Appendix B Teslin Conceptual Flood Mitigation Design Options

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.

B.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 Teslin.

B.1.1 POPULATION

Teslin has a population of 239 with 144 private dwellings according to 2021 census data (Statistics Canada 2023c). The population has decreased by approximately 6% from 2016 when the population was 255 (Statistics Canada 2023c).

B.1.2 STUDY AREA

The Study Area in Figure B2 outlines the areas that are considered in this Project at Teslin. 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.

B.1.3 FIRST NATIONS

The Teslin Study Area is within the Traditional Territories of the Teslin Tlingit Council (TTC). TTC has multiple parcels of Category B Settlement Lands along Teslin Lake, in Teslin. The land claim selections are C-30B/D, C-28B/D, C-34B/D, and C-33B/D. This means that TTC has surface rights at various locations along the lake. Figure B2 illustrates the TTC settlement lands within the Study Area.

B.1.4 BATHYMETRY AND TOPOGRAPHY

Bathymetry data for Teslin Lake adjacent to Teslin were not provided to Stantec.

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

- 2014 LiDAR derivative 1m horizontal resolution Digital Elevation Model (DEM), UTM Zone 8 CSRS NAD1983, CGVD1928 (Government of Yukon 2022d)

All elevations are reported in CGVD2013. 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 LiDAR meets the base requirement in terms of accuracy or precision for flood mapping per NRCan (2022b).

B.1.5 GEOLOGY

Based on the surficial geology mapping (Yukon Geological Survey, 2020), the Study Area consists of lodgement and ablation till, generally made up of clays, silts and sands in the southwest area of the site and large grained sands and gravel towards the southeast area of the site. Morainic terrain, such as that seen in Teslin, is common at the confluence of mountain valleys. The till deposits along the Teslin Lake shoreline are overlain by a veneer of organics (peat) and lacustrine deposits.

Based on borehole and testpit data provided in the Yukon Permafrost Database (Government of Yukon, 2022b), the soil conditions in the flooding areas within the Teslin area are likely to consist of intermixed layers of silt, sand and clay tills to depths exceeding 15 m. Based on the borehole and testpit data reviewed from the Yukon Permafrost Database (Government of Yukon, 2022b), permafrost was not encountered; however, permafrost may be present in the Teslin area based on the Permafrost Probability Model (Yukon Geological Survey, 2020) and the Canada Permafrost Map (The National Atlas of Canada, 1995). Based on the Permafrost Probability Model, the Study Area is located within a region of sporadic discontinuous permafrost (10-20% of land area underlain by permafrost). The Canada Permafrost Map also indicates the Study Area is in a region of sporadic discontinuous permafrost (10–50% of land area underlain by permafrost) with a low (<10% by volume of visible ice) ground ice content in the upper 10–20 m of the ground. The Teslin Lake shoreline likely does not contain permafrost due to the thermal influence of the lake.

B.1.6 HYDROGEOLOGY

The sand, silt, and clay tills in the southwest area of the town of Teslin are likely to result in relatively slow rates of groundwater flow. The large-grained sands and gravel towards the southeast area of the site are likely to result in relatively fast rates of groundwater flow. The groundwater would likely be impacted by the Teslin Lake levels with the areas consisting of tills to be impacted slower than the areas consisting of sands and gravels. If lake levels are high for a prolonged period of time, the areas consisting of till would likely become saturated and would take longer to dissipate and lower when lake levels decrease.

B.1.7 PAST FLOODING EVENTS AND RESPONSE

The Teslin area has been subject to numerous flooding events with records dating back to 1950s. A summary of formally 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.

1962 Flood Event

The peak water level recorded in Teslin occurred in July 1962. No documentation of damages or flood response measures taken during this flood have been provided to Stantec. WSC station 09AE002 (Teslin Lake at Teslin) reported a daily peak water level during this flood event at 686.95 m on July 2, 1962, corresponding to the highest water level recorded at the WSC station (GoC 2023).

2021 Flood Event

Significant flooding occurred in 2021 which resulted in property damage in the community, TTC Settlement Lands and surrounding areas. Flooding was in response to an above average snowpack and rapid melting. Emergency flood control measures were deployed with a cost of over $650,000 as noted by the Village of Teslin’s Flood Control Project (VoT and TTC 2022). WSC station 09AE002 (Teslin Lake at Teslin) reported a peak instantaneous WSE of 686.00 m during this flooding event on June 24, 2021 (GoC 2023).

2022 Flood Event

The 2022 flooding produced the second-highest water level recorded in Teslin in response to melting of near record snowpacks in the Teslin Lake watershed. The 2022 peak water level was approximately 0.7 m higher than the 2021 peak. The Teslin area required a substantial emergency flood response, including the deployment of sandbag dikes, superbag dikes and aquadams at multiple locations throughout the community. WSC station 09AE002 (Teslin Lake at Teslin) recorded a peak instantaneous WSE of 686.71 m on June 23, 2022, corresponding to the second highest water level recorded at the WSC station (GoC 2023).

