APPENDIX 15A

Surface Water Quantity Technical Data Report

Mackenzie Valley Highway Project
Technical Data Report—Surface Water Quantity

Prepared for:

Government of the Northwest Territories

Prepared by:

K'alo-Stantec Limited

December 2022

Project No.: 144903025

K'alo-Stantec

Limitations and Sign-off

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Executive Summary

The Government of the Northwest Territories (GNWT), Department of Infrastructure (INF) is proposing the Mackenzie Valley Highway Project (the Project) that will extend the Mackenzie Valley Highway (MVH) from Wrigley to Norman Wells. The Project consists of a 321 kilometre (km) all-season highway that largely follows the route of the existing Mackenzie Valley Winter Road (MVWR), and the construction and operation of temporary and permanent borrow sources. The project highway alignment will pass through the Dehcho Region and a portion of the Tulita District of the Sahtu Settlement Area (SSA) within the Northwest Territories (NT).

This technical data report (TDR) presents existing surface water quantity data to support the Developer's Assessment Report (DAR). Existing data were collected from Water Survey of Canada (WSC) hydrometric stations in the region; published documents were also reviewed for relevant data. Hydrologic indices (i.e., mean annual runoff, monthly distribution of annual runoff, peak flows, and low flows) were characterized for 10 watersheds identified within the RSA. These watersheds contain the major streams (i.e., tributaries of the Mackenzie River) that the project highway alignment will cross.

The mean annual runoff (MAR) in the MVH Project Area is 151 millimetre [mm] to 220 mm. Although it is known that the watersheds with drainage areas of greater than 100 km^2 are perennial, it is not known with certainty which watersheds with drainage areas of less than 100 km^2 are perennial and which ones are seasonal. It is anticipated that the surface water quantity effects assessment would not be sensitive to these uncertainties. If the affects assessment analyses show that this assumption is not valid, or if more precise estimates for the MAR and monthly distribution of runoff are needed by other disciplines, further field and/or desktop work will be required.

Engineering design and analysis of crossings (e.g., conveyance capacity and channel stability) would require a separate study tailored for such purposes. Data presented in this TDR are intended to support the surface water quantity effects assessment of the DAR; they do not provide engineering design parameters.

