

## Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options

## **E.1 Existing Conditions**

The existing conditions presented in this section provide a brief summary of characteristics of the Study Area that are pertinent to the development of mitigation options and their evaluation. The contents of this section are not a comprehensive review of all existing conditions for Army Beach and South M'Clintock.

### **E.1.1 POPULATION**

Marsh Lake has a population of 746 with 527 private dwellings according to the 2021 census data (Statistics Canada 2023c). The population has increased by approximately 7% from 2016 when the population was 696 (Statistics Canada 2023c). Census data specific to the Army Beach and South M'Clintock communities was not available.

### **E.1.2 STUDY AREA**

The Study Area in Figure E2 outlines the areas that are considered in this Project at Army Beach and South M'Clintock. The boundaries of the Study Area are based on Stantec's understanding that the flood mitigations are to be designed for communities, and that individual properties outside of the main community consolidation are not included.

### **E.1.3 FIRST NATIONS**

The Army Beach and South M'Clintock areas are within the Traditional Territories of the Kwanlin Dün First Nation (KDFN) and the Carcross Tagish First Nation (CTFN). The KDFN have a parcel of Category B Settlement Lands on the Northwest corner of the Marsh Lake area, along McClintock River. The land claim selection is R-77B. This means that KDFN has surface ownership of this parcel of land (Government of Yukon 2022). Other First Nation's with Traditional Territories near the Study Area, such as the Ta'an Kwäch'än Council (TKC), should also be considered when engaging with local stakeholders.

### **E.1.4 BATHYMETRY AND TOPOGRAPHY**

The following data sources were provided to or obtained by Stantec:

- 2022 LiDAR LAS files UTM Zone 8 CSRS NAD1983, CGVD2013 (McElhanney Ltd, GeoYukon 2023) and interpolated into a derivative 1 m horizontal resolution Digital Elevation Model (DEM) (Government of Yukon 2022e);
- Land contours and imagery from 1:2500 scale mapping in 2011 (Underhill Geomatics 2021);
- Bathymetry collected in November 2021 (Underhill Geomatics 2021); and
- Road crest profiles collected in July-August 2021 (Stantec 2021).

The LiDAR accuracy is assumed to be sufficient for the preliminary flood inundation analysis and conceptual design presented in this Report. There is insufficient metadata to determine whether the

*The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.*

## **Yukon Territory Flood Mitigation Conceptual Design Options**

### **Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options**

July 2023

LiDAR meets the base requirement in terms of accuracy or precision for flood mapping as per NRCan (2022b).

#### **E.1.5 GEOLOGY**

Based on the surficial geology mapping (Yukon Geological Survey 2020), the Study Area likely consists of Eolian sand and Glaciolacustrine mud (mix of silt and clay), sand and gravel. The Eolian sand was deposited in forms of veneers and blankets ranging in thickness between 0.1 m and greater than 1 m. The Glaciolacustrine mud, sand and gravel was deposited in form of a plain, thickness unknown. Based on the surficial geology mapping, the Eolian sand is more extensive than the Glaciolacustrine mud, sand and gravel and the surficial material is from the McConnell age. The surficial geology mapping aligns with discussions with local geotechnical engineers (C. Cowan and I. MacIntyre 2021, personal communication, 22 December, 2021) who indicated that the area generally consists of silts and fine grained sands. The thickness of the deposit of silts and fine-grained sands is unknown.

From the local discussions (C. Cowan and I. MacIntyre 2021, personal communication, 22 December 2021), permafrost conditions were considered unlikely at the Study Area. This varies however based on the Permafrost Probability Model (Yukon Geological Survey, 2020) and the Canada Permafrost Map (The National Atlas of Canada, 1995). The Permafrost Probability Model suggests the Study Area is located within a region of sporadic discontinuous permafrost (10-20%). The Canada Permafrost Map also indicates the Study Area is in a region of sporadic discontinuous permafrost (10-50%) with a low (<10%) ground ice content in the upper 10-20 m of the ground.

#### **E.1.6 HYDROGEOLOGY**

The fine-grained sands and silts at Marsh Lake are likely to result in relatively moderate rates of groundwater flow. This assumption is supported by anecdotal findings from Stantec (2021b), where groundwater in a property owner's basement in October 2021 was 0.644 m higher than Marsh Lake WSE. This is thought to be due to slow dewatering of the ground following the extended period of high water in Marsh Lake through the summer of 2021. Water well logs were reviewed in the area of the site (Government of Yukon 2023a), however, groundwater and soil conditions were not provided for the water well logs within the area of the site.

Yukon Energy Corporation completed groundwater modeling at Army Beach and South McClintock to identify properties where the groundwater level may be affected by increasing the full supply level at Marsh Lake. The modeling showed that the majority of properties on Army Beach Drive from the loop to Taylor Way and approximately 50% of properties on South McClintock Road and Bayview Road would be affected by groundwater rise as a result of increasing the full supply level (Hemmera 2019a; Hemmera 2019b).

Based on the anticipated soils at this site, the need for seepage control measures (i.e. seepage cut-off below flood mitigation option, toe drains, sump pits and pumping, etc.) may be required for the proposed flood mitigation options and should be further evaluated in preliminary and detailed designs.

*The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.*

### **E.1.7 PAST FLOODING EVENTS AND RESPONSE**

A summary of documented flood events are provided below. The flood events summarized below do not represent a comprehensive review of flooding history in the Study Area; rather, they are a summary of the flooding documentation provided to Stantec at the time of writing.

#### **2007 Flood Event**

Army Beach and South M'Clintock experienced flood conditions in 2007. High water conditions occurred due to a high snowpack, fast snowpack melt, and higher than average precipitation in the area. WSC station 09AB004 (Marsh Lake near Whitehorse) reported a peak instantaneous Water surface elevation (WSE) of 657.65 m (CGVD2013) during the flooding event on August 14, 2007 (GoC 2023).

Flood defense measures included concrete blocks, concrete barriers, superbags and sandbags. An estimated 40 properties at Marsh Lake were directly impacted by these floods (Government of Yukon 2007a). Discussions with property owners and YG officials throughout the 2021 flood indicated that during the 2007 flood, flood defenses were focused on the lake side of the properties; however, high water entered the interior of the Marsh Lake peninsula (between Army Beach and South McClintock) and flooded properties from the non-lake side.

After the water levels receded in 2007, YG developed objectives for various branches of government for moving forward, including Wildland Fire Management, Community Development, Community Services Communications, and Yukon Housing Corporation (YHC). Wildland Fire Management was responsible for the removal and cleanup of the flood defense measures and damage on public lands (sandbags, concrete blocks, Jersey Barriers); Community Development was responsible for reclaiming the Army Beach dike, borrow pits and areas for the dyke, and access trail; the YHC was responsible for developing a purchase process for private property owners to purchase the existing concrete blocks and barriers; Community Services Communications was responsible for developing a communications strategy for private property owner responsibilities and the process for private property owners to purchase concrete blocks (Government of Yukon 2007b). The YHC also developed a Flood Relief Initiative which provided financial grants to homeowners to repair their flood-damaged residences (Government of Yukon 2007c).

Many of the affected homeowners purchased concrete blocks from YG after the 2007 flood and applied for the YHC grants to repair their primary residences (no financing limit, based on the damages done by the flood) and up to \$35,000 in loans to repair secondary residences and/or outbuildings and install flood mitigation measures at their properties (YG 2007). A post-flood options analysis was completed by Tetra Tech (formerly EBA Consulting) in 2008 (EBA 2008).

#### **2021 Flood Event**

Army Beach and South M'Clintock experienced flood conditions again in the spring and summer of 2021. The flooding was largely due to record snowpack in the winter of 2020-2021 followed by rapid snowmelt and record inflows in late June and July 2021. WSC station 09AE002 reported a peak instantaneous WSE of 657.87 m (CGVD2013) during this flooding event on July 10, 2021.

Emergency flood response actions were undertaken including temporary superbag and sandbag dikes, earthfill berms, concrete blocks, and occasional water bag systems along the lake side of the properties *The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.*

## **Yukon Territory Flood Mitigation Conceptual Design Options**

### **Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options**

July 2023

and along the internal road network. The temporary flood mitigations were initially constructed to an elevation of 658.90 m. Once this elevation was achieved for the majority of the defense structure in July of 2021, the target elevation for the defenses was raised by 0.30 m to 659.20 m to enhance the temporary flood service level. Based on flooding observations from 2007, the pathway between South M'Clintock and Army Beach was raised so that a continuous flood mitigation line encircled the flood vulnerable areas of the peninsula. While this mitigated surface water from inundating the inner portion of the peninsula, elevated groundwater levels and seepage issues were observed inside this continuous temporary flood mitigation line. The temporary flood mitigations were installed by property owners, YG, Wildland Fire, and the Canadian Armed Forces (CAF). The defense structure target elevations were not considered to be flood protection design elevations. The constructed defense structures were not considered to be permanent flood defenses and are not engineered structures. Stantec (2021a) completed a detailed inventory of the temporary flood mitigations in the fall of 2021 to inform demobilization efforts by YG.

#### **E.1.8 EXISTING FLOOD MITIGATION INFRASTRUCTURE**

There is no community-wide flood mitigation infrastructure at Army Beach and South M'Clintock, although some individual property owners have implemented certain flood mitigations on their property. The establishment of the temporary flood mitigations in the summer of 2021 did establish certain widths for dikes on the lake side of buildings which may be adapted in the future for permanent flood mitigation.

