Hamlet of Hall Beach
Master Drainage Plan and Geotechnical Investigation



PRESENTED TO

Department of Community and Government Services (CGS)
Government of Nunavut

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ACRONYMS & ABBREVIATIONS

Acronyms/Abbreviations	Definition
DEM	Digital Elevation Model
GIS	Geographic Information System
GPS	Global Positioning System
SWMM	Stormwater Management Model
AES	Atmospheric Environmental Service

LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Government of Nunavut and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Government of Nunavut, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was retained by the Department of Community and Government Services (CGS), Government of Nunavut to develop a Master Drainage Plan for the Hamlet of Hall Beach (Hall Beach). CGS and Hall Beach require that a drainage study be conducted in Hall Beach, for both the existing town site and planned future subdivisions identified in the Community Plan. As part of the deliverables, CGS has also requested that a geotechnical investigation be completed to confirm the geology characteristic to the Hamlet.

The Terms of Reference (ToR) developed by CGS confirmed that Hall Beach has in-force a Community Plan (By-law No. 148) and a Zoning By-law (By-law No. 149). To make sure the community plans are developed in harmony with the local site drainage limitations, it was recommended that a complete review of the local drainage system be completed. In addition to a detailed review of the community plans and its impacts on the exiting stormwater system, CGS identified the need to review and evaluate the conditions of the existing drainage system. Based on anecdotal information and details provided by CGS, pre-existing drainage issues are present within the existing townsite.

The population of Hall Beach was estimated to be approximately 880 persons at the time of the preparation of the 2018 Hall Beach Community Plan. The Hall Beach Community Plan aims to prepare for a population of 1350 people by 2038 and is planning phased community expansion to meet the estimated population growth. The plan facilitates the development of 10 lots per year between 2018 and 2023. Any of the proposed subdivisions need to be constructed away from the core area of the community. In order to ensure that the Hamlet of Hall Beach has sufficient and suitable developable land to accommodate population growth forecast in the Community Plan, it is necessary for a qualified team of professionals to conduct a drainage study for these subdivisions.

The study conducted by Tetra Tech encompassed the following tasks:

- A review of all available background material;
- A site visit to Hall Beach by a team of hydrotechnical engineers to identify, assess, and document all drainage infrastructure and known drainage issues;
- Inventory of existing drainage issues;
- Development of inputs to a hydrologic model;
- Assess the drainage system for existing and proposed development conditions;
- Assess geotechnical conditions and terrain suitability for the proposed development plans; and
- Completion of the Hall Beach Master Drainage Plan.

2.0 REVIEW OF BACKGROUND INFORMATION

Tetra Tech collected, compiled and processed all information related to the drainage system of the Hamlet of Hall Beach, made available by officials from the Government of Nunavut and the Hamlet, and from publicly available reports and data.

The initial background review process provided Tetra Tech with an understanding of the terrain, climate, long-term land-use plans, and known drainage issues in Hall Beach.

Reviewed background data has included the following:

- 2018 Satellite Imagery (.tif);
- 2018 Digital Elevation Models (Bare earth and surface models available in .tif and .asc formats);
- 2018 Building footprint, infrastructure, and transportation vector datasets (AutoCAD .dwg and ESRI File Geodatabase or Shapefile formats);
- 2018 Hydrology (water bodies and watercourses) vector datasets (AutoCAD .dwg and ESRI File Geodatabase and Shapefile formats);
- 2018 Contours vector datasets (AutoCAD .dwg and ESRI File Geodatabase and Shapefile formats);
- 2018 Community Plan and Community Plan By-law;
- Google Earth 2017 Satellite Imagery; and
- Historical climate data for Hall Beach, monitored and made available by Environment Canada.

Additional anecdotal background information was collected through informal discussions with Hamlet staff and local residents during the 2019 field visit.

2.1 Geology Background Data Review

The following background information was collected from a variety of sources and referenced while mapping:

- Google Earth Pro™ historical imagery (starting from August 31, 2010);
- 1993 B&W air photos (1:5,000 scale);
- 1995 B&W air photos (1:5,000 scale);
- Regional surficial geology and permafrost maps (refer to the REFERENCES list of this report);
- Geotechnical site investigation reports by various consultants (refer to the REFERENCES list of this report); and
- Literature on surficial geology and permafrost in the area (Heginbottom et al. 1995; and Dredge 1988).

2.2 Community Plan, Population and Expansion Plans (Land Use)

The Government of Nunavut CGS division maintain and regularly update community plan maps for each community within the Territory. The purpose of these community plans are to outline Council's policies for managing the physical development of each Hamlet for the next 20 years. The community plan for the Hamlet of Hall Beach was updated in 2018 (included as Appendix B).

The community plan includes existing land parcels as well as proposed parcels of land allocated for future community growth. This combination of existing and proposed development forms the scope of our Master Drainage Plan, which aims to provide feedback not only on how to improve the existing drainage system, but also prescribe how the drainage features of the future area should be designed. The results of this community drainage study should be incorporated within the next community plan update.

2.3 Terrain

The community of Hall Beach, hereafter referred to as the study area, is located on the east side of the Melville Peninsula, approximately 800 km northwest of Iqaluit (Figure 2-1). The entire community was built on a northwest-to-southeast oriented marine terrace.

The upland areas of the peninsula range form moderately rugged in the west to gently rolling in the east (Dredge, 2001). The upland areas are underlain by Precambrian rocks such as granite, gneiss, and schist. Lowland areas, including the community of Hall Beach, are underlain by Palaeozoic limestone and dolomite. Most of the peninsula is covered with till, either as blankets or as thin veneers interspersed with bedrock outcrops. The till is stony, with a silty sand matrix where it is derived from granitic bedrock. The till has a finer silty matrix where it is derived from carbonates, as is the case in the Hall Beach area where it underlies marine deposits.

Non-glacial deposits are mapped along the shoreline, north and south of Hall Beach, with raised gravel and shingle beaches derived from shattered limestone (Trow 2004).

Environment Canada has maintained a meteorological station at Hall Beach since 1956. Several stations have available data: Hall Beach A (1956-2012), Hall Beach A (2012-2015), Hall Beach AWOS (2008-2012), and Hall Beach Climate (2004-2015). Environment Canada has also recently released climate normals for 1981-2010.

The mean annual air temperature climate normal for 1981-2010 was -13.6°C, significantly warmer in comparison to the previous climate normals of -14.1 and -14.4°C for 1971-2000 and 1961-1990, respectively. If we assume the same rate of change in the past 4 years to the end of 2014 as was experienced during the 10-year period between the climate normals ending 2000 and 2010 (about 0.5°C), then the mean annual air temperature now is about -13.4°C.

The annual precipitation at Hall Beach is about 215 mm, over half of which is snowfall (137 mm). Precipitation falling as snow seems to be increasing, but the proportion of precipitation falling as rain and the total precipitation are not changing significantly. Therefore, it may be that the snowfall is somewhat less dense than before in Hall Beach, as the depths of snow at the end of April and May (about 45 cm and 37 cm, respectively) also seem to be reasonably consistent with previous climate normals.

2.3.1 Surficial Geology

The surficial materials and terrain features within the study area were mapped using the regional (1:200,000 scale) surficial geology map (Dredge 1988) as a baseline. Undulating discontinuous raised beach deposits overlying a relatively flat landscape characterize the terrain. The raised beach ridges are prevalent within a few hundred meters of the existing shoreline. The ridges are up to 3.0 m in height and are composed of angular gravels with trace to some sand. Weathered bedrock underlies the beach ridges and is occasionally exposed in areas between the beach ridges. (EBA 2002).

Tetra Tech reviewed results of the recent geotechnical investigations completed by several geotechnical consultants and summarized surficial geology of the study area in the following sections. Figure 2-1 shows locations of the previous geotechnical investigation sites.

Gravel (Raised Beach Deposits, Possibly Marine-Modified Tills)

The gravel raised beach deposits can vary from clean uniform gravel to sandy gravel. Generally, the proportion of sand, silt, and clay increases with depth, with proportions of fines increasing to some silt and clay or silty/clayey by about 1.5 m below surface grade. It is usually grey to dark grey in colour, but has also been reported as brown.

Silt (Till)

A layer of native gravelly silt till, with some sand and a trace of clay underlies the gravel (EBA 1990). The thickness of this layer may vary from less than 1.0 m to over 2.0 m. The maximum reported thickness of native silt till is approximately 2.5 m. Measured soil moisture contents varied from about 8 to 17%. The soil is grey.

Bedrock

Limestone bedrock has been reported in the community under the native silt till or silty gravel (Thurber 1988a, 1988b; EBA 1990; Geocon 1985). The reported depth to bedrock is variable, ranging from about 3.0 m to 4.5 m at the community hall and 2.1 m to 4.7 m at the school, and 1.2 to 3.0 m at the nursing. Geocon reported bedrock depth at 2.7 m in the vicinity, generally consistent with the other findings.

The upper 1.0 m of the bedrock has been reported as weathered and fractured (Thurber, 1988), and Geocon (1985) reported the upper 2.8 m of bedrock as weathered. EBA (1990) has reported the upper 1.0 m of bedrock to be of very low strength, dry and light grey.

2.3.2 Permafrost

According to the Canada Permafrost Map (Heginbottom et al. 1995), the study area is located within the zone of continuous permafrost. The active layer thickness in Hall Beach is expected to be in the range of 1.0 to 2.0 m.

Visible ice varying from 5 to 10% was reported in the marine sandy/silty gravel. Generally, this layer is poorly bonded when frozen, and has soil moisture contents between about 5 and 9%.

The layer of silt (till) underlying marine deposits layer was found to be well-bonded when frozen with excess ice of 5 to 10% (EBA 1990).

Geocon (1985) reported 1.0 to 2.0 mm thick ice lenses observed in the fissures of the upper 1 m of bedrock.

No ice-rich permafrost that could comprise massive ice beds was reported in the overburden layers (EBA, 1990; Thurber, 1988b; Geocon, 1985).

Thurber (1988b) reported the ground temperatures at a depth of 6.0 m, within the bedrock, to range from -4.6°C to -6.0°C at an infilled pond west of the school, and -7.3°C to -7.8°C onshore at the school site. Extrapolated to the present day using temperature changes recorded in the climate normals, these ranges would be -3.6°C to -5.0°C for the infilled pond, and -6.3°C to -6.8°C for the onshore area.

EBA (1990) reported a wide range of ground temperatures in the overburden at the same site. It is noted that the highest temperatures encountered by EBA were within recently-placed gravel fill (0°C to -1.0°C) and the underlying native silt and silt till (-1.0°C), within a former pond area. The bedrock in that area had a temperature of about -2.0°C at 4.0 m below ground surface. Temperatures away from the former pond were lower, at about -4.5 to -5.0°C in gravelly silt till soils at about 3 to 4 m below grade. Extrapolated to the present day, temperatures of -1.0°C might be expected in the infilled pond area, and -3.5 to -4.0°C onshore, though it is noted that both EBA's and Thurber's measurements were taken in early November, and may still be a little warmer than the annual means at those depths. EBA also encountered some unfrozen zones at depths of 2.0 to 2.5 m as a result of recent fill placement in the former pond area (EBA 1990).

Geocon (1985) estimated a mean annual ground temperature of -11.0°C at a depth of 8.0 m in their Study Area 3, a study area that includes the present-day nursing station site and much of the school site as well as a residential subdivision to the west. This estimate was based on temperatures measured one day after installation of a multi-bead ground temperature cable in mid-September 1985. Extrapolating to the present day, this temperature would be about -9.8°C, probably a little cooler than the annual mean for this depth.

A series of ground temperature cables are located at various sites within the Distant Early Warning Line (FOX-MAIN) site located about 3.2 to 4.2 km south to southeast of the main hamlet area. Measurements from these cables from 2008 through 2013 suggest active layer thicknesses of 0.9 to 1.5 m at disturbed sites in granular soils. Ground temperatures measured at these sites suggest mean annual ground temperatures ranging from about -7.0 to -9.0°C between about 3.5 and 5.0 m below grade, with colder ground at shallower depths at the inland sites. Compared to the project site, the most representative DEW Line sites are along the beach, 30 to 100 m from the shoreline. The average temperature at the beach sites is about -7.6°C, between 3.0 and 3.5 m below grade. When comparing temperatures at the beach sites to the inland sites at all measured depths, they are on average about 0.6°C warmer than the inland sites, which are about 200 to 280 m from the shoreline. When considering only temperatures measured at 3.0 to 3.5 m depths, the beach sites average about 1.1°C warmer than the inland sites. Assuming the same correlation applies at greater depths, ground temperatures along the beach at about 5 m depth are estimated at about -6.9°C.

Considering the wider range of temperatures noted above for the community, and the proximity to the shoreline a mean annual ground temperature of about -6.0°C is conservatively assumed for the proposed site, below the zone of seasonal thaw.

NOTES
DETAIL INSET BASED ON DRAWING PROVIDED BY NUNAVUT HOUSING CORPORATION
DRAWING: JOB No. 06-203, DWG No. A101, REVISON 1, DATE: 14.11.17

0 1,000m
Scale: 1:25,000 @ 8.5"x11"

CLIENT
Nunavut

TETRA TECH

GEOTECHNICAL INVESTIGATION AND DRAINAGE PLANNING HALL BEACH, NU

PREVIOUS GEOTECHNICAL INVESTIGATION SITE LOCATION PLAN

PROJECT NO.	DWN	CKD	REV
TRN.WTRM03187-01.001	DBD	JS	0

OFFICE	DATE
EDM	November 2019

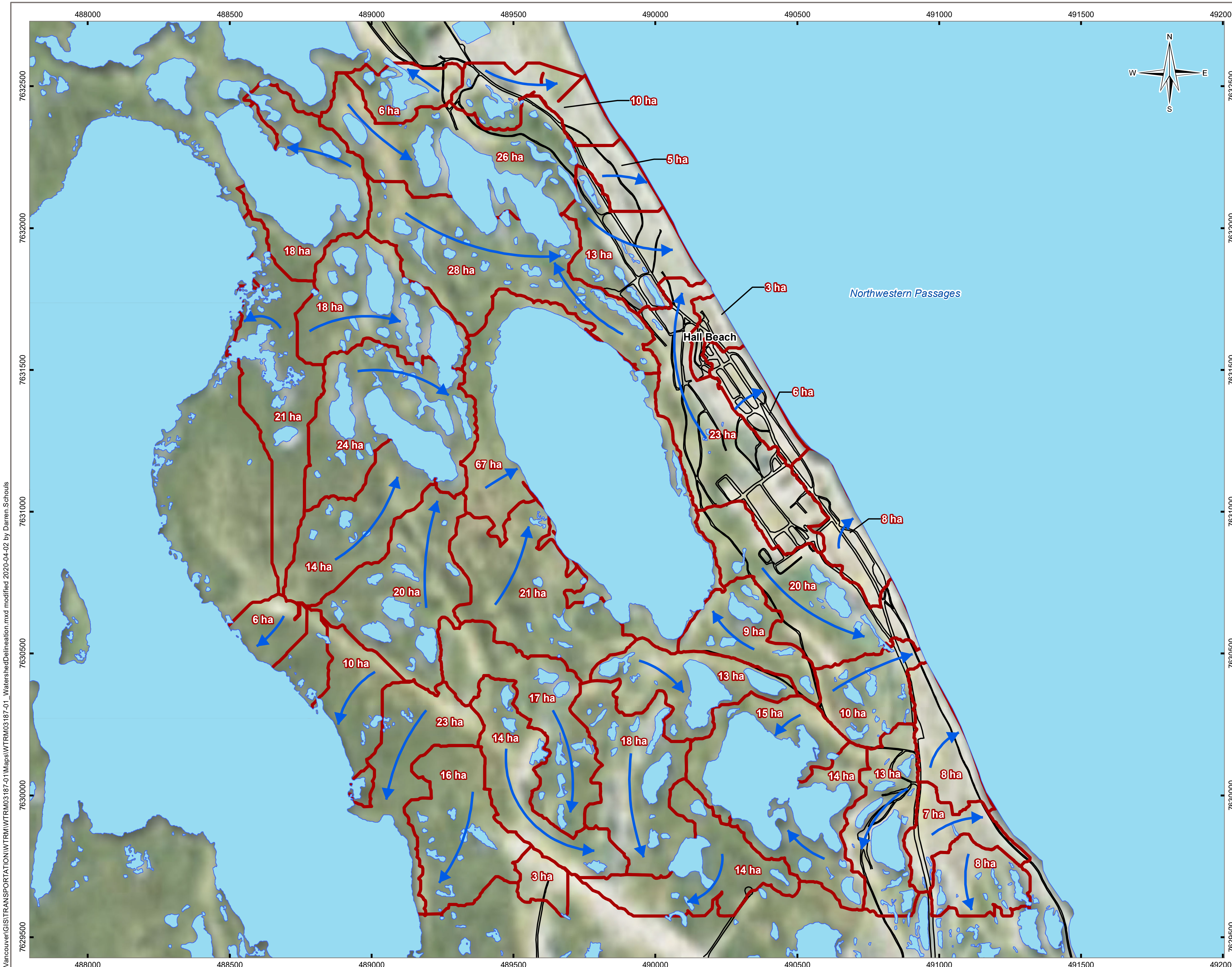
Figure 2-1

Q:\Edmonton\Drafting\PROJECTS\704-TRN.WTRM\TRN.WTRM03187-01\02_Acad\TRN.WTRM03187-01_001 Figure 1.dwg [FIGURE 1] November 19, 2019 - 2:48:01 pm (BY: DAS, DEBASHIS)

2.3.3 Topography and Watershed Delineation

A Digital Elevation Model (DEM) of the Hall Beach region was developed to represent the topography of the project area. The DEM was derived from aerial photographs used to extract elevation information through a technique called photogrammetry. The use of measurements from photographs is of sufficient accuracy for use within a drainage planning exercise.

Tetra Tech has reviewed this DEM and has performed a watershed delineation analysis to identify drainage patterns in the Hall Beach area. The existing drainage patterns are presented in Figure 2-2 and were confirmed during the 2019 freshet field visit. Note that several paths are impacted by the presence of other surficial obstructions such as buildings and conveyance systems such as culverts and ditches.

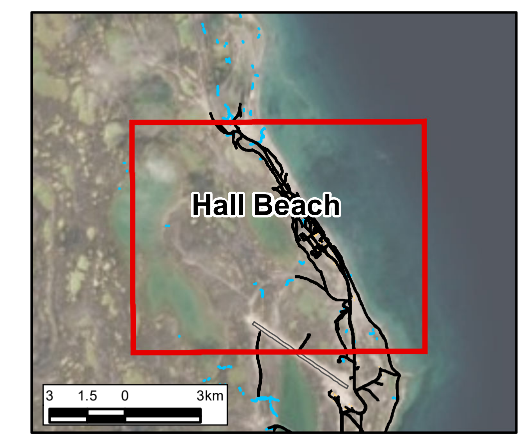


LEGEND

- Flow Direction
- Watershed

Base Data

- Gravel Road
- Waterbody



NOTES

Base data source:

1. Hall Beach base data from Government of Nunavut

STATUS
ISSUED FOR USE

HALL BEACH MASTER DRAINAGE PLAN

Watershed Delineation

PROJECTION	DATUM	CLIENT
UTM Zone 17	NAD83	Nunavut

Scale: 1:13,000

200 100 0 200

Metres

TETRA TECH

FILE NO.				
WTRM03187-01_WatershedDelineation.mxd				
OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DS	SL	ER	0

DATE	PROJECT NO.
April 2, 2020	TRN.WTRM03187-01

Figure 2-2

2.4 Climate

2.4.1 Recorded Data

Climate data for Hall Beach are based on records collected at Hall Beach A from 1975 to present. Data are collected and published by Environment and Climate Change Canada (ECCC). Figures 2-3 to 2-5 present the climate normals determined by ECCC for the period of 1981 to 2010.

The daily average, maximum and minimum temperatures in February, the coldest month of the year, are -32.5°C, -28.4°C, and -36.6°C respectively. The equivalent temperatures in July, the warmest month of the year, are 6.7°C, 10.1°C, and 3.3°C respectively. The annual mean daily temperature is -13.6°C. Extreme maximum and minimum recorded temperatures are 24.8°C and -54.1°C respectively. The average annual precipitation for the climate normal period is 215.4 mm, with 99.3 mm of rainfall and 136.8 cm of snowfall. Precipitation amounts is highest in the summer month of August, with a maximum recorded daily rainfall of 52.6 mm which occurred on August 27, 1980.

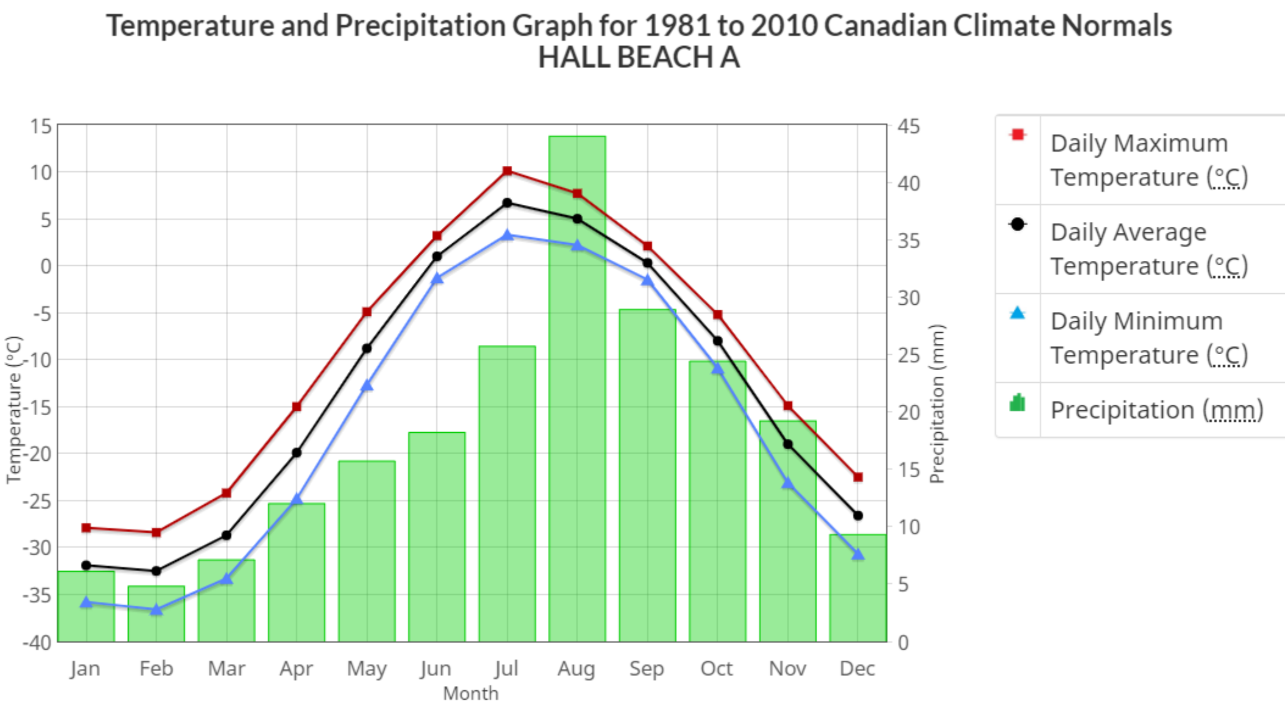


Figure 2 3: Temperature and Precipitation (1981-2010). Hall Beach A

1981 to 2010 Canadian Climate Normals station data

Temperature

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Daily Average (°C)	-31.9	-32.5	-28.7	-19.9	-8.8	1.0	6.7	5.0	0.3	-8.0	-19.0	-26.6	-13.6	A
Standard Deviation	3.0	3.4	2.7	2.8	2.3	1.4	1.0	1.1	1.3	2.7	3.3	4.0	1.3	A
Daily Maximum (°C)	-27.9	-28.4	-24.2	-15.0	-4.9	3.2	10.1	7.7	2.1	-5.2	-14.9	-22.5	-10.0	A
Daily Minimum (°C)	-35.8	-36.6	-33.3	-24.8	-12.7	-1.3	3.3	2.2	-1.5	-10.9	-23.1	-30.7	-17.1	A
Extreme Maximum (°C)	1.3	0.4	-0.5	3.3	4.4	21.1	22.8	**24.8**	13.5	4.2	-0.1	0.4		
Date (yyyy/dd)	1985/ 18	2006/ 27	1980/ 23	1975/ 28	1974/ 20	1973/ 29	1969/ 23	**1991/ 05**	1988/ 02	1988/ 06	1985/ 02	1985/ 06		
Extreme Minimum (°C)	-50.0	**-54.1**	-52.5	-44.1	-31.1	-20.6	-3.3	-5.1	-16.7	-33.6	-42.2	-53.9		
Date (yyyy/dd)	1972/ 18	**1979/ 12**	1996/ 24	1981/ 15	1970/ 06	1972/ 01	1972/ 01	1981/ 30	1972/ 28	1978/ 30	1976/ 29	1986/ 16		

Figure 2-4: Temperature Climate Normals 1981-2010. Hall Beach A

1981 to 2010 Canadian Climate Normals station data

Precipitation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Rainfall (mm)	0.0	0.0	0.0	0.2	2.2	11.2	25.6	41.3	17.2	1.5	0.1	0.0	99.3	C
Snowfall (cm)	7.3	6.0	9.2	14.4	15.4	7.2	0.1	3.1	12.0	27.6	24.0	10.6	136.8	C
Precipitation (mm)	6.1	4.8	7.1	12.0	15.7	18.2	25.7	44.0	28.9	24.4	19.2	9.3	215.4	C
Average Snow Depth (cm)	33	34	39	43	43	19	0	0	1	9	22	29	23	C
Median Snow Depth (cm)	32	34	38	43	44	19	0	0	0	8	21	29	22	C
Snow Depth at Month-end (cm)	34	35	41	45	37	2	0	0	2	16	28	32	23	C
Extreme Daily Rainfall (mm)	0.5	0.0	0.0	3.2	16.4	33.0	35.3	**52.6**	29.5	5.6	0.8	0.2		
Date (yyyy/dd)	1960/ 18	1957/ 01	1957/ 01	1984/ 18	2001/ 22	1976/ 23	1976/ 07	**1980/ 27**	2005/ 10	1998/ 05	1987/ 05	1998/ 05		

Figure 2-5: Precipitation Climate Normals 1981-2010. Hall Beach A

Computed short duration rainfall characteristics in the form of Intensity Duration Frequency (IDF) data for Hall Beach A were obtained from Environment and Climate Change Canada and are presented in Table 2-3. The ECCC data was computed with a Gumbel frequency distribution.

Table 2-3: Intensity Duration Frequency (IDF) Data for Hall Beach A (1987 to 2004)

T (years)	2	5	10	25	50	100
5 min	1.2	2.3	3.1	4	4.7	5.4
10 min	1.6	3.2	4.3	5.7	6.7	7.7
15 min	1.9	3.6	4.7	6	7.1	8.1
30 min	2.6	4.4	5.6	7.1	8.2	9.3
1 h	3.9	5.7	6.9	8.4	9.5	10.7
2 h	5.5	7.6	9	10.8	12.1	13.4
6 h	10.7	15.5	18.8	22.8	25.8	28.8
12 h	13.3	19.3	23.3	28.3	32	35.7
24 h	16.4	23.8	28.6	34.8	39.3	43.8

2.4.2 Climate Change Predictions

2.4.2.1 Hall Beach Regional Climate Projections

Atlas Canada (The Prairie Climate Centre, 2019) climate change projections were retrieved for the Municipality of Hall Beach. Tetra Tech analysed projected changes between the 30-year time periods of 1976-2005 and 2021-2050 for the RCP8.5 climate change scenario. Between these two time periods, the annual mean temperature is expected to increase by 3.2 °C from -13.1 °C to -9.9 °C. Annual precipitation is expected to increase by 14 percent from 256 mm to 291 mm. The maximum 1-day precipitation is expected to increase by 11 percent from 19 mm to 21 mm between the same time periods. Seasonal mean temperature and precipitation projections are shown in Table 2-4 and Table 2-5 below.

Table 2-4: Atlas Canada RCP8.5 Climate Change Temperature Projections Summary

		1976-2005	2021-2050		2051-2080	
Variable	Period	Mean (°C)	Mean (°C)	Increase (°C)	Mean (°C)	Increase (°C)
Mean Temperature	Annual	-13.1	-9.9	3.2	-6.5	6.6
Mean Temperature	Spring	-18.3	-15.8	2.5	-13	5.3
Mean Temperature	Summer	4.5	6.3	1.8	8.5	4
Mean Temperature	Fall	-9.3	-5.4	3.9	-2	7.3
Mean Temperature	Winter	-29.5	-25	4.5	-19.7	9.8

Table 2-5: Atlas Canada RCP8.5 Climate Change Precipitation Projections Summary

		1976-2005	2021-2050		2051-2080	
Variable	Period	Mean (mm)	Mean (mm)	Increase (%)	Mean (mm)	Increase (%)
Precipitation	Annual	256	291	14	332	30
Precipitation	Spring	47	52	11	58	23
Precipitation	Summer	96	106	10	115	20
Precipitation	Fall	79	90	14	106	34
Precipitation	Winter	34	42	24	53	56
Max 1-Day Precipitation		19	21	11	24	26

As a result of the projected increase in spring temperatures for the 2021-2050 time period, the timing of the spring snowmelt event is expected to occur approximately 6 days earlier in the spring season. Due to the projected increase in fall temperatures, the timing of the start of snowfall in the fall season is expected to be delayed by approximately 9 days compared to the 1976-2005 time period..

As a result of the projected change in spring melt and fall freeze dates, the duration of the snowfall season is expected to decrease for the 2021-2050 time period by approximately 15 days. Due to the expected shorter snowfall duration, a reduction in total snow accumulation is expected. However, as a result of the projected monthly precipitation increases, snowfall in the Hall Beach region is expected to increase. The combined net effect of a shorter winter and increased precipitation is an increase in snowfall during the winter months. It is estimated that the increase will be in excess of 5%.

In the spring, despite the timing of the freshet being expected earlier, the 2021-2050 warming rate is projected to be very similar to the average warming rate on record in the 1976-2005 time period. As climate change is projected to translate into an increase of 0.07 mm per day during the spring snowmelt period, it is expected that over the freshet period, lasting approximately 15 days, the total increase in precipitation is a nominal 1 to 2 mm. Therefore, Tetra Tech estimates the springtime snowmelt runoff rates for the 2021-2050 time period to increase by a marginal amount.

During the part of the year when temperatures in Hall Beach are above-freezing, rainfall is projected to increase by approximately 25%, from 107 mm to 134 mm, for the 2021-2050 time period. Due to the projected increase in rainfall, larger and more severe summer precipitation events are expected for the Hall Beach region in the 2021-2050 time period. Figures 2-6 and 2-7 below show the Atlas Canada temperature and precipitation projections discussed in this section.

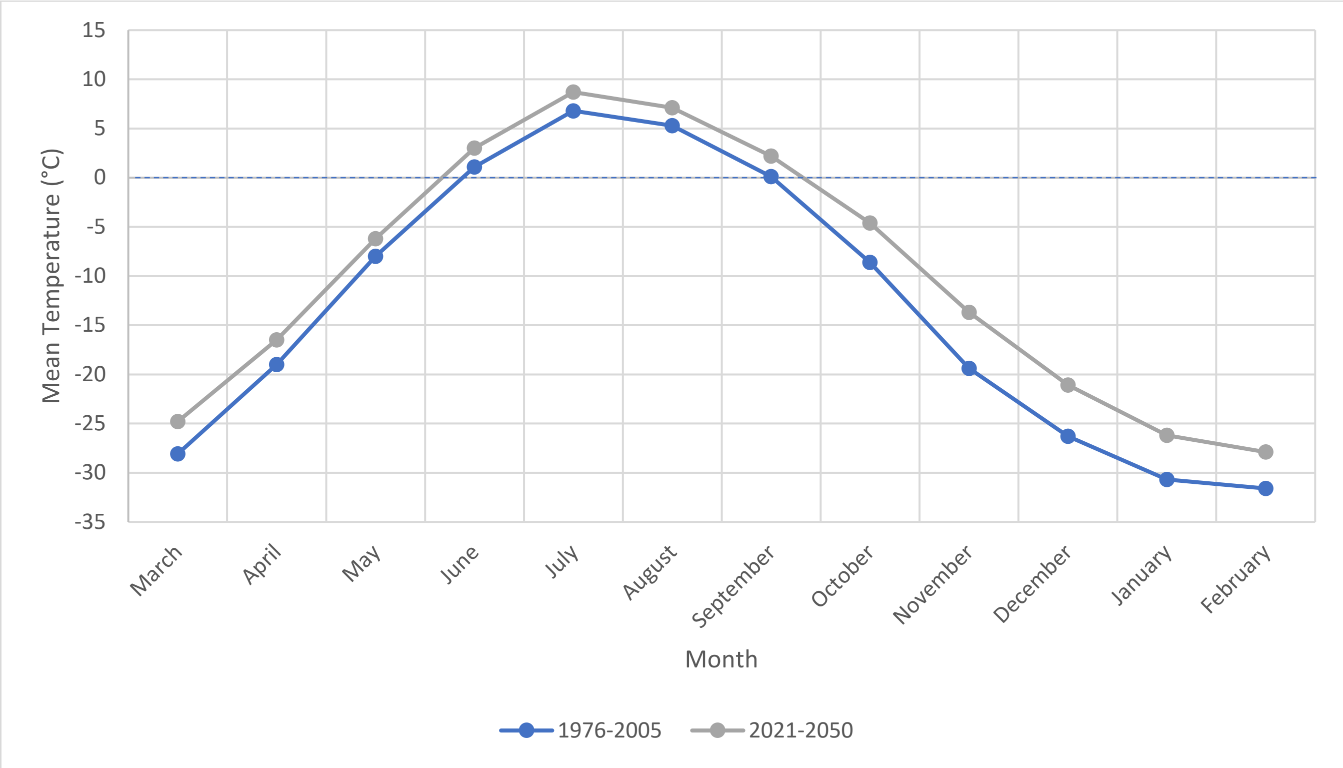


Figure 2-6: Atlas Canada Projected Monthly Mean Temperature

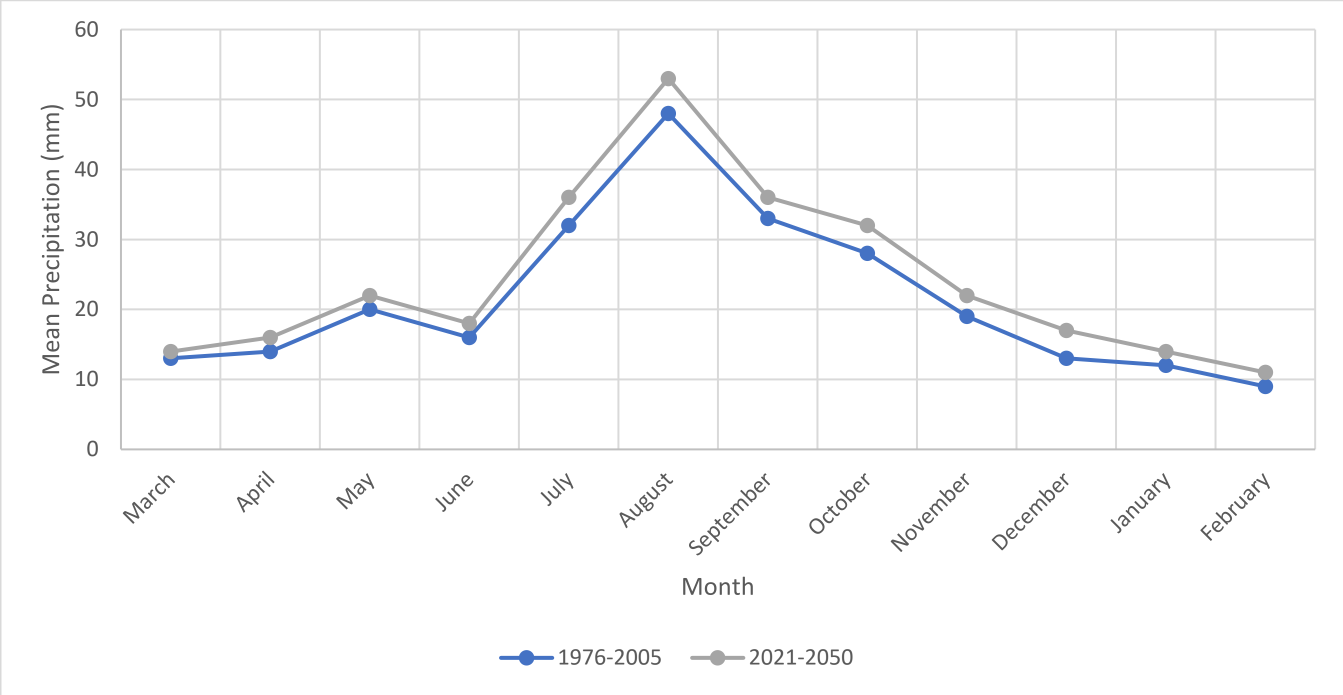


Figure 2-7: Atlas Canada Projected Monthly Mean Precipitation

2.4.2.2 Short Duration Rainfall Events

Climate change effects on short duration rainfall events are available through the IDF_CC Online Tool v4.0 developed by Western University (Simonovic, Schardong, Gaur, & Sandink, 2018). The tool provides rainfall intensity-duration-frequency (IDF) data from historic observations and climate change scenarios from 24 Global Circulation Models (GCMs).

Projected IDF data for the RCP 8.5 scenario and the time period of 2021 to 2050 is listed in Table 2-6. Detailed hydrological modelling of Hall Beach was conducted based on these climate change adjusted rainfall depths.

Table 2-6: Projected IDF at Hall Beach (2021 to 2050)

T (years)	2	5	10	25	50	100
5 min	1.1	1.99	2.87	4.49	6.01	8.13
10 min	1.41	2.39	3.48	5.43	7.53	10.39
15 min	1.83	3.05	4.29	6.45	8.41	11.2
30 min	2.63	4.24	5.78	8.37	10.53	12.8
1 h	4.2	6.17	7.82	10.05	11.86	13.59
2 h	6.08	8.52	10.5	12.99	14.82	16.54
6 h	11.33	16.58	21.1	27.82	33.14	38.8
12 h	14.01	20.59	26.28	34.81	41.52	49.14
24 h	17.78	26.12	33.07	42.45	50	57.21

2.4.3 Climate Change Implications

Due to limited climate change research available for the Hamlet of Hall Beach, relevant findings from Lewis and Miller's "*Climate Change Adaptation Action Plan for Iqaluit"* (2010) were utilized for this section of the report. Lewis and Miller (2010) presented a summary of perceived sensitivities to climate change in Iqaluit, including the following:

Infrastructure

1. *Damage to infrastructure is expected to increase due to increases in climate variability and extreme events.*
2. *A decrease in the permafrost layer was identified as the most significant climate-related concern for infrastructure.*
3. *The following may be particularly at risk: buildings with shallow foundations; buildings, roads and buried pipes along steep south facing slopes and/or in areas of high snow accumulation; any building or road in areas of poor drainage where water may pool.*
4. *The following infrastructure may be vulnerable to other climate change impacts: buildings or piping in poor condition due to age, absence of regular maintenance, outdated design or over-extended use; infrastructure located along the coast which may be susceptible to damage from flooding or storm surges; the drainage system which may be impacted by changes in precipitation; and the City's water supply.*
5. *All new municipal infrastructure shall be designed and constructed to specifications that withstand projected changes in climate over their expected design life and meet sustainable development standards.*

6. *City outfalls should be designed to fall outside the range in tidal variability.*

Buildings

7. *With an increase of the active layer of permafrost, many existing building foundations could experience structural damage.*
8. *With a change in weather patterns such as extreme storm events, more extreme temperature variations, increased humidity in snow and more rain, buildings will be more susceptible to weathering and moisture damage.*
9. *Some waterfront buildings are vulnerable to flooding at extreme high tides or under storm surge conditions and minimum foundation levels may need to be established.*

Water Supply System

10. *Changes in permafrost will have implications for both existing and new underground piping.*
11. *Warmer air temperatures could cause surface evaporation of the City's water supply and could eventually reach temperatures that allow algae and other micro-organisms to grow, thereby compromising water quality.*
12. *Increased rainfall could potentially put the municipal water supply at risk by washing contaminants and soil into the reservoir.*

Wastewater Treatment System

13. *Increased precipitation, in the form of heavy rainfall, could overwhelm the system and cause failure or overflow, which could contaminate adjacent water bodies.*

Waste Disposal System

14. *Increase in the active layer of permafrost could lead to changes the freeze-thaw cycle, drainage and water flow around the landfill. Design and operation of the landfill needs to take this into consideration.*

3.0 EXISTING DRAINAGE SYSTEM AND ISSUES

A critical task in the development of a Drainage Master Plan is to identify, assess, and log all critical drainage infrastructure and known deficiencies. This process included the location and description of the physical assets that compose the drainage system, including key geometric characteristics and conditions. Using field and desktop data, this information was used to build a georeferenced map of the drainage infrastructure. The inventory also includes the location and description of existing issues such as ponding and damaged culverts. The following sections describe the activities conducted during the site visit, and the development of the georeferenced map of the drainage system.

