation equipment?

Basement/crawlspace waterproofing examples

Erosion Program

SOUTHERN LAKES ENHANCED STORAGE CONCEPT • EROSION 1



The primary factors that influence shoreline erosion processes on the Southern Lakes are beach and shoreline sediment types, water levels, waves, recession rates, sediment transport and ice effects.

Introduction

Over the last several years, Yukon Energy has engaged regularly with Yukoners and done significant research on the idea of increased water storage in the lakes south of Whitehorse. The Corporation has worked hard to understand the potential environmental and socio-economic impacts that could occur as a result of the concept.

Over the next few months, this research will be reviewed and used to decide whether to move the concept forward to the YESAA environmental and socio-economic assessment phase.

Wave-induced currents along the shoreline transport beach sediment in and out of, or along the shoreline causing sand deposits and erosion.

Summary of the Concept

Electricity demand in Yukon is highest during the cold, dark winter months, which is also the time of year when water levels in our lakes and rivers are naturally low. In order for Yukon Energy to produce enough hydroelectricity for Yukoners during the winter the Corporation must hold back (or store) water in Marsh, Tagish and Bennett Lakes during the fall, when water levels are higher.

Right now, the amount of water Yukon Energy is allowed to store (Full Supply Level) is not always enough to meet energy demands in winter, so fossil fuels are burned to make up the difference.

The Southern Lakes Enhanced Storage Concept would involve changing Yukon Energy's water license so the Corporation could store up to 30 centimeters more water in the fall and early winter and use up to an additional 10 cm of water below the current level in the spring.

This water would be available for winter energy production when it's needed the most, and would provide cost-effective and environmentally responsible energy. The concept would not increase naturally-occurring high water levels that occur in the Southern Lakes and the additional water storage would not be carried over year-to-year.

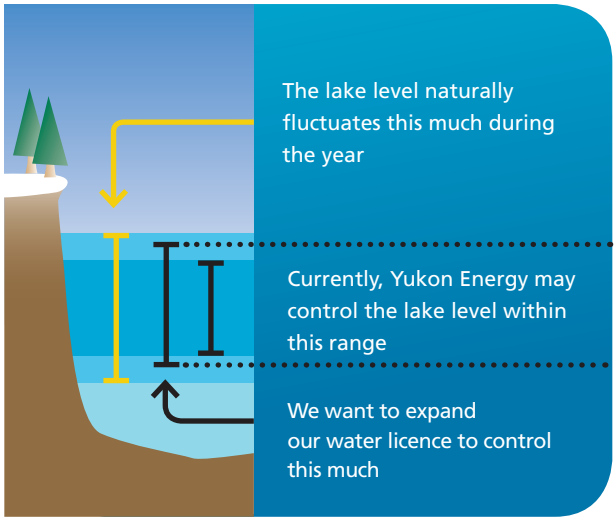
Erosion Program

SOUTHERN LAKES ENHANCED STORAGE CONCEPT • EROSION 2

Potential Impacts to Properties Related to Erosion

There are already naturally-occurring erosion issues in some areas of the Southern Lakes. The Corporation's previous erosion studies identified six shoreline areas containing multiple properties that are currently experiencing erosion and may experience additional erosion as a result of the concept.

The proposed increase to the Full Supply Level will result in additional shoreline areas of up to 30 vertical centimeters being inundated for a longer period of time each year. This additional period of higher lake levels may result in additional shoreline erosion due to wave action. It is important to note that the proposed increase is well below the natural high water level that occurs each year in late summer.



Shoreline erosion along the Southern Lakes is site-specific and depends on the location and aspect of the property, as well as the characteristics of the shoreline. Such natural characteristics include the slope of the foreshore and bluffs, and the type of material in these areas such as sand and gravel. The presence of vegetation also affects the rate of erosion.

Initial Meeting (one-on-one)
- Discuss shoreline erosion on property
- Discuss YEC shoreline erosion mitigations
- Get your feedback

Design a preliminary shoreline-unit specific erosion mitigation plan

Follow-up meeting (one-on-one or groups)
- Review prepared preliminary shore-line-unit specific erosion mitigation plan
- Incorporate com-ments and feedback for final design

Final mitigation plans and landowner feedback are reported to Yukon Energy and used in decision making on whether to proceed with a project assessment and permitting

Landowner Engagement Process

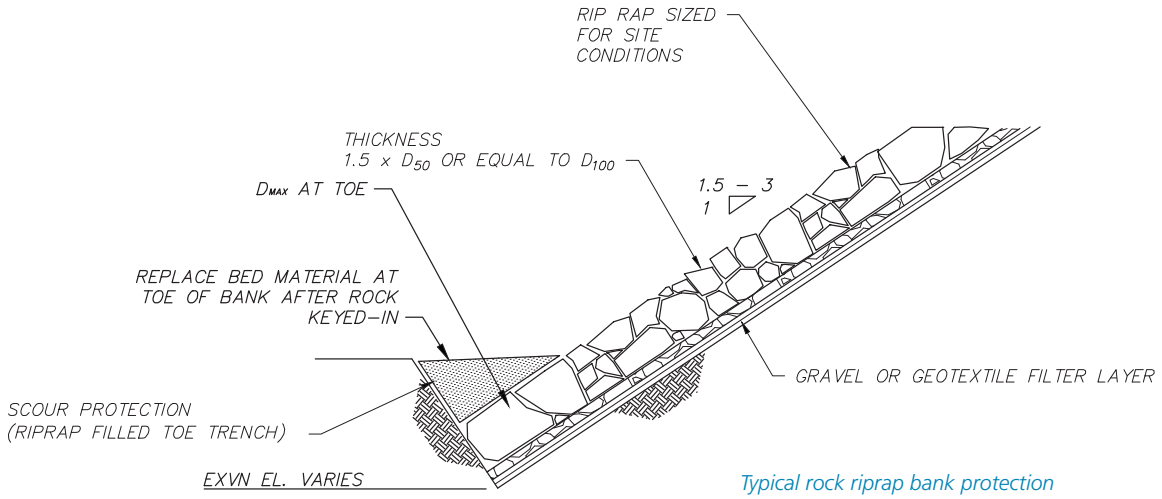
An important part of this next step is engaging with landowners who may experience erosion on their properties as a result of the concept.