It is Stantec's understanding that at the time of writing, decommissioning of the temporary flood mitigation structures at Army Beach and South M'Clintock has not been completed by YG. Individual property owners may have made alterations to the temporary mitigations on their property.

#### **E.1.9 WIND, WAVES, AND EROSION**

The flow velocities at Marsh Lake are not expected to introduce erosion risks to flood mitigations. Erosion protection from riverine flow velocities is not anticipated to be required at Army Beach/South M'Clintock flood mitigations.

As a lake community, Army Beach/South M'Clintock is affected by beach processes and erosion due to wind and waves. If flood mitigations are required at Army Beach/South M'Clintock, they would need to be capable of withstanding not only the erosion potential from wind and waves, but higher WSEs due to wave runup and potential lake seiche. Natural beach processes and morphodynamics should be studied and considered in preliminary and detailed design phases of flood mitigations.

#### **E.1.10 HYDROLOGY**

The communities of Army Beach and South M'Clintock are located along the northwest side of Marsh Lake. The Marsh Lake is a widening of the Yukon River ranging from three to four km in width. This lake is a part of the Southern Lakes which area chain of finger lakes forming the headwaters of the Yukon River.

WSC Station 09AB004 (Marsh Lake near Whitehorse) is located on the northwest side of the Marsh Lake. Gross drainage area to the WSC station is not reported by GoC (2023). The hydrology review considered WSEs at WSC Station 09AB004. Flood frequency analysis for WSEs was performed by both Morrison

*The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.*

**Yukon Territory Flood Mitigation Conceptual Design Options**  
**Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options**

July 2023

Hershfield (2022) and Yukon University (2022) for WSEs at WSC Station 09AB004. Table E1 summarizes the frequency results of these two studies.

**Table E1 Flood Frequency Analyses at WSC Station 09AB004 from Morrison Hershfield (2022) and Yukon University (2022) for Army Beach/South M'Clintock**

|  | Morrison Hershfield (2022) | Yukon University (2022) |
|--|----------------------------|-------------------------|
| Years Included in Analysis   | 1985-2022                  | 1970- 2021              |
| Number of Years  | 38                         | 52                      |
| Selected Distribution  | Log-Pearson Type 3         | Gumbel                  |
| Water Surface Elevation (m) <sup>1</sup>                             |                            |                         |
| 1:2-Year Event (50% AEP)   | 656.70                     | 656.70                  |
| 1:20-Year Event (5% AEP)   | 657.45                     | 657.60                  |
| 1:100-Year Event (1% AEP)  | 657.83                     | not provided            |
| 1:200-Year Event (0.5% AEP)  | 657.98                     | 658.30                  |
| <sup>1</sup> Elevations provided in CGVD2013 for WSC Station 09AB004 |                            |                         |

The Yukon University (2022) flood frequency analysis results were adopted for the Project because the 1:200-year event WSE was higher and would yield more conservative designs.

Table E1 illustrates the on-record daily minimum, mean, and maximum WSEs, the WSE during the highest year on record (2021), and the WSEs for the 1:2-year and 1:200-year event at WSC Station 09AB004 from Yukon University (2022). The mentioned water levels do not include wave runoff which could be affected by wind, its direction, intensity, duration, resulting tides, and the beach profile.



## **E.1.11 PRELIMINARY INUNDATION MAPPING**

Floodplain mapping and the associated flood policy is ultimately what is required for design and implementation of flood mitigations at communities. Wind/wave analysis and floodplain mapping has not been completed to date at Army Beach/South M'Clintock and is not within the scope of this Project. However, an understanding of inundation extents under the 1:200-year event is required for conceptual design of flood mitigations.

In lieu of floodplain mapping, Stantec performed preliminary existing conditions (no mitigation) inundation analysis for Army Beach/South M'Clintock using WSEs. This analysis considered the 1:200-year WSE (658.30 m) developed by Yukon University (2022) in a flat-water inundation scenario (based on survey from Underhill 2022). The resulting water surface was overlain on the existing conditions topographic/bathymetric elevation data (McElhanney Ltd, GeoYukon 2023) and the limits of inundation were mapped (Figure E2). The preliminary inundation analysis does not take into account flow pathways and blockages. That is, if the land in a given location is below the 1:200 WSE surface, it presents as inundated whether or not there is an overland flow path for the water to arrive there. The inundation analysis performed herein is provided for information only and is considered a high-level estimate of the flood inundation under the 1:200-year WSE from Yukon University (2022).

Relatively large areas of the Army Beach/South M'Clintock peninsula are inundated in preliminary inundation mapping. The inundation encroaches on private residential properties and community infrastructure in the southern half of the peninsula and two properties on the north-west tip of the peninsula at the end of East Bank Road.

The preliminary inundation analysis indicated that approximately 57 properties would be inundated at Army Beach/South M'Clintock including an estimated 52 private residences and 5 community features (Bay View Road, South M'Clintock Road, Army Beach Road, Taylor Way, and pathway between South M'Clintock and Army Beach).

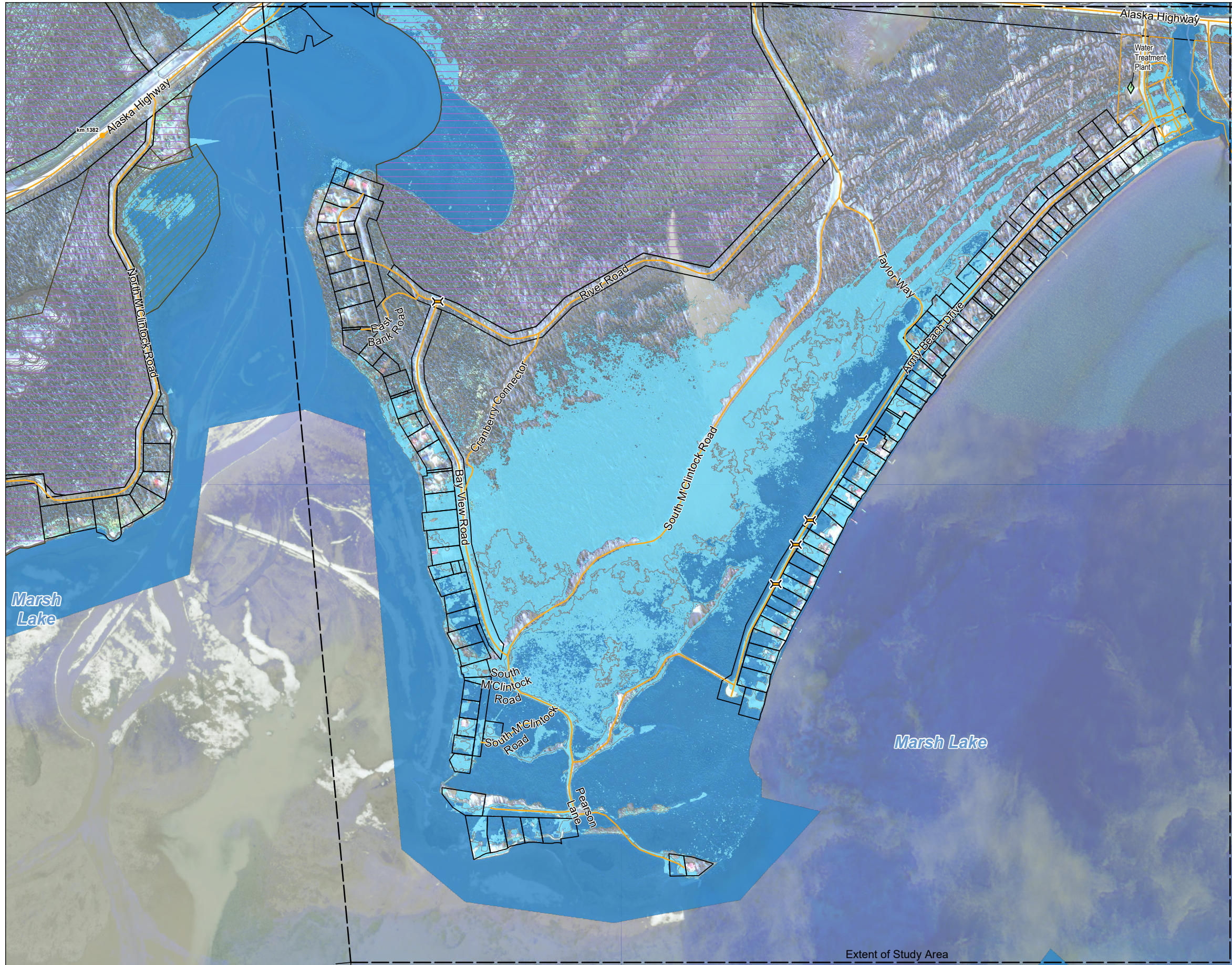
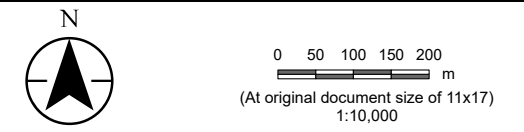
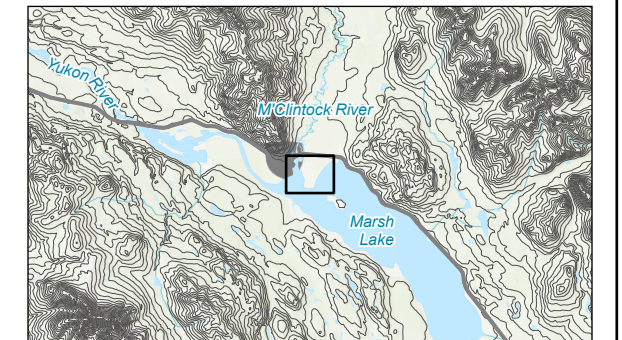


Figure No. **E2**  
 Title **Army Beach and South M'Clintock Study Area**  
 Client/Project Government of Yukon 144903232  
 Community Services | Infrastructure Development Branch  
 Yukon Territory Flood Mitigation Conceptual Design Options  
 Project Location Army Beach/South M'Clintock, Yukon Prepared by LLT on 2023-05-08 TR by JM on 2023-05-08



- Culvert/ Bridge
  - Community Infrastructure and Points of Interest
  - Highway Kilometre Post
  - Road
  - Parks Campgrounds Surveyed
  - Topographic Contour (10 m)
  - Topographic Contour (2 m)
  - Land Parcel - Surveyed
  - First Nation Settlement Lands - Surveyed
  - First Nation Heritage Site
- Water Depth at 1:200 WSE Inundation (m)
- 0 - 1
  - 1 - 2
  - > 2 m depth color swatch"/> > 2

The preliminary inundation analysis does not take into account flow pathways and blockages. That is, if the land in a given location is below the 1:200 WSE surface, it presents as inundated whether or not there is an overland flow path for the water to arrive there.