3.1 Site Visit

A site visit was conducted on August 28, 2019 by two Tetra Tech staff, Mark Aylward-Nally and Josh Weidner. The purpose of the site visit was to:

- Discuss ongoing drainage issues and maintenance practices with the Hall Beach foreman, Mr. Dan Kanauk;

- Conduct a walkthrough inspection of the drainage system of the Hamlet; and
- Conduct informal interviews with local residents regarding known drainage issues.

3.1.1 Walkthrough Inspection

A walkthrough of Hall Beach was conducted on August 28, 2019. The objective of the site visit was to:

- Develop an understanding of the drainage patterns through the town;
- Identify main drainage routes and key infrastructure assets;
- Get GPS points of key infrastructure locations, for instance upstream and downstream culvert ends;
- Measure culvert dimensions and document culvert conditions;
- Identify areas of ponding;
- Record a photo inventory of key elements of the drainage infrastructure;
- Identify drainage outlet locations; and
- Conduct Informal Interviews with Hamlet residents.

Based on the walkthrough inspection, Tetra Tech has observed the following:

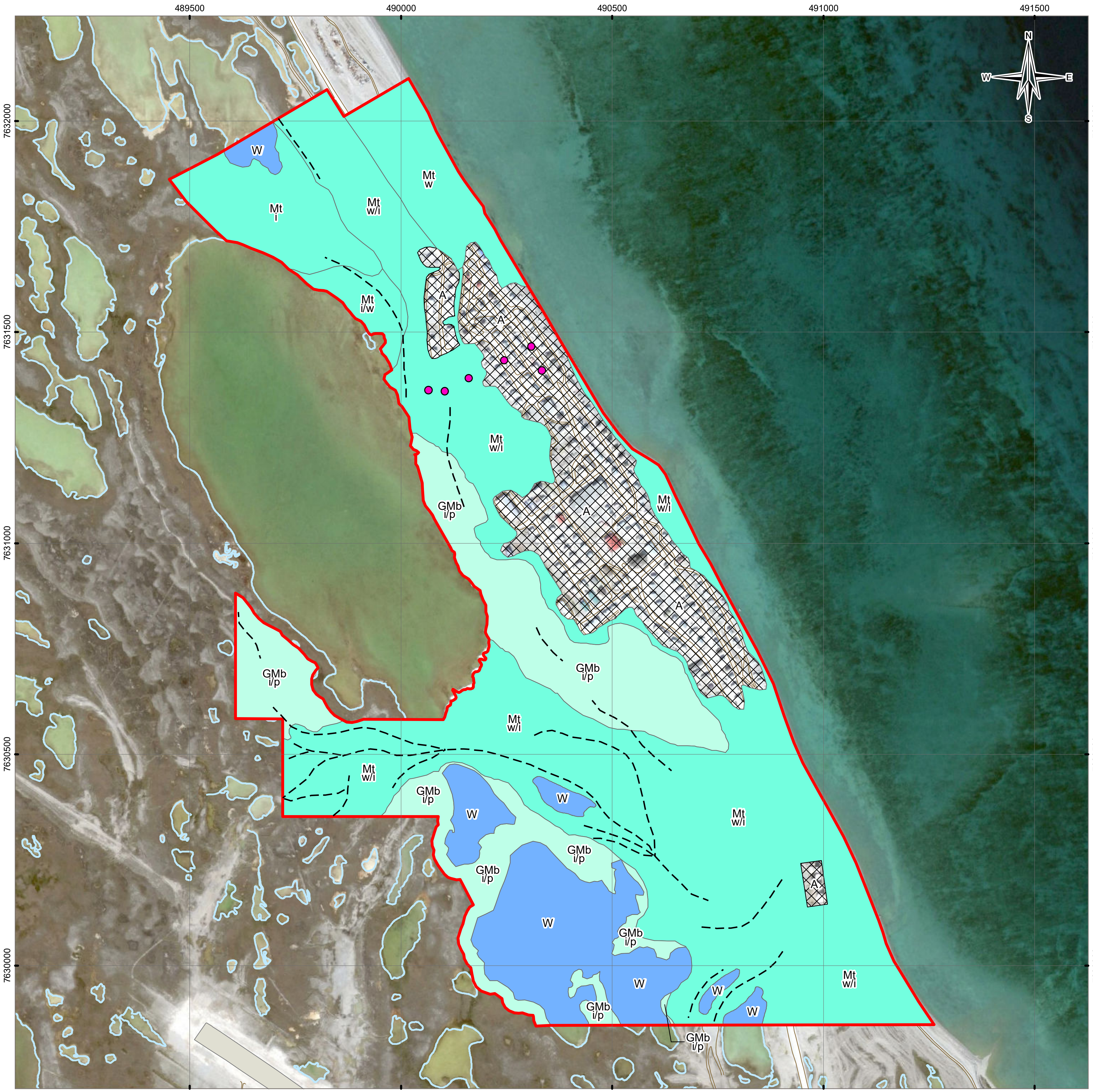
- Several areas are plagued by nuisance ponding, including residences and around the Co-op building, impacting access to homes and the grocery store.
- Several of the existing CSP culverts are buried and/or crushed.
- High water levels during spring freshet were confirmed by the Hamlet foreman as the main drainage concern, and cause ponding throughout the community.

Photographs of the existing system components and their condition are included in Appendix E.

3.2 Geology Field Reconnaissance

The site reconnaissance visit was conducted by Dr. Roujanski of Tetra Tech's Edmonton office on September 11, 2019. The purpose of the field reconnaissance was to confirm the findings of the background data review and preliminary terrain mapping, as well as to collect additional data relevant to potential terrain-related constraints.

The fieldwork focused on the proposed community expansion areas. A foot traverse was conducted across the study area with stops at selected observation sites shown on Figures 3-1 and 3-2. The collected information includes types of surficial materials, surface expression, and soil drainage conditions., No permafrost-related processes and phenomena were observed during the site reconnaissance. Numerous GPS-linked photographs of the terrain features were taken. Measuring active layer thickness (ALT) with the permafrost probe within the study area was found ineffective due to the high clast content of the surficial materials and very shallow top of bedrock.



LEGEND

- Field Observation Site Location
- Raised Beach Ridge
- Study Area
- Runway
- Gravel Road
- Watercourse
- Waterbody

NOTES
Terrain Classification based on data provided by Carleton.
Hydrology and transportation base data provided by Government of Nunavut, August 2016
Imagery provided by Google Earth (August 11, 2016)

SURFICIAL MATERIAL

M — **Marine (Littoral) Deposit:** sediments (coarse sand, gravel, and shingles with variable amounts of silt) derived from shattered limestone, related to marine inundation during periods of higher sea level.

GM — **Glaciomarine Deposit:** stony sandy silt, poorly sorted, 1 to 5 m thick; mantles and reflects topography of the underlying till or bedrock; Unit may include patches of marine deposits or till.

W — **Water:** water bodies such as lakes and ponds.

A — **Anthropogenic Material:** human-made or modified geological material whose original properties have been changed.

SURFICIAL EXPRESSION

b **Blanket:** deposit greater than 1 m thick (generally 1 to 5 m thick; more than 0.3 m for organic deposits); minor irregularities of the underlying unit (generally bedrock) are masked.

t **Terrace:** level or gently inclined surface flanked by steep slope or scarp.

DRAINAGE CLASS

w Well Drained Surface

i Imperfectly Drained Surface

p Poorly Drained Surface

DELIMITERS

/ First component more common than second (e.g. i/w means that 60-75% of the polygon area is imperfectly drained, with the remainder being well drained).

TERRAIN CODE

Upper case letter = Surficial Material
Lower case letter = Surficial Expression

Ov//Fp — Delimiter; Second unit; First unit
p/i — Secondary Drainage; Primary Drainage; Drainage Delimiter

STATUS
ISSUED FOR USE

GEOTECHNICAL INVESTIGATION AND DRAINAGE PLANNING HALL BEACH, NUNAVUT

Terrain Map

PROJECTION	DATUM	CLIENT
UTM Zone 17	NAD83	Nunavut

Scale: 1:10,000
200 100 0 200
Metres

FILE NO.
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DATE	PROJECT NO.
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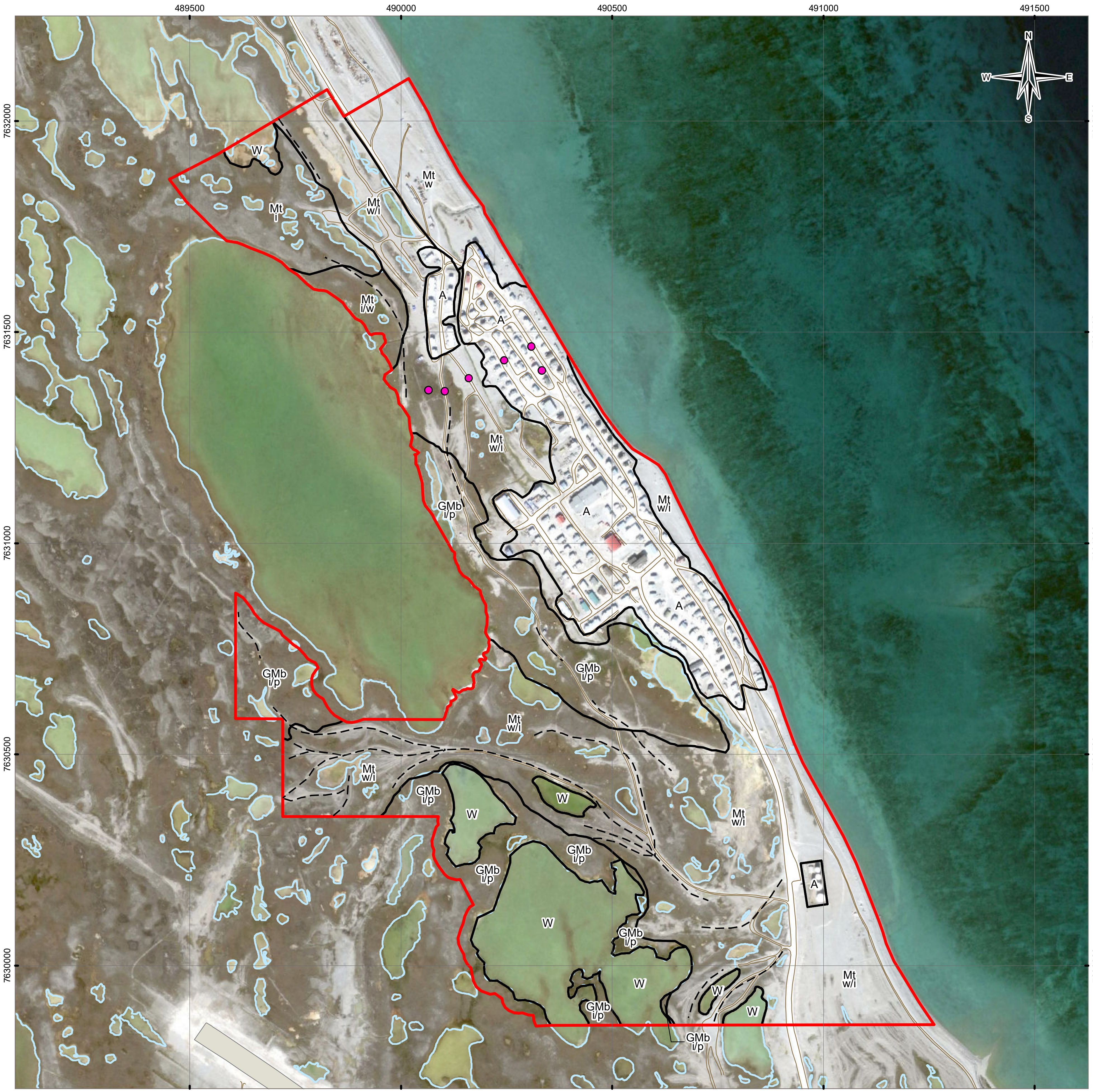
Figure 3-1



LEGEND

- Field Observation Site Location
- Raised Beach Ridge
- Study Area
- Runway
- Gravel Road
- Watercourse
- Waterbody

NOTES
Terrain Classification based on data provided by Carleton.
Hydrology and transportation base data provided by Government of Nunavut, August 2016
Imagery provided by Google Earth (August 11, 2016)

SURFICIAL MATERIAL

M — **Marine (Littoral) Deposit:** sediments (coarse sand, gravel, and shingles with variable amounts of silt) derived from shattered limestone, related to marine inundation during periods of higher sea level.

GM — **Glaciomarine Deposit:** stony sandy silt, poorly sorted, 1 to 5 m thick; mantles and reflects topography of the underlying till or bedrock; Unit may include patches of marine deposits or till.

W — **Water:** water bodies such as lakes and ponds.

A — **Anthropogenic Material:** human-made or modified geological material whose original properties have been changed.

SURFICIAL EXPRESSION

b **Blanket:** deposit greater than 1 m thick (generally 1 to 5 m thick; more than 0.3 m for organic deposits); minor irregularities of the underlying unit (generally bedrock) are masked.

t **Terrace:** level or gently inclined surface flanked by steep slope or scarp.

DRAINAGE CLASS

w Well Drained Surface

i Imperfectly Drained Surface

p Poorly Drained Surface

DELIMITERS

/ First component more common than second (e.g. i/w means that 60-75% of the polygon area is imperfectly drained, with the remainder being well drained).

TERRAIN CODE

Upper case letter = Surficial Material
Lower case letter = Surficial Expression

Ov//Fp ← Delimiter, Second unit
p/i ← Secondary Drainage, Drainage Delimiter
First unit
Primary Drainage

STATUS
ISSUED FOR USE

GEOTECHNICAL INVESTIGATION AND DRAINAGE PLANNING HALL BEACH, NUNAVUT

Terrain Map

PROJECTION	DATUM	CLIENT
UTM Zone 17	NAD83	Nunavut

Scale: 1:10,000
200 100 0 200
Metres

TETRA TECH

FILE NO.				
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March 26, 2020	TRN.WTRM03187-01			

Figure 3-2

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3.3 Geology Terrain Mapping

3.3.1 Surficial Geology and Permafrost

Surficial geology mapping of the proposed Hall Beach community expansion areas was carried out by Mr. Vladislav E. Roujanski, Ph.D., P.Geol. and Ms. Jennifer Stirling, P.Geo., with GIS support provided by Ms. Megan Verburg and Ms. Stephanie Leusink.

The existing surficial geology map of the region (Dredge 1988) was reviewed and modified to create a detailed terrain map of the study area. The B&W air photos (stereopairs) listed in Section 2.1 were interpreted using a Sokkia MS27 stereoscope. Surficial geology polygons were delineated on Google Earth Pro™ historical imagery of the study area using Google Earth Pro™ mapping tools.

The resultant terrain map shows spatial distribution of surficial materials. Surficial geology polygons were delineated in areas where terrain and subsurface data was available. This information was then extrapolated to unknown areas using appearance (texture, colour, hue etc.) on the air photos.

All terrain polygons were assigned a drainage class, except for "the Anthropogenic Material" map unit, drainage of which was modified during the land development. The following three drainage classes are used to characterize drainage conditions across the study area:

- well drained (**w**),
- imperfectly drained (**i**), and
- poorly drained (**p**).

These drainage classes are relative and qualitative.

The terrain map is presented at a scale of 1:12,000 and should be considered accurate to that scale (Figures 3-1 and 3-2).

3.3.2 Development Suitability Ranking

Construction suitability within the study area is based on the presence of terrain constraints. and potential geohazards.

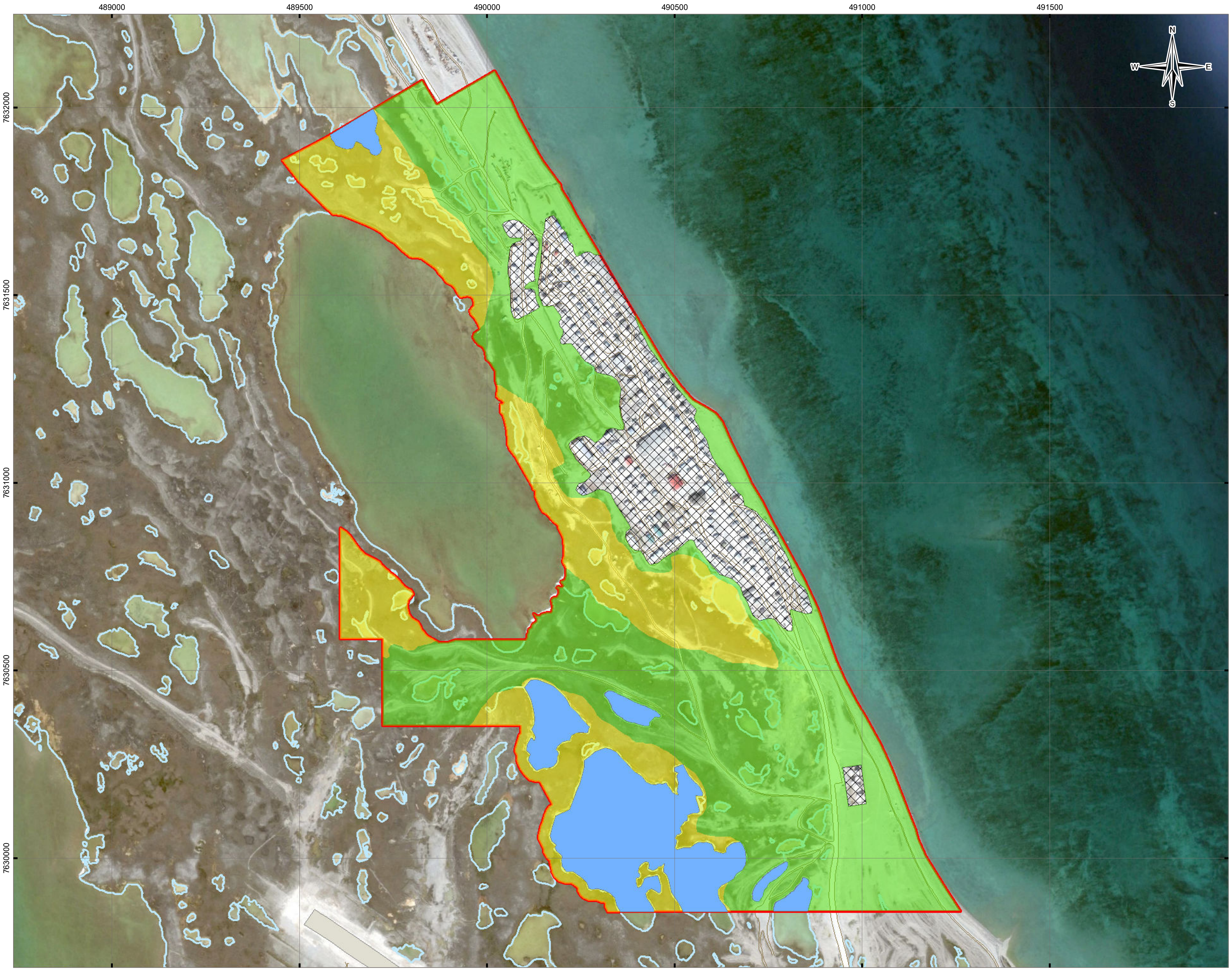
Terrain constraints in the study area include surficial material type, permafrost conditions (thermal state and ice content), drainage conditions, and slope steepness. These naturally occurring features affect the design, construction techniques and maintenance of the community infrastructure, housing and facilities.

Geohazards in the study area consist of potential permafrost degradation in the form of thermokarst and thermal erosion. Although these processes haven't been observed during the recent site reconnaissance, they were identified through background data review and may adversely affect existing or potential infrastructure, housing and facilities.

A Development Suitability Map of the study area was produced at a scale of 1:12,000 and is shown in Figure 3-3.

The development suitability classes for the project area were established as follows:

- **Suitable for Development:** Ground surface is flat and well- to imperfectly-drained; permafrost appears to be predominantly ice-poor with ground ice content generally less than 10% by volume of visible ice or does not contain excess ice and, therefore permafrost terrain is generally stable; permafrost processes are inactive to limited;
- **Conditionally Suitable for Development (Provided Tetra Tech's Drainage Improvement Plan is Implemented):** Ground surface is imperfectly to -poorly-drained with pools of standing water; permafrost may contain excess ice but appears to be relatively stable to potentially unstable to human-induced disturbance;



LEGEND

Study Area

Construction Suitability

Suitable for Development

Conditionally Suitable for Development Provided the Drainage Improvement Plan is Implemented

Terrain Not Assessed for Development Suitability

Anthropogenic

Water

Base Features

Runway

Gravel Road

Watercourse

Waterbody

NOTES

Base data source:
Terrain Classification based on data provided by Carleton.
Hydrology and transportation base data provided by Government of Nunavut, August 2016
Imagery provided by Google Earth (August 11, 2016)

STATUS
ISSUED FOR USE

GEOTECHNICAL INVESTIGATION AND DRAINAGE PLANNING HALL BEACH, NUNAVUT

Development Suitability

PROJECTION	DATUM	CLIENT
UTM Zone 17	NAD83	Nunavut

Scale: 1:10,000

200 100 0 200

Metres

TETRA TECH

FILE NO.
WTRM03187-01_Figure3_3_Suitability.mxd

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DATE	PROJECT NO.
March 26, 2020	TRN.WTRM03187-01

Figure 3-3

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3.3.3 Development of the Georeferenced Map

Using the GPS points, field notes and photographs obtained during the site visit, the topology of the drainage network was put together in a GIS shapefile. The shapefile includes locations of open channels (ditch or swale) and culverts. A naming convention was developed and every asset was named in the shapefile. Connectivity of the drainage system was developed using data from the site visit, and was supplemented by mapping data provided by the government. A separate shapefile was created to mark areas with drainage issues identified during the site visit. The drainage issues identified included ponding areas, damaged culverts, and uncontrolled overland flow. Figures 3-4 to 3-6 in Section 3.6 highlight the documented drainage issues.

3.4 Drainage

The community of Hall Beach is built above natural grades with highly pervious material. From Tetra Tech's 2019 site visit, there was little to no evidence of observable overland flow during periods of rainfall. Drainage issues for the community are purely attributed to springtime snowmelt, a time when the lakes west and south of the community rise. The rising water levels cause surface ponding in the hamlet in multiple areas and prevent timely drainage of low points within the hamlet.

Tetra Tech has completed a delineation of the existing drainage patterns within Hall Beach using the 2015 Aerial Photograph derived DEM as well as from observations and photographs collected during the site visit. Drainage areas and flow paths are presented on Figure 2-2 in Section 2.3.3. These flow paths were corroborated by anecdotal information provided by community members.

Based on the 2018 Community Plan, the majority of the land allocated for future expansion of the community is located on the west side of the existing community, towards the lake, and south towards the existing airport lands. Developing drainage paths and proposed drainage infrastructure for these future development areas is included within the scope of the Master Drainage Plan.

3.5 Drainage Infrastructure

During the 2019 site visit, existing ditches, swales, and natural streams were observed. Additionally, 7 culverts were assessed. The diameter of the culverts ranged from 500 mm to 2000 mm. Several of the culverts were damaged or partially or fully buried, and some were more functional than others. An Inventory of Existing Culverts is included in Appendix E. Naturally formed swales and streams were observed throughout the community including few formal ditches.

3.6 Drainage Issues

Developing and maintaining a well-functioning drainage system is an ongoing concern within most northern communities. From Tetra Tech's 2019 site visit, several types of drainage issues in Hall Beach were identified. Many existing culverts were damaged, buried, and/or blocked with sediment, rocks, and debris. A lack of formalized swales or ditches was an issue that resulted in ponding water, affecting the mobility of residents.

Typical drainage issues identified within the community of Hall Beach are detailed in Table 3-1.

Table 3-1: Hall Beach Drainage Issues

Issue	Cause
Damaged culvert inlet/outlet	Damage caused by excavator cleaning snow and/or ice during spring
Buried or blocked culvert inlet/outlet	Culvert inlet and/or outlet blocked due to sediment, rock, and debris deposition, and/or ice blockage.
Ponding	Blocked culverts, poor grading, lack of an outlet.

Figures 3-4 to 3-6 below depict the drainage issues and existing infrastructure identified in Hall Beach. Figures 3-7 to 3-11 show examples of the typical drainage issues identified during Tetra Tech's site visit. Appendix E includes a summary of the existing culverts identified within the community.

LEGEND

Culverts

- Partially Blocked
- Damaged

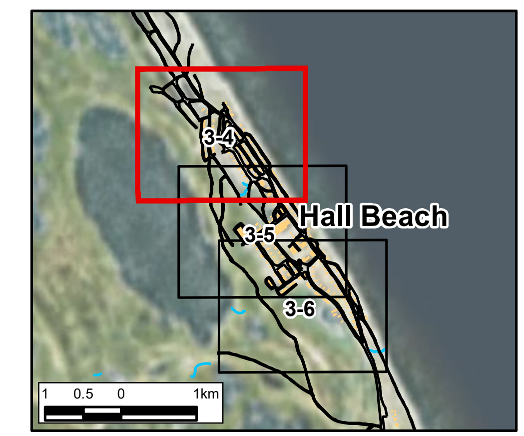
C## Culvert Number

Open Channels

- Well Defined Flow Path
- Ponding

Base Data

- Parcel
- Gravel Road
- Topographic Contour (5 m)
- Watercourse
- Waterbody



NOTES
Base data source:
1. Hall Beach base data from Government of Nunavut

STATUS
ISSUED FOR USE

HALL BEACH MASTER DRAINAGE PLAN

Hall Beach Drainage Issues

PROJECTION	DATUM	CLIENT
UTM Zone 17	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

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FILE NO.
WTRM03187-01_DrainageIssues.mxd

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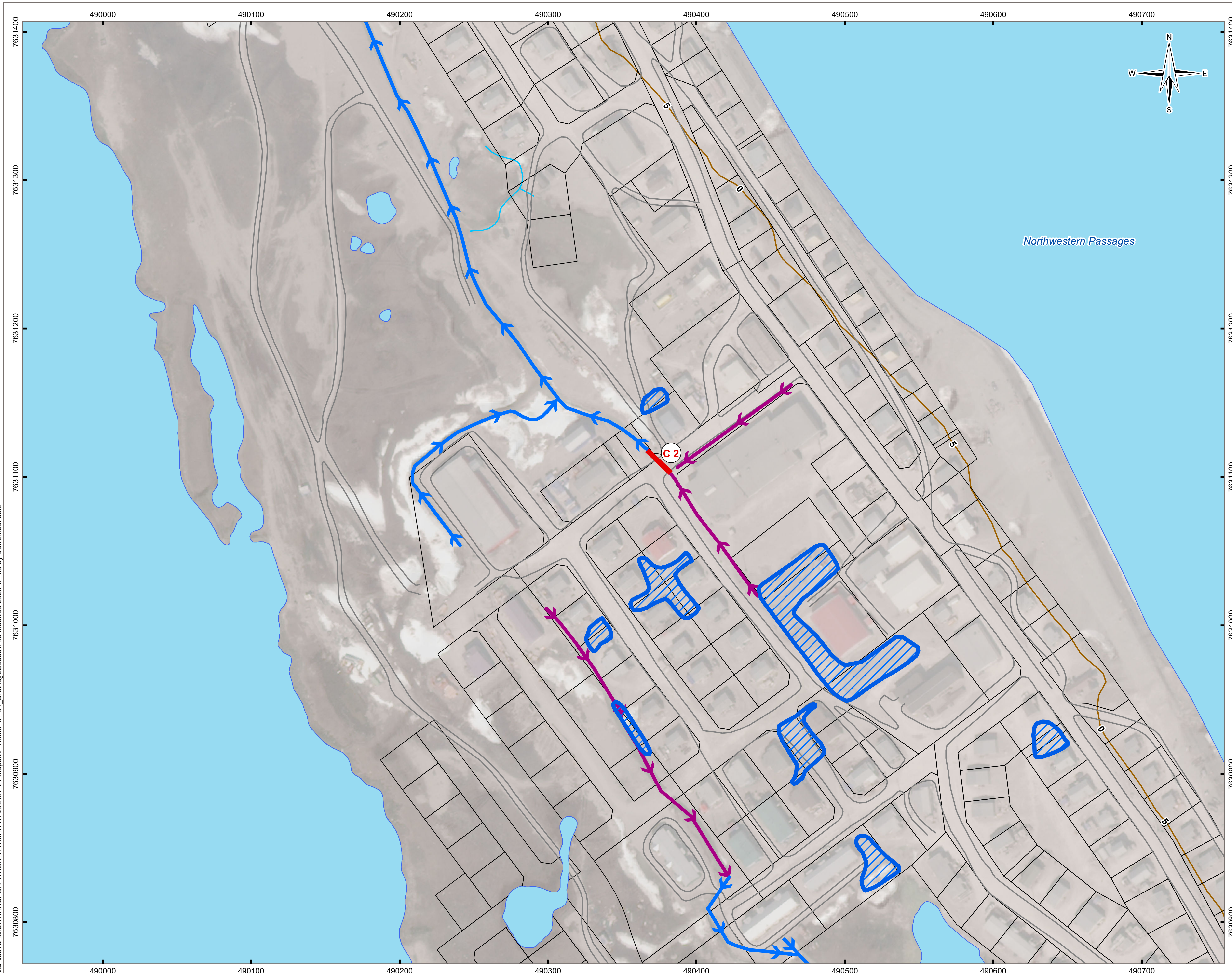
PROJECT NO.
TRN.WTRM03187-01

Figure 3-4



LEGEND

Culverts

- Blocked

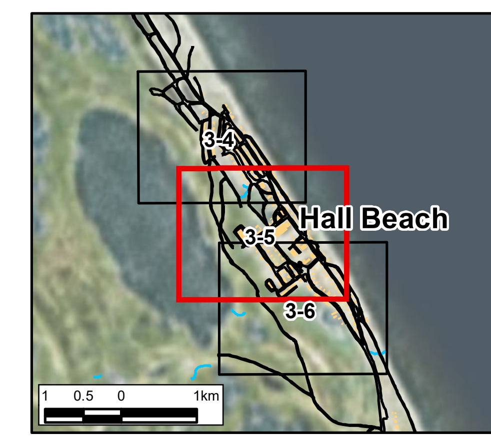
C## Culvert Number

Open Channels

- Well Defined Flow Path
- Overland Flow Path
- Ponding

Base Data

- Parcel
- Gravel Road
- Topographic Contour (5 m)
- Watercourse
- Waterbody



NOTES
Base data source:
1. Hall Beach base data from Government of Nunavut

STATUS
ISSUED FOR USE

HALL BEACH MASTER DRAINAGE PLAN

Hall Beach Drainage Issues

PROJECTION	DATUM	CLIENT
UTM Zone 17	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

TETRA TECH

FILE NO.
WTRM03187-01_DrainageIssues.mxd

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DATE	PROJECT NO.
April 6, 2020	TRN.WTRM03187-01

Figure 3-5

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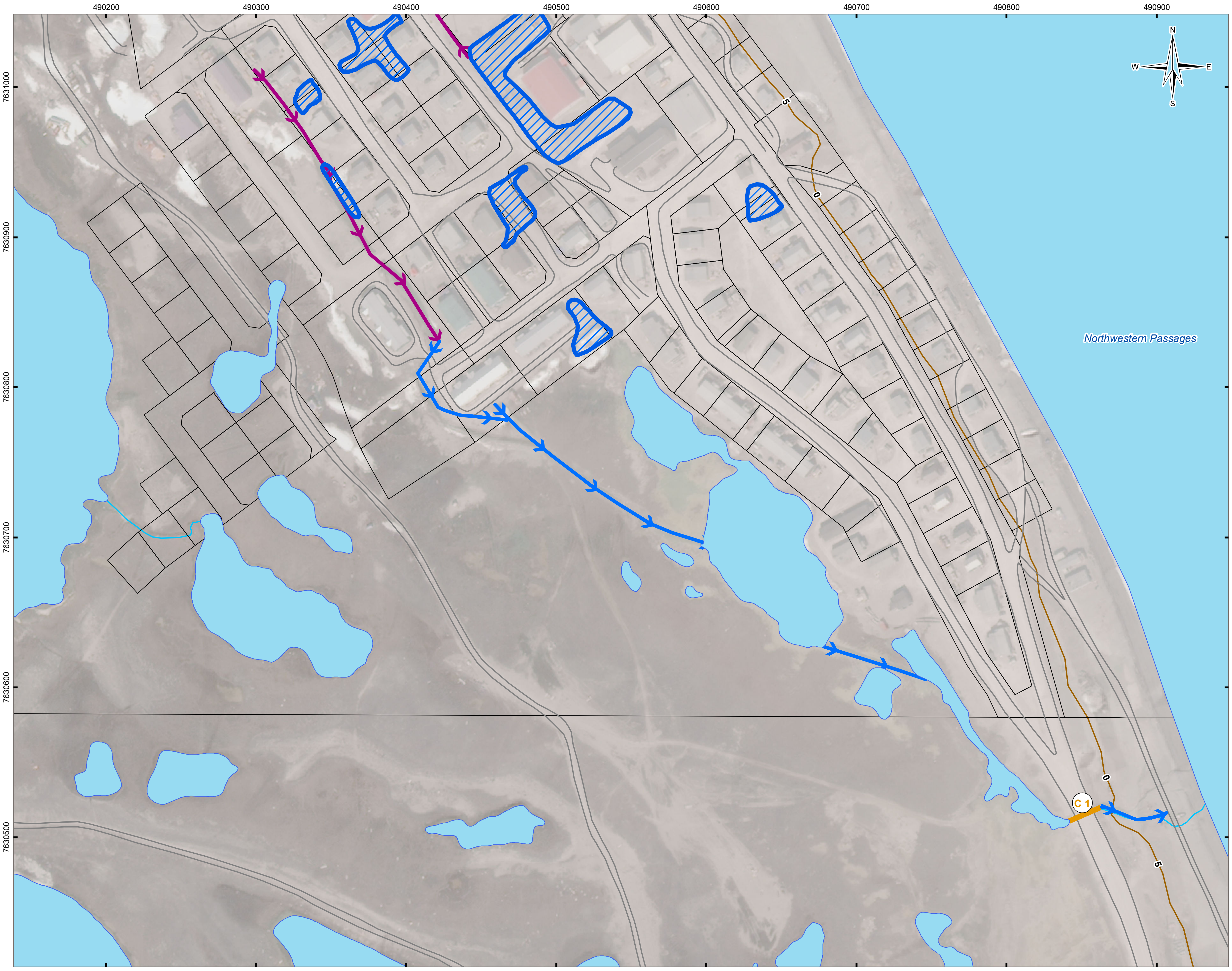


LEGEND

Culverts

C## Culvert Number

Damaged

Open Channels

Well Defined Flow Path

Overland Flow Path

Ponding

Base Data

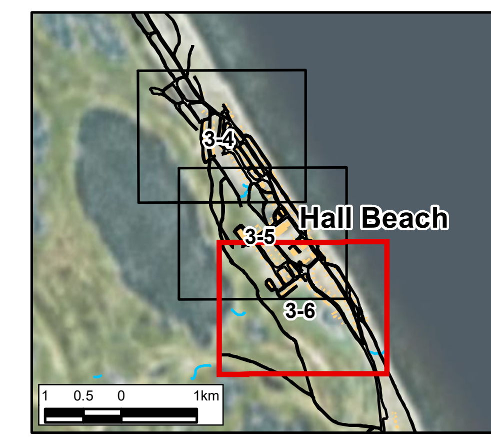
Parcel

Gravel Road

Topographic Contour (5 m)

Watercourse

Waterbody



NOTES
Base data source:
1. Hall Beach base data from Government of Nunavut

STATUS
ISSUED FOR USE

HALL BEACH MASTER DRAINAGE PLAN

Hall Beach Drainage Issues

PROJECTION	DATUM	CLIENT
UTM Zone 17	NAD83	Nunavut

Scale: 1:2,500

40 20 0 40

Metres

FILE NO.
WTRM03187-01_DrainageIssues.mxd

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DATE
April 6, 2020

PROJECT NO.
TRN.WTRM03187-01

TETRA TECH

Figure 3-6

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Figures 3-7 to 3-11: Hall Beach Drainage Issues – Site Visit August 28

Figure No.	Description	Image
3-7	Damaged culvert inlet. Culvert C7	
3-8	Partially buried and damaged culvert inlet. Culvert C6	
3-9	Area where ponding water typically occurs near building	

Figure No.	Description	Image
3-10	Area beside Co-op Grocery store that typically ponds. Regrading required.	
3-11	Sloughing of material into swales and ditches preventing free flow and causing standing water.	

4.0 ANALYSIS OF DRAINAGE SYSTEM

Drainage principles, design criteria, and design scenarios used to develop the proposed drainage system for the Hamlet of Hall Beach are described in this section of the report, as well as modelling results and recommendations.

4.1 Drainage Principles

According to the guidelines for community drainage system planning, design, and maintenance in northern communities (CSA Group, 2015), the drainage system should be designed in accordance with the level of risk that is established during the planning process. The CSA Group also noted that:

- *It is recognized that the capacity of any drainage system might be exceeded at some point.*
- *The design will be impacted by physical constraints present within communities.*
- *The desired acceptable level of risk might not be achievable in any given community due to physical (spatial) limitations, resources, subsurface conditions, and topography, among other factors.*
- *The acceptable level of risk established might be impacted by the changing the climate, for example, due to the changing climate, what was previously considered to be a 1-in-10-year event might occur on average every five years in the future."*

In addition to the CSA Group's design principles, the development of the proposed upgrades was based on Tetra Tech's practical principles as follows:

1. Effectively capture and route water around populated areas to protect buildings and communities.
   a. Where possible, minimize the imposition of waterways through populated areas by restricting use of large ditches to areas outside of the populated areas;
2. Utilize shallow swales for driveway crossings and roadside drainage.
3. Minimize complexity for drainage system construction, maintenance, and management by:
   a. Minimizing the number of different culvert diameters specified.
   b. Minimizing the number of new culverts, which would not only need to be barged to Hall Beach for installation, but also need to be maintained once installed.
   c. Minimizing the number of different ditch and swale dimensions specified.
   d. Keeping the design simple such that the Hamlet foreman and crew can not only construct but also maintain the new drainage systems with ease.
4. Capture and immediately convey water towards the nearest major watercourse/waterbody (i.e. ocean, lake, river, or stream).
5. Use multiple outlets to add redundancy at critical locations throughout the system.
6. Design using projected precipitation trends to account for future climate change.
7. Select culvert sizes based on available roadway embankment cover.

8. Design drainage swales through driveways to comfortably accommodate the tires and undercarriage of vehicles.

9. Develop plans recognizing the land use limitations, for example remove nuisance ponding from the front of the Northern Store and from the foot of exterior staircases leading to residences.

4.2 Design Criteria

As per the guidelines for community drainage system planning, design, and maintenance in northern communities (CSA Group, 2015), the culvert design capacity prescribed by the CSA Group is:

- *Size culverts to accept design flow at 80% capacity under free flow condition (1:10 year event).*
- *Size culverts to accept 1:100 design flow at 80% of available head at entrance.*

In addition to the above requirements the proposed drainage system was developed to meet the following general criteria:

1. Ditches and swales were sized to convey the 10-year snowmelt event. The 10-year snowmelt event was selected as the critical 10-year event following a review of freshet snowmelt events and a number of rainstorm durations ranging from 1 hour to 24 hours. The goal was to provide sufficient capacity to handle the critical event. Tetra Tech has further upsized the culverts to add additional capacity to compensate for debris deposition blocking the culverts and limiting their capacity. Buried culverts and significant deposition were noted in the majority of culverts identified in the field visit described in Section 3.1.

2. Ditches were sized to maintain at least 100 mm of freeboard during the 10-year snowmelt event.

3. Swales were sized to maintain at least 50 mm of freeboard during the 10-year snowmelt event.

4.3 Design Scenarios

The model was run with six design storm scenarios: the 10-year 1-hour, 10-year 24-hour, 10-year snowmelt, 100-year 1-hour, 100-year 24-hour, and 100-year snowmelt event. Using historical data extracted from the Hall Beach weather station, a synthetic distribution was developed to represent the rainfall pattern likely to develop over the course of a 24-hour rainfall event.

The 1-hour storm distributions were developed using the Northern Quebec AES distribution. Climate change adjusted precipitation volumes for each of the scenarios were obtained using the IDF_CC Tool v4.0 developed by Western University as described in Section 2.4.2.2 of this report. The resulting peak flow rates for each design storm are summarized in Table 4-1.

As stated in Section 4-2, the 10-year snowmelt event was selected as the critical 10-year event following a review of freshet snowmelt events and a number of rainstorm event durations ranging from 1 hour to 24 hours. The snowmelt events were estimated by running a continuous model of Hall Beach between 1989 and 2019. Annual freshet flow rates were generated over this time span. A statistical analysis was carried out on the estimated annual flow rates to produce 10-year and 100-year snowmelt-driven flow rates (Figure 4-1). The results of the statistical analysis for culvert C6 are shown in Table 4-2.

Table 4-1: Hall Beach Design Storm Events

Design Storm Events	Peak Flow Rate (m^3/s) *
10-year 1-hour	0.02
10-year 24-hour	0.09
10-year Snowmelt	**0.48**
100-year 1-hour	0.53
100-year 24-hour	0.27
100-year Snowmelt	0.65

* Peak Flow Rate measured through culvert C6 in the PCSWMM model.