B.1.8 EXISTING FLOOD MITIGATION INFRASTRUCTURE

Most of the flood mitigation works installed in 2021 and 2022 were sandbag dikes and pumping to temporarily mitigate the flooding. Permanent shoreline armouring with riprap was completed along approximately 300 m adjacent to the central portion of Smarchville (Geddes Drive) as documented in the 2022 Flood Protection and Shoreline Erosion Plan (CGEL 2022). Additional permanent flood and erosion protection works were planned for 2022 and 2023, including: berms surrounding properties at km1245, the cabins at east side of the hotel/restaurant property and on the west side of Smarchville (CGEL 2022). Shoreline armoring with riprap was proposed along the central part of the community, on the east side of Smarchville and near the community marina (CGEL 2022). Some construction work was completed in 2022 but the location and status of these works had not been provided to Stantec at the time of writing. Photographs collected by Stantec in the Smarchville area in June 2023 display shoreline armouring with riprap and a platform for the temporary deployment of superbags.

B.1.9 WIND, WAVES, AND EROSION

The low flow velocities from water moving through Teslin Lake are not expected to introduce erosion risks to flood mitigations.

As a lake community, Teslin is affected by beach processes and erosion due to wind and waves. If flood mitigations are required at Teslin, 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.

B.1.10 HYDROLOGY

Teslin is located on Teslin Lake at the mouth of Nisutlin Bay (Figure B2). Water supply to Teslin Lake consists predominantly of snowmelt and rainfall induced runoff, with major tributaries from the south (Teslin River) and the northeast (Nisutlin River). Teslin Lake drains north into the Teslin River, which flows into the Yukon River downstream (north) of Lake Laberge but upstream (south) of Carmacks.

WSC Station 09AE002 (Teslin Lake at Teslin) is located on the southeast shore of the Nisutlin Bay connection to Teslin Lake (Figure B2). Gross drainage area to the WSC station is not reported by GoC (2023). Flood frequency analysis was performed by both Morrison Hershfield (2022) and Yukon University (2022) for WSEs at WSC Station 09AE002. Table B1 summarizes the frequency results of these two studies for the 1:2-year event (50% Annual Exceedance Probability, or AEP), 1:20-year event (5% AEP), 1:100-year event (1% AEP), and 1:200-year event (0.5% AEP).

Table B1 Flood Frequency Analyses at WSC Station 09AE002 from Morrison Hershfield (2022) and Yukon University (2022)

	Morrison Hershfield (2022)	**Yukon University (2022)**
Years Included in Analysis	1980-2022	1970-2022
Number of Years	43	53
Selected Distribution	Log-Pearson Type 3	Average of Lognormal 3 and Gumbel
Water Surface Elevation (m) [1]		
1:2-year Event (50% AEP)	684.17	684.20
1:20-year Event (5% AEP)	685.91	685.90
1:100-year Event (1% AEP)	686.79	not provided
1:200 Event-year (0.5% AEP)	687.13	687.30
[1] Elevations provided in CGVD2013 for WSC Station 09AE002		

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

Figure B1 illustrates the recorded daily minimum, mean, and maximum WSEs, the WSE during the highest year on record (1962), and the WSEs for the 1:2-year and 1:200-year event at WSC Station 09AE002 from Yukon University (2022). Past high-water events at Teslin (1961, 1962, 1964, 1972, 2012, and 2022) have all occurred during open water conditions and are likely to be highly correlated to high snowpack conditions in the previous winter (Yukon University 2022). As illustrated in Figure B1, water levels at Teslin typically begin to rise in mid-May with the onset of freshet and increase through June. Water levels typically decrease through July. Therefore, based on the available data and the documented flood processes at Teslin, flood conditions at Teslin may to persist for several weeks into mid-June and early July.