- Notes**
1. Coordinate System: NAD 1983 Yukon Albers
  2. Data Sources: Government of Yukon; Government of Canada
  3. Imagery Government of Yukon Geomatics Yukon; ESRI World Imagery



S:\11232\projects\144903232\figures\reports\YukonWide\YukonWideFigures.aprx Revised: 2023-07-04 By: LTrudel

## **E.2 Mitigation Options and Evaluation**

The scope of this Project is to develop conceptual engineered flood mitigation options; these options for Army Beach and South M'Clintock are presented in this section. Non-engineered options presented in Section 3.3.1 of the main body of this Report (emergency response-based, mitigation funding to property owners, land purchase/exchange, regulation of flow, management of ice, nature-based approaches) should be considered as part of a comprehensive approach to flood mitigation in the Yukon.

Based on the objectives and assumptions presented in the main body of this Report, three conceptual flood mitigation options were developed for Army Beach/South M'Clintock (Table E2) using combinations of the typical engineered flood mitigation designs from Section 3.3.2. Flood mitigations in the three options were provided for areas which are inundated under the 1:200-year WSE (658.30 m) in the preliminary inundation mapping (Figure E2). The top elevation of the flood mitigations is designed to reach the DFSL which in the case of Army Beach/South M'Clintock (lake site) is assumed to be 660.30 m (i.e., 2.0 m of freeboard above the 1:200-year WSE as outlined for lake sites in Section 3.2).

Areas which are above the 1:200-year WSE in the preliminary inundation analysis but below the DFSL are not included in this Project. These areas may need to be included in future design advancements depending on the requirements of future territorial flood policy.

**Table E2 Summary of Conceptual Design Options**

| <b>Location</b>  | <b>Option 1</b>   | <b>Option 2</b>  | <b>Option 3</b>  |
|--|---|--|--|
|  | <i>lower capital costs,<br/>higher<br/>response/maintenance</i> | <i>higher capital costs,<br/>lower<br/>response/maintenance -<br/>scenario A</i> | <i>higher capital costs,<br/>lower<br/>response/maintenance -<br/>scenario B</i> |
| South M'Clintock   | Platform with Temporary Superbag Dike                           | Earthen Dike   | Structural Dike  |
| Road and Trail Connecting S. M'Clintock to Army Beach  | Platform with Temporary Superbag Dike                           | Road Raising   |  |
| Army Beach   | Platform with Temporary Superbag Dike                           | Earthen Dike   | Structural Dike  |
| Individual Property at South Extent of Peninsula   | Temporary Sandbag Dike  |  |  |
| Internal Road Network: Army Beach Drive (North and South End), Taylor Way, South M'Clintock Road and Bay View Road | Platform with Temporary Superbag Dike                           | Road Raising   |  |

Section E2.1, E2.2 and E2.3 provide a description, Class D OPC, and qualitative evaluation of the conceptual options specified in Table E2.

Other engineered flood mitigation approaches may have merit but would require additional study and design efforts.

*The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.*

**Yukon Territory Flood Mitigation Conceptual Design Options**  
**Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options**

July 2023

## **E.2.1 OPTION 1**

### **Description**

The conceptual flood mitigations for Option 1 are illustrated in Figure E3.

Two platforms would be established along the lakeshores for approximately 1,340 m at South M'Clintock and approximately 990 m at Army Beach. The platforms along both locations would generally follow the existing grade, with occasional raising of up to 0.5 m to bring the platform elevation to within 2 m of the DFSL. During flood conditions, each platform would require double superbags to reach the DFSL. Access points may be installed in/across the platform as necessary. Floodboxes may be required at topographic low points. The lake side of the embankment platform may extend below the OHWM in certain locations.

A temporary double superbag dike would be established on the approximately 550 m long trail connecting South M'Clintock and Army Beach. This temporary superbag dike would connect the flood mitigations at South M'Clintock and Army Beach, resulting in a continuous flood mitigation line encircling the inundated portions of the peninsula.

Temporary superbag dikes would be established on either side of the road for approximately 480 m of Bay View Road, 1,270 m of South M'Clintock Road, 1,640 m of Army Beach Road, and 250 m of Taylor Way. While these internal roads are inside the flood mitigation line encircling the peninsula, the long duration of flooding at Army Beach/South M'Clintock and the generally moderate groundwater flow rates are likely to result in elevated groundwater levels within the peninsula (as was observed during the 2021 flood). Flood mitigations for the internal road network would therefore be provided to preserve access to properties and continuous flood mitigation line. The elevations for the internal roads are within 2 m of the DFSL and would require double superbag dikes for the indicated lengths.

One individual property at the south extent of the peninsula would have a temporary sandbag dike around the structure. The temporary sandbag dike would range in height from approximately 1.5–2.0 m. The perimeter of the sandbag ring dike would be approximately 240 m.

S:\11232\projects\144903232\figures\reports\YukonWide\YukonWide\Figures\Export.aprx Revised: 2023-07-04 By: LTrudell

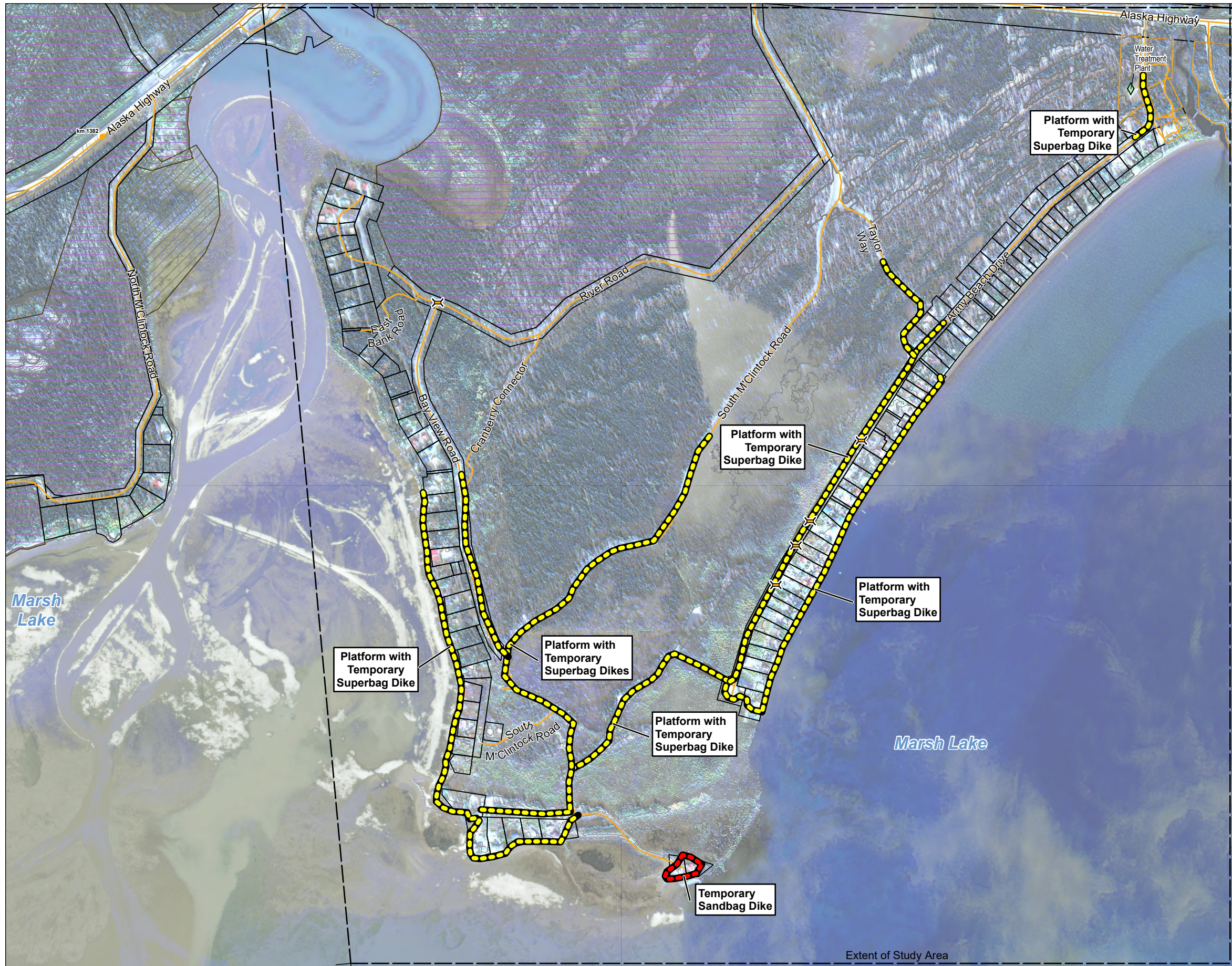
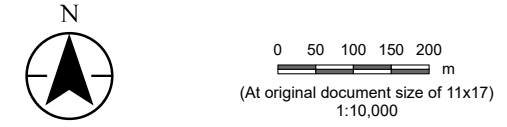
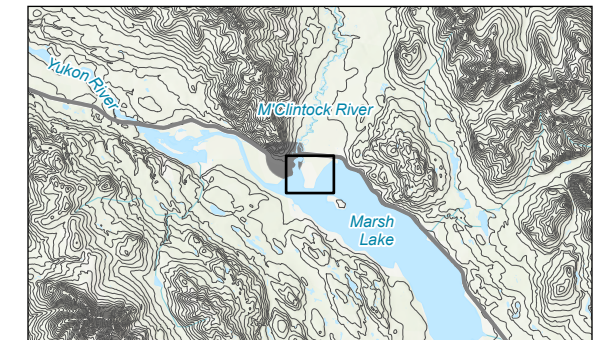