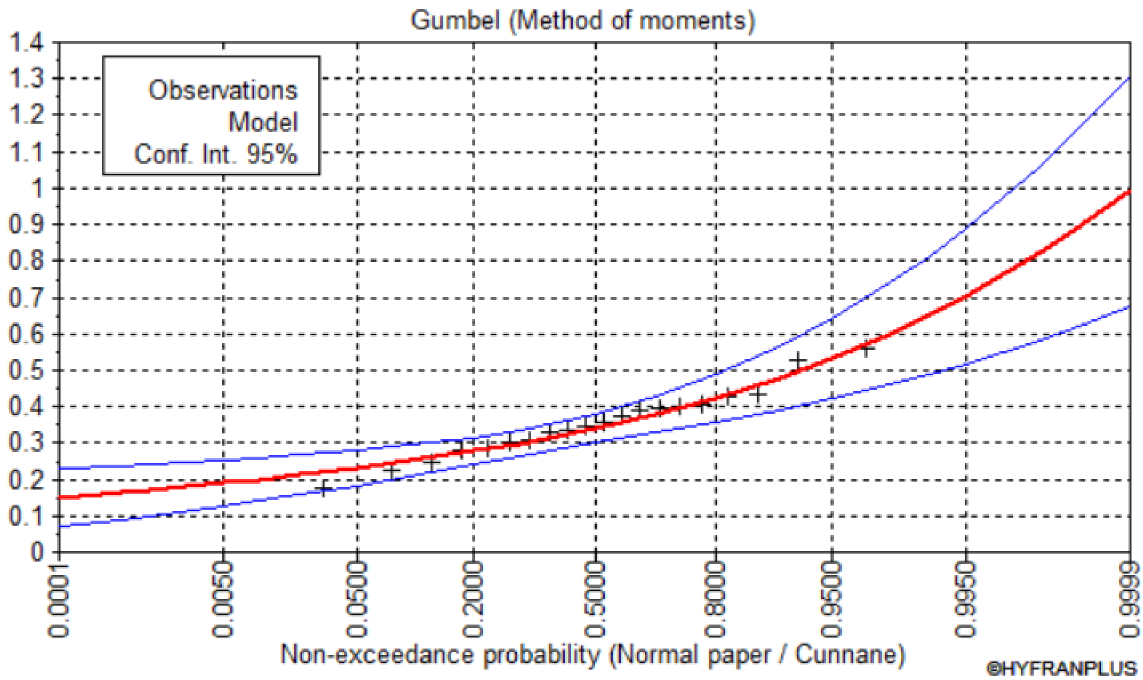


Figure 4-1: Peak Annual Flow Rate Data Fitting

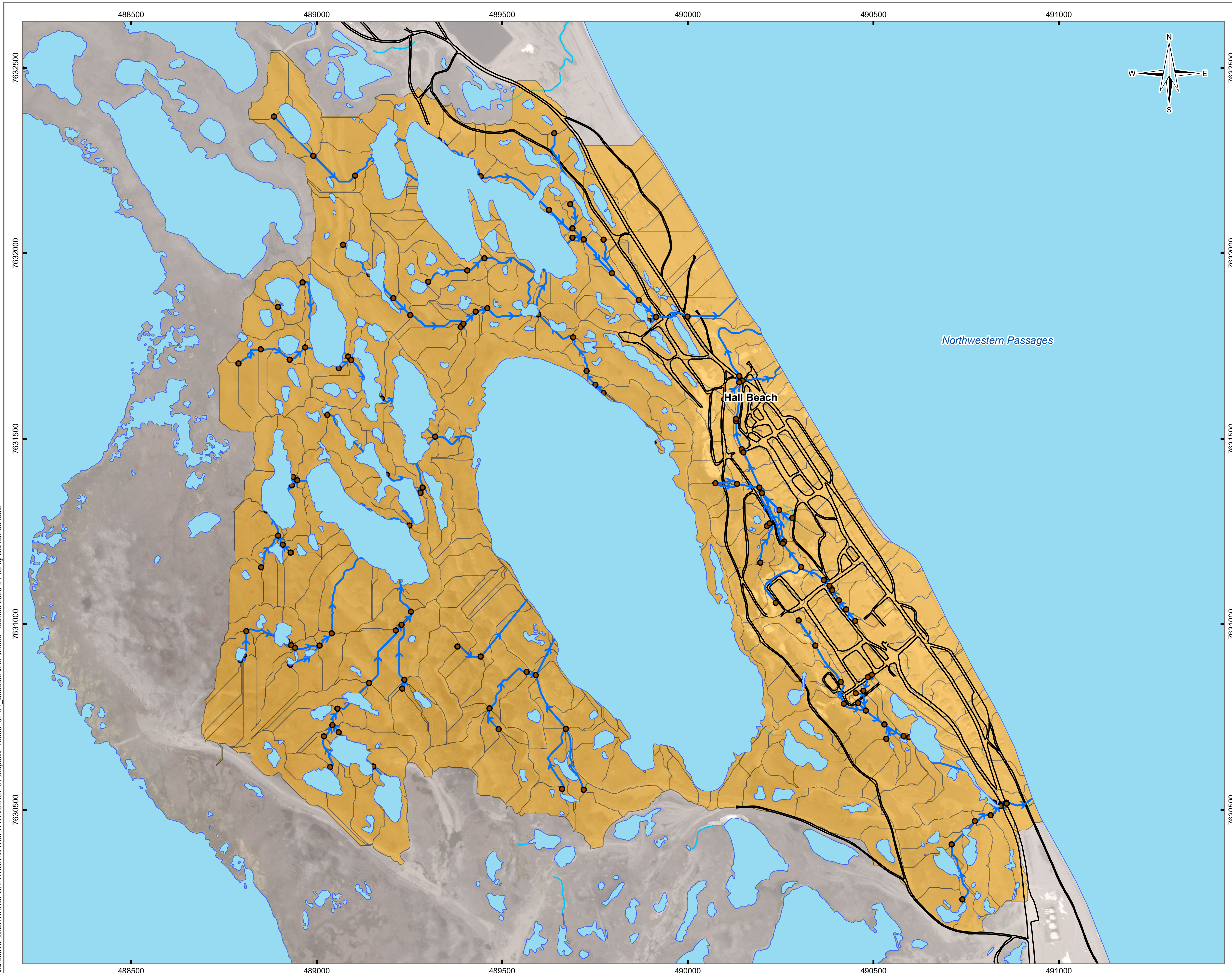
Table 4-2: Snowmelt Design Storm Events for Culvert C6

Return Period (years)	Peak Flow Rate (m^3/s)
200	0.70
100	0.65
50	0.6
20	0.53
10	0.48
5	0.42
2	0.34

4.4 Modelling of System

A systems analysis approach was adopted to design the proposed drainage system for the Hamlet of Hall Beach. PCSWMM, a state-of-the-art stormwater program was used to develop the model of the drainage system. The model uses a node-link arrangement where links represent conduits, such as ditches and culverts; and junctions represent a point where two or more links are joined, according to how the drainage network operates.

In addition, the drainage area is split into subareas or subcatchments, which are the hydrological units used to calculate flows. Flows calculated from a subcatchment are assigned to a junction, and then hydraulically routed through the drainage network. Through this approach, flows are aggregated through the system until discharged at an outfall point. Figure 4-2 shows the sub-catchments, junctions and conduits represented in the model. Input parameters for the subcatchments, junctions and conduits are presented in Appendix G.

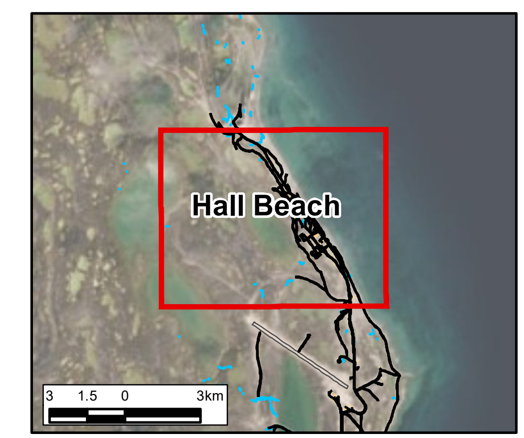


LEGEND

- Junction
- Natural Drainage Path
- Subcatchment

Base Data

- Gravel Road
- Watercourse
- Waterbody



NOTES
Base data source:
1. Hall Beach base data from Government of Nunavut

STATUS
ISSUED FOR USE

HALL BEACH MASTER DRAINAGE PLAN

PCSWMM Model of Natural Drainage Paths

PROJECTION	DATUM	CLIENT
UTM Zone 17	NAD83	Nunavut

Scale: 1:10,000
200 100 0 200
Metres

FILE NO.
WTRM03187-01_Subcatchments.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DS	SL	ER	0

DATE	PROJECT NO.
April 6, 2020	TRN.WTRM03187-01

Figure 4-2

Q:\Vancouver\GIS\TRANSPORTATION\WTRM\WTRM03187-01\Maps\WTRM03187-01_Subcatchments.mxd modified 2020-04-06 by Darren.Schouls

Although the typical process followed in developing a stormwater management plan includes the development of a hydrologic/hydraulic model of the existing system, the absence of a proper drainage system within the community has forced Tetra Tech to advance directly to the modelling of the proposed system and then use the modelling results to size and identify the type of infrastructure required to convey the estimated flows.

After modelling the scenarios described in Section 4.3, Tetra Tech proposes that five of the existing culverts be replaced and that two new culverts be added to the existing system, as shown in Table 4-3. In addition, Tetra Tech is also recommending that a formal system of swales and ditches be integrated into the community allowing for the safe conveyance of runoff. Table 1 in Appendix F shows the specifications and modelled performance of the proposed culverts for the 10-year snowmelt design scenario. As detailed, Tetra Tech is recommending that the proposed culverts range in size between 600 mm to 1200 mm.

As the CSA recommends that culverts be sized to a minimum of 450 mm in diameter, Tetra Tech has opted to maintain this minimum size requirement. It should be noted that in certain cases the swale profiles and site limitations will force the embedment of some culverts so to meet the minimum depth of cover requirements set by the supplier of the selected culvert. The minimum cover requirements are needed to structurally support the integrity of the culverts. Figure 4-3 provides a schematic representation of the typical installation details where the integration of the minimum depth of cover requires culvert embedment.

Table 4-3: Summary of Recommended Culvert Actions

Recommended Culvert Action	Number of Culverts	Total Length (m)
Clean Out	2	26.5
Remove	5	65.1
Total Existing Culverts	**7**	**91.6**
Replace Existing	5	65.1
New	1	17.5
New - Future Community Expansion	1	18.1
Total New Culverts	**7**	**100.7**

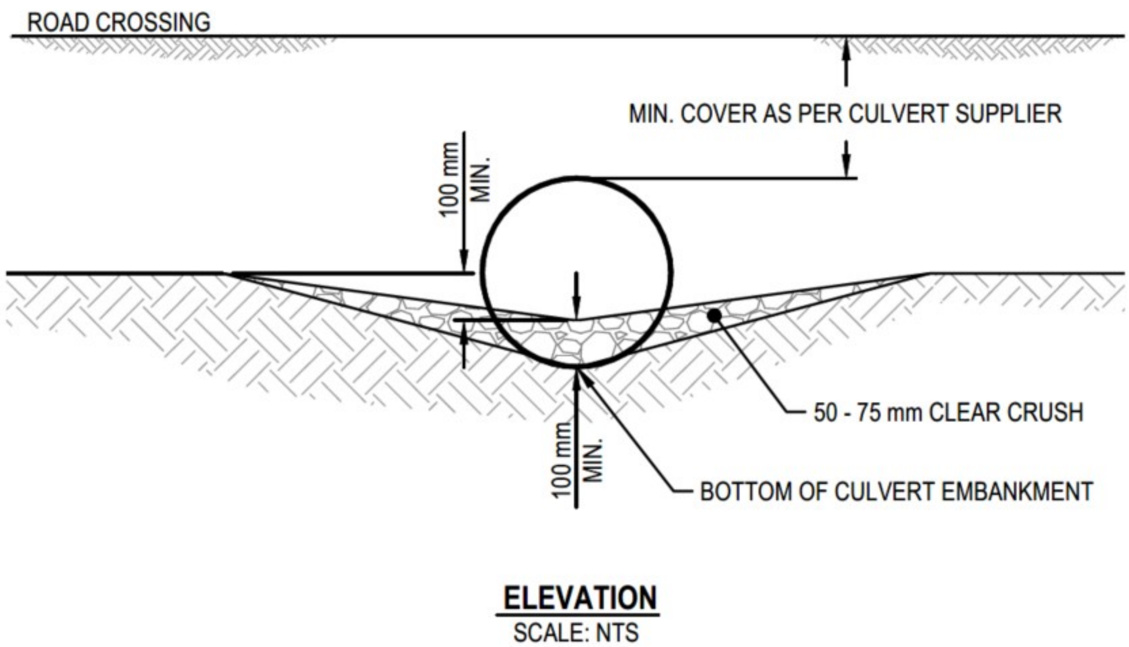


Figure 4-3: Typical Embedded Culvert Details

As noted in the proposed plans, a number of swales are being proposed. Adding deep/wide ditches would inevitably impact the ability of the hamlet residents to access their properties and would likely impact traffic movement.

4.5 Drainage Recommendations

This section presents a summary of recommended actions needed to upgrade the Level of Service of the drainage system of the Hamlet of Hall Beach. Currently, there are a number of deficiencies as identified in Section 3.0. Tetra Tech has developed the following series of recommendations which, when implemented, will remedy the issues identified throughout the community.

The proposed upgrades for the community include the upgrading of culverts, ditches and swales.

4.5.1 Culverts

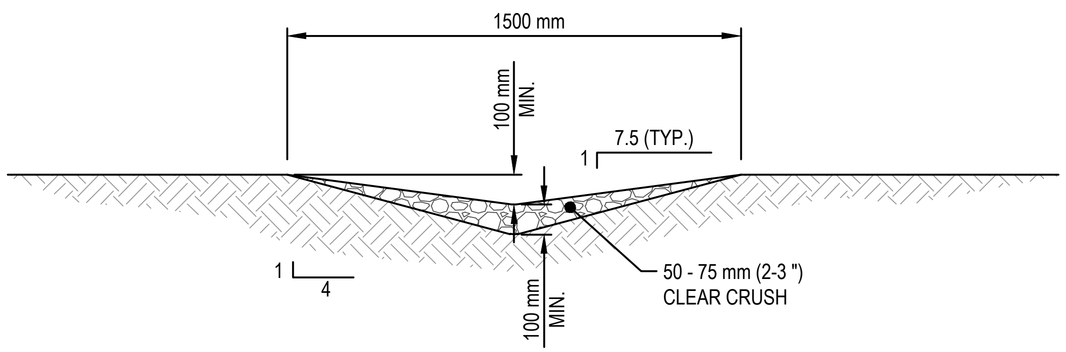
1. The minimum culvert size should be 450 mm. The minimum culvert size recommendation from CSA Group (2015) is 450 mm for de-icing purposes.
2. Cover over culverts shall meet the structural requirement set by the supplier of the selected pipe type. A recommended minimum cover of 300 mm should be included where vehicular traffic is likely to be present.
3. For long-term durability, the proposed culvert material should be Smooth Wall Steel Pipe (SWSP). The use of SWSP including a wall thickness of 10 to 12 mm will afford the community a very long service life. As detailed in Appendix E, most if not all corrugated steel pipes in Hall Beach have failed to retain their structural integrity, and have likely been damaged by maintenance equipment or road traffic. If, however, CSP culverts are preferred, Tetra Tech recommends the use of culvert end stiffeners or sleeves to better

support the structural integrity of the ends of the culverts. A sample photo of a culvert end stiffener is included in Appendix H. Note that Tetra Tech recommends a wider stiffener covering a width equal to 2 times the culvert diameter. Details of a culvert end stiffener and sleeve are included in Figure 6-5 in Section 6.3.1.

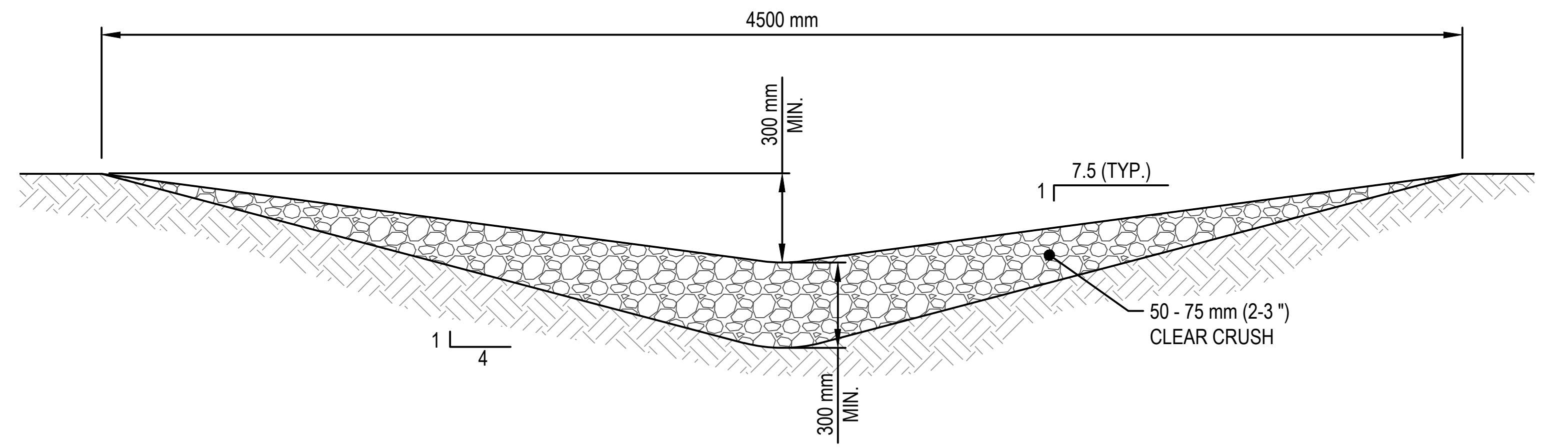
4. Culverts should be provided with high visibility markers to prevent damage during spring cleaning activities.
5. An annual maintenance program should be implemented to prepare the system for the spring freshet. This may include the steaming of specific culverts and/or the removal of debris limiting the capacity of the culvert crossings.
6. Table 1 in Appendix F includes the proposed culvert upgrades throughout the hamlet.
7. Based on the areas of erosion noted during our site visit and on water velocities modelled using PCSWMM, Tetra Tech recommends the use of riprap aprons for culvert inlets and outlets. Appendix F includes riprap and geotextile recommendations for all culvert aprons.
8. Culverts are to extend a minimum of one culvert diameter past the embankment as shown in Figure 6-9 in Section 6.3.3.
9. Headwall and endwall side slopes are to be 1.5H:1V to 2H:1V. Side slopes of 2H:1V are preferred where space allows.
10. Where space does not allow for a riprap protected side slope, culvert inlets and outlets should include a concrete headwall as a recommended alternative option.

4.5.2 Ditches and Swales

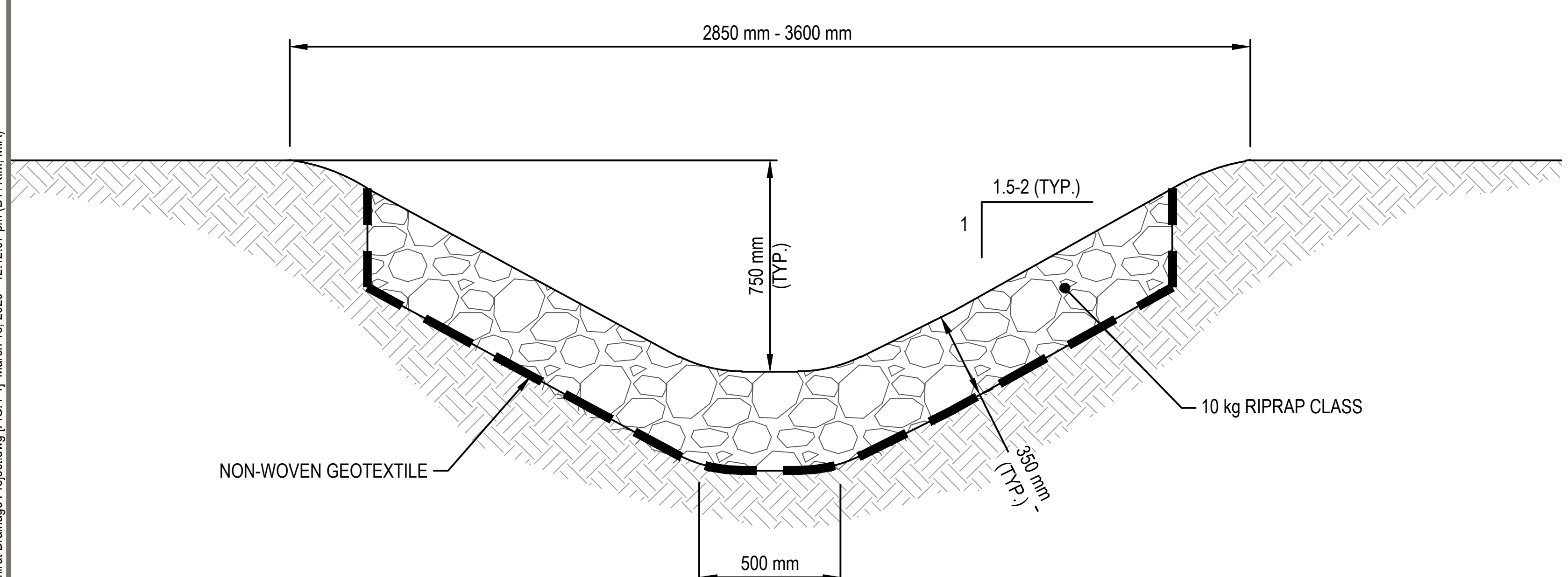
1. Open channels must include a revetment system for erosion protection, particularly in areas where permafrost can be impacted. Failure to do so may lead to hydraulic erosion, which in turn may lead to thermal degradation of the permafrost layer.
2. Ditches and swales should be as flat as possible, but not flatter than 0.5%.
3. Ditches to have a minimum bottom width of 500 mm, a minimum depth of 750 mm and side slopes ranging between 1.5H:1V to 2H:1V. Flatter side slopes should be considered near schools and children's playgrounds.
4. Ditches are to be lined with a 10 kg class riprap layer having a minimum thickness of 350 mm. See Figure 4-4 for riprap gradation.
5. Ditches are to be lined with a non-woven geotextile between the existing soil and the specified riprap layer.
6. Swales are to include a minimum depth of 100 mm. Swale side slopes are to be 7.5H:1V minimum to allow for vehicular traffic to safely cross without damage. Swales are to be lined with a 50-75 mm (2-3") clear crush layer with a minimum thickness of 100 mm in the centre of the swale. Figure 4-4 includes typical cross section details for the proposed ditches and swales.
7. The community of Hall Beach may wish to increase the active depth of the existing swales throughout the community by raising the road profiles. This may be necessary to formalize the proposed swale sections detailed in Figure 4-4.
8. To the extent possible, ponding water nearby and underneath of buildings should not be promoted. Grading practices underneath buildings should promote the movement of water away from the footprints of buildings.



1 TYPICAL SWALE
FIG.1 SCALE: 1:25



2 TYPICAL LARGE SWALE
FIG.1 SCALE: 1:25



3 TYPICAL DITCH
FIG.1 SCALE: 1:25

10 kg RIPRAP CLASS			
ROCK GRADATION PERCENTAGE (kg)			
15 %	50 %	85 %	
1	10	30	
APPROXIMATE AVERAGE DIMENSIONS (mm)			
15 %	50 %	85 %	100 %
90	195	280	330

TYPICAL 50-75 mm (2-3") CLEAR CRUSH GRADATION
SCALE:NTS

LEGEND

NOTES

NUM	DATE	DWN	CKD	APR	DESCRIPTION
A	03/24/20	MJK	ER	DNM	ISSUED FOR REVIEW

REVISIONS

PROFESSIONAL SEAL

CLIENT

Nunavut

TETRA TECH

HALL BEACH DRAINAGE PLAN

TYPICAL DITCHES AND SWALE DIAGRAMS

PROJECT NO.	OFFICE	DES	CKD	REV	DRAWING
WTRM03187-01	VANC	ER	ER	A	FIG.4-4
DATE	SHEET No.	DWN	APP	STATUS	
March 24, 2020	- of -	MJK	DNM	IFR	

5.0 SURFICIAL GEOLOGY AND PERMAFROST RESULTS

Most of the study area is underlain by marine (littoral) deposits composed of sand, gravel and shingles with high amounts of silt.

Surficial geology units are shown on the detailed terrain and permafrost feature map (Figures 3-1 and 3-2) and are summarized below.

Marine (Littoral) Deposits (**M**) are sediments (coarse sand, gravel, and shingles with variable amounts of silt) derived from shattered limestone, related to marine inundation during periods of higher sea level.

Glaciomarine Deposits (**GM**) consist of stony sandy silt, poorly sorted, 1 to 5 m thick. They mantle and reflect topography of the underlying till or bedrock. This unit may include patches of marine deposits or till.

Anthropogenic Material (**A**) consists of human-made or modified geological material whose original properties have been changed. It is shown in Figures 3-1 and 3-2 as a separate terrain unit.

No permafrost-related terrain features, processes and phenomena were observed within the study area except for frost-shattered stony material, which is commonly underlain by shallow limestone bedrock.

6.0 DRAINAGE MASTER PLAN

Based on the issues identified in the field, and on the modeling results, a number of upgrades are proposed for the existing drainage system, as well as for the proposed community expansion areas. The system being proposed is composed of ditches, swales and culverts, with outlet locations as shown in Figures 6-1 to 6-3. With the proposed upgrades combined with a proper maintenance program including removal of debris/sediments and de-icing, the proposed system will handle the design flows identified in Section 4.3 of this report.

6.1 Community Plan (Proposed Development Areas)

The 2018 Hall Beach Community Plan included in Appendix B outlines proposed developments which will allow for future community growth. Existing topography and drainage conditions were reviewed and a preliminary design of drainage infrastructure for the proposed development areas was developed.

Appendix B also includes the community plan overlaid on top of the geological development suitability discussed in Section 3.3.2. For parcels located on conditionally suitable terrain, extra drainage measures are recommended due to observed poor drainage and/or geological conditions. Site specific improvements could be implemented to make these areas developable. Tetra Tech recommends the following drainage measures for the expansion lots near the southeast edge of the lake, outlined in purple line in Figures B-1 and B-2:

- Raising the elevation of this area with suitable fill material is required to protect the permafrost layer and prevent flooding during periods of high-water levels.
- Piles through the glaciomarine layer into bedrock may be required to prevent settlement from the melting of permafrost.

There is a subsurface drainage path through this proposed lot area coming from the lake which makes drainage conditions imperfect to poor. Specific to the development grades, the use of gravel pads should be considered including a 1% minimum slope directing water away from the building footprint. Figure 6-4 provides details as to the recommended grades which may be considered at the time of development. Relocation of this proposed lot area to the GN proposed lots, outlined in dashed lines and shown in Figure B-2 is a suitable alternative.

The GN proposed parcels outlined in dashed lines are proposed relocation options available for consideration. These lots are located in areas which appear to be well-drained, as well as suitable for construction. The proposed revisions are intended to protect future development from potential drainage issues. The Development Suitability Map identified in Section 3.3.2 confirms the suitability of the area based on the nature of the local geology. Due to the suitability of the proposed lots, development in this area is the recommended alternative to developing the lots near the southeast edge of the lake.

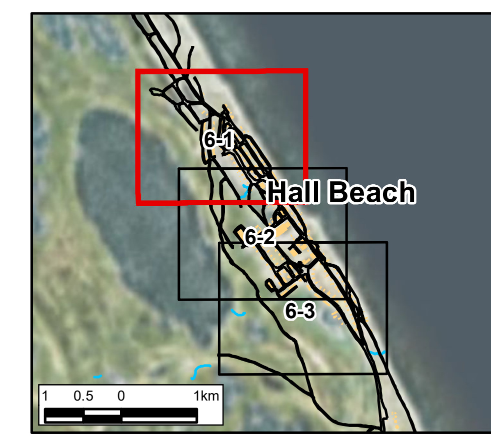
LEGEND

C## Culvert Number

Culverts
- Clean
- Replace
- New - Future Community Expansion

Open Channels
- Formalize Typical Ditch
- Existing Channel
- Channel By Others
- Natural Drainage Path

Base Data
- Current Parcel
- GN Proposed Parcel
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES
Base data source:
1. Hall Beach base data from Government of Nunavut

STATUS
ISSUED FOR USE

HALL BEACH MASTER DRAINAGE PLAN

Hall Beach Conceptual Drainage Design And Proposed Grading Area

PROJECTION	DATUM	CLIENT
UTM Zone 17	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

TETRA TECH

FILE NO.
WTRM03187-01_DrainageDesign.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DS	SL	ER	0

DATE	PROJECT NO.
April 6, 2020	TRN.WTRM03187-01

Figure 6-1

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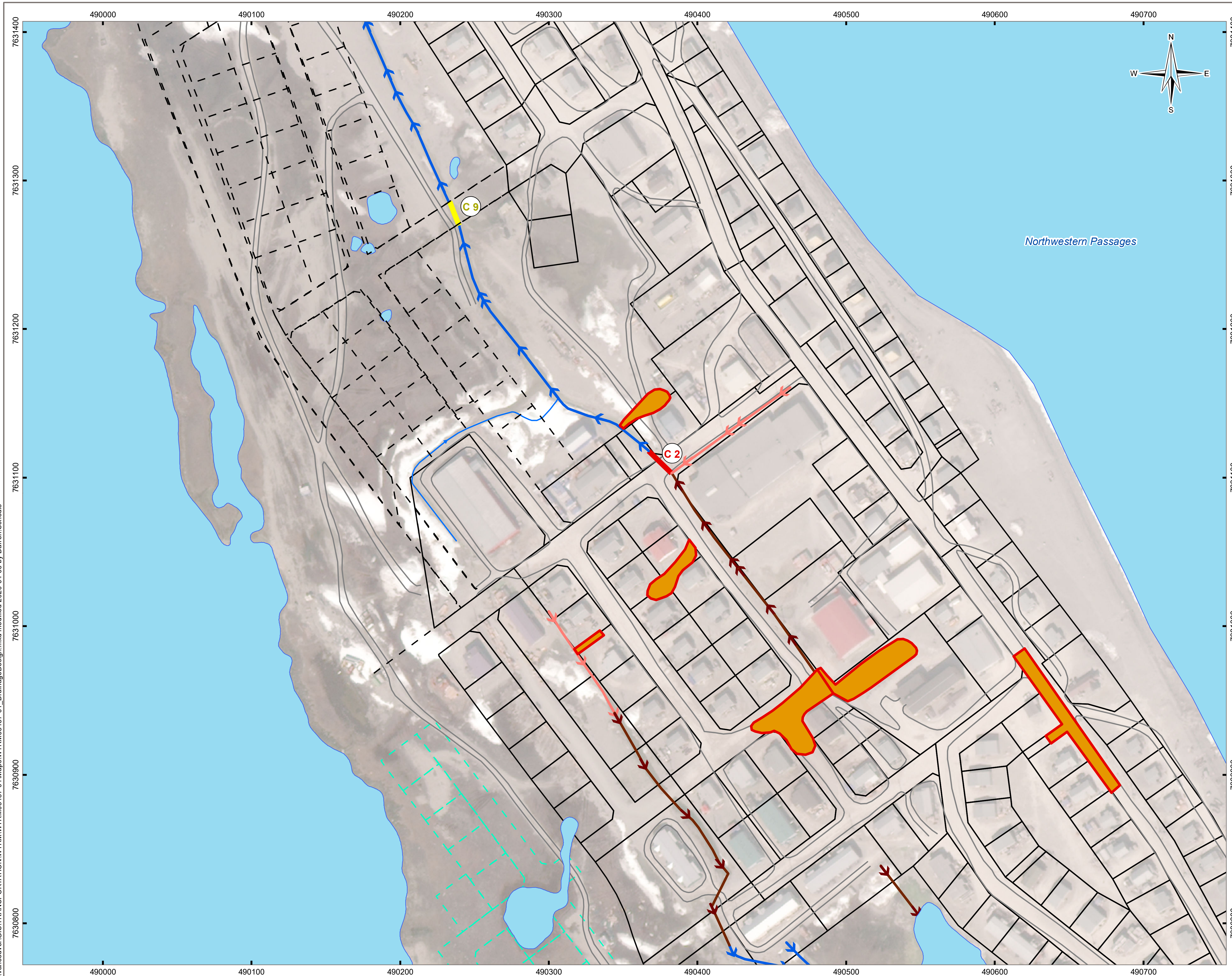


LEGEND

Grading

C## Culvert Number

Culverts

Replace

New - Future Community Expansion

Open Channels

Formalize Typical Ditch

Formalize Typical Swale

Formalize Typical Large Swale

Natural Drainage Path

Base Data

Current Parcel

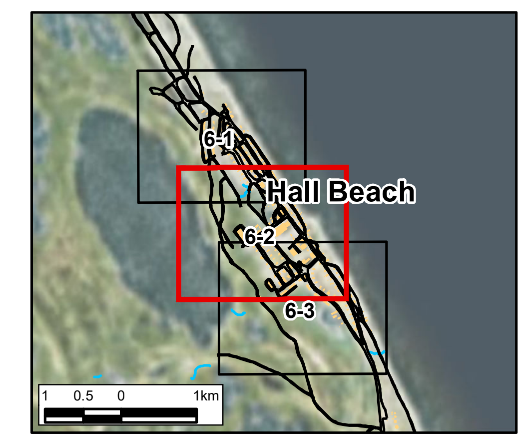
Relocate Current Parcel

GN Proposed Parcel

Gravel Road

Topographic Contour (5 m)

Waterbody



NOTES
Base data source:
1. Hall Beach base data from Government of Nunavut

STATUS
ISSUED FOR USE

HALL BEACH MASTER DRAINAGE PLAN

Hall Beach Conceptual Drainage Design And Proposed Grading Area

PROJECTION	DATUM	CLIENT
UTM Zone 17	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

FILE NO.
WTRM03187-01_DrainageDesign.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DS	SL	ER	0

DATE
April 6, 2020

PROJECT NO.
TRN.WTRM03187-01

TETRA TECH

Figure 6-2

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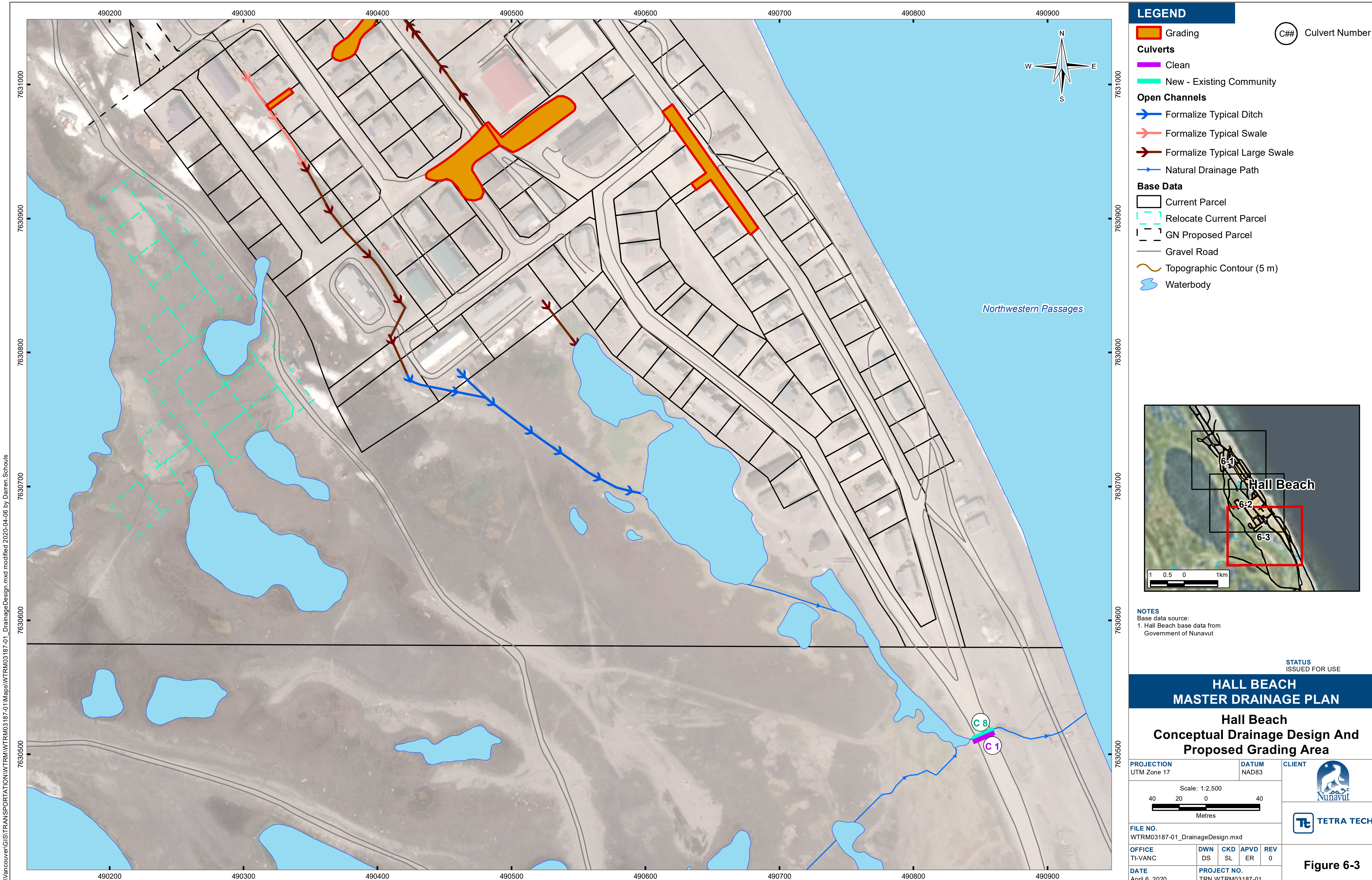

490200
490300
490400
490500
490600
490700
490800
490900
7631000
7630900
7630800
7630700
7630600
7630500
Northwestern Passages
C 8
C 1
N
S
E
W
LEGEND
Grading
C##
Culvert Number
Culverts
Clean
New - Existing Community
Open Channels
Formalize Typical Ditch
Formalize Typical Swale
Formalize Typical Large Swale
Natural Drainage Path
Base Data
Current Parcel
Relocate Current Parcel
GN Proposed Parcel
Gravel Road
Topographic Contour (5 m)
Waterbody
6-1
Hall Beach
6-2
6-3
1 0.5 0 1km
NOTES
Base data source:
1. Hall Beach base data from Government of Nunavut
STATUS
ISSUED FOR USE
HALL BEACH
MASTER DRAINAGE PLAN
Hall Beach
Conceptual Drainage Design And
Proposed Grading Area
PROJECTION
UTM Zone 17
DATUM
NAD83
CLIENT
Nunavut
Scale: 1:2,500
40 20 0 40
Metres
FILE NO.
WTRM03187-01_DrainageDesign.mxd
TETRA TECH
OFFICE
Tt-VANC
DWN
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ER
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0
DATE
April 6, 2020
PROJECT NO.
TRN.WTRM03187-01
Figure 6-3
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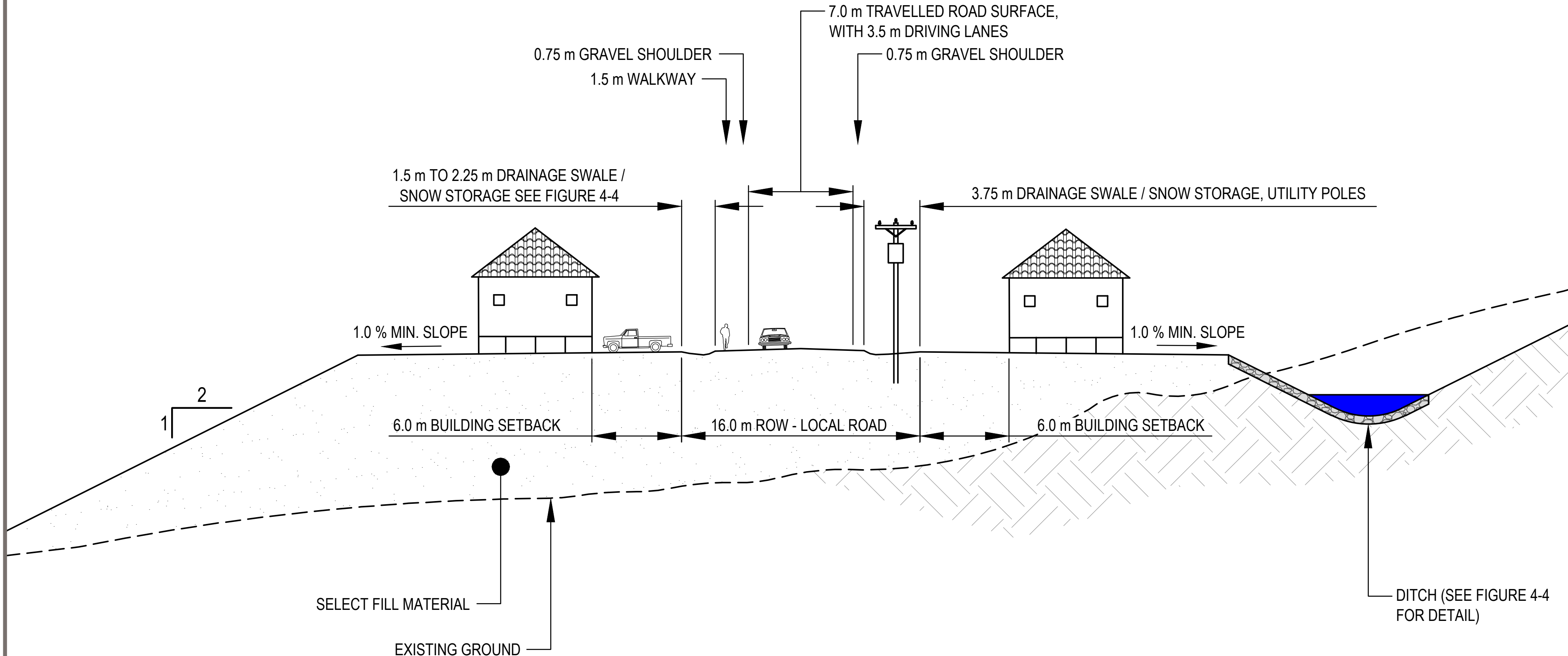


LEGEND

-

NOTES
- Dimensions as per CAN/CSA-S503-15 Figure 5

0 20
Scale: 1: 400 (metres)

ISSUED FOR USE

CLIENT

Nunavut

TETRA TECH

HALL BEACH MASTER DRAINAGE PLAN

ABOVE GRADE DEVELOPMENT DETAIL

PROJECT NO.	DWN	CKD	REV
TRN.WTRM03187	AD	ER	0
OFFICE	DATE		
VANC	March 5, 2020		

Fig. 6-4

6.1.1 Grading Plan

Tetra Tech has identified areas in the community in which poor drainage conditions should be improved via regrading. Regrading areas are shown in Figures 6-1 to 6-3 and include the following recommendations:

- Lower the road profile east of the Co-op grocery store, south of the major intersection as shown on Figure 6-2. This will decrease the ponding identified on the west side of the road by allowing water to pass over the road and drain into the ocean.
- Ponding was identified around several residences. Infilling and regrading depression areas to promote drainage away from buildings will solve the ponding issues.
- Ponding was identified around the Co-op grocery store. The depressed area on the south side of the building should be infilled with suitable material and graded to promote surface drainage towards the west and into the proposed swale shown in Figure 6-2. The area on the north side of the building should be similarly regraded to promote surface drainage westward to the proposed roadside swale.
- The proposed roadside swale running north from the Co-op store to culvert C2 should be constructed and graded with a consistent slope of 0.5% minimum. This will drain the areas around the Co-op store and school eliminating the observed ponding issues. It is critical that this swale is maintained annually, so to protect the area from future flooding.
- The ditch from culvert C2 running north to its eventual outfall to the ocean should be regraded to promote uninterrupted flow. A consistent slope of 0.5% minimum from culvert C2 to culvert C7 will improve this important community drainage watercourse during high water level periods such as during the spring freshet.