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Abbreviations

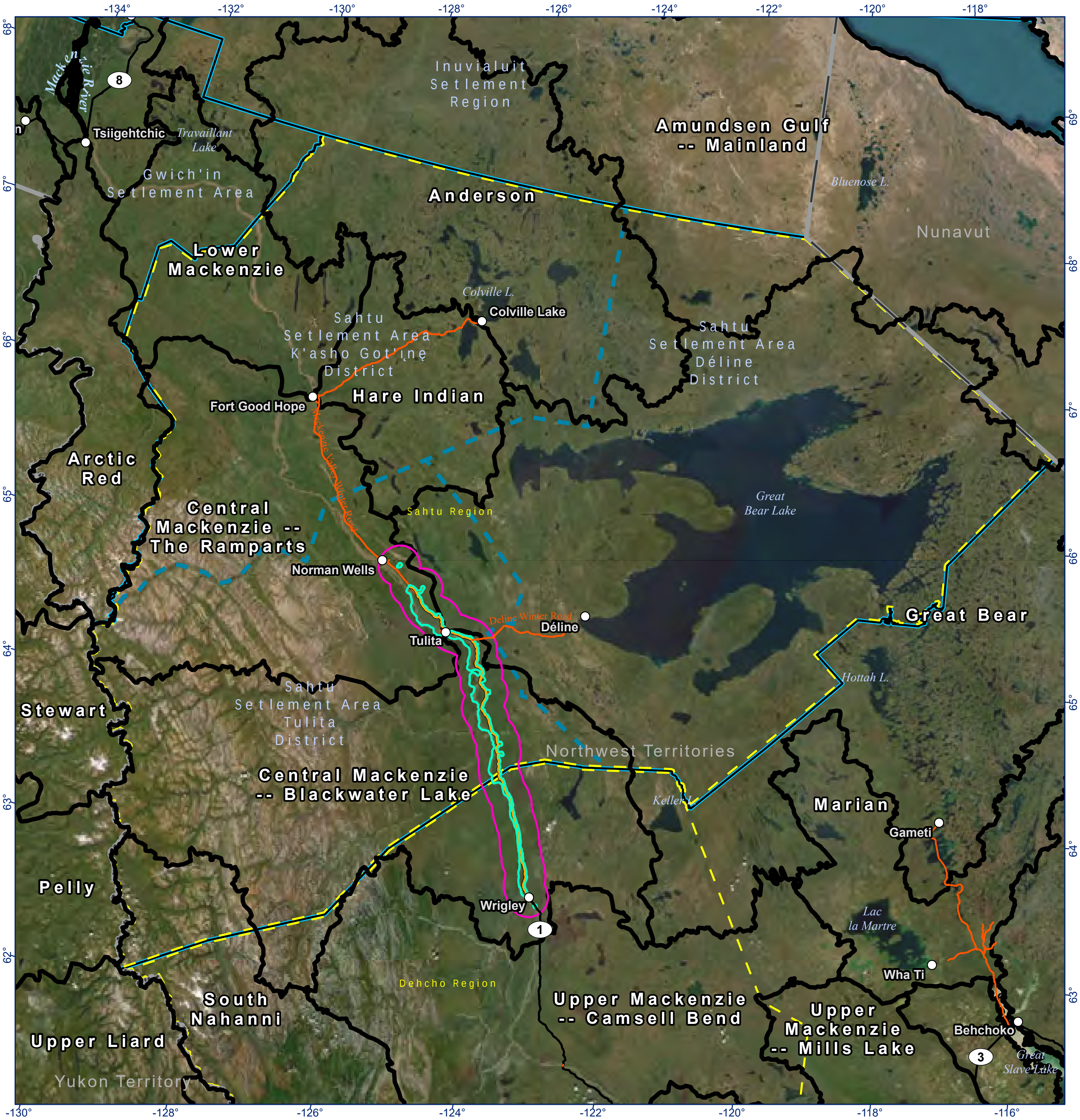
7Q10a…	Annual 7-day low flow with 10-year return period
7Q10s…	June to September 7-day low flow with 10-year return period
DA	drainage area
DAR	Developer's Assessment Report
GNWT	Government of the Northwest Territories
INF	Department of Infrastructure
km	kilometre
KM	kilometre marker
km^2	square kilometre
LSA	Local Study Area
m	metre
m^3	cubic metre
m^3/s	cubic metre per second
MAR	mean annual runoff
mm	millimetre
MVH	Mackenzie Valley Highway
MVLWB	Mackenzie Valley Land and Water Board
MVWR	Mackenzie Valley Winter Road
NT	Northwest Territories
RSA	Regional Study Area
SSA	Sahtu Settlement Area
TDR	technical data report
the Project	Mackenzie Valley Highway Project
TK	traditional knowledge
TLRU	traditional land and resource use
WSC	Water Survey of Canada

1 Introduction

The Government of the Northwest Territories (GNWT), Department of Infrastructure (INF) is proposing the Mackenzie Valley Highway Project (the Project) that will extend the Mackenzie Valley Highway (MVH) from Wrigley to Norman Wells, Northwest Territories (NT). The Project consists of a 321 kilometre (km) all-season highway that largely follows the route of the existing Mackenzie Valley Winter Road (MVWR), and the construction and operation of temporary and permanent borrow sources. The project highway alignment will pass through the Dehcho Region and a portion of the Tulita District of the Sahtu Settlement Area (SSA) within the NT (Figure 1.1).

The Project is subject to an environmental assessment and the requirements of Part 5 of *the Mackenzie Valley Resource Management Act*. This technical data report (TDR) presents the baseline surface water quantity data to support the Developer's Assessment Report (DAR), as required by the Terms of Reference (MVEIRB, 2015).

The study area is described in Section 2 and existing data are reviewed in Section 3. Hydrologic indices for the study area are characterized in Section 4 and recommendations are provided in Section 5.