Figure No. **E3**  
**Army Beach and South M'Clintock Conceptual Flood Mitigation Design - Option 1**  
 Client/Project: Government of Yukon  
 Community Services | Infrastructure Development Branch  
 Yukon Territory Flood Mitigation Conceptual Design Options  
 Project Location: Army Beach/South M'Clintock, Yukon  
 Prepared by LLT on 2023-04-11  
 TR by JM on 2023-04-11  
 144903232



- Culvert/ Bridge
- Community Infrastructure and Points of Interest
- Highway Kilometre Post
- Road
- Parks Campgrounds Surveyed
- Topographic Contour (10 m)
- Topographic Contour (2 m)
- Land Parcel - Surveyed
- First Nation Settlement Lands - Surveyed
- First Nation Heritage Site
- Proposed Mitigation Feature**
- Earthen Dike
- Platform with Temporary Superbag Dike
- Road Raising
- Structural Dike
- Temporary Sandbag Dike

**CONCEPTUAL DESIGN**  
 This document is for general information only  
 and is not for permits, tendering, or construction.



- Notes**
1. Coordinate System: NAD 1983 Yukon Albers
  2. Data Sources: Government of Yukon; Government of Canada
  3. Imagery: Government of Yukon Geomatics Yukon; ESRI World Imagery



**Yukon Territory Flood Mitigation Conceptual Design Options**  
**Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options**  
 July 2023

**Class D OPC**

The Class D OPC's for capital and annual costs are summarized in Table E3, considering the Class D level of accuracy (+/-50%). Table E3 also provides the Class D OPCs on a per inundated property basis (from Section E.1.11).

**Table E3 Option 1 Summary of Class D OPCs**

|  | Class D OPC                   | Number of Inundated Properties (Section E.1.11) <sup>1</sup> | Class D OPC per Inundated Property |
|--|-------------------------------|--|------------------------------------|
| Capital Cost   | \$ 25,486,700 - \$ 38,230,050 | 57   | \$ 447,136 - \$ 670,703            |
| Annual Cost (Flood Year)   | \$ 8,477,300 - \$ 12,715,950  |  | \$ 148,725 - \$ 223,087            |
| Annual Cost (Non-Flood Year)   | \$ 90,800 - \$ 136,200        |  | \$ 1,593 - \$ 2,390                |
| <sup>1</sup> As described in Section E.1.11, the inundated properties from the preliminary inundation analysis consists of 52 private residences and 5 community features. |                               |  |                                    |

The components, assumed unit costs, and estimated quantities which produce the Class D OPCs are detailed in Table E4 (capital costs), Table E5 (annual cost, flood year), and Table E6 (annual cost, non-flood year).

*The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.*

**Yukon Territory Flood Mitigation Conceptual Design Options**  
**Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options**  
 July 2023

**Table E4 Option 1 Capital Costs Class D OPC**

| Item No.   | Description of Work                                   | Units | Qty.  | Unit Price     | Amount          |
|--|---|-------|-------|----------------|-----------------|
| <b>Section 1A Option 1: General Conditions</b>   |   |       |       |                |                 |
| a)   | Mobilization/Demobilization                           | LS    | 1     | \$1,517,060.00 | \$1,517,060.00  |
| b)   | Site Preparation/Restoration                          | LS    | 1     | \$303,500.00   | \$303,500.00    |
| <i>Total 1A</i>  |   |       |       |                | \$1,820,560.00  |
| <b>Section 1B Option 1: Earthworks &amp; Landscaping, Platform (South M'Clintock &amp; Army Beach)</b> |   |       |       |                |                 |
| a)   | Clearing and Grubbing                                 | M2    | 17500 | \$10.00        | \$175,000.00    |
| b)   | Topsoil Stripping and Stockpiling, 300mm Depth        | M3    | 5250  | \$25.00        | \$131,250.00    |
| c)   | Platform Topsoil                                      | M2    | 14300 | \$20.00        | \$286,000.00    |
| d)   | Platform Seeding                                      | M2    | 14300 | \$5.00         | \$71,500.00     |
| e)   | Geotextile Fabric                                     | M2    | 20400 | \$10.00        | \$204,000.00    |
| f)   | Embankment Fill, Clay Core                            | M3    | 9240  | \$100.00       | \$924,000.00    |
| g)   | Embankment Fill, Granular Shell                       | M3    | 22350 | \$50.00        | \$1,117,500.00  |
| h)   | Riprap  | MT    | 23820 | \$141.00       | \$3,358,620.00  |
| i)   | Toe Drain: Perforated Pipe, Geotextile and Drain Rock | M     | 2310  | \$300.00       | \$693,000.00    |
| j)   | Slope Stabilization                                   | M     | 2310  | \$3,000.00     | \$6,930,000.00  |
| <i>Total 1B</i>  |   |       |       |                | \$13,890,870.00 |
| <b>Section 1C Option 1: Floodboxes, Platform</b>   |   |       |       |                |                 |
| a)   | Reinforced Concrete Pipe                              | M     | 480   | \$1,000.00     | \$480,000.00    |
| b)   | Gatewell Manhole c/w Sluice Gate                      | EA    | 24    | \$17,500.00    | \$420,000.00    |
| c)   | Concrete Headwall                                     | EA    | 48    | \$5,000.00     | \$240,000.00    |
| d)   | Slide Gate  | EA    | 24    | \$3,000.00     | \$72,000.00     |
| e)   | Riprap  | MT    | 480   | \$141.00       | \$67,680.00     |
| <i>Total 1C</i>  |   |       |       |                | \$1,279,680.00  |
| <i>Contingency (20%)</i>   |   |       |       |                | \$3,398,222.00  |
| <i>Subtotal</i>  |   |       |       |                | \$20,389,332.00 |
| <i>Location Adjustment Factor (LCAF)</i>   |   |       |       |                | 1.25            |
| <b>Capital Costs Base Price</b>  |   |       |       |                | \$25,486,700.00 |
| <b>Capital Costs Upper Bound</b>   |   |       |       |                | \$38,230,050.00 |

The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.

**Yukon Territory Flood Mitigation Conceptual Design Options**  
**Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options**  
 July 2023

**Table E5 Option 1 Annual Costs During a Flood Year Class D OPC**

| Item No.   | Description of Work                   | Units | Qty.  | Unit Price                                 | Amount          |
|--|---------------------------------------|-------|-------|--|-----------------|
| <b>Section 1D Option 1: Annual Costs, Flood Year</b> |                                       |       |       |  |                 |
| a)   | Inspections                           | LS    | 1     | \$100,000.00                               | \$100,000.00    |
| b)   | Minor Repairs & Vegetation Management | LS    | 1     | \$10,000.00                                | \$10,000.00     |
| c)   | Storage of Superbags and Sandbags     | LS    | 1     | \$500.00                                   | \$500.00        |
| d)   | Sandbags c/w Sandfill (1.0m – 2.0m)   | M     | 250   | \$464.00                                   | \$116,000.00    |
| e)   | Superbags c/w Sandfill (1.0m – 2.0m)  | M     | 10850 | \$500.00                                   | \$5,425,000.00  |
|  |                                       |       |       | <i>Total 1D</i>                            | \$5,651,500.00  |
|  |                                       |       |       | <i>Contingency (20%)</i>                   | \$1,130,300.00  |
|  |                                       |       |       | <i>Subtotal</i>                            | \$6,781,800.00  |
|  |                                       |       |       | <i>Location Adjustment Factor (LCAF)</i>   | 1.25            |
|  |                                       |       |       | <b>Annual Cost, Flood Year Base Price</b>  | \$8,477,300.00  |
|  |                                       |       |       | <b>Annual Cost, Flood Year Upper Bound</b> | \$12,715,950.00 |

**Table E6 Option 1 Annual Costs During a Non-Flood Year Class D OPC**

| Item No.   | Description of Work                   | Units | Qty. | Unit Price                                     | Amount       |
|--|---------------------------------------|-------|------|--|--------------|
| <b>Section 1E Option 1: Annual Costs, Non-Flood Year</b> |                                       |       |      |  |              |
| a)   | Inspections                           | LS    | 1    | \$10,000.00                                    | \$10,000.00  |
| b)   | Minor Repairs & Vegetation Management | LS    | 1    | \$50,000.00                                    | \$50,000.00  |
| c)   | Storage of Superbags and Sandbags     | LS    | 1    | \$500.00                                       | \$500.00     |
|  |                                       |       |      | <i>Total 1F</i>                                | \$60,500.00  |
|  |                                       |       |      | <i>Contingency (20%)</i>                       | \$12,100.00  |
|  |                                       |       |      | <i>Subtotal</i>                                | \$72,600.00  |
|  |                                       |       |      | <i>Location Adjustment Factor (LCAF)</i>       | 1.25         |
|  |                                       |       |      | <b>Annual Cost, Non-Flood Year Base Price</b>  | \$90,800.00  |
|  |                                       |       |      | <b>Annual Cost, Non-Flood Year Upper Bound</b> | \$136,200.00 |

The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.