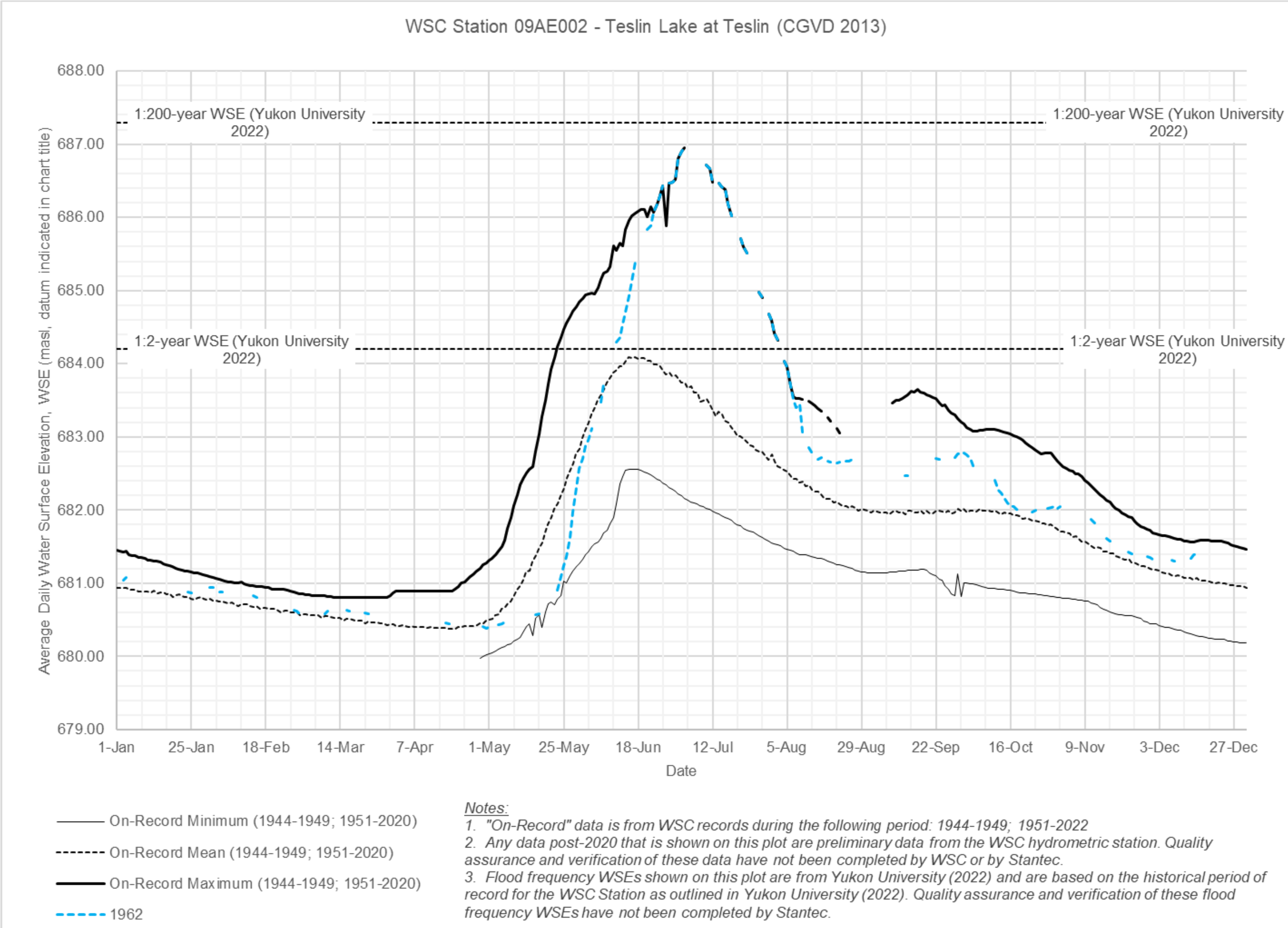


Figure B1 Historical Water Surface Elevations at WSC 09AE002 (Teslin Lake at Teslin)

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.

B.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 have not been completed to date at Teslin and is not within the scope of this Project. However, an understanding of inundation extents under 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 Teslin using WSEs. This analysis considered the 1:200-year event WSE (687.30 m) at WSC Station 09AE002 from Yukon University (2022). The resulting water surface was overlain on the existing conditions topographic and bathymetric elevation data (GeoYukon 2023) and the limits of inundation were mapped (Figure B2). 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 WSE from Yukon University (2022). As stated in Section 3.6, the inundation/flood vulnerability of the Nisutlin bridge is not in the scope of work of this Project. 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.

Inundation occurs at multiple locations spread across Teslin in this preliminary scenario. North of the Alaska Highway on the west side of Nisutlin Bay the inundation encroaches on Sawmill Road and private properties, including the local hotel/restaurant. The inundation continues to the west including the community marina and portions of the central part of the community. The preliminary inundation extends westward along the shore of Teslin Lake to encroach on multiple private properties and community infrastructure, including the Teslin Tlingit Heritage Centre, extending to the western edge of the study area approximately 7 km from the central portion of the community. No inundated properties were identified on the east side of the Teslin bridge in this preliminary analysis.

The preliminary inundation analysis indicated that an estimated 30 private residential properties and 4 community features/properties would have at least 25% of their area inundated (inundated properties).

Figure No.

B2

Title

Existing Conditions and Preliminary Flood Inundation at Teslin

Client/Project 144903232

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

Project Location
Teslin,
Yukon

Prepared by LLT on 2023-05-08
TR by JM on 2023-05-08

N

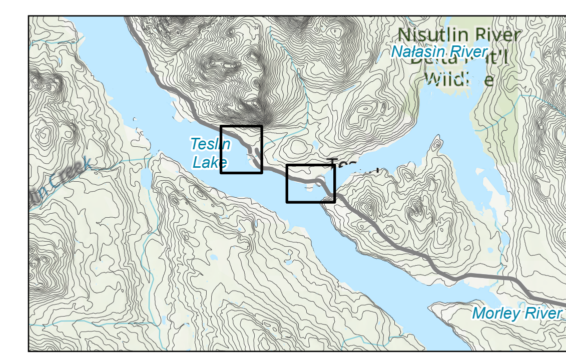
0 50 100 150 200
m
(At original document size of 11x17)
1:10,000

- WSC Station
- Culvert/ Bridge
- Community Infrastructure and Points of Interest
- Highway Kilometre Post
- Road
- Runway
- Topographic Contour (10 m)
- Topographic Contour (2 m)
- Land Parcel - Surveyed
- First Nation Settlement Lands - Surveyed

Water Depth at 1:200 WSE Inundation (m)

- 0 - 1
- 1 - 2
- > 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

Stantec Yukon

B.2 Mitigation Options and Evaluation

The scope of this Project is to develop conceptual engineered flood mitigation options; these options for Teslin 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, two flood mitigation options were developed for Teslin (Table B2) using combinations of the typical engineered flood mitigation designs from Section 3.3.2. Flood mitigations in the two options are provided for areas which are inundated under the 1:200-year WSE (687.3 m) in the preliminary inundation mapping (Figure B1). The top elevation of the flood mitigations is designed to reach the DFSL which in the case of Teslin (lake site) is assumed to be 689.3 m (i.e., 2 m above the 1:200 WSE as outlined for lake sites in Section 3.2). For comparison purposes, CGEL (2022) proposed flood mitigations with a crest elevation of 686.7 m (CGVD28 datum) corresponding to the elevation of highest flood on record in 1962 (equivalent to 686.96 m with CGVD2013 datum). This is approximately 2.3 m lower than the DFSL being used in this Report.