- Proposed Mackenzie Valley Highway Alignment - Issued for EA 2022
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- Regional Study Area
- Community
- All-Season Road
- Winter Road
- District Boundary
- Region Boundary
- Settlement Area Boundary
- Sub-Basin
- Territorial Boundary

0 40 80 Kilometres

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Notes
1. Coordinate System: NAD 1983 Northwest Territories Lambert
2. Data Sources: Centre for Geomatics Government of NWT, Government of Canada, Stantec
3. Background: World Topographic Map: Esri, FAO, NOAA, USGS, NRCan
World Imagery: Earthstar Geographics
World Hillshade: Esri, USGS

Project Location
Wrigley to Norman Wells, NWT

Prepared by AT on 2023-03-07
TR by AJ on 2023-03-07

Client/Project
144903025-0063 REVB

Government of Northwest Territories
Mackenzie Valley Highway Project

Figure No.
1.1

Title
MVH Project Overview

2 Study Area

The Project is located in the Mackenzie Valley region of the NT between the current terminus of the existing all-weather highway in Wrigley (Highway #1, kilometre marker [KM] 690 of the MVWR) and Norman Wells (KM 1011 of the MVWR). The project highway alignment parallels the Mackenzie River to its west and passes through the community of Tulita (KM 938 of the MVWR). The Project is in the Mackenzie River basin and within the Central Mackenzie-Blackwater Lake, Central Mackenzie-the Ramparts, and Great Bear sub-basins, as defined by the Standard Drainage Area Classification (NRCan, 2003; Figure 2.1). The Project Development Area is defined as the area to be utilized by the Project and includes a 100 metre (m) buffer on either side of the project highway alignment between Wrigley and Norman Wells. It also includes the temporary and permanent borrow sources and associated access roads once these are made available.

The local and regional study areas presented in this TDR are the areas where data was compiled/collected to allow for an understanding of the environment in support of the project-specific effects assessment and the cumulative effects assessment. The study area does not include potential borrow sources as these were not identified at the time of writing.