## **Qualitative Evaluation**

Table E7 summarizes the performance of Option 1 with respect to the evaluation criteria which were previously outlined in the main body of this Report.

**Yukon Territory Flood Mitigation Conceptual Design Options**  
**Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options**  
 July 2023

**Table E7 Option 1 Qualitative Evaluation**

| Criteria No. | Criteria Title  | Evaluation  | Anticipated Performance Rating |
|--------------|---|---|--------------------------------|
| 1            | Viability and Reliability under Extreme Conditions  | temporary dikes may degrade under long duration of flooding (several weeks or months); wind/wave impacts would be mitigated by elevated DFSL and erosion mitigation measures however ice/debris damage from wave action is a risk for temporary superbag dikes; risk of vandalism and degradation risk increases with duration that the temporary dikes are deployed; seepage control measures likely required given underlying soils and long duration of flooding | Low Performance                |
| 2            | Time to Implementation  | geotechnical investigations required including borehole drilling to address shoreline stability and construction requirements for platforms; hydraulic modelling, wind/wave analysis, and erosion mitigation design required; medium regulatory risk; moderate anticipated design effort; property owner agreements required; moderate anticipated construction effort  | Medium Performance             |
| 3            | Capital Cost Per Inundated Property   | reduced capital costs in exchange for increased operational and maintenance costs when compared to permanent flood mitigation infrastructure (Option 2 and 3); per-inundated-property capital cost is \$447,136/property  | Medium Performance             |
| 4            | Maintenance and Storage   | storage required for substantial number of superbags and sandbags; stockpiling of material required for superbags/sandbags; numerous platforms will require inspections, maintenance, and vegetation clearing; floodbox maintenance will be required  | Low Performance                |
| 5            | Response and Activation   | numerous temporary superbag dikes require training, labour, and a timely response in a flood scenario to be effective; property-owner deployed temporary sandbag dikes; floodbox slide gates would need to be manually closed prior to arrival of flood and opened following abatement of the flood; traffic control may be required on roads   | Low Performance                |
| 6            | Aesthetics and Community Function   | alterations to existing landscape (platforms up to 0.75 m high) during non-flood conditions in front of private properties; the platforms may be used as a community feature (e.g., walking path) if the community members are supportive; temporary alteration of private/community function and view during flood conditions from temporary superbag and sandbag dikes  | Medium Performance             |
| 7            | Future Adaptability   | three-high temporary superbag dikes or additional raising of road may be completed in future for enhanced flood mitigation; additional sandbags may be provided for raising temporary sandbag dikes; permanent increases in height to platform structure are likely possible without additional widening of structure but will require engineering study  | High Performance               |
| 8            | Alteration of Existing Hydraulics, Erosion/ Sedimentation, Ice Processes, and Slope Stability | intrusions into Marsh Lake; portions of mitigations on beach areas may impact natural beach processes and morphodynamics but are not anticipated to substantially disrupt existing lake and river processes   | High Performance               |
| 9            | Disaster Mitigation and Adaptation Function (DMAF) Applicability                              | percentage of people directly affected is high, making this project a strong candidate; medium ROI given mitigations to access roads to private residential properties  | Medium Performance             |

*The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.*

## **E.2.2 OPTION 2**

### **Description**

The conceptual flood mitigations for Option 2 are illustrated in Figure E4. Option 2 differs from Option 1 in that it includes permanent flood mitigation infrastructure (i.e., road raising and earthen dikes).

At South M'Clintock, an earthen dike with an approximate height of 5.0 to 5.5 m greater than the existing ground would be installed over an approximate length of 1,340 m to meet the DFSL elevation. The earthen dike crest would be located farther out into the lake than the platform was in Option 1, because the toe of the dike can not extend into existing structures on the private properties. The earthen dike would have a footprint of approximately 35 m and would extend below the Ordinary High Water Mark (OHWM). Floodboxes would be required at topographic low points. The lake side of the earthen dike would be lined with riprap to mitigate erosion risk from waves. The earthen dike footprint and the root-free zone may encroach onto private property meaning agreements may be required with landowners.

At Army Beach, an earthen dike with an approximate height of 5.0 m greater than the existing ground would be installed over a length of 990 m to meet the DFSL elevation. As with the South M'Clintock earthen dike, the Army Beach earthen dike crest would be located farther out into the lake than the platform was in Option 1 because the toe of the dike can not extend into existing structures on the private properties. The earthen dike footprint would be approximately 30 m, and would extend below the OHWM. Access points may be installed in the dikes where access to the lake is required. Floodboxes would be required at topographic low points. The lake side of the earthen dike would be lined with riprap to mitigate erosion risk from waves. The earthen dike footprint and the root-free zone may encroach onto private property meaning agreements may be required with landowners.

Approximately 480 m of Bay View Road, 1,270 m of South M'Clintock Road, and 1,640 m of Army Beach Road (west and east portions) would be raised by an approximate height of 1.5 to 2.0 m above the existing road elevation such that the roads function as dikes. Approximately 250 m of Taylor Way would be raised by an approximate height of 2.0 m and the 650 m extent of the Trail that connects South M'Clintock Road to Army Beach Road would be raised approximately 1.0 to 1.5 m so that they also function as dikes. Modifications to existing driveway entrances would likely be required if the roads are raised. Floodboxes and/or culvert improvements may be required, depending on the local drainage conditions.

The proposed temporary sandbag dike around the individual property at the south extent of the peninsula presented in Option 1 would be maintained in Option 2.

S:\11232\projects\144903232\figures\reports\YukonWide\YukonWide\Figures\Export.aprx Revised: 2023-07-04 By: LTrudell



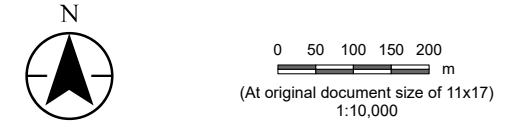
Figure No. **E4** **DRAFT**

Title  
**Army Beach and South M'Clintock  
 Conceptual Flood Mitigation Design -  
 Option 2**

Client/Project  
 Government of Yukon  
 Community Services | Infrastructure Development Branch  
 Yukon Territory Flood Mitigation Conceptual Design Options

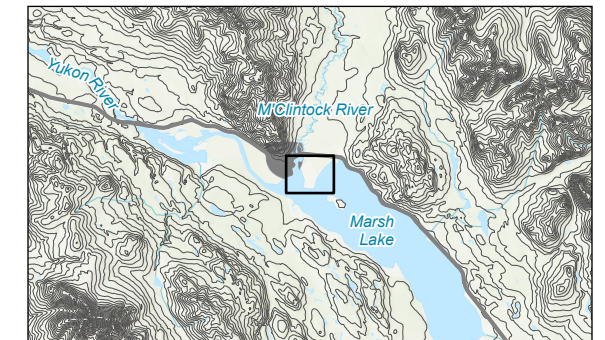
Project Location  
 Army Beach/South M'Clintock,  
 Yukon

144903232  
 Prepared by LLT on 2023-04-11  
 TR by JM on 2023-04-11



- Culvert/ Bridge
- Community Infrastructure and Points of Interest
- Highway Kilometre Post
- Road
- Parks Campgrounds Surveyed
- Topographic Contour (10 m)
- Topographic Contour (2 m)
- Land Parcel - Surveyed
- First Nation Settlement Lands - Surveyed
- First Nation Heritage Site
- Proposed Mitigation Feature
  - Earthen Dike
  - Platform with Temporary Superbag Dike
  - Road Raising
  - Structural Dike
  - Temporary Sandbag Dike

**CONCEPTUAL DESIGN**  
 This document is for general information only  
 and is not for permits, tendering, or construction.



- Notes**
1. Coordinate System: NAD 1983 Yukon Albers
  2. Data Sources: Government of Yukon; Government of Canada
  3. Imagery Government of Yukon Geomatics Yukon; ESRI World Imagery



**Yukon Territory Flood Mitigation Conceptual Design Options**  
**Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options**

July 2023

**Class D OPC**

The Class D OPC's for capital and annual costs are summarized in Table E8, considering the Class D level of accuracy (+/-50%). Table E8 also provides the Class D OPCs on a per inundated property basis (from Section E.1.11).

**Table E8 Option 2 Summary of Class D OPCs**

|  | Class D OPC                   | Number of Inundated Properties (Section E.1.11) <sup>1</sup> | Class D OPC per Inundated Property |
|--|-------------------------------|--|------------------------------------|
| Capital Cost   | \$ 58,785,400 - \$ 88,178,100 | 57   | \$ 1,031,323 - \$ 1,546,985        |
| Annual Cost (Flood Year)   | \$ 339,750 - \$ 509,625       |  | \$ 5,961 - \$ 8,941                |
| Annual Cost (Non-Flood Year)   | \$ 23,250 - \$ 34,875         |  | \$ 408 - \$ 612                    |
| <sup>1</sup> As described in Section E.1.11, the inundated properties from the preliminary inundation analysis consists of 52 private residences and 5 community features. |                               |  |                                    |

The components, assumed unit costs, and estimated quantities which produce the Class D OPCs are detailed in Table E9 (capital costs), Table E10 (annual cost, flood year), and Table E11 (annual cost, non-flood year).