Yukon Energy will use your input as well as the input of your neighbours to help develop one consistent erosion mitigation plan for your shoreline unit. If implemented, this plan would combat existing erosion as well as any potential concept-related erosion and would provide a long-term benefit should the concept move forward.

Please note that it is not necessary for you to support the Southern Lakes Enhanced Storage Concept to participate in this engagement process. This process allows us to fully understand the issues and costs related to potential mitigation of shoreline erosion, which will provide Yukon Energy with a more accurate estimate of the costs and benefits of the project for the assessment process and Yukon ratepayers.

RipRap

SOUTHERN LAKES ENHANCED STORAGE CONCEPT • EROSION 3



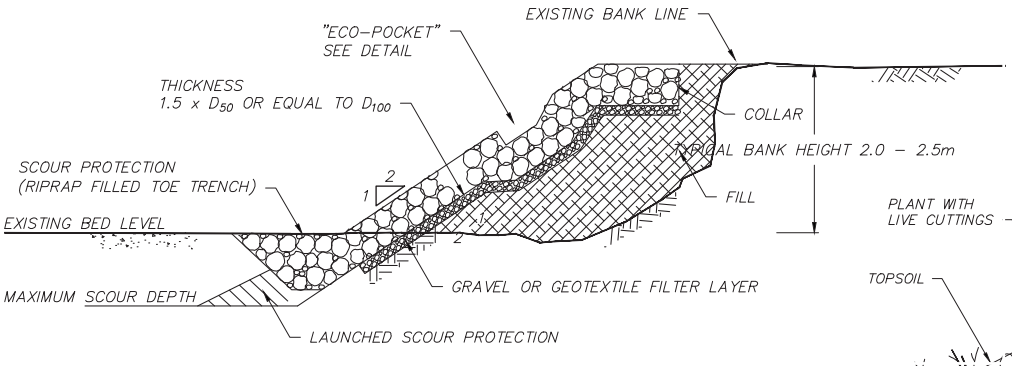
Typical rock riprap bank protection

Typical riprap involves using quarried angular rock to protect eroding slopes. The size of the rock and the thickness of the armour layer depend on the extent of the erosive forces on the slope. An underlayer is used between the rock and eroding slope to keep fine sediments from eroding away between the spaces in the rocks. The toe of the riprap can either be excavated into the bottom of the slope or an apron can be constructed to avoid excavation. Riprap is typically used where erosion is extensive or in proximity to infrastructure, and construction requires access for large and heavy machinery (e.g., excavators and dump trucks). In order to make this option feasible a good source of quality rock needs to be available in reasonable proximity to the site.

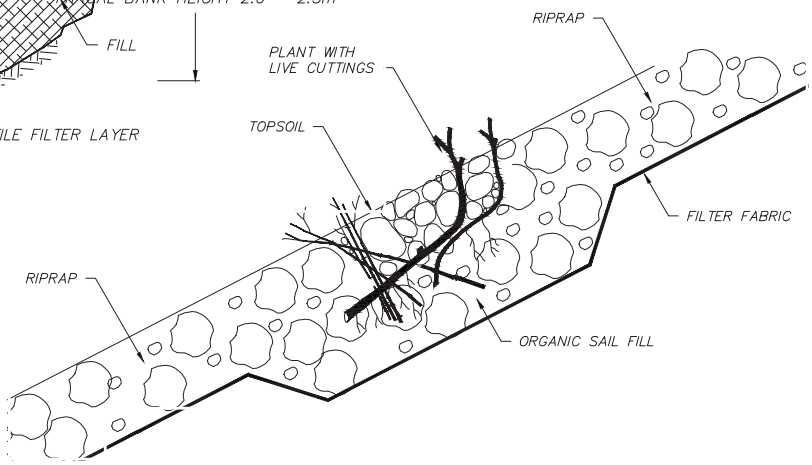
Advantages	Disadvantages
Highly effective protection	Artificial and unnatural appearance
Very low maintenance	Does not provide valuable habitat
Effective on high and steep slopes with significant erosion	Access required for large and heavy equipment
Requires minimal manual labour	High initial cost

Vegetated RipRap

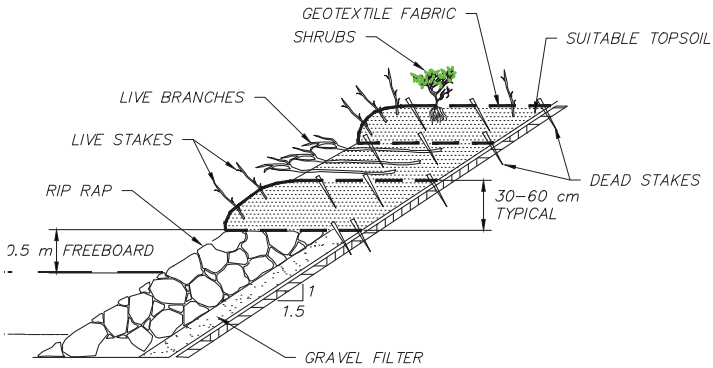
SOUTHERN LAKES ENHANCED STORAGE CONCEPT • EROSION 4



Typical riprap with vegetated ecopocket



Vegetated riprap is the same as typical riprap with the addition of vegetation within and or above the riprap slope. Vegetation can be in the form of “eco-pockets” which are small pockets of soil and vegetation in various locations on the surface of the rock slope. The planting of stakes or live cuttings in the spaces between the rocks are also an effective planting option. The top of the riprap slope can be planted with grass seed, brush, stakes or live cuttings or trees.