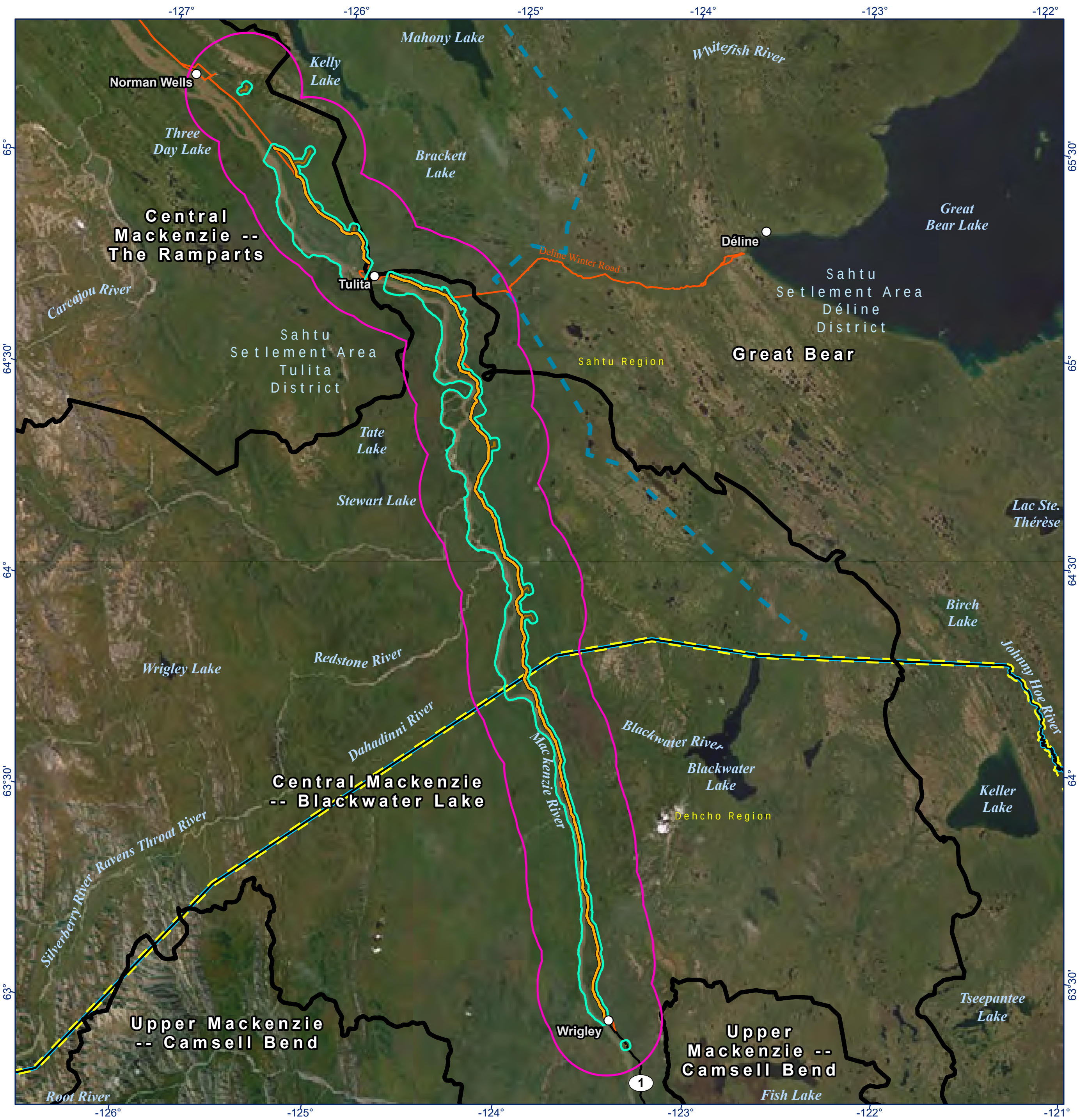
2.1 Local Study Area

The Local Study Area (LSA) is a 1 km buffer centred on the Project Development Area (which is currently the alignment of the MVWR). This buffer was extended to include the mainstem of Mackenzie River and potential water sources for construction of the MVH to encompass the anticipated extent of Project-related direct and indirect effects on surface water quantity (Figure 2.1).

2.2 Regional Study Area

The Regional Study Area (RSA) is a 15 km buffer centred on the Project Development Area. The RSA includes surface water quantity-related features that could be affected by the cumulative effects of Project activities interacting with the activities of other existing, past or reasonably foreseeable projects in the area. The RSA does not include the entire Central Mackenzie-Blackwater Lake, Central Mackenzie-the Ramparts, and Great Bear sub-basins because:

- the majority of the Central Mackenzie-Blackwater Lake and Central Mackenzie-the Ramparts sub-basins are to the west of the Mackenzie River, which is not affected by the Project.
- the majority of the Great Bear sub-basin is upstream of the Project and, therefore, not affected by the Project. Only a short segment (4 km) of the Project is in the Great Bear sub-basin. This segment includes a proposed bridge over the Great Bear River, which is undergoing a separate regulatory process. Therefore, the Great Bear sub-basin is not be discussed further in this report.



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Project Location
Wrigley to Norman Wells, NWT

Prepared by CES on 2023-03-07
TR by CS on 2023-03-07

Client/Project
144903025-0064 REVB

Government of Northwest Territories
Mackenzie Valley Highway Project

Figure No.
2.1

Title
Water and Sediment Quality Assessment Areas

Notes
1. Coordinate System: NAD 1983 Northwest Territories Lambert
2. Data Sources: Centre for Geomatics Government of NWT, Government of Canada, Stantec
3. Background: World Topographic Map: Esri, FAO, NOAA, USGS, NRCan
World Imagery: Earthstar Geographics
World Hillshade: Esri, USGS

3 Review of Existing Data

A review of existing traditional knowledge (TK) and traditional land and resource use (TLRU) and a literature review of relevant information is presented in this section for characterizing the existing conditions for surface water quantity.