*The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.*

**Yukon Territory Flood Mitigation Conceptual Design Options**  
**Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options**  
 July 2023

**Table E9 Option 2 Capital Costs Class D OPC**

| Item No.          | Description of Work   | Units | Qty.   | Unit Price      | Amount                 |
|-------------------|---|-------|--------|-----------------|------------------------|
| <b>Section 2A</b> | <b>Option 2: General Conditions</b>                         |       |        |                 |                        |
| a)                | Mobilization/Demobilization                                 | LS    | 1      | \$3,499,130.00  | \$3,499,130.00         |
| b)                | Site Preparation/Restoration                                | LS    | 1      | \$699,900.00    | \$699,900.00           |
|                   |   |       |        | <i>Total 2A</i> | <b>\$4,199,030.00</b>  |
| <b>Section 2B</b> | <b>Option 2: Earthworks &amp; Landscaping, Earthen Dike</b> |       |        |                 |                        |
| a)                | Clearing and Grubbing                                       | M2    | 10650  | \$10.00         | \$106,500.00           |
| b)                | Cut and Re-use Onsite - Native Material                     | M3    | 1000   | \$15.00         | \$15,000.00            |
| c)                | Cut and Dispose Offsite - Native Material                   | M3    | 5000   | \$30.00         | \$150,000.00           |
| d)                | Import and Place Fill - Native Material                     | M3    | 1000   | \$15.00         | \$15,000.00            |
| e)                | Embankment Fill, Clay Core                                  | M3    | 67540  | \$100.00        | \$6,754,000.00         |
| f)                | Embankment Fill, Granular Shell                             | M3    | 125530 | \$50.00         | \$6,276,500.00         |
| g)                | Topsoil Stripping and Stockpiling, 300mm Depth              | M3    | 3195   | \$25.00         | \$79,875.00            |
| h)                | Riprap  | MT    | 47670  | \$141.00        | \$6,721,470.00         |
| i)                | Geotextile Fabric   | M2    | 40740  | \$10.00         | \$407,400.00           |
| j)                | Embankment Seeding  | M2    | 33060  | \$5.00          | \$165,300.00           |
| k)                | Embankment Topsoil  | M2    | 33060  | \$20.00         | \$661,200.00           |
| l)                | Toe Drain: Perforated Pipe, Geotextile and Drain Rock       | M     | 2130   | \$300.00        | \$639,000.00           |
| m)                | Slope Stabilization   | M     | 2130   | \$3,000.00      | \$6,390,000.00         |
|                   |   |       |        | <i>Total 2B</i> | <b>\$28,381,245.00</b> |
| <b>Section 2C</b> | <b>Option 2: Floodboxes, Earthen Berm</b>                   |       |        |                 |                        |
| a)                | Reinforced Concrete Pipe                                    | M     | 480    | \$1,000.00      | \$480,000.00           |
| b)                | Gatewell Manhole c/w Sluice Gate                            | EA    | 24     | \$17,500.00     | \$420,000.00           |
| c)                | Concrete Headwall   | EA    | 48     | \$5,000.00      | \$240,000.00           |
| d)                | Slide Gate  | EA    | 24     | \$3,000.00      | \$72,000.00            |
| e)                | Riprap  | MT    | 480    | \$141.00        | \$67,680.00            |
|                   |   |       |        | <i>Total 2C</i> | <b>\$1,279,680.00</b>  |

*The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.*

**Yukon Territory Flood Mitigation Conceptual Design Options**  
**Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options**  
 July 2023

| <b>Section 2D</b> | <b>Option 2: Road Raising</b>               |    |       |  |                 |
|-------------------|---|----|-------|--|-----------------|
| a)                | Rough Grading                               | M2 | 95310 | \$5.00                                   | \$476,550.00    |
| b)                | Subgrade Preparation                        | M2 | 95310 | \$5.00                                   | \$476,550.00    |
| c)                | 80mm Minus Granular Subbase, Variable Depth | M3 | 62880 | \$40.00                                  | \$2,515,200.00  |
| d)                | 100mm Minus Granular Base, 100mm Depth      | M3 | 5150  | \$50.00                                  | \$257,500.00    |
| e)                | BST Surfacing                               | M2 | 32090 | \$50.00                                  | \$1,604,500.00  |
|                   |   |    |       | <i>Total 2D</i>                          | \$5,330,300.00  |
|                   |   |    |       | <i>Contingency (20%)</i>                 | \$7,838,051.00  |
|                   |   |    |       | <i>Subtotal</i>                          | \$47,028,306.00 |
|                   |   |    |       | <i>Location Adjustment Factor (LCAF)</i> | 1.25            |
|                   |   |    |       | <b>Capital Costs Base Price</b>          | \$58,785,400.00 |
|                   |   |    |       | <b>Capital Costs Upper Bound</b>         | \$88,178,100.00 |

The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.

**Yukon Territory Flood Mitigation Conceptual Design Options**  
**Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options**  
 July 2023

**Table E10 Option 2 Annual Costs During a Flood Year Class D OPC**

| Item No.          | Description of Work                       | Units | Qty. | Unit Price                                 | Amount       |
|-------------------|---|-------|------|--|--------------|
| <b>Section 2E</b> | <b>Option 2: Annual Costs, Flood Year</b> |       |      |  |              |
| a)                | Inspections                               | LS    | 1    | \$100,000.00                               | \$100,000.00 |
| b)                | Minor Repairs & Vegetation Management     | LS    | 1    | \$10,000.00                                | \$10,000.00  |
| c)                | Storage of Sandbags                       | LS    | 1    | \$500.00                                   | \$500.00     |
| d)                | Sandbags c/w Sandfill (1.0m - 2.0m)       | M     | 250  | \$464.00                                   | \$116,000.00 |
|                   |   |       |      | <i>Total 2E</i>                            | \$226,500.00 |
|                   |   |       |      | <i>Contingency (20%)</i>                   | \$45,300.00  |
|                   |   |       |      | <i>Subtotal</i>                            | \$271,800.00 |
|                   |   |       |      | <i>Location Adjustment Factor (LCAF)</i>   | 1.25         |
|                   |   |       |      | <b>Annual Cost Flood Year Base Price</b>   | \$339,750.00 |
|                   |   |       |      | <b>Annual Cost, Flood Year Upper Bound</b> | \$509,625.00 |

**Table E11 Option 2 Annual Costs During a Non-Flood Year Class D OPC**

| Item No.          | Description of Work                           | Units | Qty. | Unit Price                                     | Amount      |
|-------------------|---|-------|------|--|-------------|
| <b>Section 2F</b> | <b>Option 2: Annual Costs, Non-Flood Year</b> |       |      |  |             |
| a)                | Inspections                                   | LS    | 1    | \$5,000.00                                     | \$5,000.00  |
| b)                | Minor Repairs & Vegetation Management         | LS    | 1    | \$10,000.00                                    | \$10,000.00 |
| c)                | Storage of Sandbags                           | LS    | 1    | \$500.00                                       | \$500.00    |
|                   |   |       |      | <i>Total 2F</i>                                | \$15,500.00 |
|                   |   |       |      | <i>Contingency (20%)</i>                       | \$3,100.00  |
|                   |   |       |      | <i>Subtotal</i>                                | \$18,600.00 |
|                   |   |       |      | <i>Location Adjustment Factor (LCAF)</i>       | 1.25        |
|                   |   |       |      | <b>Annual Cost, Non-Flood Year Base Price</b>  | \$23,250.00 |
|                   |   |       |      | <b>Annual Cost, Non-Flood Year Upper Bound</b> | \$34,875.00 |

The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.

## **Qualitative Evaluation**

Table E12 summarizes the performance of Option 2 with respect to the evaluation criteria which were previously outlined in the main body of this Report.

**Yukon Territory Flood Mitigation Conceptual Design Options**  
**Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options**  
 July 2023