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.

Several of the mitigations presented in this section overlap with those proposed in CEGL (2022). As-built documentation have not been provided and field review of installed flood mitigation infrastructure is not in the scope of this Project, meaning the extent and installation status of the flood mitigations in CEGL (2022) could not be verified. Therefore, the costing and evaluations in this Report do not account for flood mitigations that may have already been installed. The contents of this Report can be considered a conservative estimate of the effort and resourcing required for flood mitigation at Teslin.

Table B2 Summary of Conceptual Design Options

Location	Option 1 *lower capital costs, higher response/maintenance*	Option 2 *higher capital costs, lower response/maintenance*
Geddes Drive (Smarchville)	Platform with Temporary Superbag Dike	Earthen Dike
Jackson Ave/Nisutlin Drive	Platform with Temporary Superbag Dike	Earthen Dike
Community Marina	Platform with Temporary Superbag Dike	
Hotel/Restaurant	Platform with Temporary Superbag Dike	Earthen Dike
Teslin Tlingit Heritage Centre	Platform with Temporary Superbag Dike	Earthen Dike
Sawmill Road	Road Raising	
West Side of the Study Area at km1251 (3 properties)	Temporary Sandbag Dike	
Km1249 Immediately North of Fox Creek (1 property)	Temporary Sandbag Dike	
Km1245 South of the Airstrip (3 properties)	Temporary Sandbag Dike	

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.

South end of Sawmill Road (1 property)	Temporary Sandbag Dike
Tlingit Drive (1 property)	Temporary Sandbag Dike

Section B2.1 and B2.2 provide a description, Class D Opinion of Probable Cost (OPC), and qualitative evaluation of conceptual options specified in Table B2.

Other engineered flood mitigation approaches that may have merit; but were not advanced to conceptual design in this Project include:

- Road raising along Nisutlin Drive/Jackson Ave—not considered due inadequate width between houses and road embankment when raising road crest to DFSL. Required gradient on driveways to connect to roadway would not meet design standards.

B.2.1 OPTION 1

Description

The conceptual flood mitigations for Option 1 are illustrated in Figure B3.

On the west side of the community, an approximately 685 m long platform in Smarchville would be established around Lift Station 4 and residential properties along Geddes Drive and Smarch Cres. The platform would be 1.5 m above existing ground for approximately 100 m in the middle of the dike, and 2.0–2.5 m higher than the existing ground for the remaining length on either side. The platform would require a double superbag dike for its full length to reach the DFSL. Space is limited between the properties and the lake; agreements with the property owners would be required. The lake side of the platform would be lined with riprap to mitigate erosion risk from waves and may require slope stabilization measures due to the added weight from the new fill along the top of bank.

In central part of the community, an approximately 830 m long platform would be established around properties along Jackson Ave and Nitsutlin Drive, including the Seniors Complex at 11 Craft Street and Lift Station 2. The platform would be 1.5–2.0 m higher than the existing ground for approximately 200 m at the east end of the structure, and approximately 3.0–3.5 m above existing ground for the remaining 580 m. The platform would require a double superbag dike for its full length to reach the DFSL. Space is limited between the properties and the lake; agreements with the property owners would be required. The lake side of the platform would be lined with riprap to mitigate erosion risk from waves and may require slope stabilization measures due to the added weight from the new fill along the top of bank.

An approximately 150 m platform near the community marina would be established around the lift station, public washrooms and the property at 4 Nisutlin Drive. The platform would be 0.5–2.0 m higher than the existing ground and would require a double superbag dike for its full length to reach the DFSL. The lake side of the platform would be lined with riprap to mitigate erosion risk from waves.

To the north of the Alaska Highway bridge crossing, a 410 m platform would be established around the buildings at the local restaurant and hotel. The existing ground is relatively low at this location, meaning the platform would be 3.5 m higher than the existing ground. The platform would require a double superbag dike for its full length to reach the DFSL. Particularly around the hotel, space is limited and agreements with the property owners would be required. The lake side of the platform would be lined with riprap to mitigate erosion risk from waves. This area is not anticipated to require slope stabilization measures based on the topography of the lake shore and the location of the proposed platform.

To the west of the community at the Teslin Tlingit Heritage Centre, a platform approximately 220 m long would be constructed around five structures on the property. The platform would be 0.5–1.0 m higher than the existing ground and would require a double superbag dike to reach the DFSL. The lake side of the platform would be lined with riprap to mitigate erosion risk from waves. This area is not anticipated to require slope stabilization measures based on the topography of the lake shore and the location of the proposed platform.

An approximately 200 m long segment of Sawmill Road would be raised near its intersection with the Alaska Highway. The crest of this road segment would be raised to the DFSL to maintain access throughout the community (up to a 2.5 m raise in height), including to the properties along Sawmill Road. The lake side of the road raising would be lined with riprap to mitigate erosion risk from waves. This area is not anticipated to require slope stabilization measures based on the topography of the lake shore and the location of the proposed road raise.