3.1 Traditional Knowledge and Traditional Use

The GNWT has been collecting TK and TLRU information relevant to the Project since 2021. Older TK and TLRU information, as described in the following sections, supplement the more recent data.

3.1.1 Sahtu Region

As described in the Cultural and Traditional Land Use TDR, Sahtu harvesters mentioned powerful ice breaks during the spring break around the area the Great Bear River Bridge (TRRC, 2019).

In addition to the TK and TLRU information described in the Cultural and Traditional Land Use TDR, older information documented by Golder (2015) are helpful in characterizing the existing surface water quantity conditions. Golder (2015) provides TK and TLRU information about surface water quantity in the Sahtu Region. Golder (2015) indicates that in the Sahtu Region:

- The waters of the Sahtu have traditionally supplied water for drinking and cooking, provided food (e.g., fish), and have been major travel routes.
- Local land users and elders are familiar with their surroundings, including the lands and waters, and with flood conditions caused by ice jams or intense rainstorms.
- Residents have expressed concerns about lowered water levels due to past developments that included water withdrawals.
- During the past decades, residents observed lake water levels decreasing, even without the impact of development.
- Creation of artificial streams along the winter roads have been observed during spring melt. Beaver dams were believed to add to the drainage problem.
- Less spring debris has been noted in the Mackenzie River.

Results from the Project-specific TLRU study developed by the Tulita Renewable Resources Council (TRRC, 2022) indicates that:

- Overflows have resulted from previous road construction and operation and has affected valued resources.
- Overflow within the LSA and along existing portions of the MVWR has affected undertaking of TLRU.
- There are many beaver dams within the LSA that have caused overflow.

- All the water resources within the LSA are still used and accessed for TLRU.
- More water and wildlife monitoring in the LSA should be used to mitigate potential Project effects.
- There are concerns about potential Project effects on water flowing into the Bear River (community drinking water source).
- The sewer lagoon seeps towards the winter road between Tulita and Four Mile Creek, which causes the overflow on winter road access.
- There are concerns about potential Project effects from vehicle breakdown near open-water sources, specifically near Bear Rock, which is of interest to the community, that have potential to contaminate water sources.
- MVWR flooding occurs near Frank Yalle cabin area, and between the community of Tulita and Four Mile Creek.
- Bear River floods in the spring during the Mackenzie River ice breakup.
- Water is collected from any river or lake nearby the construction of the Bear River Bridge Project which has potential to affect community drinking because the community of Tulita requires a water truck to access water intake from Bear River on the other Bear River Bridge (all year round).

3.1.2 Dehcho Region

Cultural and Traditional Land Use TDR mentions that during the Wrigley Community Consultation, participants identified concerns about impacts of the Project on water in general and the Mackenzie River in particular (Dessau, 2012).

In addition to the TK and TLRU information described in the Cultural and Traditional Land Use TDR, older information documented by Dehcho First Nations (2011) are helpful in characterizing the existing surface water quantity conditions. Dehcho First Nations (2011) provides TK and TLRU information about surface water quantity in the Dehcho Region:

- The region is getting warmer and wetter overall, with more rainfall in August and September and even into October.
- Climate change is creating more incidences of ice crusting along the ground, which may make it more difficult for boreal caribou to forage for ground lichens.
- Wetter summers and falls result in higher water levels on smaller rivers and streams.
- Lower lake levels (possibly due to increased capacity of the ground to absorb water) impact animals.

3.2 Literature Review

A literature review was completed to understand existing surface water quantity conditions along the project highway alignment. Background information on surface water quantity for the Sahtu and Dehcho Regions were obtained from the following resources:

- Water Survey of Canada (WSC) archived hydrometric data (WSC, 2021)
- Mackenzie Valley Land and Water Board (MVLWB) public registry (www.https://mvlwb.com/registry)
- Central Mackenzie Surface Water and Groundwater Baseline Assessment. Report 1: Technical State of Knowledge (Golder, 2015)
- Environmental Impact Statement for Mackenzie Gas Project Volume 3, Section 5 (IORVL, 2004)
- Three Hydrotechnical Assessment reports for Mackenzie Valley Highway: Dehcho Segment (Tetra Tech, 2020a), Mount Gaudet Access Road (Tetra Tech, 2020b), and Prohibition Creek Access Road (Tetra Tech, 2020c)
- Mackenzie Valley Highway Extension Pehdzeh Ki Ndeh – Dehcho Region. Project Description Report (Dessau, 2012)

Surface water quantity information from the abovementioned resources are summarized in the following sections.