**Table E12 Option 2 Qualitative Evaluation**

| <b>Criteria No.</b> | <b>Criteria Title</b>   | <b>Evaluation</b>   | <b>Anticipated Performance Rating</b> |
|---------------------|---|---|---------------------------------------|
| 1                   | Viability and Reliability under Extreme Conditions  | permanent structures would withstand long duration of flooding (several weeks or months); wind/wave impacts and damage risks from ice/debris would be mitigated by elevated DFSL and structural elements on lake side of dikes; small number of temporary sandbag dikes vulnerable to damage from ice/debris and waves; seepage control measures likely required given underlying soils and long duration of flooding | High Performance                      |
| 2                   | Time to Implementation  | geotechnical investigations required including borehole drilling to address bank stability and construction requirements for dikes; hydraulic modelling, wind/wave analysis, and erosion mitigation design required; high regulatory risk; high anticipated design effort; property owner agreements required; substantial anticipated construction effort  | Low Performance                       |
| 3                   | Capital Cost Per Inundated Property   | increased capital costs in exchange for decreased operational and maintenance costs when compared to options requiring substantial temporary deployments (Option 1); per-inundated-property capital cost is \$1,031,323/property  | Low Performance                       |
| 4                   | Maintenance and Storage   | low storage requirements for superbags (temporary sandbag dikes at 1 residential property); numerous large dikes will require inspections, maintenance, and vegetation clearing; floodbox maintenance will be required  | High Performance                      |
| 5                   | Response and Activation   | 1 property-owner deployed temporary sandbag dike; floodbox slide gates would need to be manually closed prior to arrival of flood and opened following abatement of the flood   | High Performance                      |
| 6                   | Aesthetics and Community Function   | substantial permanent alteration of existing landscape and lake views by earthen dike construction (>2 m in height); dike crests may be established as a community feature (e.g., walking path) if the community members are supportive; temporary alteration of private property function during flood conditions from temporary sandbag dikes   | Low Performance                       |
| 7                   | Future Adaptability   | temporary superbag dike may be deployed on earthen and structural dike crest and raised roads in future for enhanced flood mitigation; additional sandbags may be provided for raising temporary sandbag dikes; permanent increases in height of dike possible but challenging due to space constraints and will require engineering study and are likely to require widening of structure (space is limited)         | Low Performance                       |
| 8                   | Alteration of Existing Hydraulics, Erosion/ Sedimentation, Ice Processes, and Slope Stability | intrusions into Marsh Lake; portions of mitigations on beach areas may impact natural beach processes and morphodynamics but are not anticipated to substantially disrupt existing lake and river processes   | High Performance                      |
| 9                   | Disaster Mitigation and Adaptation Function (DMAF) Applicability                              | percentage of people directly affected is high, making this project a strong candidate; ROI is low considering that infrastructure investments to remedy issues are extremely costly  | Low Performance                       |

*The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.*

### **E.2.3 OPTION 3**

#### **Description**

The conceptual flood mitigations for Option 3 are illustrated in Figure E5. Option 3 differs from Option 2 in that it includes a structural dike instead of an earthen dike along the lake side of South M'Clintock and Army Beach.

At South M'Clintock, a structural dike with an approximate height of 2.0 to 2.5 m greater than the existing ground would be installed over an approximate length of 1,340 m to meet the DFSL elevation. The structural dike would be along the lakeshore, similar to the location of the platform in Option 1. The structural dike is not expected to extend below the OHWM. Access points may be installed in the dikes where access to the lake is required. Floodboxes may be required at topographic low points. The structural dike footprint and the root-free zone may encroach onto private property meaning agreements may be required with landowners.

At Army Beach, a structural dike with an approximate height of 1.5 to 2.0 m greater than the existing ground would be installed over a length of 990 m to meet the DFSL elevation. The structural dike would be along the lakeshore, similar to the location of the platform in Option 1. The structural dike is not expected to extend below the OHWM. Access points may be installed in the dikes where access to the lake is required. Floodboxes may be required at topographic low points. The structural dike footprint and the root-free zone may encroach onto private property meaning agreements may be required with landowners.

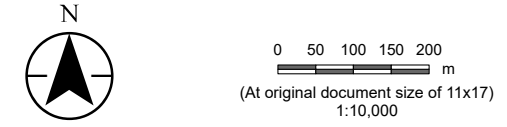
Option 3 would maintain the raising of the internal roads (Army Beach Drive, South M'Clintock Road, Bay View Road, and Taylor Way) as presented in Option 2. Option 3 would also maintain the raising of the trail connecting South M'Clintock and Army Beach as presented in Option 2.

The proposed sandbag ring dike around the individual property at the south extent of the peninsula presented in Option 1 would be maintained in Option 3.

S:\11232\projects\144903232\figures\reports\YukonWide\YukonWide\Figures\Export.aprx Revised: 2023-07-04 By: LTrudell

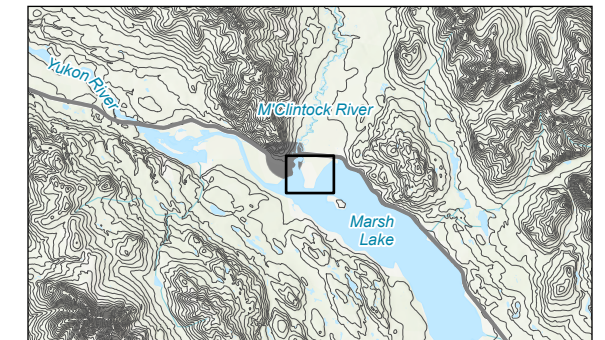


Figure No. **E5**  
 Title **Army Beach and South M'Clintock Conceptual Flood Mitigation Design - Option 3**  
 Client/Project Government of Yukon  
 Community Services | Infrastructure Development Branch  
 Yukon Territory Flood Mitigation Conceptual Design Options  
 Project Location Army Beach/South M'Clintock, Yukon  
 Prepared by LLT on 2023-04-11  
 TR by JM on 2023-04-11  
 144903232



- Culvert/ Bridge
- Community Infrastructure and Points of Interest
- Highway Kilometre Post
- Road
- Parks Campgrounds Surveyed
- Topographic Contour (10 m)
- Topographic Contour (2 m)
- Land Parcel - Surveyed
- First Nation Settlement Lands - Surveyed
- First Nation Heritage Site
- Proposed Mitigation Feature
  - Earthen Dike
  - Platform with Temporary Superbag Dike
  - Road Raising
  - Structural Dike
  - Temporary Sandbag Dike

**CONCEPTUAL DESIGN**  
 This document is for general information only  
 and is not for permits, tendering, or construction.



- Notes**
1. Coordinate System: NAD 1983 Yukon Albers
  2. Data Sources: Government of Yukon; Government of Canada
  3. Imagery Government of Yukon Geomatics Yukon; ESRI World Imagery



**Yukon Territory Flood Mitigation Conceptual Design Options**  
**Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options**  
 July 2023

**Class D OPC**

The Class D OPC's for capital and annual costs are summarized in Table 13, considering the Class D level of accuracy (+/-50%). Table 13 also provides the Class D OPCs on a per inundated property basis (from Section E.1.11).

**Table 13 Option 3 Summary of Class D OPCs**

|  | Class D OPC                   | Number of Inundated Properties (Section E.1.11) <sup>1</sup> | Class D OPC per Inundated Property |
|--|-------------------------------|--|------------------------------------|
| Capital Cost   | \$ 59,387,800 - \$ 89,081,700 | 57   | \$ 1,041,891 - \$ 1,562,837        |
| Annual Cost (Flood Year)   | \$ 339,750 - \$ 509,625       |  | \$ 5,961 - \$ 8,941                |
| Annual Cost (Non-Flood Year)   | \$ 23,250 - \$ 34,875         |  | \$ 408 - \$ 612                    |
| <sup>1</sup> As described in Section E.1.11, the inundated properties from the preliminary inundation analysis consists of 52 private residences and 5 community features. |                               |  |                                    |

The components, assumed unit costs, and estimated quantities which produce the Class D OPCs are detailed in Table E14 (capital costs), Table E15 (annual cost, flood year), and Table E16 (annual cost, non-flood year).

**Yukon Territory Flood Mitigation Conceptual Design Options**  
**Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options**  
 July 2023

**Table E14 Option 3 Capital Costs Class D OPC**

| Item No.  | Description of Work                                   | Units | Qty.  | Unit Price     | Amount          |
|---|---|-------|-------|----------------|-----------------|
| <b>Section 3A Option 3: General Conditions</b>                            |   |       |       |                |                 |
| a)  | Mobilization/Demobilization                           | LS    | 1     | \$3,534,990.00 | \$3,534,990.00  |
| b)  | Site Preparation/Restoration                          | LS    | 1     | \$707,000.00   | \$707,000.00    |
| <i>Total 3A</i>   |   |       |       |                | \$4,241,990.00  |
| <b>Section 3B Option 3: Earthworks &amp; Landscaping, Structural Dike</b> |   |       |       |                |                 |
| a)  | Clearing and Grubbing                                 | M2    | 8500  | \$10.00        | \$85,000.00     |
| b)  | Topsoil Stripping and Stockpiling, 300mm Depth        | M3    | 2550  | \$25.00        | \$63,750.00     |
| c)  | Dike Topsoil  | M2    | 6390  | \$20.00        | \$127,800.00    |
| d)  | Dike Seeding  | M2    | 6390  | \$5.00         | \$31,950.00     |
| e)  | Dike Fill   | M3    | 14900 | \$100.00       | \$1,490,000.00  |
| f)  | Sheet Pile Wall                                       | M2    | 8780  | \$1,700.00     | \$14,926,000.00 |
| g)  | Concrete Lock-Block Retaining Wall                    | M2    | 4390  | \$1,000.00     | \$4,390,000.00  |
| h)  | Handrail  | M2    | 4260  | \$140.00       | \$596,400.00    |
| i)  | Toe Drain: Perforated Pipe, Geotextile and Drain Rock | M     | 2130  | \$300.00       | \$639,000.00    |
| m)  | Slope Stabilization                                   | M     | 2130  | \$3,000.00     | \$6,390,000.00  |
| <i>Total 3B</i>   |   |       |       |                | \$28,739,900.00 |
| <b>Section 3C Option 3: Floodboxes, Structural Dike</b>                   |   |       |       |                |                 |
| a)  | Reinforced Concrete Pipe                              | M     | 480   | \$1,000.00     | \$480,000.00    |
| b)  | Gatewell Manhole c/w Sluice Gate                      | EA    | 24    | \$17,500.00    | \$420,000.00    |
| c)  | Concrete Headwall                                     | EA    | 48    | \$5,000.00     | \$240,000.00    |
| d)  | Slide Gate  | EA    | 24    | \$3,000.00     | \$72,000.00     |
| e)  | Riprap  | MT    | 480   | \$141.00       | \$67,680.00     |
| <i>Total 3C</i>   |   |       |       |                | \$1,279,680.00  |