Five groups of properties would be protected from inundation by temporary sandbag dikes: three properties on the west side of the community at km1251 (240 m dike), one property at km1249 immediately north of Fox Creek (120 m dike), three properties at km1245 south of the airstrip (400 m dike), one property at the south end of Sawmill Road (120 m) and one property on Tlingit Drive (70 m). The height of temporary sandbag dikes may be up to 3 m high in order to reach the DFSL.

Figure No.
B3

Title
Teslin Conceptual Flood Mitigation Design - Option 1

Client/Project 144903232
Government of Yukon
Community Services | Infrastructure Development Branch
Yukon Territory Flood Mitigation Conceptual Design Options

Project Location
Teslin,
Yukon

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

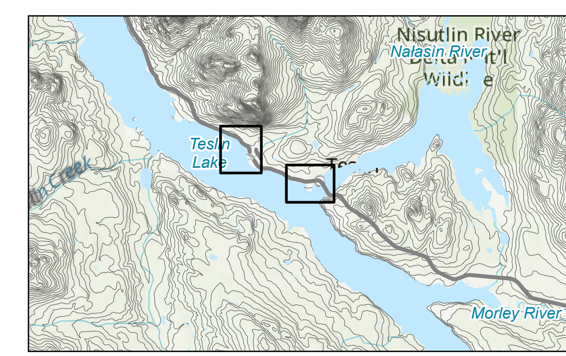
N

0 50 100 150 200 m
(At original document size of 11x17)
1:10,000

- WSC Station
- Culvert/ Bridge
- Community Infrastructure and Points of Interest
- Highway Kilometre Post
- Road
- Runway
- Topographic Contour (10 m)
- Topographic Contour (2 m)
- Land Parcel - Surveyed
- First Nation Settlement Lands - Surveyed

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

Stantec Yukon

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Class D OPC

The Class D OPC's for capital and annual costs are summarized in Table B3, considering the Class D level of accuracy (+/-50%). Table B3 also provides the Class D OPCs on a per inundated property basis (from Section B.1.11).

Table B3 Option 1 Summary of Class D OPCs

	Class D OPC	Number of Inundated Properties (Section B.1.11)[1]	Class D OPC per Inundated Property
Capital Cost	$ 39,587,500 - $ 59,381,250	34	$1,164,339 - $1,746,508
Annual Cost (Flood Year)	$ 2,891,800 - $ 4,337,700		$ 85,053 - $ 127,580
Annual Cost (Non-Flood Year)	$ 26,600 - $ 39,900		$ 783 - $ 1,174

[1]As described in Section B.1.11, the inundated properties from the preliminary inundation analysis consists of 30 private residential properties and 4 community features/properties.

The components, assumed unit costs, and estimated quantities which produce the Class D OPCs are detailed in Table B4 (capital costs), Table B5 (annual cost, flood year), and Table B6 (annual cost, non-flood year).

Table B4 Option 1 Capital Costs Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 1A	**Option 1: General Conditions**				
a)	Mobilization/Demobilization	LS	1	$2,059,790.00	$2,059,790.00
b)	Site Preparation/Restoration	LS	1	$412,000.00	$412,000.00
				Total 1A	$2,471,790.00
Section 1B	**Option 1: Earthworks & Landscaping, Platform c/w Deployable Flood Infrastructure**				
a)	Clearing and Grubbing	M2	43660	$10.00	$436,600.00
b)	Topsoil Stripping and Stockpiling, 300mm Depth	M3	13100	$25.00	$327,500.00
c)	Platform Topsoil	M2	43660	$20.00	$873,200.00
d)	Platform Seeding	M2	43660	$5.00	$218,300.00
e)	Geotextile Fabric	M2	20280	$10.00	$202,800.00
f)	Embankment Fill, Clay Core	M3	21480	$100.00	$2,148,000.00
g)	Embankment Fill, Granular Shell	M3	49430	$50.00	$2,471,500.00
h)	Class 25 Riprap, 600mm Depth	MT	23300	$141.00	$3,285,300.00
i)	Seepage Cutoff Wall-Clay, 1m Width	M3	20280	$100.00	$2,028,000.00
j)	Toe Drain: Perforated Pipe, Geotextile and Drain Rock	M	2240	$300.00	$672,000.00
k)	Slope Stabilization	M	2240	$3,000.00	$6,720,000.00
				Total 1B	$19,383,200.00
Section 1C	**Option 1: Pipes, Platform**				
a)	600mm Dia. CSP Culvert	M	550	$750.00	$412,500.00
b)	Flatback Drainage Gate, 600mm Dia.	EA	22	$3,000.00	$66,000.00
c)	Type II Concrete Headwall, 600mm Dia.	EA	22	$5,000.00	$110,000.00
d)	Canal Gate, 600mm Dia.	EA	22	$3,000.00	$66,000.00
				Total 1C	$654,500.00
Section 1D	**Option 1: Road Raising (Sawmill Rd.)**				
a)	Rough Grading	M2	3850	$5.00	$19,250.00
b)	Subgrade Preparation	M2	3850	$5.00	$19,250.00
c)	80mm Minus Granular Subbase, Variable Depth	M3	5830	$40.00	$233,200.00
d)	100mm Minus Granular Base, 100mm Depth	M3	180	$50.00	$9,000.00
e)	BST Surfacing	M2	1500	$50.00	$75,000.00
f)	Riprap	MT	1450	$141.00	$204,450.00
				Total 1D	$560,150.00

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Contingency (20%)	$4,613,928.00
Subtotal	$27,683,568.00
Location Adjustment Factor (LCAF)	1.43
Capital Costs Base Price	$39,587,500.00
Capital Costs Upper Bound	$59,381,250.00