3.2.1 Regional Hydrology

The Mackenzie River drains an approximate area of 1.8 million square kilometres (km^2); its mainstem is more than 1,700 km between the outlet of Great Slave Lake and the Beaufort Sea in Canada's Arctic (Golder, 2015).

The hydrologic regime of streams in the Central Mackenzie-Blackwater Lake and Central Mackenzie-the Ramparts sub-basins of the Mackenzie River basin is dominated by snowmelt, producing high streamflows in late-May and early-June. Streamflows normally recede during the summer and may be augmented by scattered rainfall events in summer and fall. A noticeable reduction in streamflow occurs when the streams and lakes experience freeze-up in late fall. The ice cover persists until late spring (IORVL, 2004). Smaller streams may freeze to the bottom, with zero winter flow. IORVL (2004) showed that streams with drainage areas of greater than 100 km^2 are perennial, and those with drainage areas of less than 100 km^2 may be perennial or seasonal (i.e., freeze to the bottom in winter).

Lakes are less turbulent than the rivers; therefore, they tend to freeze earlier than rivers and thaw later than rivers.

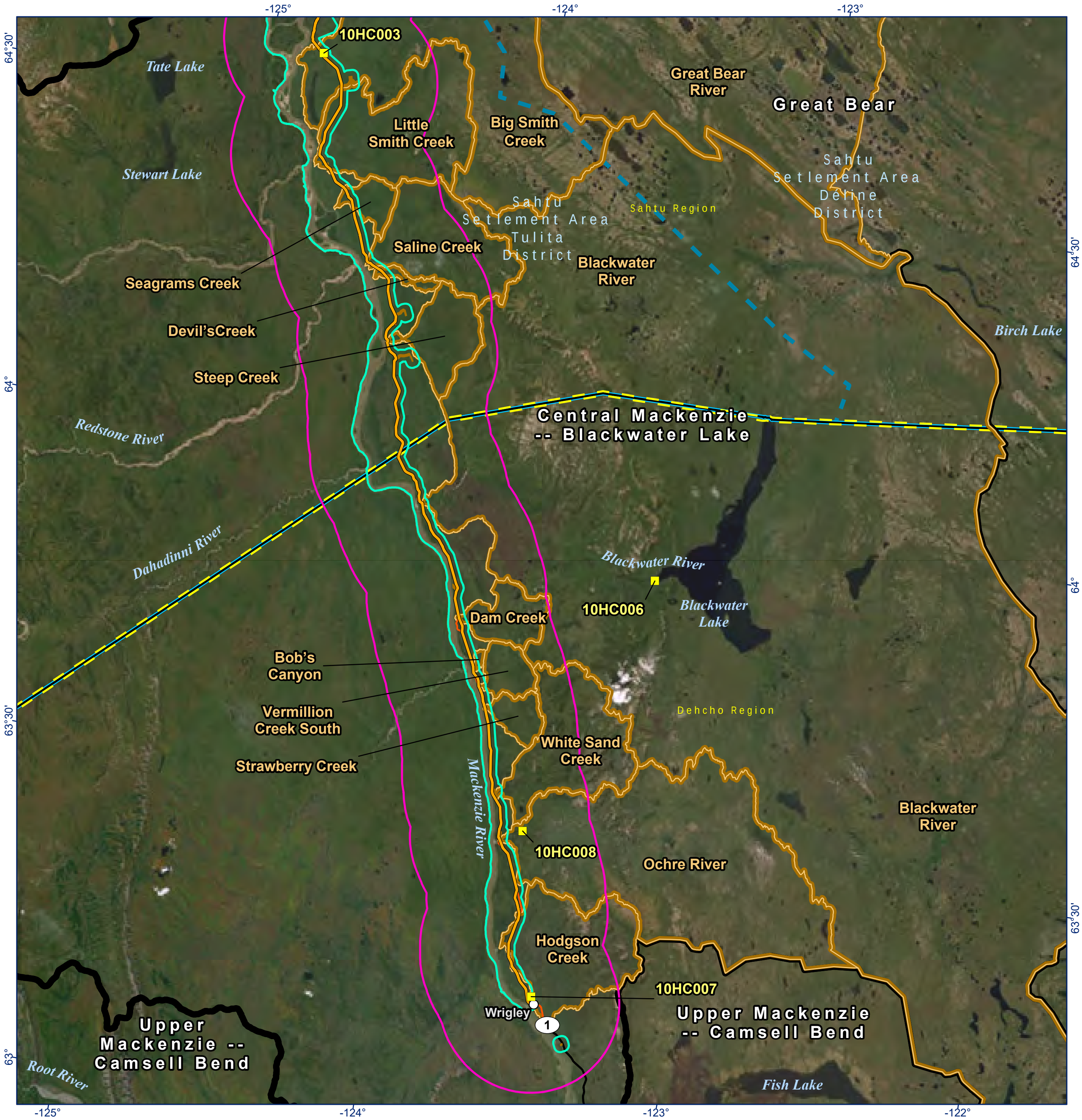
Typically, ice on the Mackenzie River at Norman Wells first appears in mid-October and freeze-up is complete by mid-November. The ice cover starts deteriorating in mid-May and break-up is complete by end of May. Average maximum ice thickness is 1.5 m in this region (IORVL, 2004; Golder, 2015).