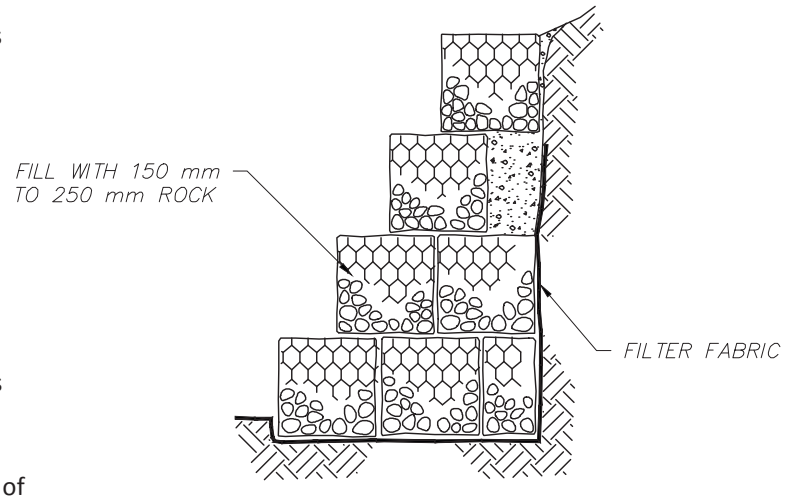


Typical riprap with vegetated soil wrap

Advantages	Disadvantage
Highly effective protection	Somewhat artificial and unnatural appearance
Low maintenance	Access required for large and heavy equipment
Effective on high and steep slopes with significant erosion	Requires more manual labour than typical riprap
More natural appearance and provides better habitat than typical riprap	Some maintenance required for vegetation

Gabion Baskets (Standard & Vegetated)

Gabion baskets are box shaped wire mesh containers that are filled with rock and stacked on top of each other to a desired height to provide protection on steep slopes. The baskets arrive from the manufacturer flattened and are assembled on site using manual labour. Small or medium sized machinery is used to fill each basket with rocks approximately 15 cm in diameter. Quarried angular rock is preferred but rounded rock can be used. The bottom row of baskets are buried into the toe of the slope and the baskets can be stacked numerous rows high. For the vegetated option stakes or live cuttings are placed between or within the baskets. Gabion baskets are typically used in areas where a high level of protection is needed but where large quality rock is not available for riprap.



Typical gabion bank protection

Advantages

Highly effective protection

Low maintenance on non-vegetated option

Effective on high and steep slopes with significant erosion

Good option where large rock is not available

Large and heavy equipment not required

Disadvantages

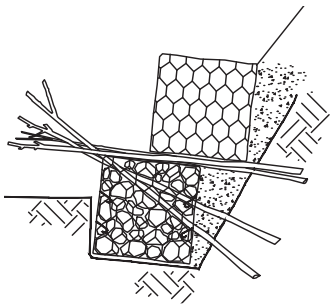
Gabion wire will corrode over time depending on conditions

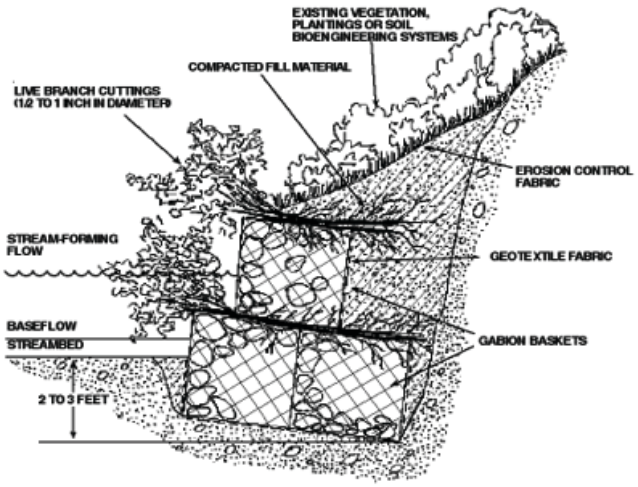
Artificial and unnatural appearance (non-vegetated option)

Does not provide valuable habitat (non-vegetated option)

Requires machinery

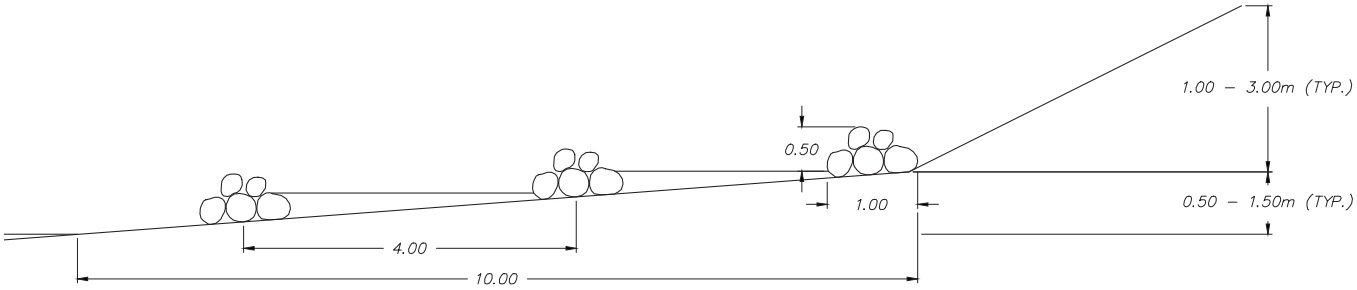
Requires manual labour, especially for vegetated option