Table B5 Option 1 Annual Costs During a Flood Year Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 1E	**Option 1: Annual Cost, Flood Year**				
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)	Superbags c/w Sandfill (2.0m)	M	2240	$500.00	$1,120,000.00
e)	Sandbags c/w Sandfill (2.0m)	M	980	$464.00	$454,720.00
				Total 1E	$1,685,220.00
				Contingency (20%)	$337,044.00
				Subtotal	$2,022,264.00
				Location Adjustment Factor (LCAF)	1.43
				Annual Costs, Flood Year Base Price	$2,891,800.00
				Annual Costs, Flood Year Upper Bound	$4,337,700.00

Table B6 Option 1 Annual Costs During a Non-Flood Year Class D OPC

Item No.	Description of Work	Units	Qty.	Unit Price	Amount
Section 1F	**Option 1: Annual Cost, Non-Flood Year**				
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 Superbags and Sandbags	LS	1	$500.00	$500.00
				Total 1F	$15,500.00
				Contingency (20%)	$3,100.00
				Subtotal	$18,600.00
				Location Adjustment Factor (LCAF)	1.43
				Annual Costs, Non-Flood Year Base Price	$26,600.00
				Annual Costs, Non-Flood Year Upper Bound	$39,900.00

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 B7 summarizes the performance of Option 1 with respect to the evaluation criteria which were previously outlined in the main body this Report.

Table B7 Option 1 Qualitative Evaluation

Criteria No.	Criteria Title	Evaluation	Anticipated Performance Rating
1	Viability and Reliability under Extreme Conditions	moderate flood duration (several weeks); 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	Medium Performance
2	Time to Implementation	geotechnical investigations required including borehole drilling to address bank stability and construction requirements for platforms; 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); per-inundated-property capital cost is $1,164,339/property	Low Performance
4	Maintenance and Storage	storage required for substantial number superbags and sandbags; stockpiling of material required for superbags/sandbags; numerous platforms will require inspections, maintenance, and vegetation clearing; floodbox maintenance may be required	Low Performance
5	Response and Activation	numerous temporary superbag dikes require training, labour, equipment, and a timely response in a flood scenario to be effective; property-owner deployed temporary sandbag dikes; floodbox slide gates need to be manually closed prior to arrival of flood	Low Performance
6	Aesthetics and Community Function	alterations to existing landscape during non-flood conditions however 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	relatively minor intrusions into Teslin 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; slope stabilization measures may be required over approximately 1.5 km	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 relatively costly investments would have to be made with critical infrastructure	Medium Performance

B.2.2 OPTION 2

Description

A site plan of the proposed civil works and temporary flood response infrastructure for Option 2 is shown in Figure B4. The main difference between Option 1 and Option 2 is that depending on site constraints (property boundaries, topography) Option 1 generally considered platforms with temporary superbag dikes, whereas Option 2 generally considers permanent earthen dikes at comparable locations. All earthen dikes would have the side slopes on the lake side lined with riprap for erosion mitigation.

On the west side of the community, an approximately 685 m long earthen dike in Smarchville would be established around Lift Station 4 and residential properties along Geddes Drive and Smarch Cres. The earthen dike would be 1.5 m above existing ground for approximately 100 m in the middle portion of the dike, and 4.0 – 5.5 m higher than the existing ground for the remaining length on either side. The earthen dike footprint would be approximately 30 m wide at the base and (along with the root-free zone) would extend onto private property. Property owner agreements would be required. This area may require slope stabilization measures due to the added weight from the new fill along the top of bank.

In the central part of the community, an approximately 830 m long earthen dike would be established to provide a platform around properties along Jackson Avenue and Nitsutlin Drive, including the Seniors Complex at 11 Craft Street and Lift Station 2. The earthen dike would be 4.0–4.5 m higher than the existing ground for approximately 200 m at the east end of the structure, and approximately 5.0–6.0 m above existing ground for the remaining 580 m. The footprint of the earthen dike would be approximately 35 m at its base and would extend onto private property; agreements with the property owners would be required. This area may require slope stabilization measures due to the added weight from the new fill along the top of bank.

An approximately 150 m platform near the community marina would be established around the lift station, public washrooms and the property at 4 Nisutlin Drive. The platform would be 0.5–2.0 m higher than the existing ground and would require a double superbag dike for its full length to reach the DFSL. This area may require slope stabilization measures due to the added weight from the new fill along the top of bank.

To the north of the Alaska Highway bridge crossing, a 410 m earthen dike would be established around the buildings at the local restaurant and hotel. The existing ground is relatively low at this location, meaning the earthen dike would be approximately 5.5–6.5 m higher than the existing ground. The footprint of the earthen dike would be approximately 35–40 m and would extend onto private property; agreements with the property owners would be required. This area is not anticipated to require slope stabilization measures based on the topography of the lake shore and the location of the proposed dike.

At Teslin Tlingit Heritage Centre, an earthen dike approximately 200 m long would be constructed around five structures on the property. The earthen dike would be approximately 3.0 m higher than the existing ground and may extend onto the Teslin Tlingit Heritage Centre property; agreements with the property owners may be required. This area is not anticipated to require slope stabilization measures based on the topography of the lake shore and the location of the proposed dike.