6.2 Construction Cost Estimate

A Class "D" cost estimate was developed for the proposed Hall Beach drainage upgrades. The cost estimate is included in Appendix D. A summary of the cost estimate is shown in Table 6-1 below. Additionally, a summary of the drainage materials required are presented in Table 6-2.

Table 6-1: Summary of Cost Estimate

	Total
Preliminaries	$71,173
Civil Works	$432,726
Miscellaneous	$15,000
Sub-total	$518,899
Project Contingencies: (40%)	$207,559
Total Estimated Construction Cost	**$726,458**

Table 6-2: Summary of Required Drainage Materials

Item	Est. Quantity	Count
600 mm Culvert	40 m	2
900 mm Culvert	38 m	3
1200 mm Culvert	25 m	2
Total Culverts	103 m	7
900 mm Culvert Sleeve	4 m	2
50-75 mm Clear Crush	283 cu. m	
10 kg Class Riprap	1246 cu. m	
Non-Woven Geotextile	4822 sq. m	
Culvert Removal		5

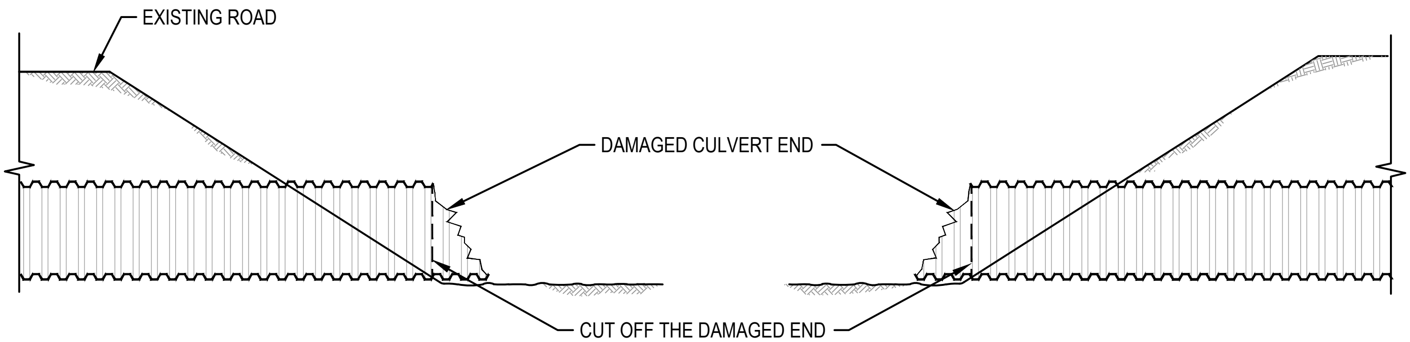
6.3 Ongoing System Maintenance

A properly maintained and monitored community drainage system is an important part of maintaining the safety and well-being of the community. To ensure proper functioning of the drainage system, a program to maintain and monitor the drainage system should be implemented.

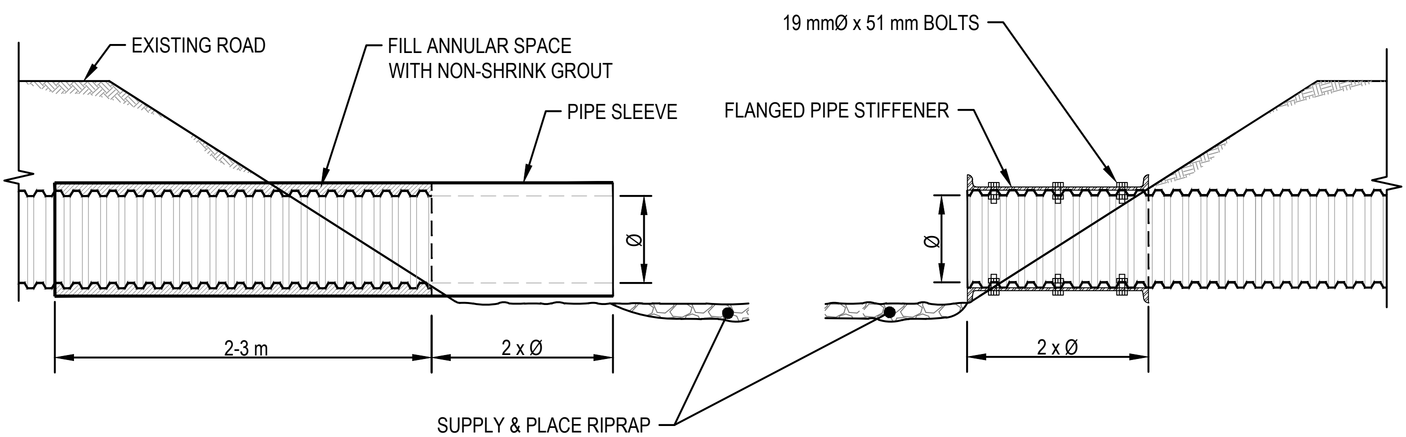
6.3.1 Culvert Maintenance and Repair

As per the guidelines for community drainage system planning, design, and maintenance in northern communities (CSA Group, 2015), culvert maintenance and repair guidelines are as follows:

- Culverts should be marked with a post painted in a bright colour and installed at the precise location of the culvert end. Culverts marking posts, when lost or damaged, shall be replaced.
- Spare culverts of each size shall be kept on hand to facilitate the repair and replacement of all sizes of culverts.
- Where the culverts are in good shape and only the ends are damaged, a SWSP sleeve should be added to reinstate the original length of the culvert. The annular space between the existing pipe and the SWSP sleeve should be grouted and sealed. A 900 mm culvert sleeve 2 m wide is recommended for both ends of culvert C1. Figure 6-5 provides a sketch covering the proposed repairs.



BEFORE REPAIR



AFTER REPAIR

PIPE SLEEVE OPTION
SCALE: NTS

PIPE STIFFENER OPTION
SCALE: NTS

NOTE:

CLIENT

Nunavut

TETRA TECH

HALL BEACH MASTER DRAINAGE PLAN

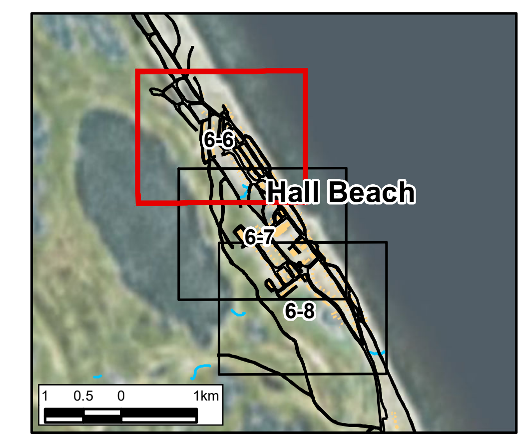
DAMAGED CULVERT END REPAIR DETAILS

PROJECT NO.	DWN	CKD	REV	
WTRM03187-01	MJK	ER	A	**FIG.6-5**
OFFICE	DATE			
VANC	March 18, 2020			

6.3.2 Snow Removal Management Plan

As per the guidelines for Community Drainage System Planning, Design, and Maintenance in Northern Communities (CSA Group, 2015), removed snow should be prevented from re-entering the drainage system. Runoff from stockpiled snow can re-enter and overwhelm the drainage system causing flooding damage.

To that end, Tetra Tech recommends that removed snow from roadways and driveways be safely deposited in one of the designated Deposition Zones as shown in Figures 6-6 to 6-8. It should be noted that there could be other locations suitable for snow deposition as local maintenance staff find appropriate. Snow deposition locations should be on either side slope of the community, either the lake side to the west or the ocean side to the community's east.



LEGEND

- Snow Deposition Area

Base Data

- Parcel
- Gravel Road
- Topographic Contour (5 m)
- Waterbody

NOTES
Base data source:
1. Hall Beach base data from Government of Nunavut

STATUS
ISSUED FOR USE

HALL BEACH MASTER DRAINAGE PLAN

Hall Beach Snow Removal Management Plan

PROJECTION	DATUM	CLIENT
UTM Zone 17	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

FILE NO.
WTRM03187-01_SnowRemoval.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DS	SL	ER	0

DATE: April 2, 2020
PROJECT NO.: TRN.WTRM03187-01

TETRA TECH

Figure 6-6

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LEGEND

Snow Deposition Area

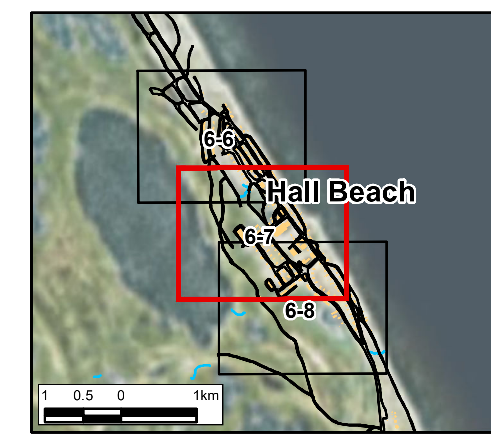
Base Data

Parcel

Gravel Road

Topographic Contour (5 m)

Waterbody



NOTES
Base data source:
1. Hall Beach base data from Government of Nunavut

STATUS
ISSUED FOR USE

HALL BEACH MASTER DRAINAGE PLAN

Hall Beach Snow Removal Management Plan

PROJECTION	DATUM	CLIENT
UTM Zone 17	NAD83	Nunavut

Scale: 1:2,500

40 20 0 40

Metres

FILE NO.
WTRM03187-01_SnowRemoval.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DS	SL	ER	0

DATE	PROJECT NO.
April 2, 2020	TRN.WTRM03187-01

TETRA TECH

Figure 6-7

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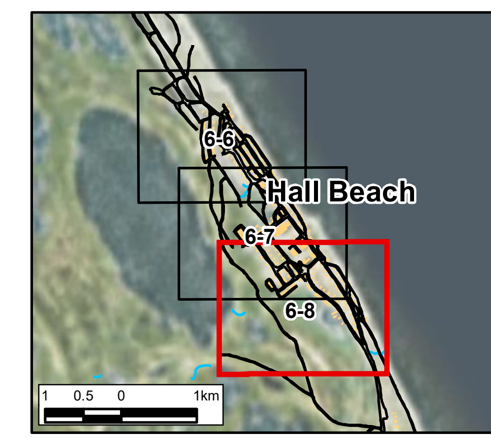
LEGEND

- Snow Deposition Area

Base Data

- Parcel
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES
Base data source:
1. Hall Beach base data from Government of Nunavut

STATUS
ISSUED FOR USE

HALL BEACH MASTER DRAINAGE PLAN

Hall Beach Snow Removal Management Plan

PROJECTION				DATUM	CLIENT
UTM Zone 17				NAD83	Nunavut
Scale: 1:2,500 (40 20 0 40 Metres)					TETRA TECH
FILE NO. WTRM03187-01_SnowRemoval.mxd					
OFFICE Tt-VANC	DWN DS	CKD SL	APVD ER	REV 0	Figure 6-8
DATE April 2, 2020	PROJECT NO. TRN.WTRM03187-01				

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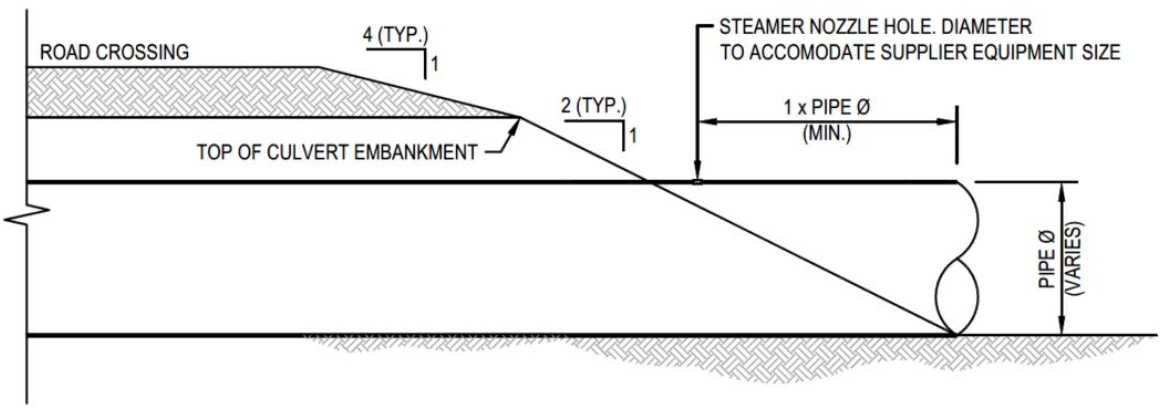
6.3.3 Culvert Thawing

An annual maintenance program should incorporate a culvert thawing strategy. Some options for thawing culverts are presented in Appendix C for consideration. Figure 6-9 below shows the proposed method for thawing ice inside culverts.



CULVERT STEAMER HOLE DETAIL
SCALE: NTS

Figure 6-9: Culvert Thawing Detail

6.3.4 Maintenance Schedule

A recommended seasonal maintenance schedule as per the Guidelines for Community Drainage System Planning, Design, and Maintenance in Northern Communities (CSA Group, 2015), is presented as follows:

Spring:

- Visually inspect and thaw frozen culverts in order of their priority level. Note any damages to culverts.
- Remove debris from blocked or partially blocked culverts.
- Collect and dispose of litter if present.
- Following the spring freshet, inspect the drainage system to identify deficiencies for repair.

Summer:

- Repair washed out ditches, swales and riprap aprons as necessary. Ponding in ditches and swales should be identified and fixed by re-sloping the ditch.
- A water pump can be used to flush blocked culverts free of sediment, rocks, and debris. Discharge of sediments into natural streams should be avoided and appropriate sediment and erosion control measures should be incorporated to protect the receiving water bodies.
- Repair damaged culvert ends. Replace or re-install culverts that have shifted or moved. Repair culverts in order of their priority level and the level of damage observed.

Fall:

- Complete repairs to the drainage system.
- Replace missing or damaged culvert marking posts.
- Create an inventory of materials required for the next year's maintenance program.

Winter:

- Monitor culverts and culvert marking posts.
- Implement the snow removal management plan as detailed in Section 6.3.2.

7.0 CLOSURE

We trust this document meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

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ER/DM/VR/tak

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APPENDIX A

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LIMITATIONS ON USE OF THIS DOCUMENT

HYDROTECHNICAL

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The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

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This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

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1.8 LEVEL OF RISK

It is incumbent upon the Client and any Authorized Party, to be knowledgeable of the level of risk that has been incorporated into the project design, in consideration of the level of the hydrotechnical information that was reasonably acquired to facilitate completion of the design.

APPENDIX B

COMMUNITY PLANS AND BYLAW NO. 148

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LEGEND

Suitability

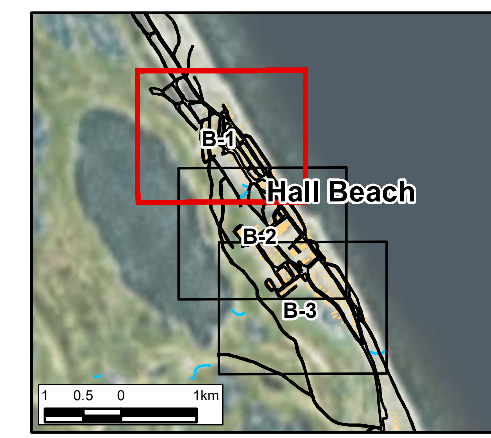
- Suitable for Development
- Conditionally Suitable for Development Provided the Drainage Improvement Plan is Implemented

Site Features

- Waste and Sewage 450 m Setback

Base Data

- Current Parcel
- GN Proposed Parcel
- Building Footprint
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES
Base data source:
1. Hall Beach base data from Government of Nunavut

STATUS
ISSUED FOR USE

HALL BEACH MASTER DRAINAGE PLAN

Revised Community Planning Map

PROJECTION	DATUM	CLIENT
UTM Zone 17	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

TETRA TECH

FILE NO.
WTRM03187-01_CommunityPlanning.mxd

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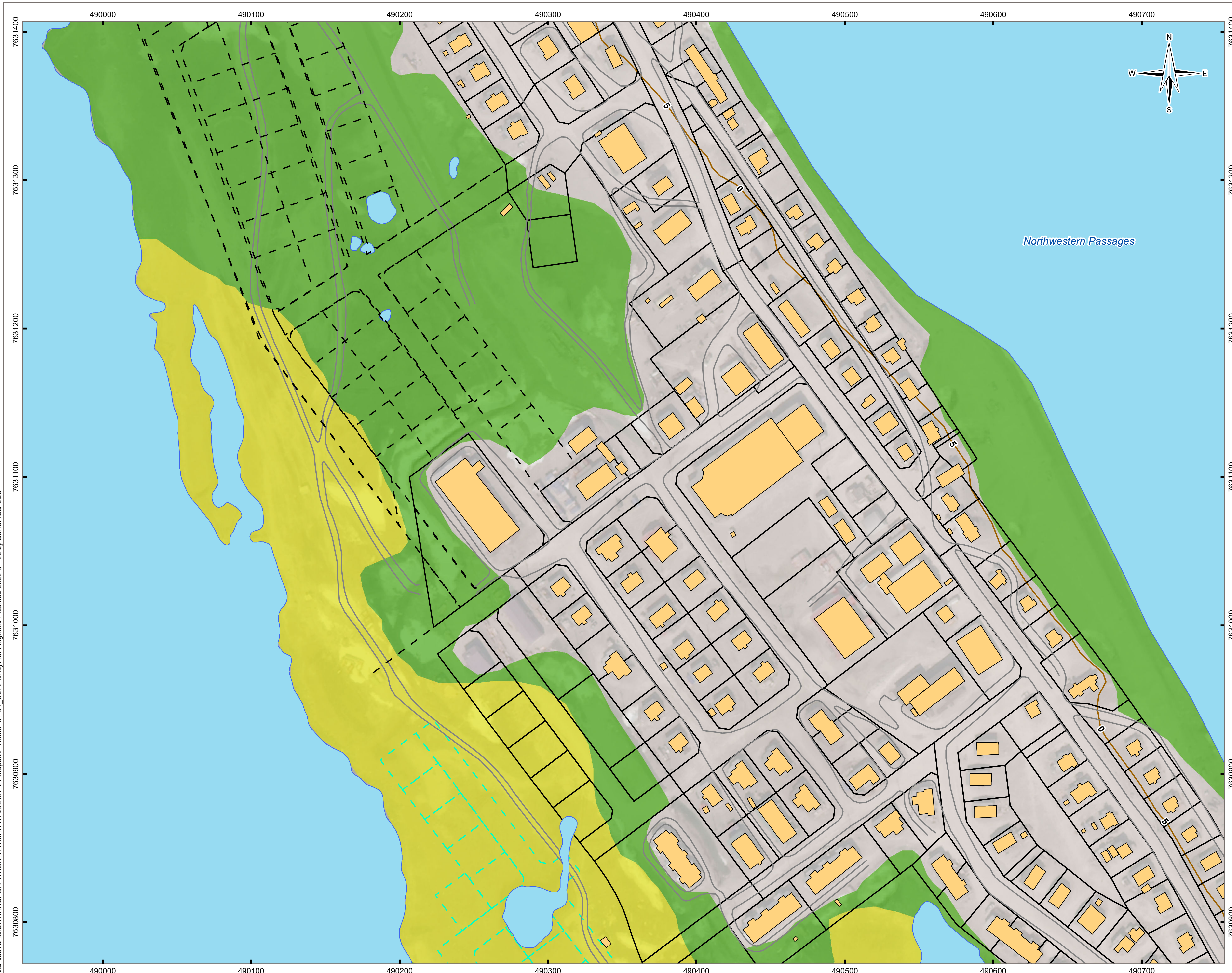
DATE
April 2, 2020

PROJECT NO.
TRN.WTRM03187-01

Figure B-1



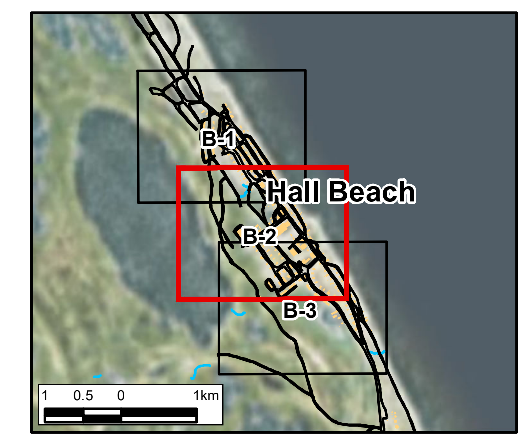
LEGEND

Suitability

- Suitable for Development
- Conditionally Suitable for Development Provided the Drainage Improvement Plan is Implemented

Base Data

- Current Parcel
- Relocate Current Parcel
- GN Proposed Parcel
- Building Footprint
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES
Base data source:
1. Hall Beach base data from Government of Nunavut

STATUS
ISSUED FOR USE

HALL BEACH MASTER DRAINAGE PLAN

Revised Community Planning Map

PROJECTION	DATUM	CLIENT
UTM Zone 17	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

TETRA TECH

FILE NO.
WTRM03187-01_CommunityPlanning.mxd

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DATE	PROJECT NO.
April 2, 2020	TRN.WTRM03187-01

Figure B-2

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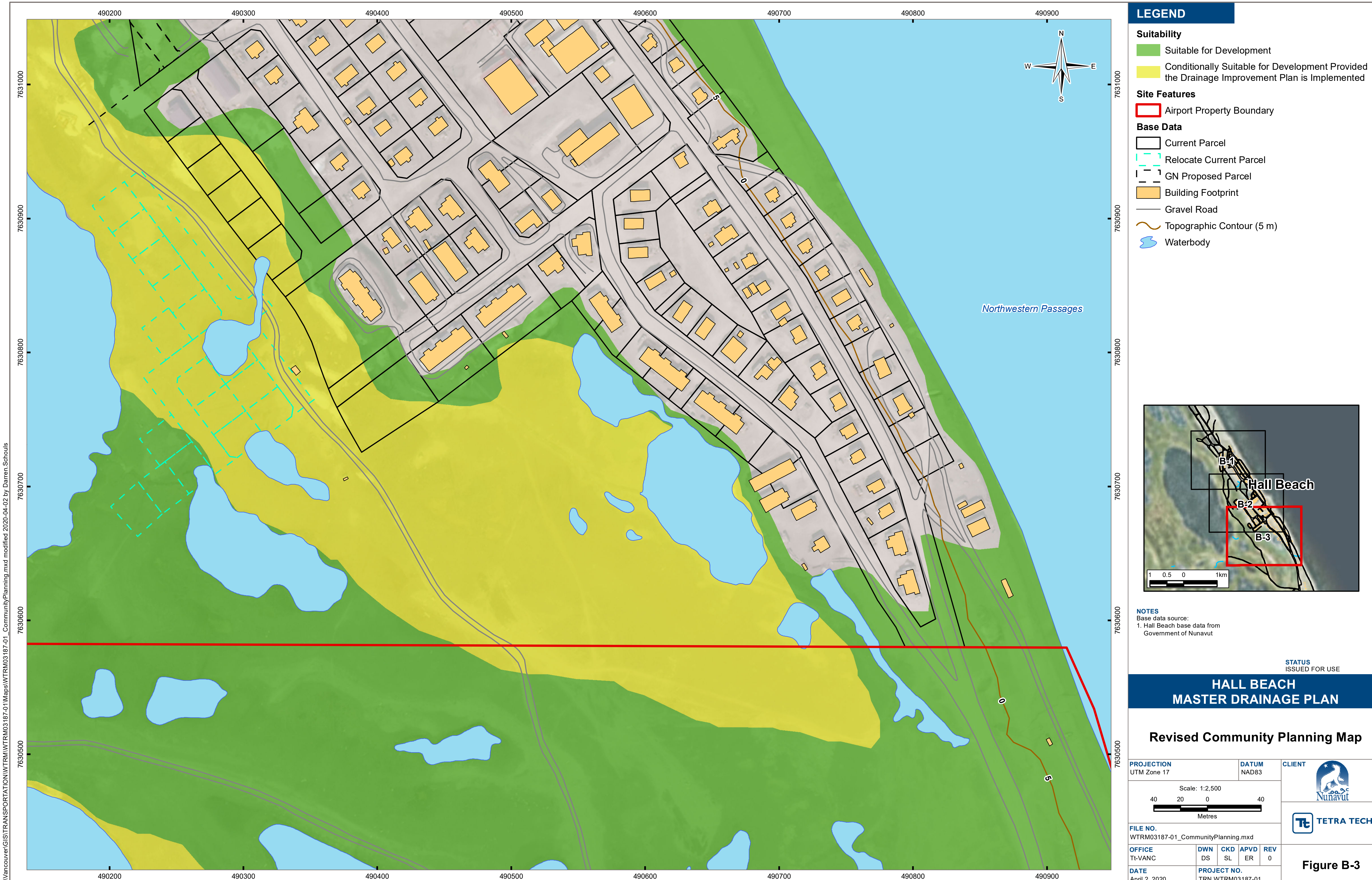
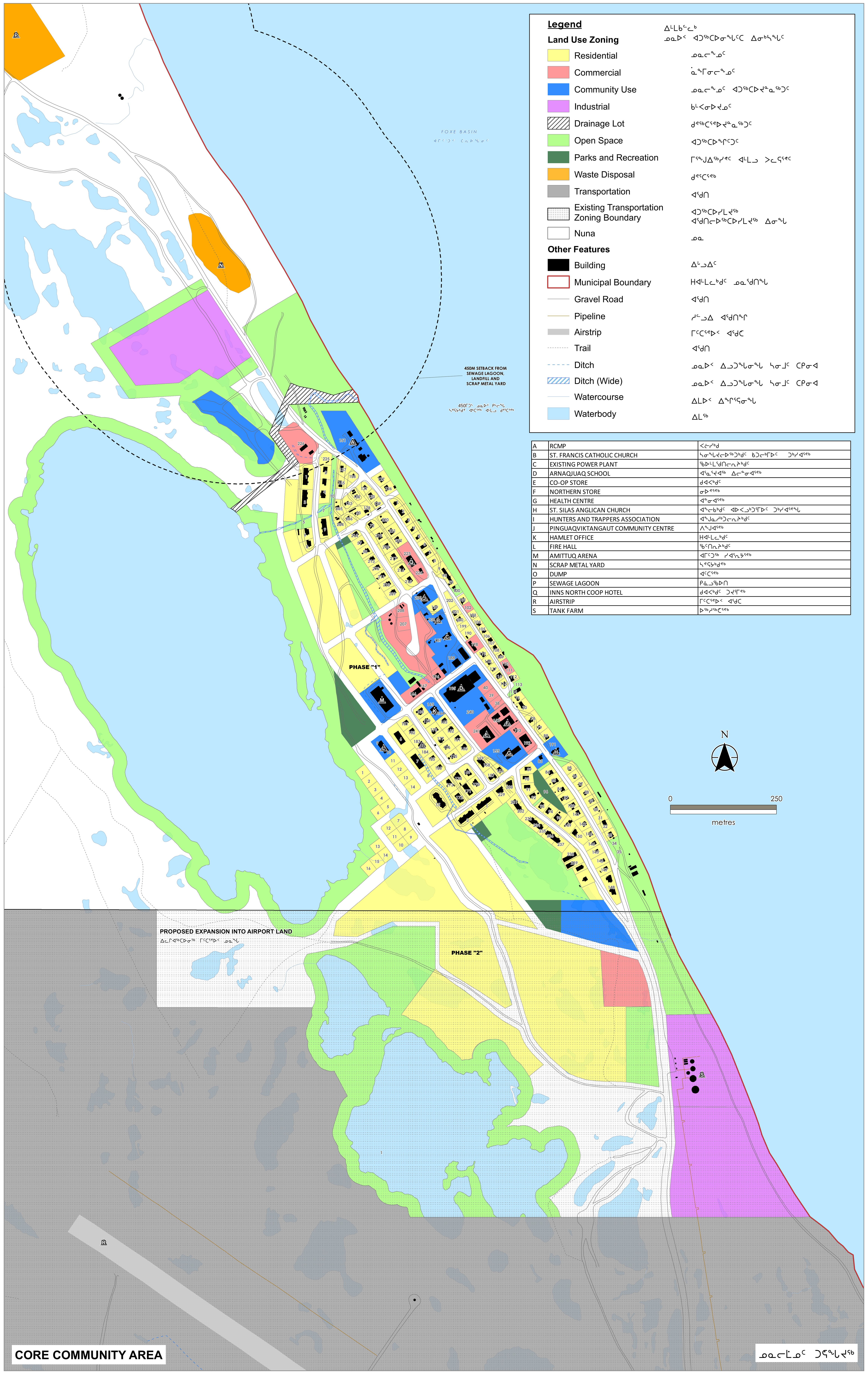