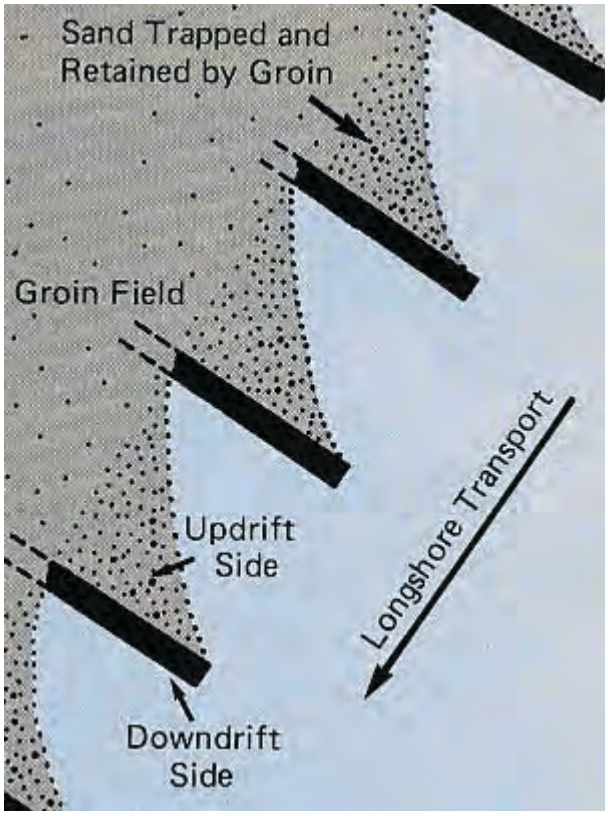
Typical vegetated gabion bank protection

Groynes (Perpendicular & Parallel)



Parallel groynes

Groynes are structures that extend into the water to protect the shoreline from erosion by disrupting the flow of water, wave action or longshore transport of sediment. Groynes can be walls made of timber or logs but are typically made of large rock similar to that used for riprap. Perpendicular groynes are only effective where beaches or bluffs are degrading due to waves and currents running parallel or near parallel to the shoreline resulting in longshore transport of sediment. Parellel groynes are only effective where onshore and offshore processes dominate.