An approximately 200 m long segment of Sawmill Road would be raised near its intersection with the Alaska Highway. The crest of this road segment would be raised to the DFSL to maintain access throughout the community (up to a 2.5 m raise in height), including to the properties along Sawmill Road.

This area is not anticipated to require slope stabilization measures based on the topography of the lake shore and the location of the proposed road raise.

Five groups of properties would be protected from inundation by temporary sandbag dikes: three properties on the west side of the community at km1251 (240 m dike), one property at km1249 immediately north of Fox Creek (120 m dike), three properties at km1245 south of the airstrip (400 m dike), one property at the south end of Sawmill Road (120 m) and one property on Tlingit Drive (70 m). The height of temporary sandbag dikes may be up to 3 m high in order to reach the DFSL.

Figure No.
B4

Title
Teslin Conceptual Flood Mitigation Design - Option 2

Client/Project 144903232
Government of Yukon
Community Services | Infrastructure Development Branch
Yukon Territory Flood Mitigation Conceptual Design Options

Project Location
Teslin,
Yukon

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

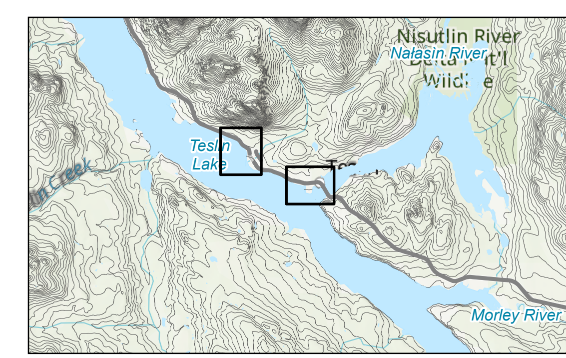
N

0 50 100 150 200 m
(At original document size of 11x17)
1:10,000

- WSC Station
- Culvert/ Bridge
- Community Infrastructure and Points of Interest
- Highway Kilometre Post
- Road
- Runway
- Topographic Contour (10 m)
- Topographic Contour (2 m)
- Land Parcel - Surveyed
- First Nation Settlement Lands - Surveyed

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

Stantec Yukon

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Class D OPC

The Class D OPC's for capital and annual costs are summarized in Table B3, considering the Class D level of accuracy (+/-50%). Table B3 also provides a ratio of the Class D OPCs to the total assessed value of inundated infrastructure (from Section A.1.10).

Table B8 Option 2 Summary of Class D OPCs

	Class D OPC	Number of Inundated Properties (Section B.1.11)[1]	Class D OPC per Inundated Property
Capital Cost	$ 68,796,900 - $ 103,195,350	34	$2,023,439 - $3,035,158
Annual Cost (Flood Year)	$ 1,021,400 - $ 1,532,100		$ 30,042 - $ 45,062
Annual Cost (Non-Flood Year)	$ 103,800 - $ 155,700		$ 3,053 - $ 4,580

[1]As described in Section B.1.11, the inundated properties from the preliminary inundation analysis consists of 30 private residential properties and 4 community features/properties.

The components, assumed unit costs, and estimated quantities which produce the Class D OPCs are detailed in Table B9 (capital costs), Table B10 (annual cost, flood year), and Table B11 (annual cost, non-flood year).

Table B9 Option 2 Capital Costs Class D OPC

Item No.		Description of Work	Units	Qty.	Unit Price	Amount
Section 2A		**Option 2: General Conditions**				
	a)	Mobilization/Demobilization	LS	1	$3,579,590.00	$3,579,590.00
	b)	Site Preparation/Restoration	LS	1	$716,000.00	$716,000.00
					Total 2A	$4,295,590.00
Section 2B		**Option 2: Earthworks & Landscaping, Dike w/o Deployable Flood Infrastructure**				
	a)	Clearing and Grubbing	M2	89950	$10.00	$899,500.00
	b)	Cut and Re-use Onsite - Native Material	M3	17330	$15.00	$259,950.00
	c)	Cut and Dispose Offsite - Native Material	M3	75670	$30.00	$2,270,100.00
	d)	Import and Place Fill - Native Material	M3	17330	$15.00	$259,950.00
	e)	Embankment Fill, Clay Core	M3	56180	$100.00	$5,618,000.00
	f)	Embankment Fill, Granular Shell	M3	186030	$50.00	$9,301,500.00
	g)	Topsoil Stripping and Stockpiling, 300mm Depth	M3	26985	$25.00	$674,625.00
	h)	Riprap	MT	42780	$141.00	$6,031,980.00
	i)	Geotextile Fabric	M2	39780	$10.00	$397,800.00
	j)	Embankment Seeding	M2	35430	$5.00	$177,150.00
	k)	Embankment Topsoil	M2	30390	$20.00	$607,800.00
	l)	Toe Drain: Perforated Pipe, Geotextile and Drain Rock	M	2240	$300.00	$672,000.00
	m)	Slope Stabilization	M	2240	$3,000.00	$6,720,000.00
					Total 2B	$33,890,355.00
Section 2C		**Option 2: Earthworks & Landscaping, Platform c/w Deployable Flood Infrastructure**				
	a)	Clearing and Grubbing	M2	2130	$10.00	$21,300.00
	b)	Topsoil Stripping and Stockpiling, 300mm Depth	M3	639	$25.00	$15,975.00
	c)	Platform Topsoil	M2	4700	$20.00	$94,000.00
	d)	Platform Seeding	M2	4700	$5.00	$23,500.00
	e)	Geotextile Fabric	M2	900	$10.00	$9,000.00
	f)	Platform Fill	M3	2500	$100.00	$250,000.00
	g)	Riprap	MT	1050	$141.00	$148,050.00
	h)	Seepage Cutoff Wall-Clay, 1m Width	M3	900	$100.00	$90,000.00
	i)	Toe Drain: Perforated Pipe, Geotextile and Drain Rock	M	130	$300.00	$39,000.00
	j)	Slope Stabilization	M	130		
					Total 2C	$690,825.00
Section 2D		**Option 2: Pipes, Earthen Berm & Platform**				
	a)	600mm Dia. CSP Culvert	M	550	$750.00	$412,500.00