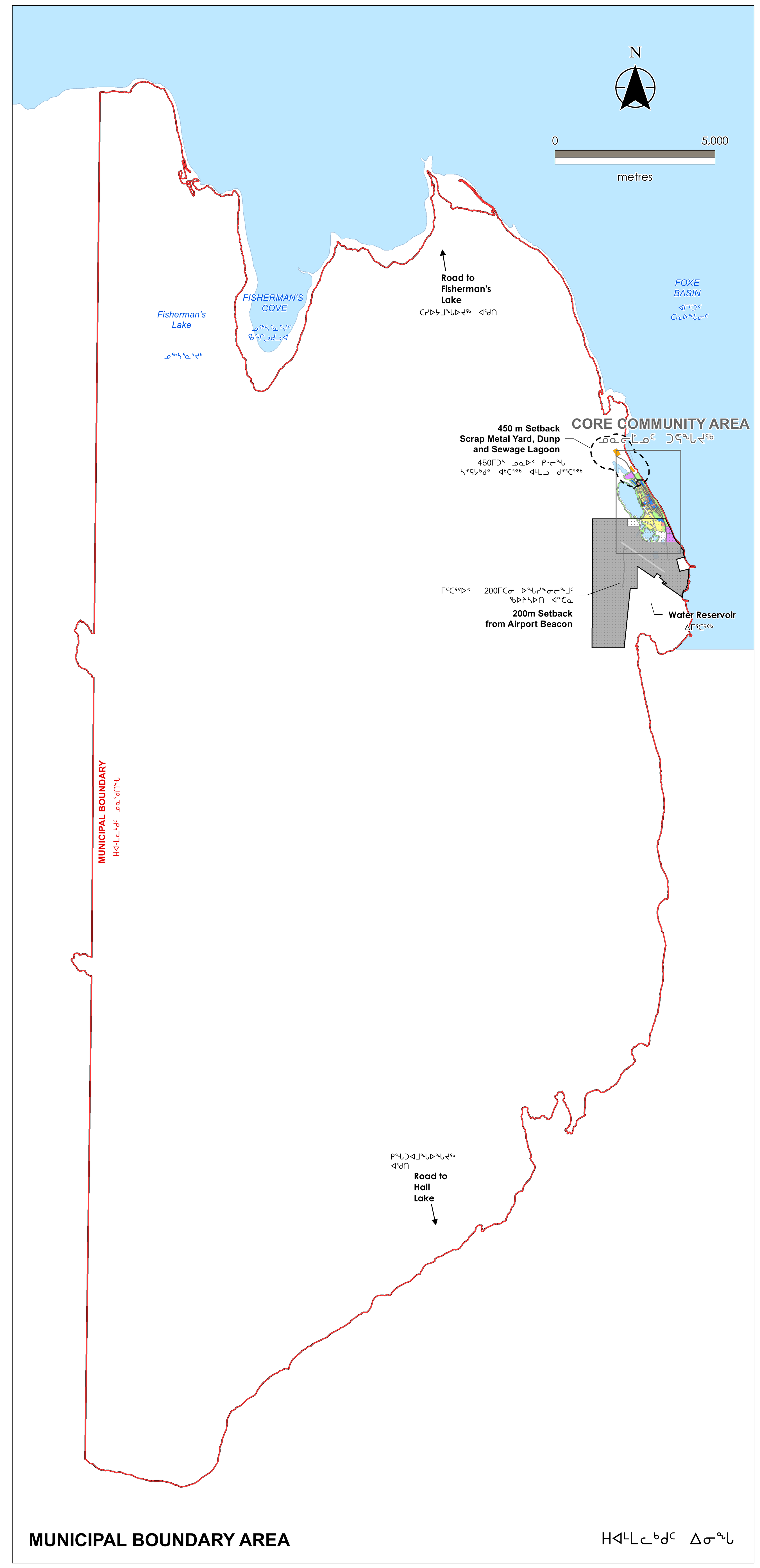
Revised Community Planning Map

Figure B-3

SCHEDULE 1: HALL BEACH LAND USE AND ZONING MAP

ᓴᓂᕋᔭᒃ ᑭᓪᓕᓯᓂᐊᕐᓂᕐᒧᑦ ᒪᓕᒐᕐᓛᖅ ᐊᒻᒪᓗ ᐅᐃᒍᖅᑎᑦ ᓄᓇᐊᑉ ᒪᓕᒐᓕᖅᑎᑦ





ZONING REGULATIONS			ᐸᕐᓇᒃᑕᐅᔪᑦ ᐊᒻᒪᓗ ᐃᓂᖓᓪᓚᑦ ᐊᑐᐊᓗᖏᑦ	
Permitted Uses	Conditional Uses	Zoning	ᐊᑐᕈᓐᓇᖅᑎᑕᐅᓪᓗᑎ	ᐊᑐᐊᓗᒃᓗᓂ ᐊᑐᕈᓐᓇᖅᑎᑕᐅᔪᑦ
Dwelling, Single-unit Dwelling, Semi-detached or Duplex Dwelling, Rowhouse Park or Playground	Bed and Breakfast Craft Studio Day Care Centre Dwelling, Multi-Unit Dwelling, Mini-Home Elders Facility Group Home Home Occupation Secondary Suite	R	ᐃᓪᓗ, ᐃᒻᒥᒃᑯᖓᔪᖅ ᐃᓪᓗ, ᐊᑦᑐᖅᓯᒪᐅᔾᑐᖅ ᐅᕝᕙᓘᓐᓃᑦ ᑲᑎᙵᓚᔾᔪᖅ ᐃᓪᓗ, ᑲᑎᙵᓚᐅᖅᑐᑦ ᑐᑭᓕᕇᑦ ᒥᕐᖑᐃᓯᕝᕕᒃᓴᖅ ᐅᕝᕙᓘᓐᓃᑦ ᐊᓃᕐᔭᕝᕕᒃ	ᐃᓕᓐᖅ ᐃᓛᕈᒪᓚᓪᓗ ᓴᓇᓂᕐᒧᑦ ᐱᓕᕆᕝᕕᒃ ᐸᐃᕆᕝᕕᒃ ᐃᓪᓗ, ᐊᑕᐅᓯᐅᙱᑦᑐᓄᑦ ᐃᓪᓗ, ᒥᑭᑦᑐᕐᔪᖅ ᐃᓐᓇᕈᖅᑦ ᐃᓪᓗᖓ ᑲᑎᖅᓯᓚᑦ ᐃᓪᓗᖓ ᐃᓪᓗᒥᑦ ᐃᔫᖅᓯᒪᓂᖅ ᓴᓂᕚᒧᑦ ᐃᓪᓗᕈᓯᕐᔪᖅ
Automotive Gas Bar Bank Caretaker Unit Commercial Recreation Convenience Store Craft Studio Day Care Centre Hotel Office Parking Lot Restaurant Retail Store Service Shop	Dwelling unit(s) in a non-residentialbuilding provided that the dwelling unit(s) are above the ground floor Home Occupation The uses permitted in the Community Use (CU) zone	C	ᓄᓇᓯᐅᑎᓄᑦ ᐅᓯᐊᓗᑖᕝᕕᒃ ᑮᓇᐅᔭᒃᑯᕝᕕᒃ ᑲᒪᔨᒃᓴᕝᕕᒃ ᐃᓪᓗ ᑮᓇᐅᔭᓕᐅᕋᓱᑦᑐᑦ ᐃᖅᑲᐃᓕᓴᕈᑎᑦ ᓂᐅᕝᕕᐅᓚᖅ ᓴᓇᙳᐊᓕᐅᕝᕕᒃ ᐸᐃᑎᕝᕕᒃ ᓱᕈᓯᓄᑦ ᑐᔪᒥᕝᕕᒃ ᐊᓪᓚᕝᕕᒃ ᓄᓇᓯᐅᑎᓄᑦ ᓄᖅᑲᙵᕝᕕᒃ ᐃᓅᒃᑎᒥᓄᑦ ᐱᔨᑦᑎᐅᑎᑦ ᓂᕆᔭᖅᑐᕝᕕᒃ ᓂᐅᕝᕕᒃ ᓴᓇᐅᐃᓐᓇᓄᑦ ᓄᓇᓯᐅᑎᓄᑦ ᐱᔨᑦᑎᕋᕝᕕᒃ	ᐃᓪᓗᖏᑦ ᐊᑦᑐᖅᓯᒪᔪᑦ9ᐃᑦ0 ᐃᓄᒃᑲᕝᕕᐅᖏᑦᑐᓂᒃ ᐃᓪᓗᓂ ᐊᑐᕈᓐᓇᖅᐳᑦ ᑖᒃᑯᐊ ᑭᓯᐊᓂ ᐃᓂᓪᓚᖓᒍᑎᒃ ᖁᓛᒎᑦ ᐊᑦᑐᖅᓯᒪᔪᑦ9ᐃᑦ0 ᓴᓇᕝᕕᐅᔪᒥᑦ. ᐊᖏᕐᕆᒥᑦ ᐊᑐᕋᔅᐅᑎᓂᖅ.
Church Communications Facility Community Hall or Centre Community Freezer Educational Facility Elders Facility Fire Hall Government Office Group Home Health Care Facility Municipal Garage Parking Lot Police Station Post Office School	Cemetery	CU	ᑐᓯᐊᕝᕕᒃ ᑐᓴᒐᒃᑕᐅᑎᓕᕆᓂᒧᑦ ᐃᓪᓗ ᐱᙳᐊᕝᕕᒃ ᓄᓇᓕᒧᑦ ᐅᕝᕙᓘᓐᓃᑦ ᑲᑎᑕᕝᕕᒃ ᐃᓕᓐᓂᐊᕐᕕᐊᕝᕕᒃ ᐃᓐᓇᕈᖅᑕᑦ ᐃᓪᓗᖓ ᖃᑦᑎᕐᓂᕐᒧᑦ ᐱᓕᕆᕝᕕᖓ ᒐᕙᒪᒃᑯᑦ ᐊᓪᓚᕝᕕᖓ ᑲᒪᔨᔭᐅᔪᓄᑦ ᐃᓪᓗ ᐋᓐᓂᕝᕕᒃᑲᕝᕕᒃ ᕼᐋᒻᒪᓚᒃᑯᑦ ᒪᓵᔾᔨᖓ ᓄᓇᓯᐅᑎᓄᑦ ᓄᖅᑲᙵᕝᕕᒃ ᐸᓖᓯᒃᑯᑦ ᐊᓪᓚᕝᕕᖓ ᑎᑎᖅᑲᒃᑯᕝᕕᒃ ᐃᓕᓐᓂᐊᕐᕖᑦ	ᐃᓚᕕᒃᑲᕝᕕᒃ ᓄᓇᓕᐅᑉ ᖁᐊᖅᑲᐅᑎᒃᑯᕕᖓ
Automotive Repair, Sales or Facility Building Supply and Contractor's Shop Caretake unit Municipal Garage Outdoor storage Rental Shop Rental Shop Warehouse	Barge staging and landing site with associated warehousing Hazardous Goods storage Power plant Tank farm	I	ᓄᓇᓯᐅᑎᓄᑦ ᓴᓇᕝᕕᒃ, ᓂᐅᕝᕕᒃ ᐱᕐᑯᑎᒃᑲᕝᕕᐅᓕᕐᓂᖏᓐᓂᑦ ᑲᒪᔨᒃ ᐃᓪᓗᖁᑖ ᕼᐋᒻᒪᓚᒃᑯᑦ ᒪᓵᔾᔨᖓ ᓯᓚᐃᓐᓇᒥᑦ ᑐᖅᑯᐃᕝᕙᒃ ᐊᑐᖅᑎᑦᑎᔾᔪᑦ ᐱᓕᕆᕝᕕᒃ ᓯᕐᓗᐊᖅ ᐱᖁᑎᒃᑯᕕᒃ ᑐᓴᐅᒪᒃᑲᐃᓂᓪᒧᑦ ᐃᓪᓗᕐᑯᑎᖓ	ᓯᒃᑲᐅᓂᒃ ᑐᓚᑦᑕᕕᑦ ᓂᐅᕋᐃᕝᕕᓪᓗ ᐱᕐᑯᑎᒃᑲᕝᕕᖕᖓᓂ ᐅᓯᔭᖏᓐᓄᑦ ᐅᓗᕆᐊᓇᖅᑐᓂᒃ ᐱᕐᑯᑎᓂᒃ ᑐᖅᑯᐃᕝᕕᒃ ᐅᒻᒪᖅᑯᑎᓕᐅᕆᕝᕕᒃ ᓴᓇᔪᓕᕆᕝᕕᖏᑦ ᐅᓯᐊᓗᒃᑲᕝᕕᑦ
Beach Shack Boat Storage Community gardens and greenhouses Dock Monument, cairn, or statue Parks Shed to store equipment for traditional, cultural, and recreational activities taking place in the Zone Snow Fence Sports field Temporary Outdoor Storage of sealift equipment during sealift Washroom facility	Communications Facility Dog Teams	OS	ᓯᔾᔨᒥᑦ ᓯᑯᓗᐊᑦ ᐅᒥᐊᓄᑦ ᐃᓂᒃᑲᕝᕕᒃ ᑐᓚᑦᑕᕝᕕᒃ ᐃᖅᑲᐅᒪᔾᔪᑦ, ᒪᑭᑕᐅᓂᒃ ᐅᕝᕙᓘᓐᓃᑦ ᐃᓄᙳᐊᖅ ᒥᕐᖑᐃᓯᕝᕕᒃᓴᖅ ᐅᕝᕙᓘᓐᓃᑦ ᐊᓃᕐᔭᕝᕕᒃ ᓯᓪᓗᐊᖅ ᐱᕐᑯᑎᒃᑲᕝᕕᓄᑦ ᐊᑐᖅᑕᐅᔪᓄᑦ ᐱᖅᑯᓯᑐᖃᒃᑯᑦ, ᐃᓕᖅᑯᓯᖁᓪᓗ ᐊᒻᒪᓗ ᑭᐱᙳᐃᔭᐅᑎᓄᑦ ᐊᑐᕐᖅᑕᐅᔪᑦ ᐃᓗᐊᒍᑦ ᑭᓪᓕᓕᐊᖑᔪᐸ ᐊᐳᑎᒧᑦ ᐊᕝᕗᕐᕕᒃ ᐃᖅᑲᐃᓕᓴᕐᑐᓄᑦ ᐱᙳᐊᕝᕕᒃ ᓯᓚᒥᑦ ᓇᑉᐸᖅᓯᒪᑲᐃᓇᖅᑐᖅ ᓯᓚᐃᓇᒥ ᑐᖅᑯᐃᕝᕕᒃ ᐅᒥᐊᔪᐊᓄᑦ ᓂᐅᕐᖅᑕᐅᔪᓄᑦ ᐱᕐᑎᓄᑦ ᖁᐃᔭᕐᑐᕝᕕᒃ	ᑐᓴᐅᒪᒃᑲᐃᓂᓪᒧᑦ ᐃᓪᓗᕐᑯᑎᖓ ᕿᒥᖕᓯᐃᑎᑦ ᕿᒥᒃᑲᕝᕕᖏᑦ
Parks	Community gardens and greenhouses Shed to store equipment for traditional, cultural, and recreational activities taking place in the Zone	PR	ᑲᑎᓗᕐᕕᒃ ᓵᓚᐃᕝᕕᒃ	ᐅ ᓄᓇᓕᖕᓄᑦ ᐱᕈᕐᓰᑉ ᐊᒻᒪᓗ ᐱᕈᕐᓰᕝᖖᒧᑦ ᐃᓪᓗ ᓯᓪᓗᐊ, ᐱᕐᑯᓯᓕᕆᔾᔪᑦ ᐊᒻᒪᓗ ᐱᙳᐊᕐᑐᓕᕆᓂᕐᒧᑦ ᒪᓕᒐᖅ
	Waste Disposal Site Scrap Metal Yard Sewage Treatment Plant	WD		ᐊᑦᑕᑯᖃᕝᕕᒃ ᓄᓇ ᑮᓈᓗᒃᑲᕝᕕᒃ ᑯᕝᕕᖅᑕᕝᕕᖓ
Airport and related uses Communications Facility	Outdoor Storage Warehouse	T	ᒥᑦᑕᕝᕕᒃ ᐊᑦᑐᐊᔪᓪᓗ ᐊᑐᕈᑦ ᖃᖓᑕᓲᓕᕆᓂᓪᒧᑦ ᑐᓴᐅᒪᒃᑲᐃᓂᓪᒧᑦ ᐱᓕᕆᕝᕕᒃ	ᓯᓚᒥᑐᑦ ᓯᕐᓗᐊᑦ ᐱᕐᑯᑎᒃᑯᕝᕕᒃ
Dog Team Temporary tenting or camping	Beach Shack Quarry Cemetery Commercial Harvesting Communications Facility Permanent hunting and fishing cabins or camps Resource exploration and development Snow fence Tourist facilities Wind Turbine	N	ᕿᒥᖕᓯᐅᑎᑦ ᕿᒦᑦ ᑐᐱᖅᓯᒪᑲᐃᓇᓂᖅ ᑕᒫᒃᑲᐃᓇᓂᓕᓗ	ᓯᔾᔨ ᓯᕐᓗᐊᖅ ᓯᐅᕐᖅᑕᕝᕕᒃ ᐃᓗᕕᒃᑲᕝᕕᒃ ᑮᓇᐅᔭᓕᐅᕋᔪᐊᖅᑐᑦ ᐊᖑᓇᓲᑎᑦ ᑐᓴᐅᒪᒃᑲᐃᓂᓪᒧᑦ ᐃᓪᓗᕐᑯᑎᖓ ᓇᐸᐃᓐᓇᖅᑐᑦ ᐊᖑᓇᓯᑎᓄᑦ ᐃᖅᑲᓗᓯᑎᓄᑦ ᐃᓪᓗᕋᓛᑦ ᑕᒻᒪᕝᕖᓪᓗ ᓄᓇᒥᙱᓪᖅᑐᓂᒃ ᕿᓂᖕᓃᑦ ᓴᓇᔭᐅᓯᕆᐊᕈᑎᖏᓪᓗ ᐊᐳᑎᒧᑦ ᐊᕝᕗᕐᕕᒃ ᐳᓚᕋᑎᓄᑦ ᐊᑐᖅᑕᐅᔪᖏᑦ ᐊᓄᕆᒧᑦ ᐆᒻᒪᖅᑯᑎᓕᐅᕈᑎᑦ

READ a third time this ____ day of ____________, 2018 A.D

______________________ ______________________

Mayor Senior Administrative Officer

ᐅᖃᓕᒫᖅᑕᐅᔪᖅ ᐱᖓᔪᐊᖓᓂ _____ ᑕᖅᑭᒥ ____________, 2018 A.D

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Community Plan
Hamlet of Hall Beach

2018

Stantec

HALL BEACH COMMUNITY PLAN
BY-LAW No. 148

A By-law of the Hamlet of Hall Beach in Nunavut Territory to adopt a General Plan pursuant to the provisions of the *Planning Act*, RSNWT, 1988, c. P-7, s.4.

WHEREAS the *Planning Act* in the Territory of Nunavut, RSNWT, 1988, c.P-7, s.4, provides for the Hamlet of Hall Beach to adopt a General Plan in keeping with the provisions of the Act; and

WHEREAS the Hamlet of Hall Beach Council has carried out a review of their existing 2010 General Plan referred to as the Hall Beach Community Plan, in accordance with the *Planning Act*; and

WHEREAS the Hamlet of Hall Beach Council has prepared the 2018 Hall Beach Community Plan considering population growth, land use, economy, climate and community members;

NOW THEREFORE the Council of the Hamlet of Hall Beach in open meeting assembled, hereby enacts as follows:

1. Schedule 1 the Hall Beach Land Use and Zoning Map forms part of this By-law.
2. This By-law may be cited as the "Hall Beach Community Plan."
3. This By-law shall come into full force and effect on the date of its Third Reading.
4. By-law No. 111 of the Hamlet of Hall Beach, and all amendments thereto, is hereby repealed.
5. Schedule 2 the Hall Beach Community Plan Forms part of this By-law

READ a first time this 14th day of November 2017.

Peter Siakuluk
Mayor

James Langille
Senior Administrative Officer

After due notice and a Public Hearing, READ a second time this 11th day of February 2019.

Mayor

Senior Administrative Officer

APPROVED by the Minister of Community and Government Services this 12 day of Apr, 2019.

Minister

READ a third time this 13th day of MAY, 2019.

Mayor

Senior Administrative Officer

Table of Contents

1.0 INTRODUCTION

1.1 PURPOSE OF THE PLAN

The purpose of the Hall Beach Community Plan is to outline Council's policies for managing the physical development of the Hamlet for the next 20 years – to 2038 – that reflect the needs and desires of the Community. The Plan is a review and update of the 2010 Hall Beach Community Plan. The plan was updated through a community consultation process. The Community Plan builds on previous plans, while incorporating new opportunities, challenges, and needs identified by the Community.

1.2 GOALS OF THE COMMUNITY PLAN

Community Plan policies emerge from the values of a community and its vision of how it would like to grow. The goals established for this Community Plan are:

1. To develop in an orderly fashion creating a healthy, safe, functional, and attractive community that reflects community values and culture.
2. To accommodate an appropriate range and mix of uses to accommodate growth and change in the community.
3. To promote the Plan as a tool for making effective and consistent decisions regarding land use and development in the community.
4. To build upon community values of participation and unity to support community projects and local economic development.
5. To protect the natural beauty of "Nuna", protect viewpoints to the water, and retain waterfront and lakeshore areas for public uses and traditional activities.

1.3 ADMINISTRATION OF THE PLAN

The Community Plan is enacted by Bylaw. Changes to the Plan can be made by amending the Bylaws in accordance with the *Nunavut Planning Act*. The Community Plan should be reviewed and updated every five years as required by the *Nunavut Planning Act*. A Zoning Bylaw is also being enacted to implement policies based on the Community Plan. The Community Plan includes Schedule 1: Hall Beach Community Plan and Zoning Map *and* Schedule 2: Community Plan of the Hamlet of Hall Beach.

2.0 GOALS AND OBJECTIVES

At the time of preparation of this Plan, the population of Hall Beach was approximately 880 people. This Plan is based on a projected population for Hall Beach of 1,350 by 2038 people. The Plan builds on the current community pattern west towards the Lake and south to the existing airport lands. The Plan accommodates 10 developed lots per year from 2018 to 2023 within the existing community area. Future community growth is planned for within a portion of land formerly identified as Transportation. During the life of this Plan the Hamlet of Hall Beach and the Government of Nunavut will need to negotiate with the Airport Authority to transfer lands from the Transportation/Airport Reserve to the Hamlet for future community growth and development.

The policies of Council are:

a) Plan for a 2038 population of 1,350 people and continue to address the shortage of housing and overcrowding.

b) Develop new residential uses west and south adjacent to existing residential areas, as identified on the Community Land Use and Zoning Map.

c) Work with Qulliq Energy Corporation to relocate the generating station to the Industrial land near the tank farm.

d) Permit future Commercial and Community Use in the core community area.

e) Allow for the expansion of the existing cemetery.

f) Permit light industrial development or outdoor storage at northern Industrial area.

g) Heavy and noxious industrial development shall be located in the southern Industrial area.

h) Construct a new community ice house in the core area.

i) Shoreline erosion is a threat to oceanfront properties. Council desires to seek out funding and partnerships to build a breakwater and/or reinforce the shoreline area in order to continue to permit current and future development.

j) Council will phase new land development as follows:

   i. Phase 1: Continue to develop existing lots within the townsite and continue to expand the residential subdivision west, which represents approximately a five-year land supply.

   ii. Phase 2: Work with the Government of Nunavut to decrease the Transportation Reserve and extend the community development boundary south.

3.0 GENERAL POLICIES

The following policies of Council apply to all development in the Hamlet regardless of land use designation:

1. The development of lots shall be subject to the following lot development policies:
   a) All service connections to buildings shall be easily accessed from the front yard on all lots and grouped together, where possible.
   b) Access to new buildings will avoid, where possible, main entrances on the southeast side to reduce problems associated with snow drifting.
   c) Buildings shall be sited to respect setbacks identified on the Zoning Chart.
   d) Any building over 500 m^2 in gross floor area shall consider potential wind impacts on surrounding development. A wind study may be required by the Development Officer.
   e) Where culverts are required, they shall be installed at the access points to lots.
   f) On any portion of a lot where fill is introduced, drainage shall be directed towards the public road. Exceptions may be made by the Development Officer. Where possible, drainage troughs shall not be located in Utility Rights of Way or Easements.
   g) Road widenings may be obtained as required at the time of development or redevelopment of a lot in situations where the road right of way is less than 16 metres wide.
2. Consideration should be given to the development of a Drainage Plan for the entire community and the adoption of a snow piling Bylaw.
3. The Hamlet will pile snow in locations to minimize downwind snow drifting and where spring melt runoff can be properly channeled to drainage ditches or waterbodies.
4. The Hamlet shall avoid piling snow within at least 30.5 metres (100 feet) of any watercourse.
5. A minimum setback distance of 30.5 metres (100 feet) of a watercourse shall be maintained, except when subject to terms and conditions of the Hamlet Council.
6. The Hamlet may consider adopting a Road Naming Bylaw.
7. Utilities or communications facilities shall be permitted in any land use designation. Other than designated Rights of Way or Easements for Utility or Communication lines, Easements alongside roadways, marked between the edge of the roadway and lot lines, will be used for distribution lines with a minimum clearance as specified in the Utility Corporations Joint Use Agreement.
8. The Hamlet shall protect cemeteries and sites of archaeological, ethnographical or historical significance from disturbance.
9. The Hamlet shall encourage development that minimizes emissions from fossil fuels, that are energy efficient and that consider alternative energy supply technology.
10. The Hamlet shall consider strategies to adapt to the future impacts of climate change, such as locating development away from low lying coastal areas and protecting existing areas against erosion.

11. The Hamlet shall generate discussions with the Hall Beach Co-op Association in order to free up the underutilized lots in the community that could be used for future commercial, residential and/or community use.

4.0 LAND USE DESIGNATIONS

4.1 RESIDENTIAL

The Residential designation provides land for primarily residential uses; however, it also permits other small scale conditional uses subject to the approval of Council. The policies of Council are intended to maintain an adequate supply of land for residential development, to build safe and livable neighbourhoods, and to protect residential areas from incompatible development. The policies of Council are:

1) The Residential designation will be used primarily for housing with all types of dwelling types permitted. Uses that are residential in nature, such as a group home, a home occupation, or bed and breakfast, will also be permitted.

2) Residential development will be phased so that a target minimum of 10 vacant surveyed lots are available at any given time.

3) In addition to the above, Council will look for opportunities for redevelopment or infill lots for new housing within the existing townsite. Council will work with Nunavut Housing Corporation to determine the appropriate housing forms (i.e., single, duplex, fourplex, 5 plex, etc).

4.2 COMMUNITY USE

The Community Use designation is intended to maintain an adequate supply of land for community uses, to provide easy access to public facilities and services, and to reserve significant and important locations for community uses. The policies of Council are:

1. The Community Use designation will be primarily for public uses (i.e., social, cultural, religious, or educational).
2. Community facilities will be centrally located to ensure safe and convenient access by residents.
3. A new school site has been planned for at the south end of the core area of the community.

4.3 COMMERCIAL

The Commercial designation is intended to support local economic development by maintaining an adequate supply of land for commercial uses in a central location within the built-up area and along main roads adjacent to future growth areas, providing good access from the community. The policies of Council are:

1. The Commercial designation will be used for commercial uses such as hotels, restaurants, retail, personal and business services, and offices (private and government).
2. Residential uses shall be permitted when located above a ground floor commercial use.

3. Commercial facilities will be located along main roads, where possible, to provide safe and convenient access by residents.
4. Community uses may be conditionally allowed by Council following community consultation and site specific regulations.

4.4 OPEN SPACE

The Open Space designation is intended to protect shoreline environments, maintain access to the sea, and to reserve open spaces within the built-up area for recreational and cultural events. The policies of Council are:

1. The Open Space designation will be used primarily for parks, walking trails, traditional and recreational uses, such as beach shacks, boat storage, community docks, and temporary storage of sealift equipment during sealift operations.
2. Owners of development will be required to maintain the development and keep the surrounding area tidy.
3. Unless otherwise noted, all Commissioner's Land forming part of the 100 foot strip (30.5 m) along the seashore measured from the ordinary high water mark will be designated Open Space.
4. Council may consider the filling of a waterbody where it is needed for future development provided that the appropriate approvals are obtained.
5. Open Space corridors will be protected for trail connections and drainage channels.

4.5 PARKS AND RECREATION

The Parks and Recreation designation is intended for developed parks and recreation areas, such as playgrounds and sports fields.

1. A playground should be located within a 300 metre walking distance from any residence in the community.
2. An area is set aside for a community sports field adjacent to the arena.

4.6 INDUSTRIAL

The Industrial designation is intended to reduce the negative effects and dangers associated with industrial uses, such as noise, dust, truck travel and the storage of potentially hazardous substances. The policies of Council are:

1. Permitted uses in the Industrial designation will include all forms of manufacturing, processing, warehousing and storage uses. Permitted uses will also include garages, power generation plants, and fuel storage.
2. Council will consider relocating the existing scrap metal yard to a site past the waste disposal site. Once relocated, the existing scrap metal yard site will be restored and consideration will be given to an industrial subdivision.

3. Permit light industrial development or outdoor storage at the northern Industrial area.
4. Heavy and noxious industrial development shall be located in the southern Industrial area.

4.7 TRANSPORTATION

The Transportation designation is intended to protect and ensure the safe operation of the airport and related activities, such as the NavCanada communications sites. The policies of Council are:

1. Permitted uses in the Transportation designation include all activities related to air traffic and uses accessory to these activities, such as commercial activities and communications sites.
2. All development within the areas affected by the Hall Beach Airport Zoning Regulations shall comply with those regulations.
3. Development applications shall be referred to Nunavut Airports for review and approval where development is proposed adjacent to the airport and/or where development has the potential to interfere with airport operations.
4. Council will discourage the use of travelled pathways that are not identified as public rights of way.
5. Council will initiate discussions with the appropriate level of government(s) to transfer a portion of airport lands, as shown on the Community Planning Map, Schedule 1 to the Hamlet for future development.

4.8 NUNA

The Nuna designation applies to all unsurveyed land within the Municipal Boundary not designated by another land use and is intended to protect the natural beauty and cultural resources of the land – 'Nuna' – while providing access for traditional, recreational and tourism activities. The policies of Council are:

1. The Nuna designation generally permits traditional, tourism and recreational uses. Permitted uses also include dog teams, quarrying, commercial harvesting, and infrastructure projects for local economic development.
2. Council shall ensure that development does not negatively impact wildlife, wildlife habitat, and harvesting and is consistent with the guiding principles of Inuit traditional knowledge.

4.9 WASTE DISPOSAL

The Waste Disposal designation is intended to identify existing or former waste disposal sites and ensure appropriate development setbacks. The policies of Council are:

1. The Waste Disposal designation permits no development, except those accessory to the operation or remediation of a waste disposal site.
2. Council will consider relocating the existing scrap metal yard to a site past the waste disposal site.

3. The Hamlet shall prohibit the development of residential uses and uses involving food storage or food preparation within the 450 metre setback from any existing or former waste disposal site, pursuant to the General Sanitation Regulation of the *Public Health Act*.
4. The Hamlet shall prohibit the development of any public road allowance or cemetery within a 90 metre setback from any existing or former waste disposal site, pursuant to the General Sanitation Regulation of the *Public Health Act*.
5. The Hamlet will continue to evaluate options for long term sewage treatment. The evaluation will consider cost-effectiveness, the degree of environmental protection, and the land use implications.
6. The Hamlet will continue to evaluate all possible options for an integrated waste management system, considering complementary strategies such as source reduction, reuse, and recycling of waste materials.
7. No materials shall enter the waste disposal site without the permission of the Hamlet Council and/or its designate.
8. The Hamlet Council recommends the relocation of the waste disposal site and supports the preparation of a site feasibility options study.

4.10 MUNICIPAL RESERVE

The Municipal Reserve designation is intended to reserve land for the future growth of the community. The policies of Council are:

1. The Municipal Reserve designation does not permit any development except temporary uses approved by Council.
2. Municipal Reserve lands shall be redesignated by amendment to this Plan prior to being used for community expansion.
3. Lands designated Municipal Reserve may be affected by significant environmental constraints to development, such as shallow waterbodies and poor drainage. All constraints shall be cleared of environmental constraints prior to the lands being redesignated for development.
4. Any proposed road network shown on the Land Use Map may need to be changed according to community needs during the subdivision process.

APPENDIX C

CULVERT THAWING METHODS

Culvert Thawing

Culverts are subject to freezing during winter and spring. During winter, ground water can continuously feed streams which either flow through culverts or over roadways causing icing. During spring breakup, daytime melting must be carried through culverts.

When a culvert freezes it can no longer do the job it was designed to do and trapped water will begin to cause problems and ultimately, money.

What's the Solution?

To thaw culverts, a combination of hot water/steam and high pressure water in a mobile environment is the effective method.

Mobile Pressure Washers

To thaw culverts quickly, a skid style hot water pressure washer/steamer, also known as a truck mounted pressure washer is the equipment of choice.

Self-contained and designed to hold up under the toughest of conditions, skid mounted pressure washers/steamers can be bolted onto the back of a truck, on an open deck trailer or in an enclosed trailer.

Enclosed Trailer Mounted Pressure Washer

Open Deck Mounted Pressure Washer

Skid Mounted Presure Washer

Culvert Nozzles

Culvert nozzles are required to dig effectively through ice. The reverse jets on the fixed and rotary nozzles pull the hose through the tube or sewer line and blast debris from the line or tube wall.

Backward ports drive the nozzle forward and flush debris
Forward ports blast into pipe and break up clogs & debris
Physically small for cornering ability up to 4200 PSI
Corrosion resistant stainless steel construction
A wide range of orifice sizes are available for various pressure and flow applications

Rotating style adds extra agitation and surface cleaning

United States Patent [19]

Olsson

[11] Patent Number: 4,770,211

[45] Date of Patent: Sep. 13, 1988

[54] **METHOD FOR THAWING OUT ROAD CULVERTS CHOKED WITH ICE**

[76] Inventor: **Lars-Uno Olsson**, Heden 4084, S-780 53 Nås, Sweden

[21] Appl. No.: **931,722**

[22] PCT Filed: **Feb. 24, 1986**

[86] PCT No.: **PCT/SE86/00080**

§ 371 Date: **Oct. 24, 1986**

§ 102(e) Date: **Oct. 24, 1986**

[87] PCT Pub. No.: **WO86/04939**

PCT Pub. Date: **Aug. 28, 1986**

[30] **Foreign Application Priority Data**

Feb. 25, 1985 [SE] Sweden 8500914

[51] **Int. Cl.**[4] **E03B 7/10**; F16L 53/00

[52] **U.S. Cl.** **138/32**; 138/28; 138/35

[58] **Field of Search** .... 138/26, 28, 32, 35; 254/262, 263, DIG. 14; 405/124, 130, 131; 137/301

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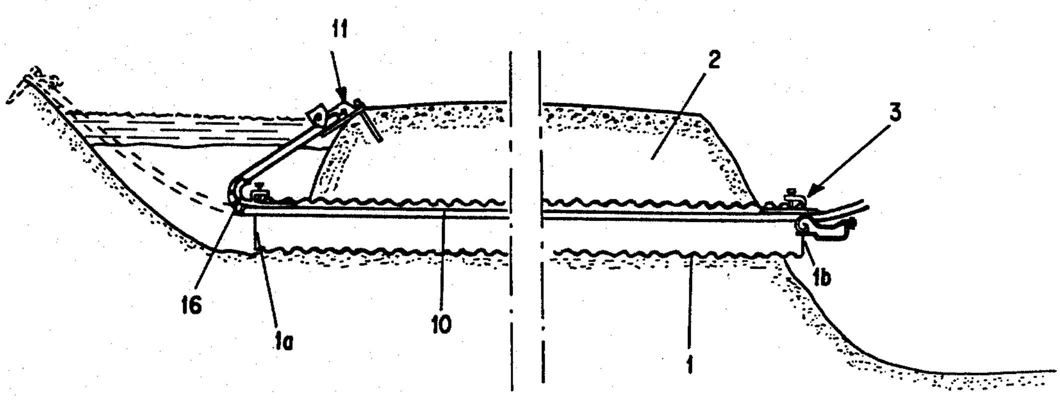
[57] **ABSTRACT**

Method for clearing a road culvert or the like which is choked with ice, wherein a substantially homogeneous rope of a material having at least a certain reversible extensibility is extended through the culvert from its inlet side to its outlet side and wherein the rope in its unloaded condition is clamped in connection with the outlet side and the inlet side respectively of the culvert so that the rope extends through the culvert.

4 Claims, 3 Drawing Sheets



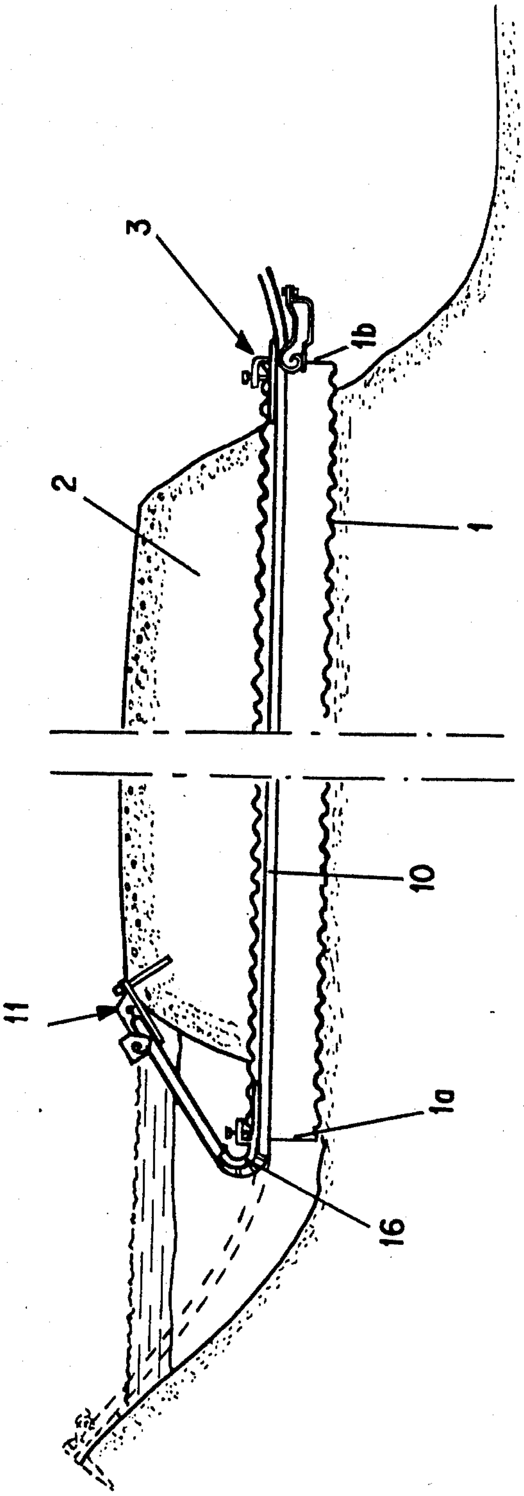


Fig. 1

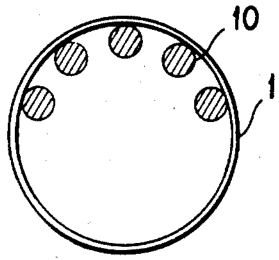


Fig. 5

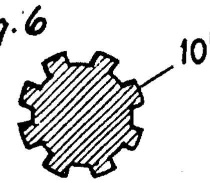


Fig. 6

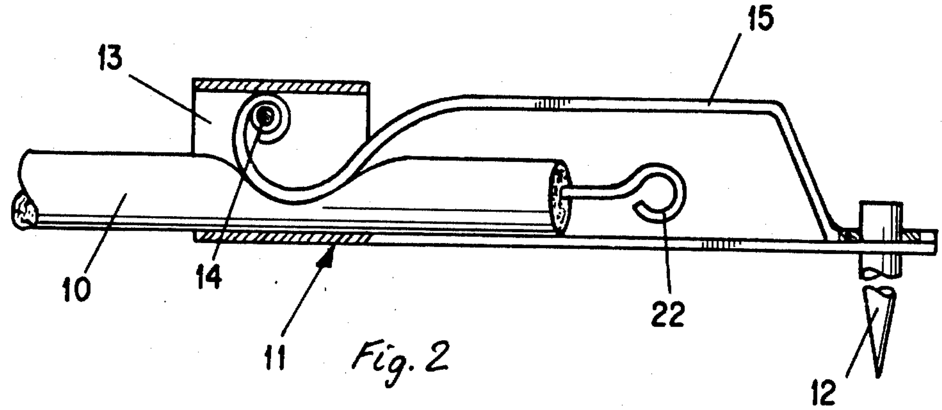


Fig. 2

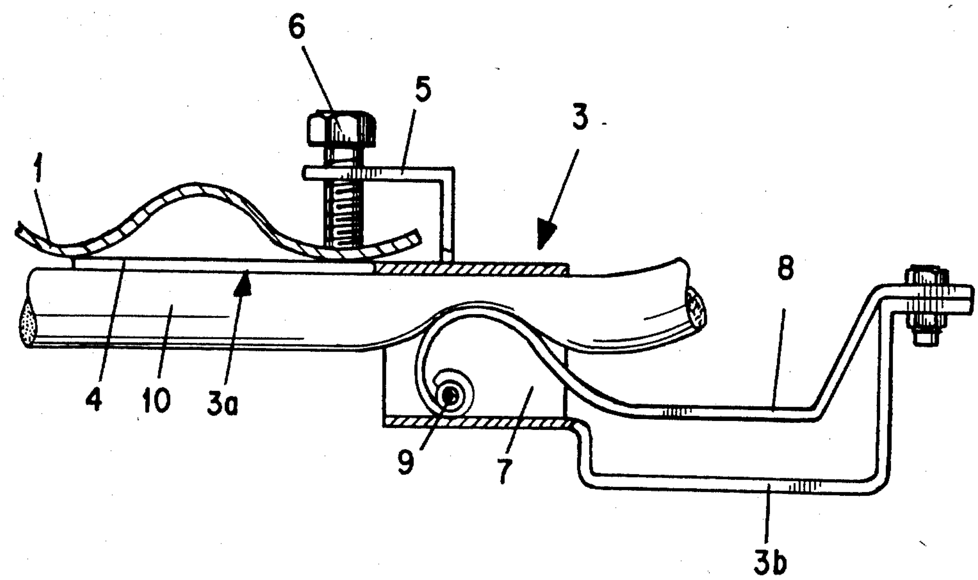
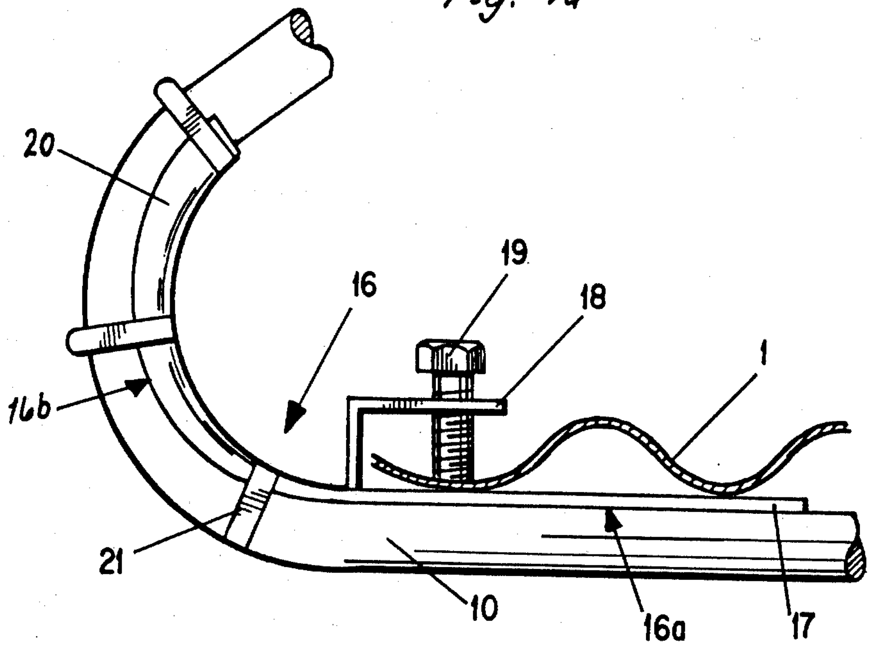


Fig. 3

Fig. 4a



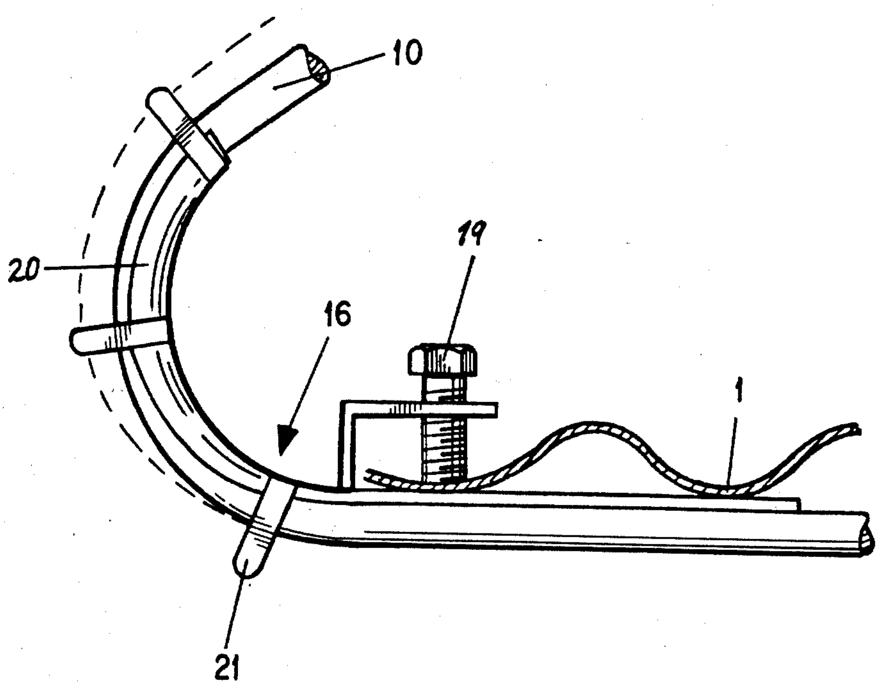


Fig. 4b

METHOD FOR THAWING OUT ROAD CULVERTS CHOKED WITH ICE

BACKGROUND OF THE INVENTION

The present invention relates to a method for thawing out road culverts choked with ice and also relates to an apparatus for carrying out said method.

A common problem in connection with winter maintenance is that road culverts become completely choked with ice, which makes it impossible to drain melted ice through the road culverts in warm weather, and especially by the spring flood. If such a road culvert that is completely choked with ice is not thawed out before the spring flood this may cause serious flooding and also a danger of parts of the road way being washed away.

In order to prevent the above mentioned, serious consequences of a road culvert choked with ice it is presently common practice to continously inspect road culverts which by experience are known to cause problems. When a road culvert choked with ice is found during such a periodical inspection, the procedure is presently to send out a clearing partrol, usually two persons, by car for thawing out the road culvert in question. Today steam generators are mostly used for thawing out road culverts in this manner, although attempts have also been made to use conventional building dryers. Already from the above it is clear that the thawing out of a road culvert in the conventional manner brings about relatively high costs which apart from transport costs also include wage costs for two persons and the cost for the steam generator.

Apart from the fact that the conventional clearing method discussed above is relatively expensive it also suffers from a number of more or less serious disadvantages that are clear from the following general description of the presently employed method using steam thawing. As indicated above a steam generator is transported out to the working place on a lorry or the like, and when the ends of the road culvert have been exposed the steam generator is started and is connected through hoses to steam pipes used for the thawing. In certain cases it is only necessary to thaw out a smaller passage through the culvert, whereupon the flow of water through this smaller passage continues to widen the passage in the ice until the culvert is completely cleared. In such a case it is, for obtaining the best result, absolutely necessary that the first thawing out of the smaller passage is carried out relatively close to the upper portion of the road culvert since the water will eat its way down through the ice towards the bottom of the culvert. Since road culverts may have a length of up to 15–20 meters, depending upon the width of the road, such a thawing out of a first small passage through the entire length of the road culvert is very difficult to achieve with a satisfactory result by means of a steam pipe. The reason for this is that if the steam pipe has such a length that it may reach through the entire length of the road culvert it will not be possible to keep it close to the upper portion of the road culvert throughout the entire length thereof and accordingly the steam pipe will deflect such that in the worst case it will leave the culvert close to its bottom. Accordingly it may also happen that the steam pipe will be stopped and cannot be brought through the entire length of the road culvert in case stones have fallen into the road culvert and remained therein on the bottom of the culvert.

In other cases it is not sufficient to thaw out only a smaller passage in the road culvert in order to avoid flooding, and therefore it will be necessary to clear the whole culvert in order to avoid the risk that a smaller passage is frozen again. It will also be realized that in the above discussed case where it proves impossible even to thaw out a first small passage in the road culvert by means of a steam pipe, it may become necessary to clear the whole culvert. In such a case when the whole culvert is to be cleared the procedure is such that a number of unperforated steam pipes, being upon in the outer end and having a length of approximately 3 meters are successively introduced from the outlet side of the culvert. When these unperforated pipes have been inserted to their full length they are withdrawn and are exchanged for perforated steam pipes which are fixed in position. Then steam is turned on to perform its thawing action until this length of the culvert may be cleared. This procedure is repeated until the culvert has been cleared throughout its length. The last portion of the length of the culvert is usually cleared from its inlet side, but it will be realized that if the culvert has a length of 10–15 meters and possibly even 20 meters it will be necessary for the persons performing the clearing to crawl into the culvert in order to be able to carry out a great deal of the work. Even if this work is not extremely risky it is cold and damp and generally unpleasant. Naturally such a clearing of a complete culvert is very time consuming, and especially so by larger culvert diameters and lengths.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a method and an apparatus by means of which the above discussed disadvantages in connection with conventional methods may be eliminated as far as possible.