Advantages

Highly effective protection depending on transport scenario

Very low maintenance

Requires minimal manual labour

Disadvantages

Only effective under specific transport scenarios

High initial cost

Artificial and unnatural appearance

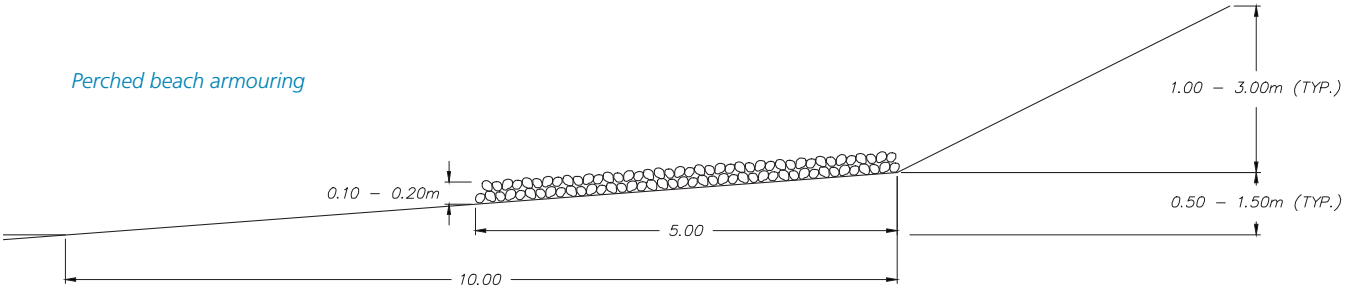
Does not provide valuable habitat

Access required for large and heavy equipment

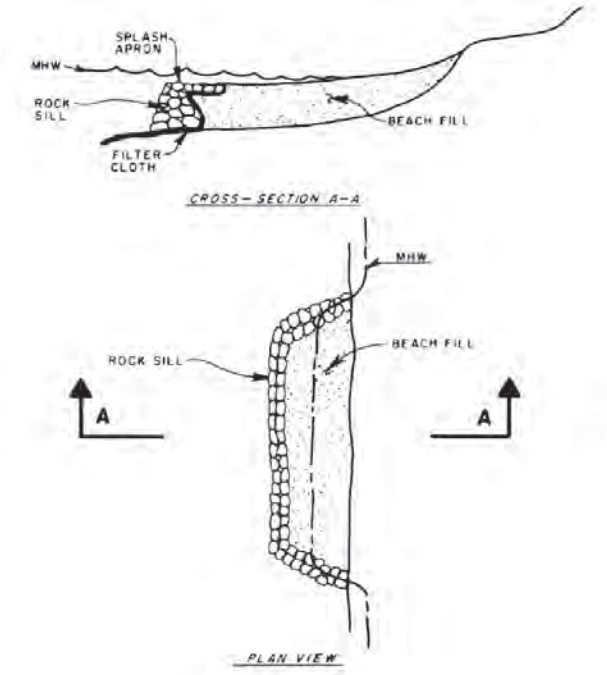
Perched Beach

SOUTHERN LAKES ENHANCED STORAGE CONCEPT • EROSION 7

Perched beach armouring



A perched beach involves protecting an eroding beach by armouring the shoreline with a rock sill along with beach fill on the landward side of the armour. An alternate method involves laying a thin layer of armour protection on the surface of the beach to prevent additional degradation from occurring. With the beach fill option an armoured berm is constructed with large rock and the beach fill can either be backfilled beach material or left empty to gradually fill with natural beach material. With the alternate method the entire beach or portions of the beach along the shoreline can be covered with rock.



Advantages

Reduces wave effects

Installed on existing foreshore

Does not impact backshore slopes

Highly effective protection under longshore or onshore/ offshore transport scenarios

Low maintenance

Requires minimal manual labour

Disadvantages

Impacts existing beach and foreshore area

Does not directly protect backshore slopes

Somewhat artificial and unnatural appearance

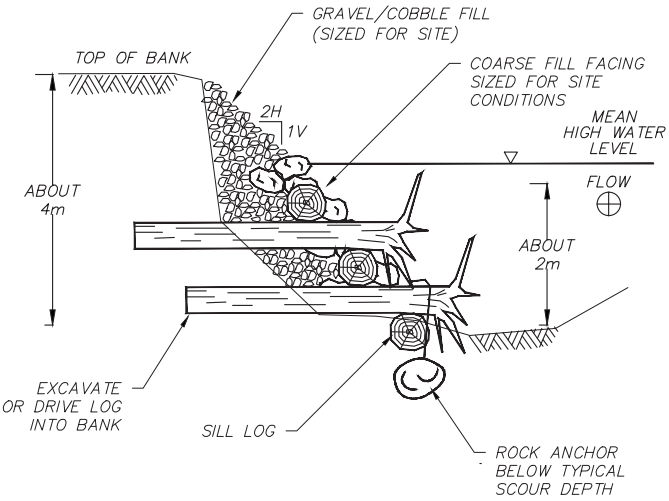
Does not provide valuable habitat

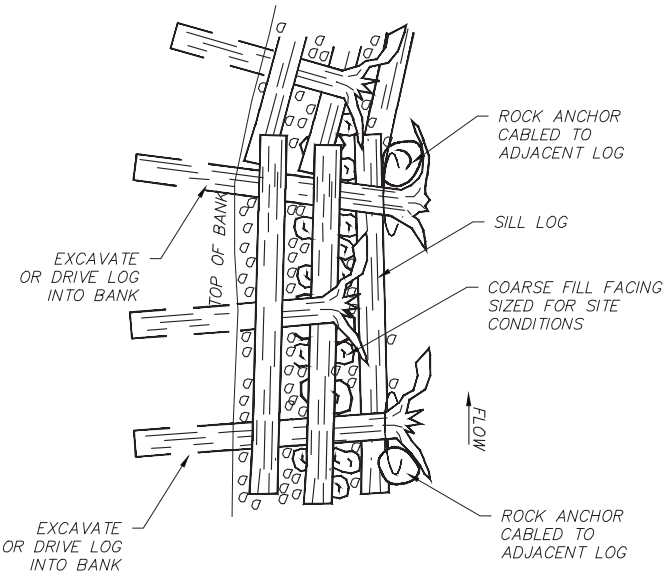
Access required for large and heavy equipment

Cribwall

A cribwall is a wall made of logs or timber to protect a vertical or near vertical eroding slope. For a high level of protection the wall can be built vertically with alternating logs parallel and perpendicular to the slope and backfilled with rock. See drawings below for an example of this method.

The toe of the wall can be buried into the ground for additional protection. For a less engineered option a series of logs can be laid beside each other or stacked to provide a moderate level of protection as shown in the photo below. The logs can also be cabled together or anchored into the ground to provide more durable protection.