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	b)	Flatback Drainage Gate, 600mm Dia.	EA	22	$3,000.00	$66,000.00
	c)	Type II Concrete Headwall, 600mm Dia.	EA	22	$5,000.00	$110,000.00
	d)	Canal Gate, 600mm Dia.	EA	22	$3,000.00	$66,000.00
					Total 2D	$654,500.00
Section 2E		**Option 2: Road Raising (Sawmill Rd.)**				
	a)	Rough Grading	M2	3850	$5.00	$19,250.00
	b)	Subgrade Preparation	M2	3850	$5.00	$19,250.00
	c)	80mm Minus Granular Subbase, Variable Depth	M3	5830	$40.00	$233,200.00
	d)	100mm Minus Granular Base, 100mm Depth	M3	180	$50.00	$9,000.00
	e)	BST Surfacing	M2	1500	$50.00	$75,000.00
	f)	Riprap	MT	1450	$141.00	$204,450.00
					Total 2E	$560,150.00
					Contingency (20%)	$8,018,284.00
					Subtotal	$48,109,704.00
					Location Adjustment Factor (LCAF)	1.43
					Capital Costs Base Price	$68,796,900.00
					Capital Costs Upper Bound	$103,195,350.00

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.

Table B10 Option 2 Annual Costs During a Flood Year Class D OPC

Item No.		Description of Work	Units	Qty.	Unit Price	Amount
Section 2F		**Option 2: Annual Cost, Flood Year**				
	a)	Inspections	LS	1	$25,000.00	$25,000.00
	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
	d)	Superbags c/w Sandfill (2.0m)	M	130	$500.00	$65,000.00
	e)	Sandbags c/w Sandfill (2.0m)	M	980	$464.00	$454,720.00
					Total 2F	$595,220.00
					Contingency (20%)	$119,044.00
					Subtotal	$714,264.00
					Location Adjustment Factor (LCAF)	1.43
					Annual Cost, Flood Year Base Price	$1,021,400.00
					Annual Cost, Flood Year Upper Bound	$1,532,100.00

Table B11 Option 2 Annual Costs During a Non-Flood Year Class D OPC

Item No.		Description of Work	Units	Qty.	Unit Price	Amount
Section 2G		**Option 2: Annual Cost, Non-Flood Year**				
	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
					Total 2G	$60,500.00
					Contingency (20%)	$12,100.00
					Subtotal	$72,600.00
					Location Adjustment Factor (LCAF)	1.43
					Annual Cost, Non-Flood Year Base Price	$103,800.00
					Annual Cost, Non-Flood Year Upper Bound	$155,700.00

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.

Qualitative Evaluation

Table B12 summarizes the performance of Option 2 with respect to the evaluation criteria which were previously outlined in the main body of this Report.

Table B12 Option 2 Qualitative Evaluation

Criteria No.	Criteria Title	Evaluation	Anticipated Performance Rating
1	Viability and Reliability under Extreme Conditions	moderate flood duration (several weeks); wind/wave impacts and ice/debris damage risks would be mitigated by elevated DFSL and erosion mitigation measures; numerous temporary sandbag dikes vulnerable to damage from ice/debris and waves; 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; wind/wave analysis and erosion mitigation design ; 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 $2,023,439/property	Low Performance
4	Maintenance and Storage	no storage requirements; numerous large dikes will require inspections, maintenance, and vegetation clearing; floodbox maintenance will be required	Medium Performance
5	Response and Activation	numerous 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	Medium 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 dike crest in future for enhanced flood mitigation; additional sandbags may be provided for raising temporary sandbag dikes; permanent increases in height to dikes are possible but will require engineering study and are likely to require widening of structure	Medium Performance
8	Alteration of Existing Hydraulics, Erosion/ Sedimentation, Ice Processes, and Slope Stability	relatively minor intrusions into Teslin 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; slope stabilization measures may be required over approximately 1.5 km	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 (especially for Option 2) considering that infrastructure investments to remedy issues are extremely costly	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.

B.2.3 SUMMARY TABLES

Table B13 summarizes the Class D OPCs each of the conceptual design options.

Table B13 Summary of Class D OPCs

	Option 1 Class D OPCs					Option 2 Class D OPCs				
Capital Cost	$	39,587,500	-	$	59,381,250	$	68,796,900	-	$	103,195,350
Annual Cost (Flood Year)	$	3,060,000	-	$	4,590,000	$	1,189,600	-	$	1,784,400
Annual Cost (Non-Flood Year)	$	26,600	-	$	39,900	$	103,800	-	$	155,700

Table B14 provides a summary of the evaluation of each of the conceptual design options.

Table B14 Summary of Qualitative Evaluation of Conceptual Options

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