This object is achieved by means of a method and an apparatus of the kind indicated in the enclosed patent claims. From the patent claims the characteristic features of the invention are also clear.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplifying embodiments of the invention are described more closely below in connection with the enclosed drawings, on which:

FIG. **1** is a schematic illustration of the principles of the present invention in connection with a road embankment with a road culvert, both in cross section,

FIG. **2** illustrates a ground attachment of the apparatus according to the invention.

FIG. **3** illustrates a culvert attachment of the apparatus according to the invention.

FIG. **4*a*** illustrates an edge cover in combination with the rope in its unloaded condition.

FIG. **4*b*** illustrates the edge cover according to FIG. **4*a***, but with the rope in its loaded condition.

FIG. **5** illustrates a modified embodiment with several apparatuses according to the invention positioned in a road culvert, and

FIG. **6** illustrates another embodiment of the rope having an alternative cross-sectional shape.

Although the invention is described herein with reference only to the clearing of a road culvert, it should be obvious that the invention with the same advantage may be used for thawing out other types of culverts for draining off melted ice and/or rain-water. An example of this may be culverts used in fields by farmers in order to prevent flooding of the fields.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 schematically illustrates the use of the invention by a road culvert 1 extended through a road embankment 2 in order to conduct melted ice and/or rainwater from an inlet side 1*a* to an outlet side 1*b*. Mostly the outlet side 1*b* of the culvert is relatively freely accessible from the outside even if the road culvert 1 is completely choked with ice, and thus, for reasons which will be explained below, a culvert attachment 3 is positioned in connection with the outlet and 1*b* of the culvert. An embodiment of the culvert attachment 3 is illustrated in greater detail in FIG. 3 from which it is clear that the culvert attachment has a first portion 3*a* intended to be clamped to the culvert. In the illustrated embodiment the first portion 3*a* comprises an inner leg 4 and an outer leg 5 between which the culvert 1 is introduced and clamped by means of a bolt 6 engaging a threaded bore in the outer leg 5. The other portion 3*b* of the culvert attachment is formed integral with the first portion 3*a* and is at its outer end releasably connected to a clamping means 8, for instance by means of a screw-nut connection 8*a*. In the illustrated embodiment the clamping means 8 consists of a flat bar being bent into a helical shape in its free end for a pivotal mounting on a pin 9 being firmly connected to a plate secured to the culvert attachment substantially midway between its ends. Through the pivotal mounting of the clamping means 8 on the pin 9 a rope 10 that will be more closely described below may be released and clamped between the helical end of the clamping means 8 and a portion of the culvert attachment close to the middle thereof by swinging the clamping means 8 upwardly and downwardly respectively about the pin 9.

In connection with the inlet side 1*a* of the road culvert 1 and at a distance therefrom a ground attachment 11 is anchored in the road embarkment 2 or at some other suitable place in accordance with what will be discussed below. In FIG. 2 a suitable embodiment of the ground attachment 11 is illustrated which in one of its ends is provided with a peg 12 which is pointed in one of its ends and which is intended to be forced down into the ground for anchoring the ground attachment. In its other end the ground attachment 11 is provided with a plate 13 which essentially corresponds to the plate 7 on the culvert attachment of FIG. 3 and which accordingly is provided with a pin 14 for pivotal mounting of one end of a clamping means 15 which in turn corresponds to the clamping means 8 of FIG. 3. Thus, the clamping means 15 has a helically shaped end for mounting on the pin 14, and in its opposite end it is releasably attached to the ground attachment 11, preferably by means of a nut 15*a* screwed into a threaded upper portion of the anchoring peg 12. It will now be realized that in accordance with what has been described in connection with FIG. 3 the clamping means 15 is intended for releasably clamping the rope 10 between its helical end a portion of the ground attachment 11.

In the case illustrated in FIG. 1 where the ground attachment is anchored in connection with the road embankment 2 it also becomes necessary to provide an edge cover 16 at the inlet end 1*a* of the culvert, and this partly for guiding the rope 10 around the relatively sharp bend and at the same time also for protecting the rope. As is clear from FIGS. 4*a* and 4*b* the edge cover 16 in a suitable embodiment consists of a first portion 16*a* which to a great extent corresponds to the first portion 3*a* of the culvert attachment 3 and thus comprises an inner leg 17 and an outer leg 18 between which the culvert 1 is clamped by means of a bolt 19 screwed into a threaded bore in the outer leg 18. The other portion 16*b* of the edge cover provides the guiding proper for the rope 10 and for this purpose includes an upwardly bent guide rail 20 having a smooth curvature for deflecting the rope 10 between 90° and 180°, in the illustrated embodiment approximately 135°. For providing the best guiding the guide rail 20 has an inner, longitudinal groove having a shape essentially corresponding to that of the rope 10. For additionally securing and guiding the rope 10 in the guide rail 20 the latter is also provided with a number of guide loops 21 evenly distributed along the length of the guide rail, and through these loops the rope is threaded.

For reasons of clarity it should be mentioned that although the elongated means, which according to the invention is intended to be extended through a road culvert, herein is referred to as a rope this term is not intended to delimit the invention regarding the cross-sectional shape or surface of the elongated means. Although the rope in the illustrated embodiments has a substantially circular cross-sectional shape it is obvious that the term rope should also cover rectangular, triangular or other suitable cross-section shapes.

As mentioned above the rope 10 is intended to be extended through the road culvert 1 and to be clamped at the culvert attachment 3 as well as at the ground attachment 11. The rope is substantially solid or homogeneous (possibly with air bubbles contained in the material) and in the illustrated embodiments it has a basically circular sectional area. The rope is cut into a suitable length corresponding to the length of the road culvert to which it is to be attached. Characteristic of the rope is that it is manufactured from a material which at least to a certain degree may be reversibly extended, i.e. a material which when it is subject to a tension load undergoes a certain, not permanent, reduction in cross section. Thus, when the tension load is removed the rope shall resume its original shape. By an embodiment of the invention where a free passage is established through ice in the road culvert by simply pulling the rope out from the culvert, it is sufficient if the rope has a relatively low reversible extensibility sufficient for reducing the cross-sectional area of the rope to such a degree that it without problem is released from the surrounding ice. By another embodiment where the passage through the ice is established with the rope remaining in the culvert by extending the rope to such an extent that its cross-sectional area is greatly reduced, it must on the other hand be possible to subject the material to such a tension load that its cross-sectional area is substantially reduced to half without any danger of the material rupturing or breaking. A material that has been found suitable for the later embodiment and that complies with the requirements thereof is a synthetic rubber EPDM (SIS 1626-70).

In either or both of its ends the rope is provided with a hook 22 the function of which will be described below. In certain cases it may also be preferable to provide the free ends of the rope with a not shown web or stocking intended to protect the rope from external damage through for instance gravel and rocks.

According to an emboidment of the invention the clearing or thawing out of a road culvert is carried out in the following manner:

In good time before the winter, when the culvert is open, the above described equipment is installed, and when installed it can remain there year after year and it will not be necessary to dismount it unless some portion thereof is damaged. The assembly is carried out such that a culvert attachment **3** of the kind described above is clamped to the outlet side **1***b* of the culvert **1**. The ground attachment **11** may be secured by forcing the anchoring peg **12** into the ground by means of any suitable tool so that it is firmly anchored, and the anchoring may be carried out in alternative places depending upon the surrounding terrain. Hereby it is determining that the ground attachment shall be anchored at a spot where there is little danger that it will become covered by ice during winter. The reason for this is naturally that it must be easy to get hold of the end of the rope **10** being positioned in connecton therewith without having to expose said end by chopping off ice. Of importance for the positioning is also that the anchoring position must be as close as possible to the inlet end **1***a* of the culvert so that the length of the rope may be reduced. In view of this the positioning illustrated with full lines in FIG. **1** seems to be preferable in most cases, but it is also possible to position the ground attachment as illustrated with broken lines in FIG. **1**, in which case the rope will be extended obliquely upwardly in FIG. **1**.

As mentioned above the positioning of the ground attachment **11** illustrated with full lines in FIG. **1** also necessitates the mounting of an edge cover **16** at the inlet end **1***a* of the culvert for deflecting and guiding the rope **10**. By the alternative positioning illustrated with broken lines it would be possible to manage without any edge cover or with an edge cover of a simpler design. When the culvert attachment, the ground attachment and possibly an edge cover have been installed the rope **10** is extended through the culvert and, where appropriate, the rope is then threaded through the edge cover, and its ends are clamped to the culvert attachment and to the ground attachment respectively. The clamping is carried out in such a way that the clamping means **8** and **15** respectively is disengaged and is swung about the pin **9** and **14** respectively, whereupon the rope is installed in the respective attachment and is clamped in position by means of the clamping means which are secured by the nut **8***a* and **15***a* respectively. The rope **10** is clamped to the attachments in its substantially unloaded condition, i.e. without being subject to any essential tension load. However, especially in connection with longer road culverts it may be necessary to clamp the rope **10** when the same is subject to a certain, low tension load in order to make sure that the rope does not hang down towards the middle but runs close to the upper edge of the culvert **1** throughout its extension, and as discussed in the introduction this is essentially in order to make it possible for the water flowing through an opened passage to eat its way down in the ice so that the ice may be efficiently cleared away. The rope remains in the above described position and when it is discovered, during a routine inspection discussed above, that the culvert is completely choked with ice so that melted ice cannot be drained therethrough it will, by employing the invention, no longer be necessary to send out any special patrol for clearing the culvert, but in most cases the person carrying out the inspection may carry out the clearing by himself. By one embodiment the procedure is such that the rope is released at the culvert attachment **3** by the outlet side **1***b* of the culvert, possibly subsequent to exposing this side by removing snow, through disengaging the clamping means **8** and swinging the same about the pin **9**. The rope which in this embodiment should have a high reversible extensibility is then stretched or tensioned by hand from the outlet side **1***b* while remaining clamped at the ground attachment **11**, and through this tension load and due to the tensibility of the material the rope **10** is immediately released from the ice as its cross-sectional area is greatly reduced. Hereby a free passage for the melted ice is established around the circumference of rope and when this has been achieved the rope is clamped to the culvert attachment **3** again in its loaded condition so that the water may continue to flow in the passage in such a way that it wears its way through the ice and finally clears the whole culvert. When the culvert has been cleared the rope is released from the culvert attachment **3** again and is unloaded so that it resumes its original shape and finally it is clamped again so that the procedure may be repeated if the culvert should become choked with ice once more. As has been mentioned above it is obvious that the rope **10** by this embodiment should have as high a reversible extensibility as possible in order to establish the largest possible passage for the melted ice when it is stretched or tensioned. In this embodiment it may also be suitable if the rope has a rectangular cross-sectional shape in order to leave as wide a passage as possible for the melted ice to thereby ensure a positive clearing of the complete culvert.

When the ground attachment is positioned as illustrated with broken lines in FIG. **1** there is a danger that the reduction of the cross section of the rope at the end closest to the ground attachment, due to the great distance from the place where the tension load is applied, goes on so slowly that the water beginning to flow in freezes before sufficient flow has been established in order to keep the passage open. For that reason it may be preferable in all cases to use the variant illustrated with full lines in FIG. **1**, having an edge cover **16**. The reason for this is that when the rope is stretched about the edge cover the passage may be opened up more quickly by performing the tensioning or stretching in two different steps. In FIG. **4***a* the rope is illustrated guided about the edge cover in its unloaded condition, but in FIG. **4***b* the broken lines illustrate how the extension of the rope is blocked by the guide rail **20** of the edge cover so that the reduction of the cross-sectional area of the rope, when the rope is normally tensioned, has been fully established up to the guide rail and possibly a distance around the same, while the remaining portion of the rope still maintains its full cross-sectional dimension so that no melted ice or snow enters from above. At this state the rope is clamped at the culvert attachment **3** when in its loaded condition and the person moves to the ground attachment **11** and exposes the same when necessary. Then the rope is released at the ground attachment and since only a relatively short portion of the rope from the edge cover **16** and up to the ground attachment is unloaded this portion of the rope may quickly be stretched or tensioned so that a full flow through the established passage is immediately obtained and so that the above mentioned danger of freezing is elminated.

By certain road culverts which by experience are known to cause serious problems, or by road culverts having a large diameter it may suitable to provide several ropes **10** at a distance from each other in connection with the upper portion of the culvert, and for instance in the way schematicaly illustrated in FIG. **5**. Another alternative that may be considered in connection with larger road culverts is to employ thicker ropes therein, but in such a case it may be necessary to provide some kind of not shown auxiliary device having a gear mechanism for tensioning or stretching the rope.

In FIG. 6 a rope 10' is illustrated having an alternative cross-sectional shape with longitudinal grooves or channels. This rope is intended to be twisted in connection with the streching or tensioning thereof so that the grooves assume a screw line shape around the rope. Apart from the fact that this configuration establishes a somewhat larger passage for the melted ice it also gives the ice a non-uniform surface so that the melted ice more efficiently wears off the ice. This is even further emphasized if the grooves or channels initially are helically shaped in the rope.

In extremely difficult situations where the above described method is not sufficient or in cases where it is desirable to open up a culvert in spite of the fact that there is no water such as melted ice or snow present that can wear down through the ice during its flow through the culvert, it is in accordance with another embodiment also possible to use the invention together with a conventional steam unit or possibly together with a hot-air unit, such as a building dryer. For this purpose a hook 22 is provided in one or possibly both ends of the rope. By connecting a particular steam pipe (possibly a flexible steam hose), which is closed in one end and in said end is provided with a loop for engaging the hook 22 and which is perforated along a portion of its length, to the steam unit the complete culvert may be cleared from one side without the necessity for crawling into the culvert. This is achieved by hooking-up the loop of the steam pipe to the hook 22 of the rope, whereupon the steam pipe, through withdrawal of the rope, is pulled stepwise through the culvert as this is thawed out. Due to the fact that the steam pipe is pulled in through the passage established by the rope it will not be necessary to take up separate holes for the perforated steam pipe and moreover the complete culvert may be thawed out in one operation independent of the length of the culvert. This work is naturally speeded up even further if several ropes are installed in the culvert in accordance with FIG. 5, whereby a corresponding number of steam pipes may be used. It should be realized that by this embodiment it is, as mentioned, sufficient if the rope only has a certain reversible extensibility, since it is intended to establish a passage through the ice by being completely withdrawn from the culvert. Thus, the reduction of the cross-sectional area need only be sufficient to ensure that the rope is released from the ice.

Although preferred embodiments of the invention have been described and illustrated herein it should be obvious to those skilled in the art that a great number of changes and modifications may be carried out without departing from the scope of the invention. For instance it is possible to employ alternative designs for the culvert attachment, the ground attachment and the edge cover, both regarding their preferred clamping to the culvert, anchoring in the ground and clamping of the rope respectively. Thus, the scope of the invention should only be restricted by the enclosed patent claims.

I claim:

1. A method for clearing road culverts or the like having become choked with ice, comprising the steps of: extending a substantially homogenous rope of a material having at least a certain reversible extensibility through the culvert from its inlet side to its outlet side before it becomes choked with ice; clamping the rope in its unloaded condition in connection to the outlet side and inlet side of the culvert so that the rope extends through the culvert; and, once the culvert has become choked with ice, releasing the rope from its clamping in connection with the outlet side of the culvert; applying a tension load to the rope from the released end for reducing the cross-sectional area of the rope and thereby forming a free passage through the culvert around the circumference of the rope; clamping the rope again in connection with the outlet side of the culvert, in the loaded extended condition of the rope; and allowing a continuous flow of melted ice or snow in the passage formed around the circumference of the rope, thereby clearing the road culvert.

2. A method as described in claim 1, wherein a rope having a high reversible extensibility is used and wherein the rope is clamped close to the upper portion of the culvert.

3. A method as described in claim 2, wherein the rope in connection with the inlet side of the culvert is deflected from its extension within the culvert through an edge cover; the corresponding end of the rope is clamped at a distance from the inlet side of the culvert and both ends of the rope, one after the other, are released from the clamping, are tensioned or extended and clamped again.

4. A method for clearing road culverts or the like having become choked with ice, comprising the steps of: extending a substantially homogeneous rope of a material having at least a certain reversible extensibility through the culvert from its inlet side to its outlet side before it becomes choked with ice; clamping the rope in its unloaded condition in connection to the outlet side and the inlet side of the culvert so that the rope extends through the culvert; and, once the culvert has become choked with ice, releasing both ends of the rope at their respective clamping positions; connecting a steam pipe perforated along a portion of its length to one end of the rope; connecting the steam pipe to a steam unit; applying a tension load to the end of the rope not connected to the steam pipe, for reducing the cross-sectional area of the rope so that it is released from the ice; successively pulling the rope out from the culvert for forming a free passage through the culvert and successively pulling the steam pipe into the passage in the ice established by withdrawing the rope; thereby successively clearing the culvert by means of steam supplied from the steam unit.

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US005986237A

United States Patent [19]

Sterling et al.

[11] **Patent Number: 5,986,237**

[45] **Date of Patent: Nov. 16, 1999**

[54] **METHOD FOR THAWING FROZEN ROAD CULVERTS**

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[73] Assignee: **Iceworm International Inc.**, Alberta, Canada

[21] Appl. No.: **08/936,825**

[22] Filed: **Sep. 25, 1997**

[51] **Int. Cl.**[6] **H05B 1/00**; H01C 3/06

[52] **U.S. Cl.** **219/213**; 219/549; 338/214

[58] **Field of Search** 219/213, 528, 219/544, 538, 546; 404/77, 79; 405/131, 128; 338/214

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Primary Examiner—Teresa Walberg

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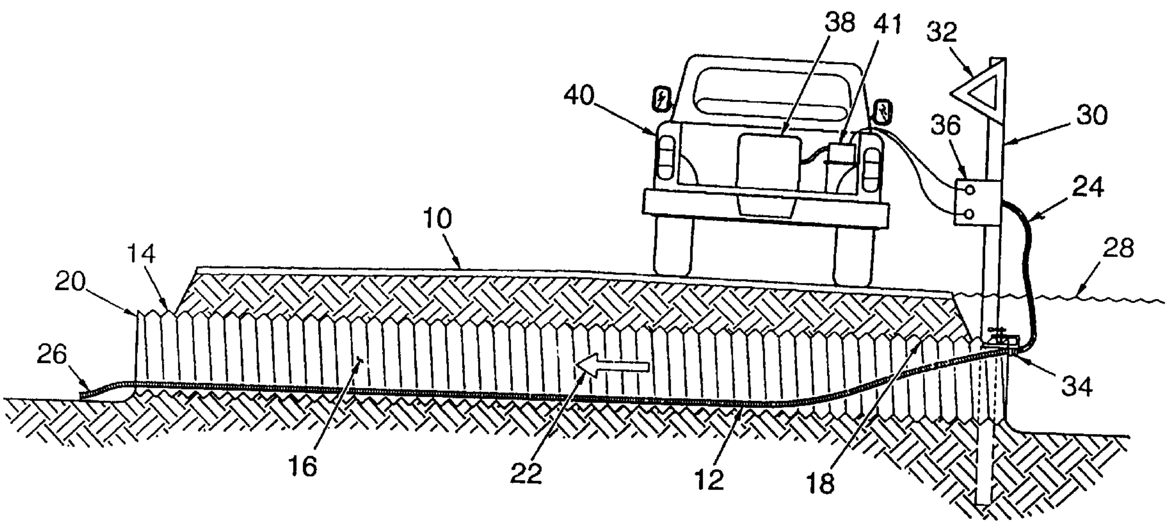
Attorney, Agent, or Firm—Davis and Bujold

[57] **ABSTRACT**

A method for thawing frozen road culverts. The first step involves positioning an electrically conductive cable in a road culvert prior to an ice blockage occurring. A connection end of the electrically conductive cable is anchored in an accessible location. The second step involves connecting a power source to the connection end of the electrically conductive cable after an ice blockage of the road culvert has occurred and supplying power to the electrically conductive cable, such that energy generated by power flowing through the electrically conductive cable causes a flow path to be created through the ice blockage in the road culvert.

7 Claims, 2 Drawing Sheets



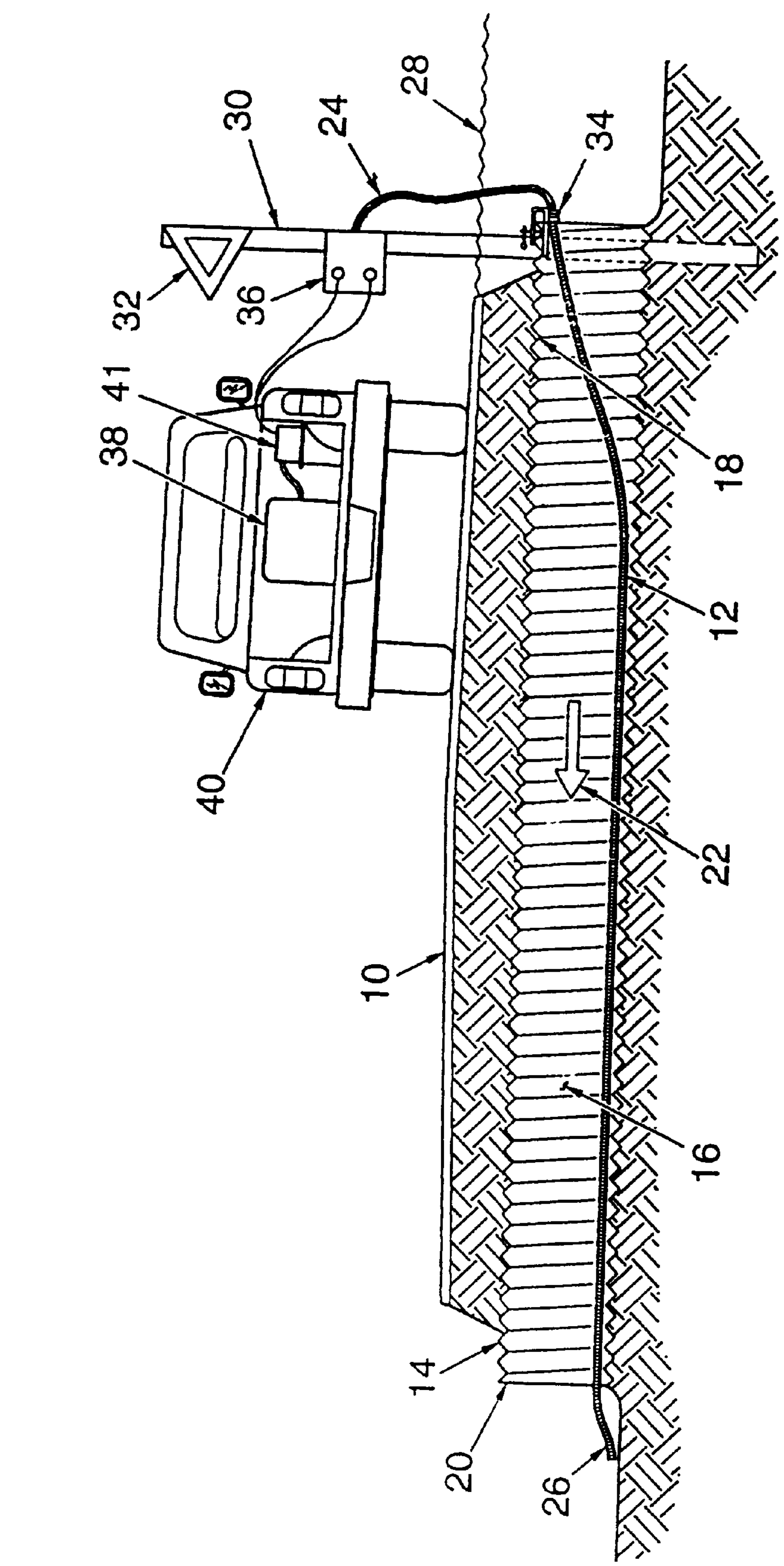


FIGURE 1

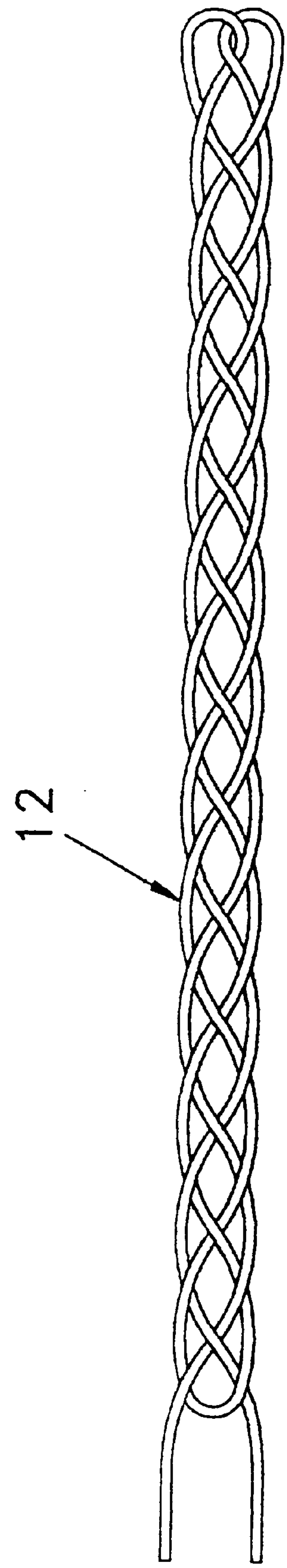


FIGURE 2

METHOD FOR THAWING FROZEN ROAD CULVERTS

FIELD OF THE INVENTION

The present invention relates to a method for thawing frozen road culverts.

BACKGROUND OF THE INVENTION

With the coming of spring every year there is a daily cycle of melting and freezing. The heat of the sun during the day causes snow to melt. As the sun goes down the temperature falls and water resulting from melting of the snow freezes.

Culverts are strategically placed under roads which are in a path followed by a flow of water from the melting snow. The culverts divert the flow of water so the road does not wash out. Unfortunately, the daily cycle of melting and freezing sometimes results in a culvert becoming blocked by an ice plug. If the ice plug is not removed in a timely fashion, the flow of water seeks an alternative path which often results in a washing out of portions of the road.

At the present time, steam truck crews are dispatched whenever it is noted that a culvert is plugged by ice. Removal of an ice plug from a culvert is generally a slow process. High pressure steam is injected into the ice plug, usually from a downstream side of the culvert, until a flow of water is restored. An ice plug that extends part way into a culvert generally can be removed by high pressure steam within three hours. Ice plugs that extend completely through a culvert can take considerably longer to remove.

The problem of road culverts plugging with ice has become so prevalent, that oversize culverts are frequently used for the express purpose of reducing the frequency of the problem.

SUMMARY OF THE INVENTION

What is required is a more time efficient method of thawing frozen road culverts.

According to one aspect of the present invention there is provided a method for thawing frozen road culverts. The first step involves positioning an electrically conductive cable in a road culvert prior to an ice blockage occurring. A connection end of the electrically conductive cable is anchored in an accessible location. The second step involves connecting a power source to the connection end of the electrically conductive cable after an ice blockage of the road culvert has occurred and supplying power to the electrically conductive cable, such that energy generated by power flowing through the electrically conductive cable causes a flow path to be created through the ice blockage in the road culvert.

According to another aspect of the present invention, there provided, a combination including a road culvert and an electrically conductive cable. The road culvert has an interior bore with an upstream end and a downstream end relative to normal water flow. The electrically conductive cable is positioned in the interior bore and extends substantially the length of the road culvert from the upstream end toward the downstream end. A connection end of the electrically conductive cable is anchored in an accessible location, such that a power source connectable to the connection end of the electrically conductive cable to supply power to energize the electrically conductive cable.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the invention will become more apparent from the following description in which reference is made to the appended drawings, wherein:

FIG. **1** is a front elevation view, in section, of a culvert that has been equipped with an electrically conductive cable in accordance with the teachings of the present method.

FIG. **2** is a detailed top plan view of a electrically conductive cable illustrated in FIG. **1**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred method for thawing frozen road culverts will now be described with reference to FIG. **1**.

The teachings of the preferred method, as will hereafter be further described, require that an electrically conductive cable **12** be positioned in a road culvert **14**. Road is generally indicated by reference numeral **10**. Road culvert **14** has an interior bore **16** with an upstream end **18** and a downstream end **20** relative to a direction of normal water flow as indicated by arrow **22**. Electrically conductive cable **12** has a connection end **24** and a remote end **26**. Beneficial results have been obtained using electrically conductive cable **12** made from #10 insulated copper wire, although in applications requiring higher temperatures wire made from alloys that can withstand higher temperatures may be used. Electrically conductive cable **12** is positioned in interior bore **16** of road culvert **14** and, preferably, extends substantially the length of road culvert **14** from upstream end **18** toward downstream end **20**. It is essential that electrically conductive cable **12** is positioned at upstream end **18**, for it is at upstream end **18** that a lockage by ice is most likely to occur. It is not always ssential that electrically conductive cable **12** reach all the ay to downstream end **20**. Each installation must be made having regard to surface topography and other conditions prevailing. Some road culverts become blocked at both ends, others are prone only to upstream blockage. Connection end **24** of electrically conductive cable **12** is anchored in an accessible location. When choosing an accessible location must bear in mind the conditions that will prevail when an ice blockage condition is encountered. There is likely to be an accumulation of water upstream of road culvert **14**, so the accessible location ispeferably above a high water mark generally indicated by reference numeral **28**. There is also likely to be an accumulation of snow on the ground, so connection end **24** is preferably a sufficient height to be above any accumulation of snow. In order to achieve this objective, it is preferred that connection end **24** be mounted onto a post **30**. Post **30** can be marked with a sign **32** or otherwise marked so as to be readily identified by work crews. In order to ensure that electrically conductive cable **12** does not shift after installation, it is preferred that electrically conductive cable **12** be clamped by means of clamp **34** to upstream end **18** of road culvert **14**. Connection end **24** of electrically conductive cable **12** is preferably is connected to a junction box **36**. A power source **38** is used to supply power to electrically conductive cable **12**. For safety reasons, a low voltage direct current power source which generates six to forty volts is preferred. It will be appreciated that the power required will vary with the gauge and length of electrically conductive cable **12** used. It is not viewed as being cost effective to have a power source at every installation. It is viewed as being more practical to take power source **38** to the particular road culvert that is blocked, it is, therefore, preferred that power source **38** be mounted on a truck **40**. For reasons of safety, it is preferred that power source **38** have a control box **41** which include features that control current and provide overcurrent protection with a breaker trip mechanism.

The use and operation of the above described combination in accordance with the teachings of the preferred method will now be described. The first step involves positioning electrically conductive cable **12** in road culvert **14** prior to an ice blockage occurring. Of course, after an ice blockage has occurred it is too late to insert electrically conductive cable **12**. Historical data can be used to select those of road culverts **14** that are most prone to ice blockage. Connection end **24** of electrically conductive cable **24** is anchored in an accessible location, such as post **30**. It is preferred that cable be secured to road culvert **14** at upstream end **18** by means of clamp **34**. Cable **24** is then laid through road culvert **14**.

The second step involves connecting power source **38** to connection end **24** of electrically conductive cable **12** after an ice blockage (not shown) of road culvert **14** has occurred. As low voltage power source **38** is truck mounted, truck **40** can be dispatched. The connection of power source **38** to connection end **24** of electrically conductive cable **12** is made through junction box **36**. Power source **38** provides power to electrically conductive cable **12**. Tests have shown that energy generated by electrically conductive cable **12** causes a flow path to be created through the ice blockage in the immediate vicinity of electrically conductive cable **12**. The resulting flow of water then tends to accelerate the process of removing the blockage by rapidly washing away the ice. A trickle of water through road culvert **14** generally occurs in as little as two minutes and normal flow through road culvert **14** is generally restored within ten minutes. The rapid clearing of the blockage is believed to be due to more than just the heat generated by power passing through electrically conductive cable **12**.

Referring to FIG. **2**, in addition to thermal energy, there is believed to be an eddy current induced. In order to enhance this effect cable **12** is looped lengthwise back and forth in boustrophedonic fashion. The loops are then twisted together in order to make cable **12** more compact and easier to handle. Regardless of what forces are at work, the energy generated can be objectively shown to clear an ice blockage in a remarkably short time.

It will be apparent to one skilled in the art that modifications may be made to the illustrated embodiment without departing from the spirit and scope of the invention as hereinafter defined in the Claims.

The embodiments of the invention in which an exclusine property or privilege is claimed are defined as follows:

1. A method for thawing frozen road culverts, comprising the steps of:

positioning an electrically conductive cable in a road culvert prior to an ice blockage occurring, with a connection end of the electrically conductive cable anchored in an accessible location;

dispatching a mobile low voltage power source to the road culvert when a blockage occurs; and

connecting the power source to the connection end of the electrically conductive cable and supplying power to the electrically conductive cable, such that energy generated by power flowing through the electrically conductive cable causes a flow path to be created through an ice blockage in the road culvert.

2. In combination:

a road culvert having an interior bore;

an electrically conductive cable positioned in the interior bore and extending substantially the length of the road culvert;

a connection end of the electrically conductive cable being anchored in an accessible location, such that a power source is connectable to the connection end of the electrically conductive cable to supply power to energize the electrically conductive cable; and

a mobile low voltage power source for supplying power to the electrically conductive cable.

3. The combination as defined in claim **2**, wherein the road culvert has with an upstream end and a downstream end relative to normal water flow, the cable extending from the upstream end toward the downstream end.

4. The combination as defined in claim **2**, wherein the cable is looped lengthwise back and forth in boustrophedonic fashion.

5. The combination as defined in claim **4**, wherein the cable is twisted.

6. A method for thawing frozen road culverts, comprising the steps of:

positioning an electrically conductive cable in a road culvert prior to an ice blockage occurring, with a connection end of the electrically conductive cable anchored in an accessible location outside the road culvert and an opposite end of the cable being unattended and extending completely through the road culvert and projecting out through the opposite end thereof;

dispatching a mobile low voltage power source to the road culvert when a blockage occurs in the road culvert; and

connecting the power source to the connection end of the electrically conductive cable and supplying electrical power to the electrically conductive cable, such that energy generated by the electrical power flowing through the electrically conductive cable causes a flow path to be created through the ice blockage in the road culvert thereby assisting with thawing of the road culvert.

7. The combination of claim **2** wherein the accessible location of the connection end of the cable is located outside the road culvert so as to be accessible.

* * * * *

APPENDIX D

COST ESTIMATE

Community and Government Services - Government of Nunavut

Class 'D' Cost Estimate

Tetra Tech Project WTRM03187-01 - Hall Beach Drainage Project

Preliminary Estimate of Probable Costs		Total
Preliminaries		$71,173
Civil Works		$432,726
Miscellaneous		$15,000
	Sub-total	**$518,899**
Project Contingencies	40.0%	$207,559
	Total Estimated Construction Cost	**$726,458**

NMS Specs						
Preliminaries			**Unit**	**Est Quantity**	**Est. Unit Price**	**Est. Total**
01 25 01	0-1	Mob / Demob, Temporary Facilities, Security, Quality Control, etc.	lump sum	1	$47,172.60	$47,173
01 35 14	0-2	Traffic Control, Barricades, and Temporary Signage	lump sum	1	$4,000.00	$4,000
01 71 00	0-3	Construction Surveys	lump sum	1	$20,000.00	$20,000
					Sub-total Preliminaries	**$71,173**
Civil Works			**Unit**	**Est Quantity**	**Est. Unit Price**	**Est. Total**
31 14 11	1-1	Excavation and Off-Site Disposal	cu.m	2,000	$30.00	$60,000
33 42 13	1-2	Supply and Install 600 mm Steel Casing Culvert	m	40	$707.00	$28,280
33 42 13	1-3	Supply and Install 900 mm Steel Casing Culvert	m	38	$1,068.00	$40,584
33 42 13	1-4	Supply and Install 1200 mm Steel Casing Culvert	m	25	$1,610.00	$40,250
33 42 13	1-5	Supply and Install 900 mm Steel Casing Culvert Sleeve	m	4	$1,068.00	$4,272
31 37 10	1-6	Supply and Place 10 kg Class Riprap	cu. m	1,246	$100.00	$124,600
31 37 10	1-7	Supply and Place 50 - 75 mm Clear Crush	cu. m	283	$100.00	$28,300
31 32 21	1-8	Supply and Place Non-Woven Geotextile	sq. m	4,822	$20.00	$96,440
02 41 13	1-9	Culvert Removal and Off-Site Disposal	each	5	$2,000.00	$10,000
					Sub-total Site Services	**$432,726**
Miscellaneous			**Unit**	**Est Quantity**	**Est. Unit Price**	**Est. Total**
01 35 43	2-1	Dewatering	lump sum	1	$5,000.00	$5,000
01 35 43	2-2	Sediments and Erosion Control Measures	lump sum	1	$10,000.00	$10,000
					Sub-total Miscellaneous	**$15,000**

Notes:

1 Quantities shown on this table are estimates and provided for reference only.

2 Estimated quantities do not account for spare culverts and materials.

APPENDIX E

INVENTORY OF EXISTING CULVERTS

Table E-1: Inventory of Existing Culverts

Name	Proposed Culvert Action	Condition	Length (m)	Diameter (mm)	Material	Photo
C1	Clean Out Culvert	Damaged ends, partially full of debris	17.5	800	CSP	 

Table E-1: Inventory of Existing Culverts

Name	Proposed Culvert Action	Condition	Length (m)	Diameter (mm)	Material	Photo
C2	Replace Culvert	Buried, crushed, damaged inlet	21.6	500	CSP	 

Table E-1: Inventory of Existing Culverts

Name	Proposed Culvert Action	Condition	Length (m)	Diameter (mm)	Material	Photo
C3	Clean Out Culvert		9.1	2000	CSP	 

Table E-1: Inventory of Existing Culverts

Name	Proposed Culvert Action	Condition	Length (m)	Diameter (mm)	Material	Photo
C4	Replace Culvert	Buried, crushed, damaged ends	9.5	900	CSP	 

Table E-1: Inventory of Existing Culverts

Name	Proposed Culvert Action	Condition	Length (m)	Diameter (mm)	Material	Photo
C5	Replace Culvert	Crushed, damaged ends	9.5	900	CSP	 

Table E-1: Inventory of Existing Culverts

Name	Proposed Culvert Action	Condition	Length (m)	Diameter (mm)	Material	Photo
C6	Replace Culvert	Crushed	7.1	1200	CSP	 

Table E-1: Inventory of Existing Culverts

Name	Proposed Culvert Action	Condition	Length (m)	Diameter (mm)	Material	Photo
C7	Replace Culvert	Buried, crushed, damaged ends	17.4	1800	CSP	 

APPENDIX F

LIST OF PROPOSED CULVERTS

Table F-1: Proposed Culverts

Name	Proposed Culvert Action	Material	Wall Thickness (mm)	Length (m)	Diameter (mm)	Max. Flow (m^3/s)	Max. Velocity (m/s)	Max/Full Flow (%)	Max/Full Depth (%)
C1	Clean Out Culvert, add sleeve to ends	CSP		17.5	800	0.19	2.83	19	19
C2	Replace Culvert	SWSP	10-12	21.6	600	0.15	1.4	33	42
C3	Clean Out Culvert	CSP		9.1	2000	0.20	0.83	3	13
C4	Replace Culvert	SWSP	10-12	9.5	900	0.45	2.42	46	33
C5	Replace Culvert	SWSP	10-12	9.5	900	0.45	2.43	46	34
C6	Replace Culvert	SWSP	10-12	7.1	1200	0.44	1.79	35	28
C7	Replace Culvert	SWSP	10-12	17.4	1200	0.53	2.00	23	28
C8	New Culvert	SWSP	10-12	17.5	600	0.13	2.86	8	21
C9	New - Future Community Expansion	SWSP	10-12	18.1	900	0.28	1.17	47	40

Table F-2: Culvert Apron Riprap Volumes (Including Headwall and Endwall Protection)

				Inlet			Outlet			
Name	Diameter (mm)	Riprap Class (kg)	Riprap Thickness (mm)	Riprap Length (m)	Riprap Width (m)	Riprap Volume (m3)	Riprap Length (m)	Riprap Width (m)	Riprap Volume (m3)	Total Riprap Volume (m3)
C1	800	10	350	3.0	2.4	2.6	4.6	2.4	3.9	6.5
C2	600	10	350	2.3	1.8	1.4	3.5	1.8	2.2	3.6
C3	2000	10	350	7.6	6.0	16.0	11.6	6.0	24.4	40.3
C4	900	10	350	3.4	2.7	3.2	5.2	2.7	4.9	8.2
C5	900	10	350	3.4	2.7	3.2	5.2	2.7	4.9	8.2
C6	1200	10	350	4.6	3.6	5.7	7.0	3.6	8.8	14.5
C7	1200	10	350	4.6	3.6	5.7	7.0	3.6	8.8	14.5
C8	600	10	350	2.3	1.8	1.4	3.5	1.8	2.2	3.6
C9	900	10	350	3.4	2.7	3.2	5.2	2.7	4.9	8.2
Total Volume Riprap for Culvert Aprons (m^3):										**107.6**

Table F-3: Culvert Apron Geotextile Quantities (Including Headwall and Endwall Protection)