Typical crib wall

Advantages

Good for poor or limited machine access

Provides habitat

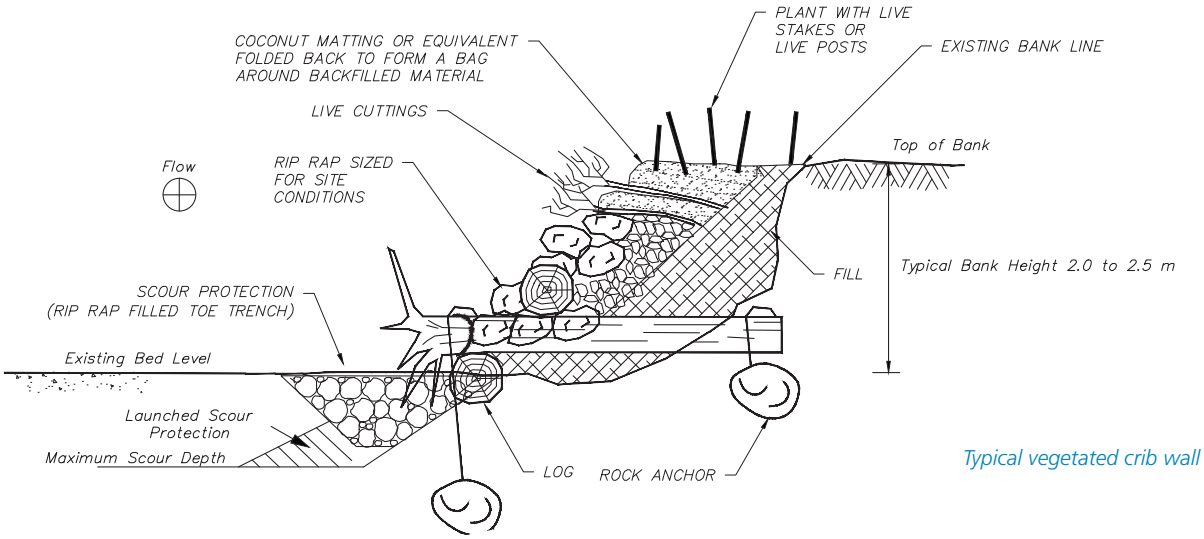
Can be built with manual labour

Disadvantages

Not ideal option if available logs are small and deciduous

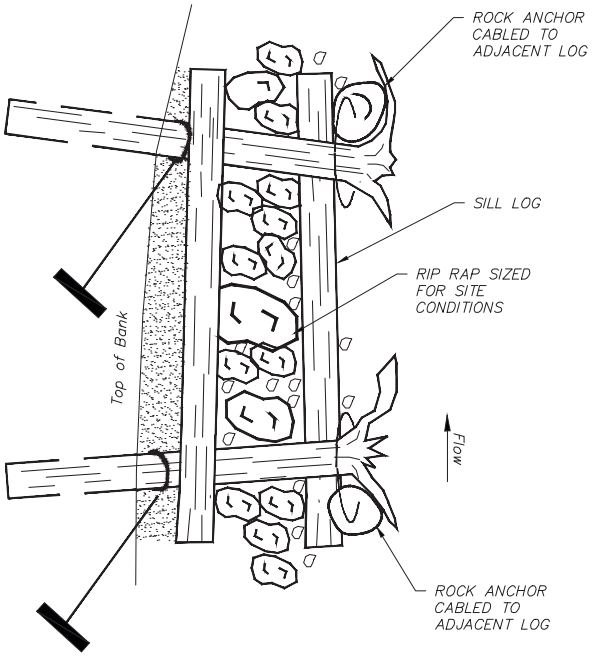
Moderate level of protection

Vegetated Cribwall



Typical vegetated crib wall

Vegetated cribwalls are similar to standard cribwalls but with the addition of vegetation incorporated into the wall. The vegetation can be stakes or live cuttings incorporated into the spaces between the logs. The top of the cribwall can be planted with grass seed, brush, stakes or live cuttings or trees. If not naturally occurring, a growing medium (soil or bags filled with soil would need to be added for the planting at the top of the cribwall.