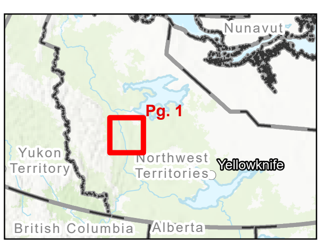
Freeze and melt dates are usually earlier for smaller streams. Therefore, ice jamming occurs in the Mackenzie River when spring snowmelt from the tributaries flow into the Mackenzie River before the ice on the Mackenzie River has decayed due to temperature (Golder, 2015).

Annual snowmelt-driven peak flows typically occur in late-May and early-June, but they can also occur in summer or fall after intense rainfall events (IORVL, 2004).

3.2.2 Local Watersheds

The watershed area of major streams that the project highway alignment crosses are shown in Figure 3.1 and Table 3.1. Stream names are based on those identified in previous surface water quantity studies (Golder, 2015; IORVL, 2004).





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Project Location
Wrigley to Norman Wells, NWT

Prepared by AT on 2023-03-07
TR by AJ on 2023-03-07

Client/Project
144903025-0059 REVB

Government of Northwest Territories
Mackenzie Valley Highway Project

Figure No.
3.1

Title
Watersheds and Hydrometric Stations

Notes
1. Coordinate System: NAD 1983 Northwest Territories Lambert
2. Data Sources: Centre for Geomatics Government of NWT, Government of Canada, Stantec
3. Background: World Topographic Map: Esri, FAO, NOAA, USGS, NRCan
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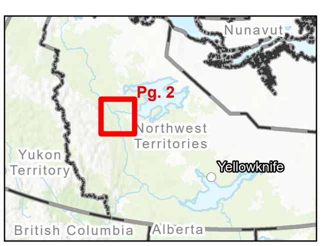

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Prepared by AT on 2023-03-07
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144903025-0059 REVB

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Table 3.1 Local Watersheds - Identified Tributaries of the Mackenzie River in the Local Study Area