		Inlet			Outlet			
Name	Diameter (mm)	Riprap Length (m)	Riprap Width (m)	Geotextile Area (m2)	Riprap Length (m)	Riprap Width (m)	Geotextile Area (m2)	Total Geotextile Area (m2)
C1	800	3.0	2.4	9.4	4.6	2.4	14.4	23.8
C2	600	2.3	1.8	5.7	3.5	1.8	8.7	14.4
C3	2000	7.6	6.0	51.0	11.6	6.0	77.8	128.7
C4	900	3.4	2.7	11.6	5.2	2.7	17.8	29.4
C5	900	3.4	2.7	11.6	5.2	2.7	17.8	29.4
C6	1200	4.6	3.6	19.6	7.0	3.6	29.9	49.6
C7	1200	4.6	3.6	19.6	7.0	3.6	29.9	49.6
C8	600	2.3	1.8	5.7	3.5	1.8	8.7	14.4
C9	900	3.4	2.7	11.6	5.2	2.7	17.8	29.4
Total Geotextile Area for Culvert Aprons (m2):								**368.7**

APPENDIX G

PCSWMM MODEL PARAMETERS

Table G-1: Subcatchment PCSWMM Model Parameters

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S1	J875	0.3	96.0	31.7	2.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S2	J18	0.8	159.5	49.2	1.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S3	J2	1.4	141.9	97.4	0.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S4	J4	1.1	92.1	121.5	3.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S5	J868	0.9	126.5	71.4	9.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S22	J18	2.4	140.1	172.7	1.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S23	J13	1.4	99.2	144.0	1.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S24	J48	1.2	103.6	118.2	1.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S26	J48	1.0	148.8	69.7	1.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S30	J16	0.7	78.5	84.1	2.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S31	J11	1.0	79.3	121.5	1.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S32	J854	0.1	26.1	47.8	2.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S33	J4	0.6	53.3	121.7	2.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S34	J20	1.1	163.4	69.1	0.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S35	J13	1.2	155.4	79.7	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S36	J29	1.5	133.0	114.8	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S37	J33	1.8	168.2	104.7	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S39	J25	0.9	80.9	113.6	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S42	J33	0.8	69.6	114.6	1.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S43	J38	0.5	114.7	46.4	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S44	J38	0.7	77.7	96.3	1.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S47	J46	1.2	120.9	100.8	0.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S48	J64	1.4	132.0	104.0	2.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S49	J50	2.5	143.4	177.1	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S51	J847	1.8	244.2	72.9	1.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S52	J62	0.5	68.6	77.1	1.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S53	J50	0.6	42.7	140.3	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S57	J52	0.9	53.2	171.5	1.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S60	J46	1.3	149.3	83.8	0.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S61	J836	1.2	81.3	144.7	1.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S64	J907	0.1	33.5	21.4	0.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S65	J62	0.5	91.6	55.7	0.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S66	J896	0.8	130.4	57.6	2.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S67	J64	1.7	154.6	108.3	1.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S69	J71	0.7	59.8	120.1	0.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S70	J866	0.6	102.6	56.8	0.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S71	J876	2.6	168.7	154.6	1.2	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S72	J88	3.1	250.9	123.4	0.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S74	J66	1.4	147.0	97.7	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S75	J84	1.4	117.6	120.6	2.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S76	J86	1.0	58.0	167.9	1.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S77	J866	1.1	161.4	70.0	0.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S78	J896	1.5	229.5	64.1	1.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S79	J82	0.6	40.8	152.0	0.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S82	J82	1.2	50.4	242.9	1.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S83	J861	1.0	125.9	81.1	0.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S84	J861	0.5	123.3	44.6	0.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S85	J90	1.6	86.4	189.7	0.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S86	J99	1.5	145.2	103.6	1.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S87	J920	0.6	77.1	76.7	1.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S88	J889	0.7	61.3	119.0	1.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S89	J850	0.6	68.9	88.9	2.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S90	J92	0.6	29.4	199.4	0.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S91	J922	0.3	76.3	40.0	1.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S95	J111	0.7	62.9	109.5	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S96	J86	0.7	120.0	58.0	2.2	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S97	J92	1.4	177.9	79.0	1.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S98	J99	0.6	80.3	74.2	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S100	J109	1.2	93.4	125.9	1.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S102	J111	0.9	176.5	48.5	2.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S103	J102	1.0	134.6	76.4	1.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S107	J102	1.4	124.9	116.0	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S108	J113	1.1	73.2	150.7	2.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S110	J137	1.0	131.7	75.9	2.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S111	J137	0.7	112.1	61.7	2.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S114	J127	1.0	94.8	104.3	2.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S117	J125	0.9	67.7	134.0	1.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S119	J889	0.6	71.7	80.1	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S120	J119	1.7	86.2	194.7	0.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S121	J139	1.7	123.7	141.0	1.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S123	J139	1.1	94.4	119.9	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S124	J131	1.6	113.3	139.1	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S125	J889	1.8	152.7	118.9	1.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S127	J133	0.8	123.7	66.8	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S129	J141	0.5	82.6	62.7	1.2	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S130	J858	1.2	174.2	66.2	2.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S131	J143	1.2	90.9	127.8	2.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S132	OF12	0.7	89.6	79.9	4.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S134	J133	0.3	90.7	30.0	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S135	J856	0.7	37.1	199.9	1.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S136	J845	0.0	4.3	52.5	0.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S137	J151	0.5	89.2	57.1	2.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S138	J147	1.2	53.1	218.7	0.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S139	J149	1.0	73.5	138.0	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S140	J167	0.6	47.1	119.9	4.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S141	J158	0.4	66.5	57.9	0.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S143	J202	1.1	53.9	197.1	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S144	J151	0.7	95.4	76.8	2.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S145	J838	1.2	63.7	181.0	8.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S146	J880	0.1	33.6	41.1	2.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S147	J227	1.1	84.8	130.1	6.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S148	J167	0.9	61.2	149.0	7.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S149	J186	0.9	85.7	104.4	2.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S150	J190	1.0	86.4	113.9	2.6	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S151	J182	0.9	102.2	91.1	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S152	J182	0.9	97.5	91.6	2.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S155	J184	0.7	63.2	106.1	2.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S923	J291	6.5	249.0	260.6	0.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S157	J215	0.8	72.6	109.9	2.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S158	J196	1.3	175.3	74.9	0.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S159	J227	2.3	95.7	241.3	3.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S160	J184	1.8	126.5	139.2	0.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S161	J902	0.7	113.9	58.5	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S163	J213	0.5	81.3	62.3	2.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S164	J917	1.4	101.5	133.8	2.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S165	J229	0.9	93.6	97.0	2.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S166	J206	0.5	68.3	77.1	0.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S167	J206	1.5	193.9	76.0	1.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S168	J41	0.9	64.3	147.5	8.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S169	J246	1.1	59.6	190.5	8.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S170	J208	1.1	62.2	180.5	0.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S171	J223	1.1	112.0	98.6	1.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S175	J291	1.1	129.0	83.2	0.6	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S176	J250	0.8	108.9	77.3	2.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S177	J844	0.7	140.3	50.9	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S179	J291	0.8	87.5	89.2	0.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S180	J238	0.6	70.6	90.6	2.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S182	J265	0.9	49.1	188.5	3.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S183	J291	5.3	308.3	171.0	0.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S184	J917	0.7	72.4	90.5	0.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S186	J252	0.8	92.8	83.8	2.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S188	J260	1.0	82.2	116.5	1.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S189	J298	1.2	74.7	157.9	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S191	J246	0.7	93.6	79.6	7.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S192	J911	0.1	44.4	16.5	0.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S193	J281	1.8	141.1	125.7	2.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S194	J844	0.6	121.0	50.4	1.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S195	J291	0.7	51.5	136.2	2.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S197	J254	1.0	101.1	98.0	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S198	J270	1.0	100.0	97.2	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S199	J270	0.9	97.7	90.8	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S200	J842	0.8	138.7	55.1	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S201	J917	1.3	114.4	112.5	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S202	J274	0.8	102.0	77.3	1.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S203	J291	7.0	403.0	173.4	0.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S204	J281	0.5	84.7	62.1	2.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S207	J268	1.6	79.3	195.6	1.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S208	J917	1.2	66.8	184.5	2.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S210	J291	0.7	32.8	219.9	0.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S211	J291	8.4	311.4	268.5	0.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S213	J285	0.7	124.1	55.7	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S214	J296	0.9	62.1	146.5	1.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S215	J291	2.4	146.2	166.7	0.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S216	J278	0.8	51.4	147.8	0.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S217	J291	10.3	462.4	223.3	0.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S218	J291	0.7	12.4	551.9	5.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S220	J298	0.5	65.9	79.2	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S221	J291	0.6	12.8	483.0	4.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S222	J300	1.0	115.7	85.4	2.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S223	J835	0.9	40.3	217.2	1.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S224	J835	0.8	114.1	72.8	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S227	J909	2.0	152.0	131.7	1.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S228	J15	1.0	107.8	96.3	6.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S229	J862	0.9	70.5	128.4	2.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S230	J17	0.2	49.8	36.1	3.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S232	J298	0.5	87.3	59.9	2.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S233	J294	1.1	113.8	96.1	1.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S234	J316	0.5	57.0	85.9	3.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S235	J298	0.7	70.8	98.4	4.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S236	J900	0.8	103.4	75.1	2.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S239	J308	0.9	41.6	215.9	0.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S240	J322	0.5	71.2	73.3	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S241	J331	1.1	97.1	108.8	3.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S243	J909	1.1	154.1	71.1	1.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S245	J291	2.2	278.1	79.7	0.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S246	J291	0.9	24.2	351.7	2.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S247	J874	0.6	112.4	54.7	9.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S248	J830	0.6	139.2	44.0	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S249	J320	0.5	73.0	63.6	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S253	J329	0.6	57.3	109.7	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S254	J326	1.4	83.7	170.4	6.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S258	J335	0.6	15.2	388.3	1.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S259	J855	0.3	36.5	86.5	5.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S260	J909	1.8	146.1	121.8	1.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S261	J331	0.9	82.7	111.5	3.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S262	J919	1.3	185.3	68.2	1.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S265	J349	1.0	46.5	205.2	0.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S266	J349	1.7	99.7	169.1	0.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S267	J291	13.2	268.0	491.0	0.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S268	J346	0.7	63.8	105.3	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S269	J848	0.9	132.1	71.0	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S270	J337	1.3	147.7	85.8	1.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S271	J291	1.0	69.3	144.0	1.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S274	J357	1.5	64.5	225.1	1.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S275	J291	0.9	82.8	107.0	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S276	J291	1.1	90.5	118.2	1.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S277	J355	1.0	65.6	155.9	1.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S278	J919	0.9	74.4	122.2	1.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S279	J365	2.5	143.2	173.0	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S281	J381	0.9	90.6	99.0	2.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S283	J381	1.2	154.7	75.6	3.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S285	J291	0.4	39.6	100.6	1.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S286	J369	1.3	107.9	118.9	2.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S288	J291	0.7	72.1	92.7	1.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S289	J291	0.6	57.8	110.1	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S291	J1	1.1	132.8	79.2	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S293	J291	1.5	139.2	106.0	2.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S294	J291	1.6	139.5	111.7	2.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S296	J392	1.4	159.6	88.8	1.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S297	J396	1.0	119.3	82.2	2.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S298	J408	0.5	91.2	56.5	2.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S299	J400	1.1	74.0	143.6	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S300	J53	1.3	99.2	134.7	3.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S301	J45	0.5	61.3	85.9	5.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S302	J47	0.8	72.7	113.3	3.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S304	J53	1.0	105.4	90.2	1.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S306	J47	1.6	82.4	188.7	2.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S307	J882	1.1	52.8	216.1	1.3	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S309	J410	0.8	121.2	69.0	1.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S310	J404	1.5	99.4	147.7	0.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S311	J417	1.0	80.0	123.6	2.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S312	J431	0.5	133.3	39.8	1.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S313	J414	0.9	65.7	142.0	1.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S314	J412	1.6	85.0	193.1	1.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S315	J832	1.4	170.7	80.0	1.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S317	J291	0.5	116.4	44.3	2.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S318	J291	1.0	57.4	166.1	3.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S319	J420	1.1	53.5	208.9	1.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S320	J431	0.9	87.4	99.0	1.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S321	J428	0.7	61.9	111.8	1.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S45	J45	0.6	72.3	88.3	3.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S323	J428	0.7	61.4	114.2	1.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S324	J426	1.6	117.5	136.3	1.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S325	J291	1.0	112.5	89.5	3.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S327	J424	1.0	47.0	209.0	1.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S328	J433	1.0	96.9	107.4	6.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S329	J31	1.2	101.4	118.1	3.4	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S330	J860	0.4	68.9	50.8	3.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S331	J441	1.4	162.1	87.8	2.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S334	J444	1.0	57.5	167.6	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S335	J453	0.2	99.1	20.8	3.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S336	J453	0.7	55.1	122.1	2.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S338	J444	0.6	83.9	71.7	2.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S339	J444	0.8	86.9	90.3	2.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S341	J31	1.1	109.1	100.9	3.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S342	J448	1.2	118.8	103.9	2.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S344	J455	0.5	51.7	97.5	1.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S345	J459	1.3	127.0	103.6	2.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S346	J59	1.6	144.1	108.7	3.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S347	J455	1.2	103.2	121.0	1.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S348	J455	0.6	170.2	36.1	2.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S350	J474	1.0	78.1	123.6	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S351	J893	0.4	121.1	36.8	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S352	J291	0.7	59.0	111.3	4.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S355	J291	0.5	52.2	98.9	4.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S356	J837	1.3	134.1	98.9	3.2	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S357	J837	0.6	48.1	116.0	5.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S358	J483	1.5	118.8	125.4	2.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S359	J483	0.9	64.0	138.3	4.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S360	J479	1.8	105.5	174.5	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S361	J501	1.3	68.6	191.2	2.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S362	J474	1.3	197.8	67.3	2.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S363	J843	1.6	152.5	106.9	1.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S364	J469	2.6	160.8	159.1	3.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S365	J503	0.5	120.0	44.8	3.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S366	J503	0.9	65.5	134.2	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S367	J291	1.1	130.4	81.7	2.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S368	J291	1.0	114.4	88.1	3.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S369	J491	1.2	119.3	102.7	2.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S370	J59	1.3	110.6	115.0	2.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S371	J491	0.6	60.2	101.5	2.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S372	J843	1.3	102.3	131.9	2.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S373	J59	0.7	83.7	78.0	3.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S374	J843	0.6	30.8	205.3	2.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S375	J546	0.5	25.4	201.9	2.0	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S377	J546	0.6	106.9	60.0	1.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S378	J479	0.7	87.6	75.8	3.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S380	J531	0.7	70.4	102.6	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S381	J513	1.2	150.8	82.4	4.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S382	J291	1.5	122.3	119.4	4.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S384	J517	1.4	134.0	102.9	3.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S385	J505	1.1	80.6	133.8	2.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S386	J505	0.5	107.2	47.6	3.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S387	J531	1.6	124.5	132.2	0.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S390	J884	0.1	48.1	29.5	0.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S391	J523	1.0	86.4	112.9	3.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S392	J59	2.2	143.4	155.3	4.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S393	J515	1.2	78.1	152.7	4.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S394	J519	0.6	69.3	93.4	4.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S395	J509	0.8	103.5	77.9	2.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S397	J523	1.1	113.7	97.1	2.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S398	J558	1.5	147.4	101.7	4.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S399	J28	1.0	59.2	171.1	5.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S400	J548	0.8	95.3	85.0	3.3	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S401	J517	0.6	101.6	62.0	3.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S402	J519	1.0	85.8	113.7	7.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S403	J883	2.5	141.4	180.3	4.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S404	J883	1.2	181.9	67.5	3.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S405	J540	1.0	93.7	110.1	3.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S406	J568	1.3	176.7	74.4	3.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S407	J556	1.4	78.3	172.7	1.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S408	J872	1.2	64.3	181.9	3.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S409	J513	0.6	91.9	61.1	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S411	J540	0.9	161.6	56.9	3.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S412	J540	1.5	96.9	153.6	3.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S413	J554	1.2	91.1	133.4	5.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S415	J59	1.0	65.4	156.5	5.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S416	J570	0.6	66.7	85.0	2.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S417	J578	1.0	83.4	125.1	4.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S418	J568	0.6	94.9	68.2	3.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S419	J563	0.8	49.4	161.8	2.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S420	J558	1.0	94.3	108.3	5.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S422	J620	1.7	99.9	169.5	1.3	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S423	J620	0.7	54.2	126.5	1.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S425	J602	0.8	59.0	134.9	1.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S426	J572	1.1	76.5	142.0	3.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S428	J849	0.5	124.1	38.3	0.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S429	J602	0.7	77.2	84.4	2.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S430	J554	0.7	61.7	117.8	3.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S431	J583	0.6	96.3	64.6	3.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S432	J630	1.1	42.4	255.0	1.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S433	J592	0.7	51.7	130.2	5.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S434	J548	1.1	102.9	102.1	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S435	J566	1.3	141.8	91.7	2.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S436	J566	0.7	73.2	96.2	3.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S437	J583	0.8	107.3	71.6	2.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S438	J590	0.5	53.9	96.4	5.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S439	J646	0.5	33.9	155.5	1.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S440	J857	0.5	65.2	80.9	0.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S441	J642	0.5	27.7	167.3	1.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S442	J659	1.1	37.2	286.6	0.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S443	J655	0.5	67.7	77.9	2.2	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S444	J857	1.3	122.0	106.0	0.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S445	J613	1.1	159.8	71.8	3.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S446	J606	0.8	118.9	69.8	3.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S447	J648	1.6	272.9	58.9	0.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S448	J592	1.2	89.2	137.7	3.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S449	J587	0.5	53.0	101.3	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S450	J840	1.2	65.4	190.9	4.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S451	J687	1.5	107.2	137.2	3.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S452	J624	1.1	184.2	59.8	2.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S453	J615	2.1	183.2	114.1	3.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S454	J594	1.0	50.7	200.5	4.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S455	J590	0.9	117.8	76.9	3.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S456	J638	0.7	34.4	213.7	6.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S457	J634	1.5	95.7	153.2	3.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S458	J613	1.1	154.6	71.7	1.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S459	J600	0.5	73.2	74.1	3.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S460	J634	0.7	64.9	111.3	5.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S461	J587	1.6	114.6	137.8	3.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S463	J640	1.4	105.1	134.9	3.0	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S464	J608	0.9	74.6	124.2	4.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S465	J606	0.6	84.8	74.5	3.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S467	J891	0.2	27.6	69.3	0.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S468	J915	2.0	193.6	104.7	0.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S469	J636	1.0	71.2	134.2	2.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S470	J915	2.1	155.1	136.8	0.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S471	J644	1.8	94.0	195.1	1.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S473	J666	0.9	62.6	140.6	5.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S474	J650	1.0	93.5	109.8	3.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S475	J657	1.2	66.2	176.4	5.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S476	J648	0.6	39.4	142.2	2.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S478	J661	2.0	142.7	139.0	2.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S479	J661	1.5	199.6	74.5	3.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S480	J680	0.7	81.8	80.8	7.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S482	J687	1.1	147.0	73.2	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S483	J683	1.0	81.4	121.5	2.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S484	J677	1.2	122.0	98.4	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S486	J675	1.1	91.3	117.1	4.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S487	J663	0.7	70.5	104.2	4.7	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S488	J655	1.4	137.3	98.5	1.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S489	J671	2.2	118.3	185.8	0.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S490	J636	0.9	96.9	91.1	4.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S491	J695	1.4	71.4	189.2	0.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S492	J689	0.8	76.4	110.0	1.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S493	J714	0.6	101.7	62.5	2.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S494	J725	1.1	95.2	115.7	3.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S495	J673	0.9	79.9	111.6	3.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S496	J699	0.7	76.3	90.9	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S497	J685	0.7	92.8	78.2	4.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S499	J915	2.3	217.1	105.7	1.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S500	J839	1.6	70.5	222.7	2.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S502	J691	1.6	121.8	129.3	4.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S503	J699	1.4	116.6	120.2	1.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S504	J910	1.5	89.8	161.7	4.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S506	J650	0.6	89.2	70.0	4.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S507	J719	1.7	140.5	118.5	2.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S508	J864	2.6	115.4	222.0	5.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S509	J725	1.4	138.4	100.4	2.9	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S510	J833	0.4	65.8	66.3	6.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S511	J711	1.5	122.2	125.9	3.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S512	J839	2.1	184.9	115.5	0.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S513	J714	0.9	99.0	92.0	1.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S514	J689	0.5	67.8	76.3	2.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S515	J706	1.2	83.7	144.4	4.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S516	J695	0.6	63.7	93.2	1.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S517	J706	1.0	56.8	184.7	8.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S518	J870	1.0	90.7	114.0	2.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S519	J740	3.4	160.4	214.9	2.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S521	J742	1.4	92.4	151.5	1.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S522	J732	0.6	60.7	99.2	2.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S525	J723	1.0	80.2	122.2	2.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S526	J723	0.9	99.4	95.2	2.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S527	J716	1.2	104.0	114.6	1.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S528	J736	1.4	108.3	129.7	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S530	J747	2.0	139.1	140.4	5.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S531	J730	0.7	57.3	114.4	9.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S532	J910	1.0	115.9	82.3	2.3	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S533	J721	1.6	102.3	158.2	3.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S534	J905	0.7	79.6	91.7	2.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S535	J783	0.7	66.4	109.8	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S536	J841	1.3	84.9	152.1	1.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S537	J755	0.5	48.7	106.7	2.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S538	J742	1.2	143.9	85.6	0.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S539	J905	1.0	169.6	61.0	3.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S541	J738	0.9	119.4	76.0	3.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S542	J759	1.0	153.5	67.1	2.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S543	J740	1.2	112.3	104.7	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S544	J755	0.6	94.7	59.9	3.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S545	J925	0.6	109.2	54.0	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S546	J789	1.8	232.2	77.7	1.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S547	J770	1.2	92.5	126.5	2.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S548	J779	1.8	198.1	91.2	1.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S549	J762	0.6	66.5	97.1	4.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S550	J751	0.5	80.4	63.6	3.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S551	J906	0.7	69.1	108.5	2.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S552	J887	0.4	58.8	71.1	4.3	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S553	J779	1.9	209.6	89.1	0.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S554	J738	1.3	105.5	121.9	2.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S555	J912	0.7	131.4	53.7	2.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S556	J841	1.2	138.5	84.0	0.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S557	J757	1.4	77.7	177.2	5.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S558	J751	0.6	89.3	63.6	2.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S559	J711	0.8	135.9	59.0	7.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S560	J753	1.5	83.2	181.1	0.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S561	J772	2.2	95.5	228.0	5.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S562	J787	1.2	115.4	106.4	1.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S563	J777	1.5	130.5	111.2	3.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S564	J768	0.6	72.7	78.8	7.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S565	J789	1.4	148.9	91.0	2.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S566	J865	1.4	116.2	116.7	0.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S567	J864	0.5	113.4	47.5	3.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S568	J785	0.6	74.9	77.1	1.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S569	J774	1.0	100.6	102.5	4.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S570	J823	1.4	91.3	149.7	0.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S571	J795	1.1	173.9	64.3	2.5	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S572	J795	1.2	79.6	152.2	2.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S573	J770	0.9	112.4	84.1	2.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S574	J783	0.7	68.1	96.4	2.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S575	J762	0.6	52.6	105.1	7.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S576	J781	0.7	118.6	59.4	3.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S577	J799	0.4	73.0	57.8	9.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S579	J812	0.7	51.6	127.3	2.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S581	J777	1.5	148.6	99.4	4.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S582	J804	0.9	44.3	193.1	6.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S583	J816	0.9	127.0	69.6	2.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S584	J809	1.0	109.8	88.5	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S585	J816	1.3	126.0	106.2	2.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S586	J772	0.8	65.4	122.0	5.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S587	J797	1.6	87.8	187.9	1.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S588	J873	1.5	167.7	88.8	3.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S589	J781	0.5	58.9	91.0	2.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S590	J826	1.3	156.6	80.8	0.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S591	J820	1.2	74.6	163.3	3.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S592	J921	2.3	320.0	72.5	0.0	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S593	J799	0.5	76.3	63.8	8.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S594	J818	1.4	80.6	174.1	2.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S595	J828	0.5	59.9	91.2	0.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S596	J916	0.3	87.5	38.6	0.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S597	J877	0.1	55.1	13.5	0.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S598	J894	0.0	17.1	16.7	0.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S599	J899	0.0	16.0	11.9	2.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S600	J926	0.1	51.7	19.0	0.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S25_1	OF11	0.4	118.6	33.8	2.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S28_1	OF11	0.3	51.4	65.6	3.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S55_1	OF10	1.7	123.8	136.6	3.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S73_1	OF10	1.3	64.4	205.0	4.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S80_1	OF10	0.8	126.3	65.1	3.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S93_1	OF12	0.4	110.4	31.7	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S99_1	OF12	2.2	190.8	114.7	3.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S116_1	OF12	0.8	42.7	197.0	3.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S126_1	OF12	0.2	127.9	16.3	2.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S154_1	OF8	0.3	138.5	21.0	2.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S172_1	OF8	0.5	68.9	74.9	7.2	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S173_1	OF8	0.3	38.7	86.1	6.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S185_1	OF9	0.0	89.6	5.3	3.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S185_2	OF8	0.2	89.6	21.1	3.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S187_1	OF9	1.2	113.6	104.5	4.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S196_1	OF9	0.7	74.6	96.3	7.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S209_1	OF9	0.8	86.1	96.2	4.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S219_1	OF7	0.8	86.3	87.9	3.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S225_1	OF7	0.6	139.6	43.7	2.9	0	0.01	0.03	1	1	0.1	0.01	4	7
S238_1	OF7	0.5	56.1	84.0	7.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S242_1	OF7	1.0	147.5	65.5	6.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S252_1	OF6	0.4	57.7	68.4	6.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S255_1	OF6	0.5	62.2	75.9	5.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S256_1	OF6	0.0	95.7	1.1	0.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S282_1	OF6	1.1	80.5	132.3	6.3	0	0.01	0.03	1	1	0.1	0.01	4	7
S284_1	OF5	0.1	21.1	70.5	2.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S292_1	OF6	0.9	102.4	92.2	6.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S303_1	OF5	0.0	53.0	3.4	4.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S303_2	OF6	0.3	53.0	56.2	4.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S305_1	OF5	0.4	69.0	61.8	7.4	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S308_1	OF5	1.2	73.9	159.8	3.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S316_1	OF5	0.7	75.0	87.3	4.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S326_1	OF5	1.2	115.4	106.5	6.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S343_1	OF5	0.8	71.5	117.9	5.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S349_1	OF4	1.0	120.9	78.8	7.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S376_1	OF4	1.0	62.5	152.8	8.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S383_1	OF4	0.1	84.9	13.4	4.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S396_1	OF4	0.8	82.9	93.4	7.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S410_1	OF3	0.1	46.7	14.5	6.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S410_2	OF3	0.3	46.7	70.5	6.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S414_1	OF3	0.2	76.0	27.4	1.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S424_1	OF3	1.1	113.7	97.8	8.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S427_1	OF3	0.4	41.3	106.4	8.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S462_1	OF2	0.9	50.0	183.9	5.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S472_1	OF2	0.1	51.6	23.4	2.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S477_1	OF2	0.1	192.8	6.4	2.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S505_1	OF2	0.5	96.7	49.5	4.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S524_1	OF1	0.2	81.7	22.4	3.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S540_1	OF1	0.1	97.0	13.3	4.4	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S6	OF11	0.9	98.7	90.7	4.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S7	OF11	1.7	140.9	119.5	3.4	0	0.01	0.03	1	1	0.1	0.01	4	7
S8	OF10	0.7	34.5	198.2	3.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S9	OF8	0.7	59.4	114.1	5.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S10	OF12	0.9	76.6	119.0	3.7	0	0.01	0.03	1	1	0.1	0.01	4	7
S11	OF14	1.7	120.7	139.4	8.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S12	J691	1.5	163.4	88.8	6.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S205_2	OF9	0.6	85.5	70.0	7.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S205_3	J17	0.6	85.5	69.6	7.0	0	0.01	0.03	1	1	0.1	0.01	4	7
S178_1	J21	0.3	89.2	36.6	6.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S273_1	J367	0.3	76.8	34.6	6.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S13_3	J49	0.4	87.7	45.7	4.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S13_4	J10	0.1	87.7	10.7	4.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S332_1	J881	0.4	113.3	35.8	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S332_2	J36	0.2	113.3	14.5	1.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S333_2	J35	0.4	178.6	24.7	2.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S337_1	J879	0.3	55.3	51.2	1.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S337_2	J32	1.2	55.3	221.1	1.6	0	0.01	0.03	1	1	0.1	0.01	4	7
S354_1	J507	0.2	102.8	21.3	2.8	0	0.01	0.03	1	1	0.1	0.01	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S354_2	J469	0.3	102.8	32.1	2.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S353_1	J507	0.0	78.3	0.7	3.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S353_2	J507	1.4	78.3	173.1	3.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S333_3	J469	1.0	178.6	54.8	2.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S333_4	J469	0.5	178.6	27.0	2.5	0	0.01	0.03	1	1	0.1	0.01	4	7
S273_2	J14	0.3	76.8	41.3	6.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S273_4	J12	0.4	76.8	50.3	6.8	0	0.01	0.03	1	1	0.1	0.01	4	7
S13_2	J5	0.0	87.7	1.1	4.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S13_5	J10	0.5	87.7	57.6	4.1	0	0.01	0.03	1	1	0.1	0.01	4	7
S178_3	J41	0.4	89.2	41.5	6.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S178_2	J248	0.3	89.2	33.0	6.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S178_5	J41	0.3	89.2	30.3	6.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S295_1	J57	0.3	62.2	48.9	2.2	0	0.01	0.03	1	1	0.1	0.01	4	7
S295_2	J57	0.4	62.2	62.8	2.2	0	0.01	0.03	1	1	0.1	0.01	4	7

Table G-2: Junctions PCSWMM Parameters

Name	X-Coordinate	Y-Coordinate	Invert Elev. (m)	Rim Elev. (m)
J4	489508.288	7632498.549	5.124	5.124
J11	489147.4	7632498.549	7.24	7.24
J13	489496.291	7632481.549	7.472	7.472
J16	488586.573	7632445.548	7.209	7.209
J18	489103.413	7632553.55	7.247	7.247
J20	488885.481	7632367.546	8.2	8.2
J25	488604.568	7632432.548	7.206	7.206
J29	489641.247	7632322.545	7.389	7.389
J33	489330.343	7632303.545	6.461	6.461
J38	488724.53	7632312.545	7.367	7.367
J46	489195.385	7632306.545	6.815	6.815
J48	488991.448	7632261.544	8.28	8.28
J50	489684.233	7632131.541	6.57	6.57
J52	489346.338	7632287.544	6.64	6.64
J62	489443.308	7632206.542	6.617	6.617
J64	488823.5	7632164.541	7.038	7.038
J66	489213.379	7632216.543	6.666	6.666
J71	489104.413	7632208.542	7.918	7.918
J82	489584.264	7632074.539	6.3	6.3
J84	489774.205	7632035.539	6.62	6.62
J86	489143.401	7631942.536	6.752	6.752
J88	488685.543	7632231.543	7.04	7.04
J90	489072.423	7632022.538	7.332	7.332
J92	489453.305	7631985.537	6.639	6.639
J99	488844.493	7632072.539	6.977	6.977
J102	489690.231	7632040.539	6.658	6.658
J111	489207.381	7631878.535	7.481	7.481
J113	489406.319	7631952.537	6.625	6.625
J119	488765.518	7631985.537	7.082	7.082
J125	488784.512	7631989.538	7.07	7.07
J127	489301.352	7631922.536	6.653	6.653

Name	X-Coordinate	Y-Coordinate	Invert Elev. (m)	Rim Elev. (m)
J131	488962.457	7631920.536	7.727	7.727
J133	489460.303	7631851.534	7.149	7.149
J137	489869.176	7631873.535	6.245	6.245
J139	489085.419	7631720.531	7.459	7.459
J141	488562.581	7631863.535	7.116	7.116
J143	489253.367	7631832.534	7.569	7.569
J147	488575.577	7631854.534	7.114	7.114
J149	488896.477	7631854.534	7.538	7.538
J151	489598.26	7631834.534	6.739	6.739
J158	489590.262	7631844.534	6.657	6.657
J167	489895.168	7631817.534	5.902	5.902
J182	489388.325	7631800.533	6.844	6.844
J184	488558.582	7631771.533	7.278	7.278
J186	488969.455	7631745.532	7.623	7.623
J190	489176.391	7631607.529	7.25	7.25
J196	488850.491	7631740.532	8.109	8.109
J202	489429.312	7631841.534	7.145	7.145
J204	489728.22	7631681.531	6.86	6.86
J206	488928.467	7631712.531	7.613	7.613
J208	488790.51	7631702.531	8.174	8.174
J213	489060.426	7631689.531	7.501	7.501
J215	489220.377	7631604.529	7.24	7.24
J223	488593.571	7631627.529	7.142	7.142
J227	489692.231	7631772.533	6.848	6.848
J229	489146.4	7631637.53	7.2	7.2
J246	490099.105	7631605.529	5.499	5.499
J248	490149.089	7631655.53	5.862	5.862
J250	489752.212	7631644.53	6.719	6.719
J254	489029.436	7631563.528	8.041	8.041
J260	488604.568	7631536.527	7.181	7.181
J265	489774.205	7631622.529	6.618	6.618
J268	488626.561	7631499.526	7.181	7.181

Name	X-Coordinate	Y-Coordinate	Invert Elev. (m)	Rim Elev. (m)
J270	488937.465	7631396.524	8	8
J274	488710.535	7631466.526	7.336	7.336
J278	488725.53	7631458.526	7.336	7.336
J281	489189.387	7631402.524	7.568	7.568
J285	489033.435	7631391.524	7.537	7.537
J294	488934.465	7631373.524	8	8
J296	489067.424	7631357.523	7.692	7.692
J297	490075.112	7631379.524	6.811	6.811
J300	489258.365	7631364.523	7.597	7.597
J316	489286.356	7631367.524	7.499	7.499
J320	488866.487	7631305.522	8.1	8.1
J322	488672.547	7631287.522	7.638	7.638
J326	490283.048	7631285.522	6.003	6.003
J329	488693.54	7631266.521	7.571	7.571
J331	490214.069	7631263.521	5.741	5.741
J335	488683.543	7631276.521	7.542	7.542
J337	488659.551	7631238.521	7.686	7.686
J346	488909.473	7631213.52	8.525	8.525
J349	488689.541	7631248.521	7.695	7.695
J355	488930.467	7631192.52	8.567	8.567
J357	489159.396	7631174.519	7.54	7.54
J365	489150.399	7631165.519	7.643	7.643
J367	490261.055	7631222.52	5.833	5.833
J369	488851.491	7631152.519	8.525	8.525
J381	490196.075	7631165.519	6.031	6.031
J392	489255.366	7631033.516	8.66	8.66
J396	488920.47	7630954.514	8.649	8.649
J400	490452.008	7631007.742	5.745	5.745
J404	489214.379	7630982.515	9.162	9.162
J408	488932.466	7630942.514	9.156	9.156
J410	489041.432	7630974.515	9.14	9.14
J412	489380.327	7630939.514	9.001	9.001

Name	X-Coordinate	Y-Coordinate	Invert Elev. (m)	Rim Elev. (m)
J414	488942.463	7630935.514	9.174	9.174
J417	488811.504	7630980.515	9.128	9.128
J420	488804.506	7630915.513	9.142	9.142
J424	488929.467	7630890.513	9.18	9.18
J426	489566.27	7630870.512	8.482	8.482
J428	488795.508	7630902.513	9.199	9.199
J431	489443.308	7630912.513	8.683	8.683
J433	490496.982	7630863.512	6.462	6.462
J441	489591.262	7630862.512	8.475	8.475
J444	489142.401	7630841.512	10	10
J448	489231.374	7630825.511	9.84	9.84
J453	489237.372	7630849.512	9.847	9.847
J455	489466.301	7630772.51	9.168	9.168
J459	489056.428	7630771.51	9.972	9.972
J474	489060.426	7630708.509	10.107	10.107
J479	489037.434	7630614.507	10.138	10.138
J483	489491.293	7630716.509	9.107	9.107
J491	490535.97	7630690.508	6.43	6.43
J501	488492.602	7630521.504	7.02	7.02
J503	489020.439	7630697.508	10.183	10.183
J505	489153.398	7630615.507	9.536	9.536
J507	490619.943	7630722.509	5.2	5.2
J509	489662.24	7630555.505	8.446	8.446
J513	489316.347	7630458.503	10.428	10.428
J515	489207.381	7630556.505	10.182	10.182
J517	489428.313	7630513.504	9.323	9.323
J519	489891.169	7630407.502	8.841	8.841
J523	489720.222	7630553.505	8.485	8.485
J531	488863.487	7630465.503	9.673	9.673
J540	490774.896	7630468.503	6.713	6.713
J546	488579.575	7630402.502	6.86	6.86
J548	489989.139	7630404.502	7.564	7.564

Name	X-Coordinate	Y-Coordinate	Invert Elev. (m)	Rim Elev. (m)
J554	490318.037	7630386.501	8.087	8.087
J556	490816.883	7630484.504	6.389	6.389
J558	489591.262	7630426.502	8.048	8.048
J563	489390.324	7630436.503	10.412	10.412
J566	490711.915	7630405.502	6.633	6.633
J568	489648.244	7630327.5	8.183	8.183
J570	489910.163	7630357.501	8.607	8.607
J572	489448.306	7630329.5	9.234	9.234
J578	490247.059	7630354.501	5.631	5.631
J583	489815.193	7630308.5	7.712	7.712
J587	490178.08	7630293.499	5.682	5.682
J590	489295.354	7630248.498	9.012	9.012
J592	489531.281	7630215.498	9.304	9.304
J594	490417.006	7630188.497	5.15	5.15
J600	489825.19	7630298.499	7.713	7.713
J602	488823.5	7630234.498	6.927	6.927
J606	489969.145	7630193.497	6.917	6.917
J608	490740.906	7630257.498	6.55	6.55
J613	489168.393	7630227.498	8.671	8.671
J615	490483.986	7630220.498	5.436	5.436
J620	488956.459	7630192.497	7.419	7.419
J624	490427.003	7630198.497	5.2	5.2
J630	489093.416	7630145.496	8.348	8.348
J634	489861.178	7630082.495	7.734	7.734
J636	490848.873	7630083.495	6.006	6.006
J638	489984.14	7630142.496	6.989	6.989
J640	489680.235	7630182.497	7.517	7.517
J642	488941.463	7630182.497	7.454	7.454
J644	489514.286	7629976.492	8.46	8.46
J646	489083.419	7630135.496	8.311	8.311
J650	489648.244	7630052.494	7.527	7.527
J655	488841.494	7630172.497	6.929	6.929

Name	X-Coordinate	Y-Coordinate	Invert Elev. (m)	Rim Elev. (m)
J657	491055.809	7630141.496	1.991	1.991
J659	489048.43	7630095.495	7.938	7.938
J661	489997.136	7629931.491	6.205	6.205
J663	489542.277	7630119.495	8.516	8.516
J666	489554.274	7630064.494	8.565	8.565
J671	489248.368	7630027.493	8.055	8.055
J673	489689.232	7630115.495	7.382	7.382
J675	489936.155	7630040.494	6.161	6.161
J677	490664.93	7630058.494	5.51	5.51
J680	490854.871	7630060.494	5.9	5.9
J683	489524.283	7629999.493	8.458	8.458
J685	490847.873	7630047.494	5.659	5.659
J687	490158.087	7630052.494	5.437	5.437
J689	489299.352	7629911.491	7.855	7.855
J691	491110.791	7630088.495	1.922	1.922
J695	489343.339	7629890.49	8.004	8.004
J699	489043.432	7629965.492	7.705	7.705
J706	490789.891	7630007.493	5.684	5.684
J711	491031.816	7629857.489	3.367	3.367
J714	489689.232	7629995.493	7.455	7.455
J716	489543.277	7629947.492	8.464	8.464
J719	490155.087	7629899.49	5	5
J721	491195.765	7629882.49	1.907	1.907
J723	489238.371	7629810.488	7.978	7.978
J725	489903.165	7629879.49	6.527	6.527
J730	491060.807	7629891.49	3.534	3.534
J732	489049.43	7629889.49	6.947	6.947
J736	490327.034	7629901.49	5.372	5.372
J738	489343.339	7629859.49	7.758	7.758
J740	490354.026	7629874.49	4.905	4.905
J742	488954.459	7629840.489	6.889	6.889
J747	490800.887	7629753.487	4.852	4.852