Advantages

Good for poor or limited machine access

Provides valuable habitat

Can be built with manual labour

Uses natural materials

Ideal for log-based foreshores

Effective slope protection

Effective on high and steep slopes with significant erosion

More natural appearance and provides better habitat than typical cribwalls

Disadvantages

Not ideal option if available logs are small and deciduous

Moderate level of protection

Limited design life in harsh environments

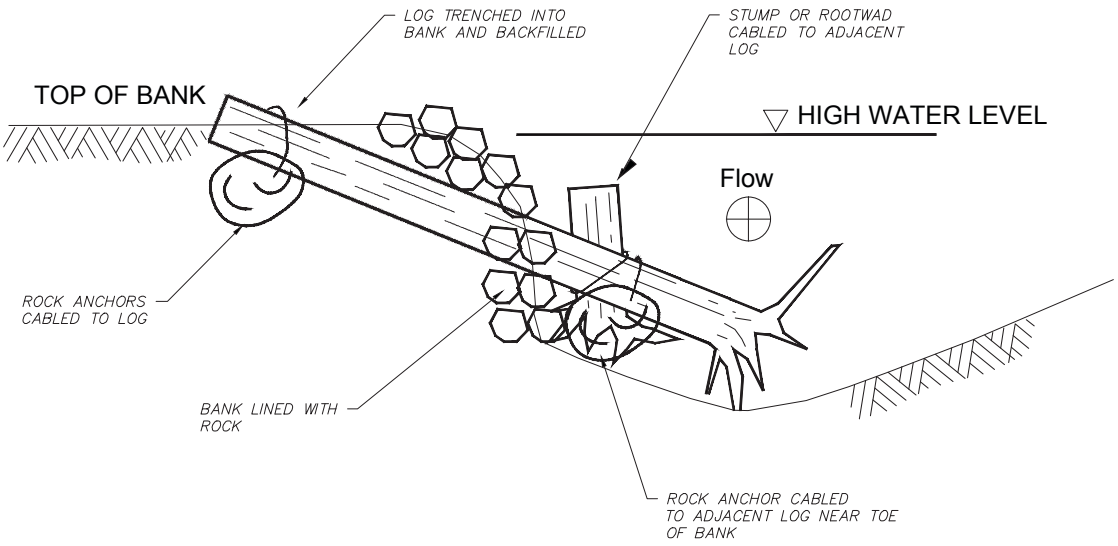
Limited structure strength

Requires excavation to embed/fill/build

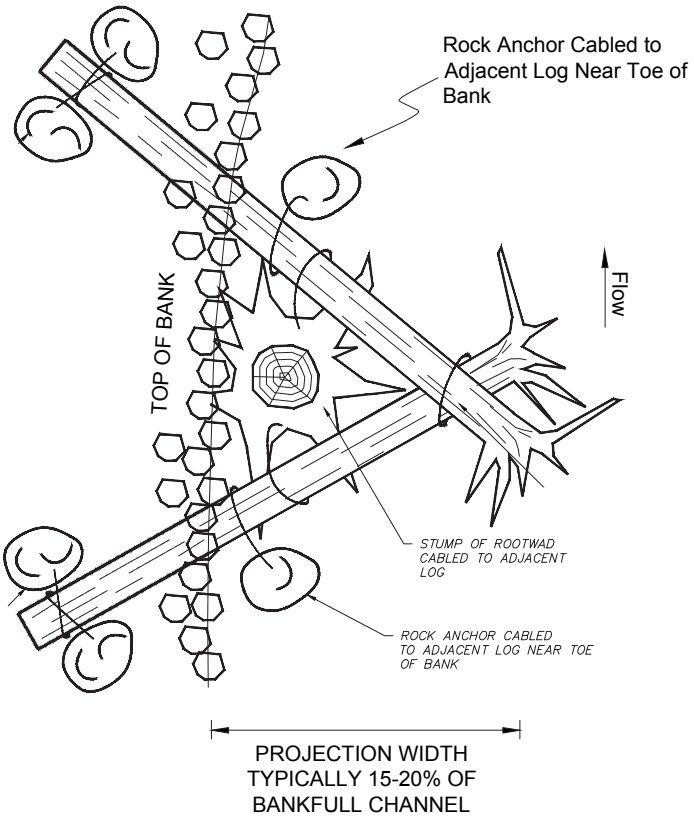
Will require maintenance to replace vegetation that does not survive

Requires more manual labour than typical cribwalls

Large Woody Debris Structures



Large Woody Debris (LWD) structures are a collection of logs that are clustered together to provide protection for eroding slopes. The logs may have the root wad attached and they are typically cabled together and or anchored into the slope or anchored to large boulders. They can be quite natural in appearance and provide habitat for fish and wildlife. They do not provide a high level of protection but are inexpensive to construct and are low maintenance. This option is not appropriate when the eroding slope is high and steep or the erosive forces are significant.



Advantages

Good for poor or limited machine access

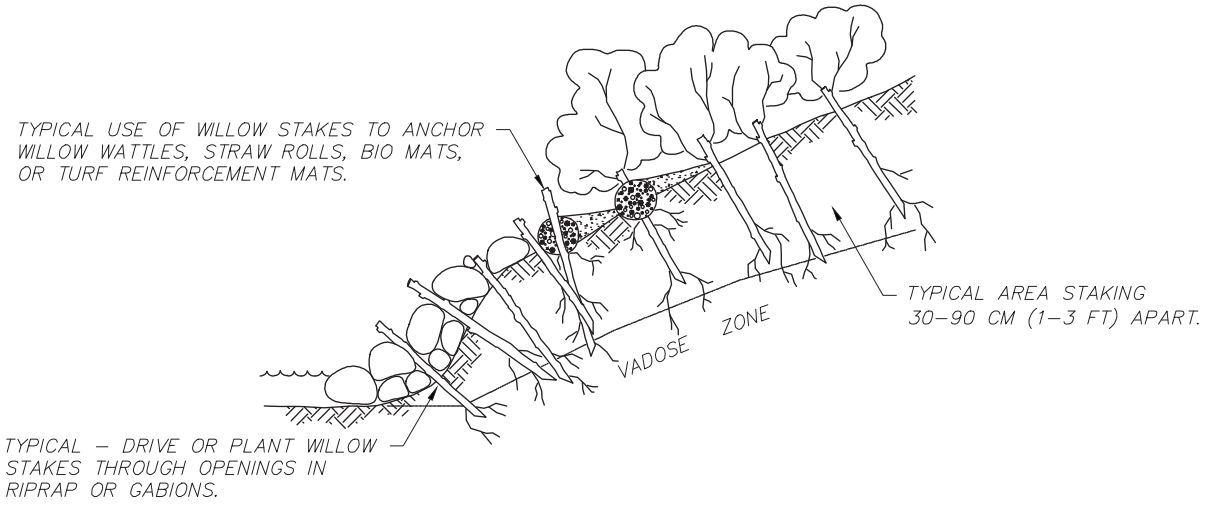
Natural appearance and provides valuable habitat

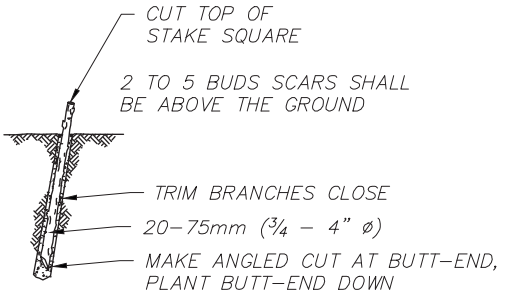
Disadvantages

Not ideal option if available logs are small and deciduous

Minimal level of protection

Live Staking





Live Staking involves cutting vegetation from a nearby source and planting the cuttings on the eroding slope or beach to decrease the rate of erosion. This method is only effective where the extent of erosion is not significant. Ideal growing conditions are required for this option. The stakes are only effective after they have established which can take several years depending on the growing conditions. This option is very natural looking when the stakes are established and can be constructed with manual labour. This option is ideal where access is difficult for large and heavy machinery.

Advantages

Provides additional protection over time as vegetation establishes

High ecological value

Low cost

No large or heavy machinery required

Natural appearance and provides valuable habitat

Disadvantages

High failure rate in initial years

Limited installation period

High initial maintenance for replanting

Requires suitable soil for growing

Requires moisture in the soil for growing

Brush Layering

Brush layering involves cutting vegetation from a nearby source and planting the brush cuttings in dense layers on the eroding slope and then backfilling with soil. This method is only effective where the extent of erosion is not significant. Ideal growing conditions are required for this option. The brush layers are only effective after they have established which can take several years depending on the growing conditions. This option is very natural looking when the brush layers are established and can be constructed manually. This option is ideal where access is difficult for large and heavy machinery.