*The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.*

**Yukon Territory Flood Mitigation Conceptual Design Options**  
**Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options**  
 July 2023

| <b>Section 3D</b> | <b>Option 3: Road Raising</b>               |    |       |  |                 |
|-------------------|---|----|-------|--|-----------------|
| a)                | Rough Grading                               | M2 | 95310 | \$5.00                                   | \$476,550.00    |
| b)                | Subgrade Preparation                        | M2 | 95310 | \$5.00                                   | \$476,550.00    |
| c)                | 80mm Minus Granular Subbase, Variable Depth | M3 | 62880 | \$40.00                                  | \$2,515,200.00  |
| d)                | 100mm Minus Granular Base, 100mm Depth      | M3 | 5150  | \$50.00                                  | \$257,500.00    |
| e)                | BST Surfacing                               | M2 | 32090 | \$50.00                                  | \$1,604,500.00  |
|                   |   |    |       | <i>Total 3D</i>                          | \$5,330,300.00  |
|                   |   |    |       | <i>Contingency (20%)</i>                 | \$7,918,374.00  |
|                   |   |    |       | <i>Subtotal</i>                          | \$47,510,244.00 |
|                   |   |    |       | <i>Location Adjustment Factor (LCAF)</i> | 1.25            |
|                   |   |    |       | <b>Capital Costs Base Price</b>          | \$59,387,800.00 |
|                   |   |    |       | <b>Capital Costs Upper Bound</b>         | \$89,081,700.00 |

The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.

**Yukon Territory Flood Mitigation Conceptual Design Options**  
**Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options**  
 July 2023

**Table E15 Option 3 Annual Costs During a Flood Year Class D OPC**

| Item No.   | Description of Work                   | Units | Qty. | Unit Price                                 | Amount       |
|--|---------------------------------------|-------|------|--|--------------|
| <b>Section 3E Option 3: Annual Costs, Flood Year</b> |                                       |       |      |  |              |
| a)   | Inspections                           | LS    | 1    | \$100,000.00                               | \$100,000.00 |
| b)   | Minor Repairs & Vegetation Management | LS    | 1    | \$10,000.00                                | \$10,000.00  |
| c)   | Storage of Sandbags                   | LS    | 1    | \$500.00                                   | \$500.00     |
| d)   | Sandbags c/w Sandfill (1.0m - 2.0m)   | M     | 250  | \$464.00                                   | \$116,000.00 |
|  |                                       |       |      | <i>Total 3E</i>                            | \$226,500.00 |
|  |                                       |       |      | <i>Contingency (20%)</i>                   | \$45,300.00  |
|  |                                       |       |      | <i>Subtotal</i>                            | \$271,800.00 |
|  |                                       |       |      | <i>Location Adjustment Factor (LCAF)</i>   | 1.25         |
|  |                                       |       |      | <b>Annual Cost Flood Year Base Price</b>   | \$339,750.00 |
|  |                                       |       |      | <b>Annual Cost, Flood Year Upper Bound</b> | \$509,625.00 |

**Table E16 Option 3 Annual Costs During a Non-Flood Year Class D OPC**

| Item No.   | Description of Work                   | Units | Qty. | Unit Price                                     | Amount      |
|--|---------------------------------------|-------|------|--|-------------|
| <b>Section 3F Option 3: Annual Costs, Non-Flood Year</b> |                                       |       |      |  |             |
| a)   | Inspections                           | LS    | 1    | \$5,000.00                                     | \$5,000.00  |
| b)   | Minor Repairs & Vegetation Management | LS    | 1    | \$10,000.00                                    | \$10,000.00 |
| c)   | Storage of Sandbags                   | LS    | 1    | \$500.00                                       | \$500.00    |
|  |                                       |       |      | <i>Total 3F</i>                                | \$15,500.00 |
|  |                                       |       |      | <i>Contingency (20%)</i>                       | \$3,100.00  |
|  |                                       |       |      | <i>Subtotal</i>                                | \$18,600.00 |
|  |                                       |       |      | <i>Location Adjustment Factor (LCAF)</i>       | 1.25        |
|  |                                       |       |      | <b>Annual Cost, Non-Flood Year Base Price</b>  | \$23,250.00 |
|  |                                       |       |      | <b>Annual Cost, Non-Flood Year Upper Bound</b> | \$34,875.00 |

The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.

## **Qualitative Evaluation**

Table E17 summarizes the performance of Option 3 with respect to the evaluation criteria which were previously outlined in the main body of this Report.

**Yukon Territory Flood Mitigation Conceptual Design Options**  
**Appendix E Army Beach and South M'Clintock Conceptual Flood Mitigation Design Options**  
 July 2023

**Table E17 Option 3 Qualitative Evaluation**

| <b>Criteria No.</b> | <b>Criteria Title</b>   | <b>Evaluation</b>  | <b>Anticipated Performance Rating</b> |
|---------------------|---|--|---------------------------------------|
| 1                   | Viability and Reliability under Extreme Conditions  | permanent structures would withstand long duration of flooding (several weeks or months); wind/wave impacts and damage risks from ice/debris would be mitigated by elevated DFSL and erosion mitigation measures; seepage control measures likely required   | High Performance                      |
| 2                   | Time to Implementation  | geotechnical investigations required including borehole drilling to address bank stability and construction requirements for dikes; hydraulic modelling, wind/wave analysis, and erosion mitigation design required; high regulatory risk; high anticipated design effort; property owner agreements required; substantial anticipated construction effort                                 | Low Performance                       |
| 3                   | Capital Cost Per Inundated Property   | increased capital costs in exchange for decreased operational and maintenance costs when compared to options requiring substantial temporary deployments (Option 1); per-inundated-property capital cost is \$1,041,891/property   | Low Performance                       |
| 4                   | Maintenance and Storage   | low storage requirements (temporary sandbag dikes at 1 residential property); numerous large dikes will require inspections, maintenance, and vegetation clearing; floodbox maintenance will be required   | High Performance                      |
| 5                   | Response and Activation   | 1 property-owner deployed temporary sandbag dike; floodbox slide gates would need to be manually closed prior to arrival of flood and opened following abatement of the flood  | High Performance                      |
| 6                   | Aesthetics and Community Function   | substantial permanent alteration of existing landscape and lake views by structural dike, raised road, dike crests likely not suitable to be established as community features; temporary alteration of private property function during flood conditions from temporary sandbag dikes   | Low Performance                       |
| 7                   | Future Adaptability   | temporary superbag dike may be deployed on structural dike crest and raised roads in future for enhanced flood mitigation; additional sandbags may be provided for raising temporary sandbag dikes; permanent increases in height to dike and road are possible but will require engineering study and are likely to require amendment of structural elements and/or widening of structure | Low Performance                       |
| 8                   | Alteration of Existing Hydraulics, Erosion/ Sedimentation, Ice Processes, and Slope Stability | intrusions into Marsh Lake; portions of mitigations on beach areas may impact natural beach processes and morphodynamics but are not anticipated to substantially disrupt existing lake and river processes  | High Performance                      |
| 9                   | Disaster Mitigation and Adaptation Function (DMAF) Applicability                              | percentage of people directly affected is high, making this project a strong candidate; ROI is low considering that infrastructure investments to remedy issues are extremely costly   | Low Performance                       |

*The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.*

## E.2.4 SUMMARY TABLES

Table E18 summarizes the Class D OPC for each of the conceptual design options.

**Table E18 Summary of Class D OPCs**

|                              | Option 1 Class D OPCs       | Option 2 Class D OPCs       | Option 3 Class D OPCs       |
|------------------------------|-----------------------------|-----------------------------|-----------------------------|
| Capital Cost                 | \$25,486,700 - \$38,230,050 | \$58,785,400 - \$88,178,100 | \$59,387,800 - \$89,081,700 |
| Annual Cost (Flood Year)     | \$ 8,477,300 - \$ 2,715,950 | \$ 339,750 - \$ 509,625     | \$ 339,750 - \$ 509,625     |
| Annual Cost (Non-Flood Year) | \$ 90,800 - \$ 136,200      | \$ 23,250 - \$ 34,875       | \$ 23,250 - \$ 34,875       |

Table E19 provides a summary of the evaluation of each of the conceptual design options.

**Table E19 Summary of Qualitative Evaluation of Conceptual Options**

| Criteria No. | Criteria Title   | Option 1           | Option 2         | Option 3         |
|--------------|--|--------------------|------------------|------------------|
| 1            | Viability and Reliability under Extreme Conditions   | Low Performance    | High Performance | High Performance |
| 2            | Time to Implementation   | Medium Performance | Low Performance  | Low Performance  |
| 3            | Capital Cost Per Inundated Property  | Medium Performance | Low Performance  | Low Performance  |
| 4            | Maintenance and Storage  | Low Performance    | High Performance | High Performance |
| 5            | Response and Activation  | Low Performance    | High Performance | High Performance |
| 6            | Aesthetics and Community Function  | Medium Performance | Low Performance  | Low Performance  |
| 7            | Future Adaptability  | High Performance   | Low Performance  | Low Performance  |
| 8            | Alteration of Existing Hydraulics, Erosion/Sedimentation, Ice Processes, and Slope Stability | High Performance   | High Performance | High Performance |
| 9            | Disaster Mitigation and Adaptation Function (DMAF) Applicability                             | Medium Performance | Low Performance  | Low Performance  |

*The contents of this appendix are subject to the project objectives, methods, assumptions, and limitations outlined in the main body of the Yukon Territory Flood Mitigation Conceptual Design Options report and in Appendix T.*