Name	X-Coordinate	Y-Coordinate	Invert Elev. (m)	Rim Elev. (m)
J751	489711.225	7629834.489	7.405	7.405
J753	488967.455	7629828.489	6.888	6.888
J755	490037.124	7629742.487	4.077	4.077
J757	491266.743	7629679.485	0.333	0.333
J759	490189.077	7629811.488	4.497	4.497
J762	490945.843	7629780.488	4.552	4.552
J768	490622.943	7629795.488	5.407	5.407
J770	489891.169	7629794.488	5.79	5.79
J772	491180.77	7629591.483	2.005	2.005
J774	489774.205	7629747.487	6.84	6.84
J777	490615.945	7629759.487	5.888	5.888
J779	489079.421	7629685.486	6.83	6.83
J781	490376.019	7629702.486	5.833	5.833
J783	490054.119	7629725.487	4.418	4.418
J785	490328.034	7629703.486	5.32	5.32
J787	489652.243	7629638.485	6.858	6.858
J789	490117.099	7629714.486	4.169	4.169
J795	489343.339	7629682.486	7.2	7.2
J797	489970.145	7629652.485	4.514	4.514
J799	491227.755	7629679.485	1.769	1.769
J804	491310.73	7629612.484	0.337	0.337
J809	489677.235	7629589.483	5.495	5.495
J812	489669.238	7629611.484	6.129	6.129
J816	489253.367	7629624.484	7	7
J818	490078.111	7629643.485	3.105	3.105
J820	490857.87	7629612.484	3.721	3.721
J830	488654.552	7631306.522	7.65	7.65
J832	489008.443	7630941.514	9.182	9.182
J833	490886.861	7630038.494	6.079	6.079
J835	488661.55	7631408.524	7.367	7.367
J836	488661.55	7632249.543	7.04	7.04
J837	489672.237	7630717.509	8.537	8.537

Name	X-Coordinate	Y-Coordinate	Invert Elev. (m)	Rim Elev. (m)
J838	490000.135	7631828.534	5.314	5.314
J839	490261.055	7629920.491	5.331	5.331
J840	489656.242	7630253.498	8.695	8.695
J841	489041.432	7629774.488	6.829	6.829
J842	488657.551	7631440.525	7.179	7.179
J843	488564.58	7630433.502	6.869	6.869
J844	488514.595	7631557.528	7.141	7.141
J847	489418.316	7632231.543	6.254	6.254
J848	488896.477	7631238.521	8.591	8.591
J849	488823.5	7630214.498	6.92	6.92
J850	489797.198	7631945.537	5.794	5.794
J855	490222.067	7631271.521	5.866	5.866
J856	489396.322	7631808.533	6.532	6.532
J857	489071.423	7630110.495	8.059	8.059
J858	489915.162	7631827.534	5.5	5.5
J860	490453.995	7630813.511	6.453	6.453
J861	488784.512	7632132.541	7.005	7.005
J862	488948.461	7631387.524	7.8	7.8
J864	490803.887	7629661.485	4.994	4.994
J866	488722.531	7632194.542	7.033	7.033
J868	489594.261	7632581.551	2.674	2.674
J870	489302.352	7629787.488	7.55	7.55
J873	490080.111	7629586.483	2.642	2.642
J874	490247.059	7631306.522	5.476	5.476
J876	489626.251	7632116.54	6.239	6.239
J879	490473.989	7630819.511	6.462	6.462
J881	490485.985	7630856.512	6.463	6.463
J882	489229.374	7630997.515	9.032	9.032
J883	490212.07	7630311.5	5.701	5.701
J887	489334.342	7629755.487	7.4	7.4
J889	489600.259	7631950.537	5.774	5.774
J893	489043.432	7630727.509	10.205	10.205

Name	X-Coordinate	Y-Coordinate	Invert Elev. (m)	Rim Elev. (m)
J896	489690.231	7632066.539	6.657	6.657
J900	489280.358	7631353.523	7.606	7.606
J902	489094.416	7631711.531	7.493	7.493
J905	489998.136	7629799.488	4.718	4.718
J906	491319.727	7629771.488	1.363	1.363
J909	489250.368	7631265.521	7.714	7.714
J910	489639.247	7629886.49	7.436	7.436
J912	489923.159	7629825.489	5.333	5.333
J915	490190.077	7629957.492	5.481	5.481
J917	489320.346	7631504.527	7.523	7.523
J919	489183.388	7631198.52	7.45	7.45
J922	489720.222	7632036.539	6.629	6.629
J925	490091.107	7629688.486	4.531	4.531
J23	490238.077	7631057.267	6.065	6.065
J26	490843.906	7630511.683	4.9	4.9
J27	490859.783	7630518.833	4.8	4.8
J30	490299.91	7631010.001	6.092	6.092
J32	490530.688	7630729.255	5.4	5.4
J34	490459.754	7630787.222	5.7	5.7
J35	490597.722	7630694.663	5.106	5.106
J36	490582.847	7630698.007	5.2	5.2
J37	490481.174	7630766.173	5.6	5.6
J39	490462.39	7631160.645	7.6	7.6
J40	491119.938	7630126.558	0.222	0.222
J1	490427.24	7631039.221	5.524	5.524
J3	490390.205	7631090.879	5.173	5.173
J5	490382.643	7631103.027	5.094	5.094
J10	490367.137	7631118.045	4.975	4.975
J12	490306.272	7631153.523	4.578	4.578
J14	490257.054	7631217.363	4.133	4.133
J15	490200.501	7631352.805	3.32	3.32
J17	490193.772	7631367.407	3.231	3.231

Name	X-Coordinate	Y-Coordinate	Invert Elev. (m)	Rim Elev. (m)
J19	490146.603	7631471.116	2.603	2.603
J21	490150.484	7631462.906	2.653	2.653
J22	490131.024	7631546.102	2.174	2.174
J24	490131.181	7631553.185	2.135	2.135
J41	490140.017	7631651.311	1.589	1.589
J42	490139.583	7631668.7	1.493	1.493
J43	490058.451	7631501.938	3.72	5.507
J44	490067.272	7631505.555	3.553	5.147
J6	490089.052	7631516.861	3.122	4.218
J7	490096.734	7631522.333	2.957	3.862
J8	490844.376	7630509.232	6.79	6.79
J9	490860.431	7630516.251	6.402	6.402
J31	490421.417	7630785.187	5.696	5.696
J45	490413.054	7630843.944	5.794	5.794
J47	490344.28	7630941.764	5.972	5.972
J53	490486.553	7630958.165	5.821	5.821
J57	490408.134	7631063.9	5.352	5.352
J49	490425.798	7631134.207	6.45	6.45
J51	490523.255	7630838.829	6.191	6.191
J54	490549.18	7630805.14	5.686	5.686
J55	490203.933	7631785.064	0.004	5.004
J56	490337.768	7630747.484	7.45	7.45
J58	490183.502	7630699.25	6.6	6.6
J59	490276.223	7630700.372	7	7
J60	489905.733	7631499.045	0	0
J291	489908.164	7631488.526	6.5	11.5
J28	490825.117	7630518.243	4.9	9.9
J469	490643.936	7630698.508	5	10
J298	490134.094	7631377.524	5.675	10.675
J920	489613.255	7631963.537	5.745	10.745
J238	489162.395	7631621.529	7.17	12.17
J308	488876.483	7631315.522	8	13

Name	X-Coordinate	Y-Coordinate	Invert Elev. (m)	Rim Elev. (m)
J648	490378.018	7630149.496	5.1	10.1
J252	489233.373	7631591.529	7.2	12.2

Table G-3: Conduits PCSWMM Parameters

Name	Inlet Node	Outlet Node	Tag	Length (m)	Rough-ness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
C15_1	J60	J55	channel_by_others	533.3	0.01	CIRCULAR	1	0	0
C15_2	J55	OF14	channel_by_others	0.367	0.01	CIRCULAR	1	0	0.0109
C3_14	J291	J43	channel_existing	158.695	0.03	RECT_OPEN	0.4	2	0.01752
C3_3	J44	J6	channel_existing	24.62	0.03	RECT_OPEN	0.4	2	0.01751
C3_17	J7	J22	channel_existing	44.706	0.03	RECT_OPEN	0.4	2	0.01752
C3	J21	J19	culvert_clean	9.086	0.023	CIRCULAR	2	0	0.0055
C8	J8	J9	culvert_clean	17.53	0.023	CIRCULAR	0.6	0	0.02214
C1	J26	J27	culvert_new	17.42	0.013	CIRCULAR	0.8	0	0.00574
C7	J41	J42	culvert_replace	17.402	0.013	CIRCULAR	1.2	0	0.00552
C4	J43	J44	culvert_replace	9.537	0.013	CIRCULAR	0.9	0	0.01751
C5	J6	J7	culvert_replace	9.436	0.013	CIRCULAR	0.9	0	0.01749
C2	J5	J10	culvert_replace	21.596	0.013	CIRCULAR	0.6	0	0.00551
C6	J22	J24	culvert_replace	7.088	0.013	CIRCULAR	1.2	0	0.0055
C35_6	J35	J469	ditch	48.252	0.03	TRAPEZOIDAL	0.5	0.5	0.0022
C35_4	J32	J36	ditch	61.148	0.03	TRAPEZOIDAL	0.5	0.5	0.00327
C35_7	J36	J35	ditch	15.263	0.03	TRAPEZOIDAL	0.5	0.5	0.00616
C35_3	J34	J37	ditch	30.061	0.03	TRAPEZOIDAL	0.5	0.5	0.00333
C35_8	J37	J32	ditch	61.819	0.03	TRAPEZOIDAL	0.5	0.5	0.00324
C3_5	J10	J12	ditch	72.083	0.03	TRAPEZOIDAL	0.5	0.5	0.00551
C3_9	J12	J14	ditch	80.661	0.03	TRAPEZOIDAL	0.5	0.5	0.00552
C3_7	J14	J15	ditch	147.441	0.03	TRAPEZOIDAL	0.5	0.5	0.00551
C3_10	J15	J17	ditch	16.092	0.03	TRAPEZOIDAL	0.5	0.5	0.00553
C3_12	J17	J21	ditch	104.995	0.03	TRAPEZOIDAL	0.5	0.5	0.00551
C3_11	J19	J22	ditch	77.81	0.03	TRAPEZOIDAL	0.5	0.5	0.00551
C3_13	J24	J41	ditch	99.076	0.03	TRAPEZOIDAL	0.5	0.5	0.00551
C3_16	J42	J55	ditch	270.781	0.03	TRAPEZOIDAL	0.5	0.5	0.0055
C35_5	J31	J37	ditch	65.026	0.03	TRAPEZOIDAL	0.5	0.5	0.00148

Name	Inlet Node	Outlet Node	Tag	Length (m)	Rough-ness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
C15_3	J56	J59	ditch	77.539	0.03	TRAPEZOIDAL	0.5	0.5	0.0058
C15_4	J59	J58	ditch	125.611	0.03	TRAPEZOIDAL	0.5	0.5	0.00318
C3_1	J400	J1	large_swale	40.07	0.03	TRIANGULAR	0.3	4.5	0.00552
C3_2	J3	J5	large_swale	14.319	0.03	TRIANGULAR	0.3	4.5	0.00552
C35_9	J45	J31	large_swale	66.424	0.03	TRIANGULAR	0.3	4.5	0.00148
C35_10	J47	J45	large_swale	120.408	0.03	TRIANGULAR	0.3	4.5	0.00148
C44	J53	J400	large_swale	60.45	0.03	TRIANGULAR	0.3	4.5	0.00126
C3_6	J1	J57	large_swale	31.228	0.03	TRIANGULAR	0.3	4.5	0.00551
C3_8	J57	J3	large_swale	32.426	0.03	TRIANGULAR	0.3	4.5	0.00552
C17	J51	J54	large_swale	42.527	0.01	CIRCULAR	1	0	0.01188
C1	J868	OF11	stream	132	0.03	TRAPEZOIDAL	1	2	0.02026
C2	J906	OF13	stream	30.035	0.03	TRAPEZOIDAL	1	2	0.04543
C4	J23	J12	stream	175.453	0.03	TRAPEZOIDAL	1	2	0.00848
C30	J27	OF4	stream	83.688	0.03	TRAPEZOIDAL	1	2	0.05745
C31	J28	J26	stream	22.424	0.03	TRAPEZOIDAL	1	2	0
C34	J469	J28	stream	277.908	0.03	TRAPEZOIDAL	1	2	0.00036
C35	J879	J37	stream	54.19	0.03	TRAPEZOIDAL	0.5	0.5	0.01591
C24	J431	J291	stream	740.49	0.03	TRAPEZOIDAL	1	2	0.00295
C33	J441	J291	stream	701.939	0.03	TRAPEZOIDAL	1	2	0.00281
C43	J837	J441	stream	169.12	0.03	TRAPEZOIDAL	1	2	0.00037
C5	J298	J17	stream	60.554	0.03	TRAPEZOIDAL	1	2	0.04039
C15	J58	J291	stream	836.261	0.03	TRAPEZOIDAL	1	2	0.00012
C35_2	J30	J47	swale	81.485	0.03	TRIANGULAR	0.2	1.5	0.00147
C39_1	J39	J49	swale	45.161	0.03	TRIANGULAR	0.15	1.5	0.02547
C39_2	J49	J5	swale	53.262	0.03	TRIANGULAR	0.15	1.5	0.02547
C6	J838	OF12	WDT	154.404	0.03	TRAPEZOIDAL	1	2	0.04017

Name	Inlet Node	Outlet Node	Tag	Length (m)	Rough-ness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
C7	J858	J838	WDT	90.96	0.03	TRAPEZOIDAL	1	2	0.00204
C8	J137	J858	WDT	65.071	0.03	TRAPEZOIDAL	1	2	0.01145
C9	J850	J137	WDT	101.85	0.03	TRAPEZOIDAL	1	2	-0.00443
C10	J922	J850	WDT	122.954	0.03	TRAPEZOIDAL	1	2	0.00679
C11	J102	J922	WDT	32.92	0.03	TRAPEZOIDAL	1	2	0.00088
C12	J920	J102	WDT	108.923	0.03	TRAPEZOIDAL	1	2	-0.00838
C13	J158	J920	WDT	128.882	0.03	TRAPEZOIDAL	1	2	0.00708
C14	J151	J158	WDT	16.952	0.03	TRAPEZOIDAL	1	2	0.00484
C16	J873	J926	WDT	18.698	0.03	TRAPEZOIDAL	1	2	0.14273
C18	J925	J818	WDT	49.03	0.03	TRAPEZOIDAL	1	2	0.0291
C20	J204	J227	WDT	103.327	0.03	TRAPEZOIDAL	1	2	0.00012
C21	J783	J925	WDT	52.34	0.03	TRAPEZOIDAL	1	2	-0.00216
C22	J755	J783	WDT	24.048	0.03	TRAPEZOIDAL	1	2	-0.01418
C23	J905	J755	WDT	87.222	0.03	TRAPEZOIDAL	1	2	0.00735
C25	J250	J204	WDT	45.518	0.03	TRAPEZOIDAL	1	2	-0.0031
C26	J265	J250	WDT	31.121	0.03	TRAPEZOIDAL	1	2	-0.00325
C27	J912	J905	WDT	86.824	0.03	TRAPEZOIDAL	1	2	0.00708
C28	J770	J912	WDT	46.642	0.03	TRAPEZOIDAL	1	2	0.0098
C29	J789	J925	WDT	36.779	0.03	TRAPEZOIDAL	1	2	-0.00984
C36	J874	J15	WDT	65.675	0.03	TRAPEZOIDAL	1	2	0.03285
C37	J759	J789	WDT	128.728	0.03	TRAPEZOIDAL	1	2	0.00255
C38	J774	J770	WDT	160.649	0.03	TRAPEZOIDAL	1	2	0.00654
C40	J917	J291	WDT	613.713	0.03	TRAPEZOIDAL	1	2	0.00167
C41	J367	J874	WDT	90.497	0.03	TRAPEZOIDAL	1	2	0.00394
C42	J719	J759	WDT	99.135	0.03	TRAPEZOIDAL	1	2	0.00507
C45	J751	J774	WDT	124.195	0.03	TRAPEZOIDAL	1	2	0.00455

Name	Inlet Node	Outlet Node	Tag	Length (m)	Rough-ness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
C46	J915	J719	WDT	73.113	0.03	TRAPEZOIDAL	1	2	0.00658
C48	J910	J751	WDT	89.411	0.03	TRAPEZOIDAL	1	2	0.00035
C49	J900	J316	WDT	17.276	0.03	TRAPEZOIDAL	1	2	0.00619
C53	J687	J915	WDT	106.971	0.03	TRAPEZOIDAL	1	2	-0.00041
C54	J896	J922	WDT	42.437	0.03	TRAPEZOIDAL	1	2	0.00066
C56	J909	J900	WDT	117.179	0.03	TRAPEZOIDAL	1	2	0.00092
C59	J876	J896	WDT	87.344	0.03	TRAPEZOIDAL	1	2	-0.00479
C62	J779	J921	WDT	116.935	0.03	TRAPEZOIDAL	1	2	0.00018
C63	J673	J714	WDT	135.614	0.03	TRAPEZOIDAL	1	2	-0.00054
C64	J357	J919	WDT	33.95	0.03	TRAPEZOIDAL	1	2	0.00265
C65	J365	J357	WDT	12.731	0.03	TRAPEZOIDAL	1	2	0.00809
C66	J889	J920	WDT	18.39	0.03	TRAPEZOIDAL	1	2	0.00158
C67	J820	J828	WDT	44.595	0.03	TRAPEZOIDAL	1	2	-0.00038
C69	J640	J673	WDT	70.348	0.03	TRAPEZOIDAL	1	2	0.00192
C70	J841	J779	WDT	104.009	0.03	TRAPEZOIDAL	1	2	-1.00E-05
C71	J62	J876	WDT	221.656	0.03	TRAPEZOIDAL	1	2	0.00171
C72	J883	J687	WDT	299.56	0.03	TRAPEZOIDAL	1	2	0.00088
C73	J392	J919	WDT	190.329	0.03	TRAPEZOIDAL	1	2	0.00636
C74	J847	J62	WDT	35.364	0.03	TRAPEZOIDAL	1	2	-0.01027
C76	J864	J820	WDT	86.606	0.03	TRAPEZOIDAL	1	2	0.0147
C77	J840	J640	WDT	77.646	0.03	TRAPEZOIDAL	1	2	0.01517
C78	J882	J392	WDT	47.066	0.03	TRAPEZOIDAL	1	2	0.0079
C79	J404	J882	WDT	21.219	0.03	TRAPEZOIDAL	1	2	0.00613
C80	J52	J847	WDT	93.614	0.03	TRAPEZOIDAL	1	2	0.00412
C83	J33	J52	WDT	22.634	0.03	TRAPEZOIDAL	1	2	-0.00791
C85	J507	J469	WDT	33.95	0.03	TRAPEZOIDAL	1	2	0.00589

Name	Inlet Node	Outlet Node	Tag	Length (m)	Rough-ness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
C86	J568	J840	WDT	87.362	0.03	TRAPEZOIDAL	1	2	-0.00586
C88	J215	J252	WDT	18.389	0.03	TRAPEZOIDAL	1	2	0.00218
C90	J725	J912	WDT	60.351	0.03	TRAPEZOIDAL	1	2	0.01979
C92	J839	J915	WDT	82.959	0.03	TRAPEZOIDAL	1	2	-0.00181
C93	J190	J215	WDT	47.492	0.03	TRAPEZOIDAL	1	2	0.00021
C94	J699	J732	WDT	76.985	0.03	TRAPEZOIDAL	1	2	0.00985
C95	J844	J911	WDT	13.539	0.03	TRAPEZOIDAL	1	2	0.0003
C96	J410	J365	WDT	276.323	0.03	TRAPEZOIDAL	1	2	0.00542
C97	J238	J190	WDT	19.804	0.03	TRAPEZOIDAL	1	2	-0.00404
C98	J202	J133	WDT	32.945	0.03	TRAPEZOIDAL	1	2	-0.00012
C100	J795	J816	WDT	133.485	0.03	TRAPEZOIDAL	1	2	0.0015
C102	J229	J238	WDT	22.633	0.03	TRAPEZOIDAL	1	2	0.00133
C103	J716	J910	WDT	118.495	0.03	TRAPEZOIDAL	1	2	0.00868
C104	J444	J404	WDT	170.598	0.03	TRAPEZOIDAL	1	2	0.00491
C105	J296	J909	WDT	217.783	0.03	TRAPEZOIDAL	1	2	-0.0001
C106	J558	J568	WDT	126.669	0.03	TRAPEZOIDAL	1	2	-0.00107
C108	J832	J410	WDT	48.138	0.03	TRAPEZOIDAL	1	2	0.00087
C110	J644	J716	WDT	41.023	0.03	TRAPEZOIDAL	1	2	-0.0001
C111	J736	J839	WDT	72.275	0.03	TRAPEZOIDAL	1	2	0.00057
C113	J46	J33	WDT	157.308	0.03	TRAPEZOIDAL	1	2	0.00225
C116	J836	J907	WDT	42.866	0.03	TRAPEZOIDAL	1	2	0.001
C118	J285	J296	WDT	48.096	0.03	TRAPEZOIDAL	1	2	-0.00322
C120	J683	J644	WDT	25.376	0.03	TRAPEZOIDAL	1	2	-8.00E-05
C121	J740	J736	WDT	38.194	0.03	TRAPEZOIDAL	1	2	-0.01223
C122	J426	J441	WDT	26.998	0.03	TRAPEZOIDAL	1	2	0.00026
C124	J88	J836	WDT	30.108	0.03	TRAPEZOIDAL	1	2	0

Name	Inlet Node	Outlet Node	Tag	Length (m)	Rough-ness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
C125	J887	J795	WDT	75.575	0.03	TRAPEZOIDAL	1	2	0.00265
C126	J881	J879	WDT	38.962	0.03	TRAPEZOIDAL	1	2	3.00E-05
C127	J260	J844	WDT	98.758	0.03	TRAPEZOIDAL	1	2	0.00041
C128	J548	J883	WDT	335.867	0.03	TRAPEZOIDAL	1	2	0.00555
C129	J902	J229	WDT	94.393	0.03	TRAPEZOIDAL	1	2	0.0031
C131	J459	J444	WDT	116.331	0.03	TRAPEZOIDAL	1	2	-0.00024
C132	J414	J832	WDT	67.903	0.03	TRAPEZOIDAL	1	2	-0.00012
C133	J860	J879	WDT	22.576	0.03	TRAPEZOIDAL	1	2	-0.0004
C134	J661	J905	WDT	141.587	0.03	TRAPEZOIDAL	1	2	0.0105
C135	J408	J414	WDT	12.365	0.03	TRAPEZOIDAL	1	2	-0.00146
C136	J870	J887	WDT	45.267	0.03	TRAPEZOIDAL	1	2	0.00331
C138	J866	J88	WDT	52.34	0.03	TRAPEZOIDAL	1	2	-0.00013
C140	J213	J902	WDT	42.424	0.03	TRAPEZOIDAL	1	2	0.00019
C141	J268	J260	WDT	46.295	0.03	TRAPEZOIDAL	1	2	0
C142	J396	J408	WDT	16.975	0.03	TRAPEZOIDAL	1	2	-0.02988
C144	J666	J683	WDT	76.603	0.03	TRAPEZOIDAL	1	2	0.0014
C146	J857	J659	WDT	28.337	0.03	TRAPEZOIDAL	1	2	0.00427
C148	J862	J285	WDT	94.203	0.03	TRAPEZOIDAL	1	2	0.00279
C149	J139	J902	WDT	12.731	0.03	TRAPEZOIDAL	1	2	-0.00267
C151	J893	J459	WDT	48.64	0.03	TRAPEZOIDAL	1	2	0.00479
C154	J71	J46	WDT	140.156	0.03	TRAPEZOIDAL	1	2	0.00787
C155	J300	J900	WDT	25.086	0.03	TRAPEZOIDAL	1	2	-0.00036
C156	J804	J899	WDT	22.244	0.03	TRAPEZOIDAL	1	2	0.0138
C157	J634	J725	WDT	235.555	0.03	TRAPEZOIDAL	1	2	0.00512
C160	J143	J856	WDT	161.882	0.03	TRAPEZOIDAL	1	2	0.00641
C161	J503	J893	WDT	38.512	0.03	TRAPEZOIDAL	1	2	-0.00057

Name	Inlet Node	Outlet Node	Tag	Length (m)	Rough-ness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
C162	J861	J866	WDT	87.704	0.03	TRAPEZOIDAL	1	2	-0.00032
C163	J842	J268	WDT	68.041	0.03	TRAPEZOIDAL	1	2	-3.00E-05
C165	J540	J556	WDT	50.019	0.03	TRAPEZOIDAL	1	2	0.00648
C166	J663	J666	WDT	62.91	0.03	TRAPEZOIDAL	1	2	-0.00078
C168	J517	J558	WDT	199.509	0.03	TRAPEZOIDAL	1	2	0.00639
C169	J50	J896	WDT	71.513	0.03	TRAPEZOIDAL	1	2	-0.00122
C173	J186	J213	WDT	110.297	0.03	TRAPEZOIDAL	1	2	0.00111
C174	J675	J661	WDT	132.484	0.03	TRAPEZOIDAL	1	2	-0.00033
C175	J455	J426	WDT	169.629	0.03	TRAPEZOIDAL	1	2	0.00404
C176	J308	J294	WDT	82.046	0.03	TRAPEZOIDAL	1	2	0
C177	J835	J842	WDT	33.838	0.03	TRAPEZOIDAL	1	2	0.00556
C178	J772	J894	WDT	22.157	0.03	TRAPEZOIDAL	1	2	0.03012
C179	J474	J893	WDT	25.573	0.03	TRAPEZOIDAL	1	2	-0.00383
C180	J111	J143	WDT	65.071	0.03	TRAPEZOIDAL	1	2	-0.00135
C181	J648	J915	WDT	260.283	0.03	TRAPEZOIDAL	1	2	-0.00146
C182	J320	J308	WDT	14.146	0.03	TRAPEZOIDAL	1	2	0.00707
C183	J849	J891	WDT	112.503	0.03	TRAPEZOIDAL	1	2	0.06163
C186	J417	J396	WDT	119.56	0.03	TRAPEZOIDAL	1	2	0.00401
C187	J757	J804	WDT	86.137	0.03	TRAPEZOIDAL	1	2	-5.00E-05
C190	J281	J300	WDT	87.915	0.03	TRAPEZOIDAL	1	2	-0.00033
C191	J92	J889	WDT	168.479	0.03	TRAPEZOIDAL	1	2	0.00513
C192	J689	J870	WDT	136.031	0.03	TRAPEZOIDAL	1	2	0.00224
C194	J730	J721	WDT	163.853	0.03	TRAPEZOIDAL	1	2	0.00993
C196	J833	J864	WDT	466.735	0.03	TRAPEZOIDAL	1	2	0.00232
C198	J566	J540	WDT	89.119	0.03	TRAPEZOIDAL	1	2	-0.0009
C199	J206	J186	WDT	53.273	0.03	TRAPEZOIDAL	1	2	-0.00019

Name	Inlet Node	Outlet Node	Tag	Length (m)	Rough-ness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
C201	J613	J857	WDT	157.617	0.03	TRAPEZOIDAL	1	2	0.00388
C202	J479	J503	WDT	92.782	0.03	TRAPEZOIDAL	1	2	-0.00049
C204	J855	J15	WDT	89.636	0.03	TRAPEZOIDAL	1	2	0.02842
C207	J655	J849	WDT	49.212	0.03	TRAPEZOIDAL	1	2	0.00018
C208	J570	J548	WDT	195.602	0.03	TRAPEZOIDAL	1	2	0.00533
C209	J546	J884	WDT	10.89	0.03	TRAPEZOIDAL	1	2	0.00037
C210	J483	J455	WDT	68.79	0.03	TRAPEZOIDAL	1	2	-0.00089
C211	J711	J730	WDT	45.564	0.03	TRAPEZOIDAL	1	2	-0.00367
C212	J48	J71	WDT	147.713	0.03	TRAPEZOIDAL	1	2	0.00245
C214	J685	J833	WDT	42.581	0.03	TRAPEZOIDAL	1	2	-0.00986
C215	J113	J92	WDT	58.906	0.03	TRAPEZOIDAL	1	2	-0.00024
C216	J86	J111	WDT	90.533	0.03	TRAPEZOIDAL	1	2	-0.00805
C217	J695	J738	WDT	31.013	0.03	TRAPEZOIDAL	1	2	0.00793
C218	J563	J517	WDT	99.955	0.03	TRAPEZOIDAL	1	2	0.0109
C219	J848	J320	WDT	75.294	0.03	TRAPEZOIDAL	1	2	0.00652
C220	J680	J685	WDT	14.97	0.03	TRAPEZOIDAL	1	2	0.0161
C221	J453	J882	WDT	160.243	0.03	TRAPEZOIDAL	1	2	0.00509
C224	J433	J881	WDT	13.287	0.03	TRAPEZOIDAL	1	2	-8.00E-05
C225	J420	J417	WDT	66.014	0.03	TRAPEZOIDAL	1	2	0.00021
C228	J184	J880	WDT	97.786	0.03	TRAPEZOIDAL	1	2	0.00269
C231	J809	J877	WDT	16.309	0.03	TRAPEZOIDAL	1	2	0.02472
C232	J412	J431	WDT	73.782	0.03	TRAPEZOIDAL	1	2	0.00431
C233	J82	J876	WDT	59.412	0.03	TRAPEZOIDAL	1	2	0.00103
C234	J428	J420	WDT	16.002	0.03	TRAPEZOIDAL	1	2	0.00356
C236	J18	J875	WDT	49.934	0.03	TRAPEZOIDAL	1	2	0.00052
C237	J505	J474	WDT	131.556	0.03	TRAPEZOIDAL	1	2	-0.00434

Name	Inlet Node	Outlet Node	Tag	Length (m)	Rough-ness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
C239	J523	J837	WDT	179.013	0.03	TRAPEZOIDAL	1	2	-0.00029
C240	J636	J680	WDT	25.314	0.03	TRAPEZOIDAL	1	2	0.00419
C241	J638	J675	WDT	124.672	0.03	TRAPEZOIDAL	1	2	0.00664
C242	J326	J874	WDT	47.548	0.03	TRAPEZOIDAL	1	2	0.01108
C244	J830	J835	WDT	110.334	0.03	TRAPEZOIDAL	1	2	0.00256
C247	J448	J453	WDT	25.619	0.03	TRAPEZOIDAL	1	2	-0.00027
C248	J797	J873	WDT	148.3	0.03	TRAPEZOIDAL	1	2	0.01262
C249	J125	J861	WDT	168.905	0.03	TRAPEZOIDAL	1	2	0.00038
C250	J531	J872	WDT	328.704	0.03	TRAPEZOIDAL	1	2	0.00857
C253	J812	J809	WDT	23.496	0.03	TRAPEZOIDAL	1	2	0.02699
C254	J519	J570	WDT	63.634	0.03	TRAPEZOIDAL	1	2	0.00368
C255	J196	J206	WDT	87.702	0.03	TRAPEZOIDAL	1	2	0.00566
C256	J650	J910	WDT	163.659	0.03	TRAPEZOIDAL	1	2	0.00056
C257	J322	J830	WDT	26.209	0.03	TRAPEZOIDAL	1	2	-0.00046
C258	J594	J648	WDT	55.169	0.03	TRAPEZOIDAL	1	2	0.00091
C259	J723	J870	WDT	73.331	0.03	TRAPEZOIDAL	1	2	0.00584
C261	J4	J868	WDT	124.502	0.03	TRAPEZOIDAL	1	2	0.01968
C263	J768	J740	WDT	332.209	0.03	TRAPEZOIDAL	1	2	0.00151
C264	J119	J125	WDT	20.367	0.03	TRAPEZOIDAL	1	2	0.00059
C265	J64	J866	WDT	106.927	0.03	TRAPEZOIDAL	1	2	5.00E-05
C266	J785	J865	WDT	171.759	0.03	TRAPEZOIDAL	1	2	0.00416
C267	J335	J322	WDT	15.561	0.03	TRAPEZOIDAL	1	2	-0.00617
C269	J747	J864	WDT	100.854	0.03	TRAPEZOIDAL	1	2	-0.00141
C270	J624	J594	WDT	14.146	0.03	TRAPEZOIDAL	1	2	0.00353
C271	J270	J862	WDT	14.215	0.03	TRAPEZOIDAL	1	2	0.01407
C272	J671	J689	WDT	137.391	0.03	TRAPEZOIDAL	1	2	0.00146

Name	Inlet Node	Outlet Node	Tag	Length (m)	Rough-ness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
C273	J99	J861	WDT	84.875	0.03	TRAPEZOIDAL	1	2	-0.00033
C274	J787	J812	WDT	33.005	0.03	TRAPEZOIDAL	1	2	0.02209
C275	J329	J335	WDT	14.146	0.03	TRAPEZOIDAL	1	2	0.00205
C279	J554	J578	WDT	84.517	0.03	TRAPEZOIDAL	1	2	0.02907
C280	J13	J4	WDT	22.78	0.03	TRAPEZOIDAL	1	2	0.10362
C281	J646	J857	WDT	33.053	0.03	TRAPEZOIDAL	1	2	0.00762
C282	J331	J855	WDT	11.317	0.03	TRAPEZOIDAL	1	2	-0.01105
C283	J182	J856	WDT	11.317	0.03	TRAPEZOIDAL	1	2	0.02758
C284	J513	J563	WDT	83.184	0.03	TRAPEZOIDAL	1	2	0.00019
C285	J11	J18	WDT	72.691	0.03	TRAPEZOIDAL	1	2	-0.0001
C286	J642	J655	WDT	108.161	0.03	TRAPEZOIDAL	1	2	0.00485
C287	J606	J638	WDT	62.319	0.03	TRAPEZOIDAL	1	2	-0.00116
C289	J381	J855	WDT	121.072	0.03	TRAPEZOIDAL	1	2	0.00136
C290	J16	J854	WDT	48.213	0.03	TRAPEZOIDAL	1	2	0.00438
C291	J762	J711	WDT	120.621	0.03	TRAPEZOIDAL	1	2	0.00982
C293	J515	J505	WDT	80.941	0.03	TRAPEZOIDAL	1	2	0.00798
C295	J630	J646	WDT	14.146	0.03	TRAPEZOIDAL	1	2	0.00262
C296	J349	J329	WDT	18.591	0.03	TRAPEZOIDAL	1	2	0.00667
C299	J369	J848	WDT	102.523	0.03	TRAPEZOIDAL	1	2	-0.00064
C300	J84	J850	WDT	99.03	0.03	TRAPEZOIDAL	1	2	0.00834
C301	J602	J849	WDT	20.009	0.03	TRAPEZOIDAL	1	2	0.00035
C302	J346	J848	WDT	28.69	0.03	TRAPEZOIDAL	1	2	-0.0023
C304	J20	J48	WDT	149.946	0.03	TRAPEZOIDAL	1	2	-0.00053
C305	J620	J642	WDT	18.251	0.03	TRAPEZOIDAL	1	2	-0.00192
C307	J600	J634	WDT	235.929	0.03	TRAPEZOIDAL	1	2	-9.00E-05
C308	J590	J613	WDT	130.885	0.03	TRAPEZOIDAL	1	2	0.00261

Name	Inlet Node	Outlet Node	Tag	Length (m)	Rough-ness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
C309	J66	J847	WDT	238.768	0.03	TRAPEZOIDAL	1	2	0.00173
C310	J25	J16	WDT	22.894	0.03	TRAPEZOIDAL	1	2	-0.00013
C311	J29	J50	WDT	222.677	0.03	TRAPEZOIDAL	1	2	0.00368
C312	J127	J113	WDT	119.429	0.03	TRAPEZOIDAL	1	2	0.00023
C313	J777	J768	WDT	53.545	0.03	TRAPEZOIDAL	1	2	0.00898
C314	J583	J600	WDT	14.146	0.03	TRAPEZOIDAL	1	2	-7.00E-05
C315	J781	J785	WDT	48.728	0.03	TRAPEZOIDAL	1	2	0.01053
C318	J141	J845	WDT	82.17	0.03	TRAPEZOIDAL	1	2	0.00129
C319	J223	J844	WDT	107.134	0.03	TRAPEZOIDAL	1	2	1.00E-05
C320	J608	J566	WDT	166.636	0.03	TRAPEZOIDAL	1	2	-0.0005
C321	J501	J843	WDT	122.125	0.03	TRAPEZOIDAL	1	2	0.00124
C322	J274	J842	WDT	65.48	0.03	TRAPEZOIDAL	1	2	0.0024
C323	J355	J346	WDT	29.706	0.03	TRAPEZOIDAL	1	2	0.00141
C324	J753	J841	WDT	92.439	0.03	TRAPEZOIDAL	1	2	0.00064
C326	J615	J624	WDT	64.096	0.03	TRAPEZOIDAL	1	2	0.00368
C327	J208	J196	WDT	82.025	0.03	TRAPEZOIDAL	1	2	0.00079
C328	J572	J592	WDT	146.745	0.03	TRAPEZOIDAL	1	2	-0.00048
C329	J147	J141	WDT	16.05	0.03	TRAPEZOIDAL	1	2	-0.00012
C330	J677	J839	WDT	470.296	0.03	TRAPEZOIDAL	1	2	0.00038
C331	J254	J281	WDT	233.269	0.03	TRAPEZOIDAL	1	2	0.00203
C332	J742	J753	WDT	17.696	0.03	TRAPEZOIDAL	1	2	6.00E-05
C333	J509	J837	WDT	197.69	0.03	TRAPEZOIDAL	1	2	-0.00046
C335	J38	J836	WDT	98.339	0.03	TRAPEZOIDAL	1	2	0.00333
C336	J149	J131	WDT	93.362	0.03	TRAPEZOIDAL	1	2	-0.00202
C338	J706	J833	WDT	105.68	0.03	TRAPEZOIDAL	1	2	-0.00374
C339	J424	J832	WDT	97.113	0.03	TRAPEZOIDAL	1	2	-2.00E-05

Name	Inlet Node	Outlet Node	Tag	Length (m)	Rough-ness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
C340	J799	J757	WDT	39.169	0.03	TRAPEZOIDAL	1	2	0.03669
C342	J278	J274	WDT	17.369	0.03	TRAPEZOIDAL	1	2	0
C344	J337	J830	WDT	79.371	0.03	TRAPEZOIDAL	1	2	0.00045
C346	J297	J298	WDT	63.69	0.03	TRAPEZOIDAL	1	2	0.01784
C348	J227	J151	WDT	124.905	0.03	TRAPEZOIDAL	1	2	0.00087
C349	J818	J873	WDT	67.447	0.03	TRAPEZOIDAL	1	2	0.00686
C351	J316	J917	WDT	167.017	0.03	TRAPEZOIDAL	1	2	-0.00014
C353	J714	J910	WDT	123.739	0.03	TRAPEZOIDAL	1	2	0.00015
C354	J919	J909	WDT	94.78	0.03	TRAPEZOIDAL	1	2	-0.00279
C355	J133	J889	WDT	253.449	0.03	TRAPEZOIDAL	1	2	0.00543
C357	J732	J841	WDT	116.373	0.03	TRAPEZOIDAL	1	2	0.00101
C358	J252	J917	WDT	123.069	0.03	TRAPEZOIDAL	1	2	-0.00262
C360	J816	J916	WDT	51.943	0.03	TRAPEZOIDAL	1	2	0.0087
C364	J856	J202	WDT	46.68	0.03	TRAPEZOIDAL	1	2	-0.01313
C365	J721	J906	WDT	169.671	0.03	TRAPEZOIDAL	1	2	0.00321
C366	J659	J699	WDT	142.023	0.03	TRAPEZOIDAL	1	2	0.00164
C367	J294	J862	WDT	19.803	0.03	TRAPEZOIDAL	1	2	0.0101
C368	J738	J887	WDT	124.083	0.03	TRAPEZOIDAL	1	2	0.00289
C371	J578	J883	WDT	56.041	0.03	TRAPEZOIDAL	1	2	-0.00125
C372	J592	J663	WDT	129.433	0.03	TRAPEZOIDAL	1	2	0.00609
C375	J843	J546	WDT	34.479	0.03	TRAPEZOIDAL	1	2	0.00026
C378	J587	J883	WDT	39.374	0.03	TRAPEZOIDAL	1	2	-0.00048
C379	J131	J139	WDT	261.921	0.03	TRAPEZOIDAL	1	2	0.00102
C380	J167	J858	WDT	22.912	0.03	TRAPEZOIDAL	1	2	0.01755
C382	J90	J86	WDT	109.646	0.03	TRAPEZOIDAL	1	2	0.00529
C374_1	J248	OF8	WDT	131.031	0.03	TRAPEZOIDAL	1	2	0.04478

Name	Inlet Node	Outlet Node	Tag	Length (m)	Rough-ness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
C292_1	J691	J40	WDT	47.874	0.03	TRAPEZOIDAL	1	2	0.03553
C377_1	J246	J41	WDT	61.437	0.03	TRAPEZOIDAL	1	2	0.06377
C150_1	J556	J28	WDT	41.253	0.03	TRAPEZOIDAL	1	2	0.03612
C229_1	J491	J32	WDT	44.189	0.03	TRAPEZOIDAL	1	2	0.02332
C238_2	J657	J40	WDT	78.849	0.03	TRAPEZOIDAL	1	2	0.02244
C238_3	J40	OF2	WDT	9.872	0.03	TRAPEZOIDAL	1	2	0.02249
C347	J297	J298	WDT	64.21	0.03	TRAPEZOIDAL	1	2	0.01769
C15_1	J60	J55	channel_by_others	533.3	0.01	CIRCULAR	1	0	0

APPENDIX H

EXAMPLE CULVERT END STIFFENER

Photo 1: Example Culvert End Stiffener