Advantages

Provides additional protection over time as vegetation establishes

High ecological value

Low cost

No large or heavy machinery required

Natural appearance and provides valuable habitat

Disadvantages

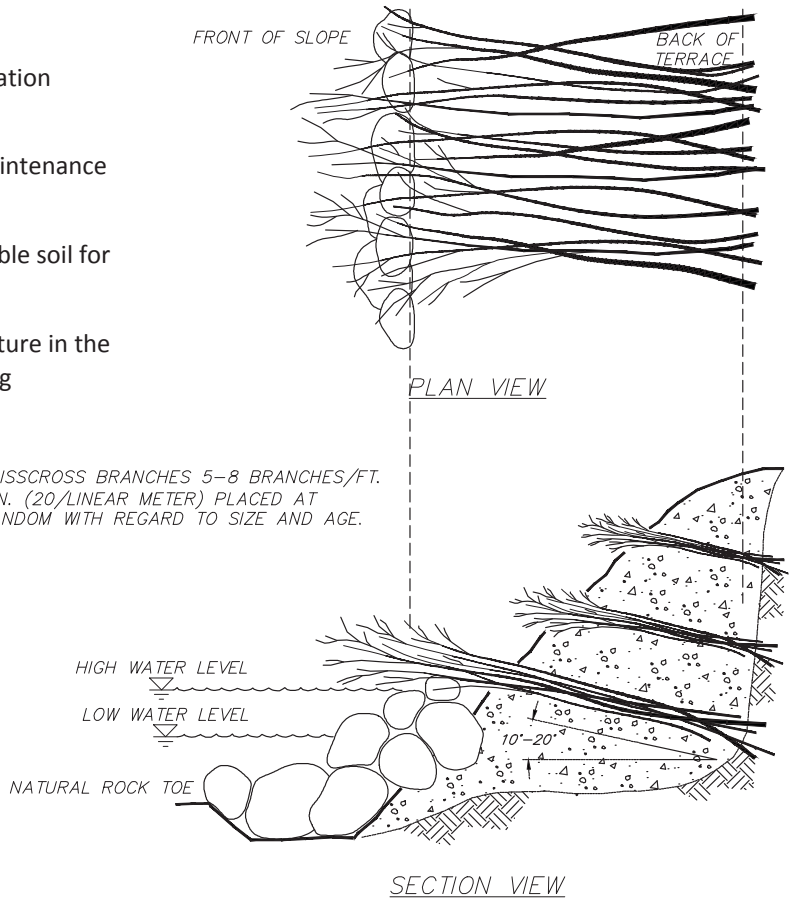
High failure rate in initial years

Limited installation period

High initial maintenance for replanting

Requires suitable soil for growing

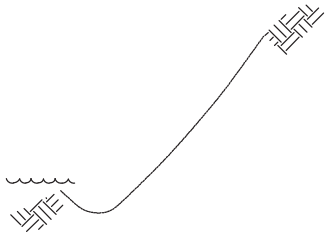
Requires moisture in the soil for growing



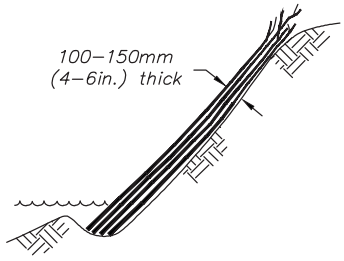
Brush Matting

Brush matting involves cutting vegetation from a nearby source and planting the brush cuttings in dense layers on the eroding slope. The cuttings are densely placed side by side and secured together with twine or rope to create a mattress like structure. This method is only effective where the extent of erosion is not significant. Ideal growing conditions are required for this option. The brush matting is only effective after the vegetation has established which can take several years depending on the growing conditions. This option is very natural looking when the brush matting is established and can be constructed with manual labour. This option is ideal where access is difficult for large and heavy machinery.

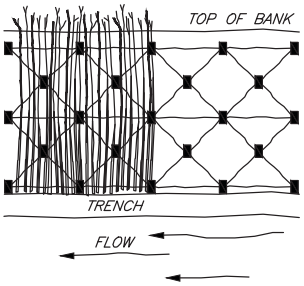
Advantages	Disadvantages
Provides additional protection over time as vegetation establishes	High failure rate in initial years
High ecological value	Limited installation period
Low cost	High initial maintenance for replanting
No large or heavy machinery required	Requires suitable soil for growing
Natural appearance and provides valuable habitat	Requires moisture in the soil for growing



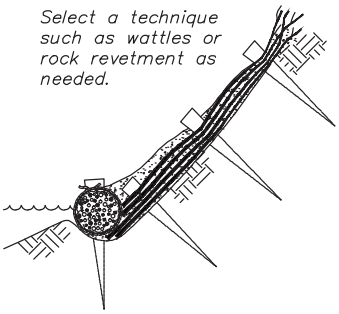
Step 1: Excavate trench and grade bank.



Step 2: Place willow branches making sure that the butt ends reach the bottom.



Step 3: Place stake (notched) on 1.0m (3ft.) centers and secure the mattress with twine, rope or wire.



Step 4: Drive the stakes deeply into the bank to tightly compress the branches against the soil. Cover and partially bury the mattress to encourage rooting.