Local Watershed[1]	Coordinates of Confluence with Mackenzie River			Drainage Area[2] (km^2)
	Zone	Latitude	Longitude	
Hodgson Creek	10	63.233667	123.482833	358
Ochre River	10	63.467167	123.690000	1,207
White Sand Creek	10	63.535167	123.731833	346
Strawberry Creek	10	63.660000	123.818667	59
Vermillion Creek South	10	63.691500	123.850000	68
Bob's Canyon	10	63.717333	123.869500	5.4
Dam Creek	10	63.790167	123.964833	110
Blackwater River	10	63.945556	124.157778	10,716
Steep Creek	10	64.183500	124.391667	154
Devil's Creek	10	64.278333	124.439500	21
Saline Creek	10	64.292667	124.502667	317
Seagrams Creek	10	64.386000	124.624167	57
Little Smith Creek	10	64.434833	124.742000	439
Big Smith Creek	10	64.590000	124.811167	1,076
Gotcha Creek	10	64.875833	125.103500	155
Four Miles Creek	10	64.910833	125.475500	17
No name creek	10	64.905333	125.652833	13
Bluefish Creek	10	64.934329	125.851403	118
Jungle Ridge Creek	9	65.061167	126.060667	60-97[3]
Nota Creek	9	65.090167	126.095333	65
Vermillion Creek North	9	65.096667	126.131333	92
Prohibition Creek	9	65.151167	126.303833	126
Christina Creek	9	65.186667	126.402167	22
Hellava Creek	9	65.192333	126.419167	27
Francis Creek	9	65.205000	126.456833	24
Canyon Creek	9	65.226500	126.523167	53
Bosworth Creek	9	65.280462	126.869560	132

Notes:

[1] Local watersheds are sorted from south to north

3.2.3 Hydrometric Stations

Streamflow records from ten Water Survey of Canada (WSC) hydrometric stations within or in the vicinity of the RSA were downloaded and used to characterize surface water quantity. These WSC hydrometric stations are shown in Table 3.2 and Figure 3.1. The WSC hydrometric stations 10HC007 (Hodgson Creek near the mouth), 10HC003 (Big Smith Creek near Highway no. 1), 10KA006 (Jungle Ridge Creek near the mouth), and 10KA009 (Canyon Creek at Pipeline Crossing) are within the LSA, and 10KA001 (Mackenzie River at Norman Wells) is the most downstream location of the RSA.

Table 3.2 Water Survey of Canada (WSC) Hydrometric Stations in the RSA

WSC Station ID	WSC Station Name	Longitude	Latitude	Period of Record	Drainage Area (km^2)
10HC007	Hodgson Creek near the mouth	123° 28' 52" W	63° 14' 39" N	2006 - 2014	358
10HC008	Ochre River near the mouth	123° 36' 45" W	63° 29' 22" N	2006 - 2017[1]	1,207
10HC006	Blackwater River at outlet of Blackwater Lake	123° 19' 22" W	63° 54' 01" N	1986 - 1994	7,850
10HC003	Big Smith Creek near Highway no. 1	124° 48' 46" W	64° 35' 33" N	1973 - 1994	980
10KA006	Jungle Ridge Creek near the mouth	126° 07' 17" W	65° 03' 27" N	1980 - 2017[1]	60
10KA009	Canyon Creek at Pipeline Crossing	126° 31' 05" W	65° 13' 54" N	2005 - 2018[2]	53
10KA005	Seepage Creek at Norman Wells	126° 43' 20" W	65° 15' 50" N	1974 - 1978	31
10KA007	Bosworth Creek near Norman Wells	126° 52' 38" W	65° 19' 25" N	1980 - 2017[1]	125
10KA001	Mackenzie River at Norman Wells	126° 51' 00" W	65° 16' 19" N	1943 - 2017[1]	1,590,000
10LD002	Jackfish Creek near Fort Good Hope	128° 38' 23" W	66° 15' 23" N	1980 - 1986	63

Notes:

1 WSC data after 2017 were provisional at the time of development of this report.

2 WSC data after 2018 were provisional at the time of development of this report.

3.2.4 Channel Assessment

Channel assessments were conducted for the majority of watersheds identified in Table 3.1 as part of the IORVL (2004) field study. A summary of the assessments is provided in Table 3.3. Tetra Tech (2020a, 2020b, 2020c) and K'alo-Stantec Limited (2020a, 2020b, 2022a) completed hydrotechnical and fish habitat assessments for crossings along segments of the project highway alignment. Although surface water hydrology characterization was not the main objective of those studies, channel information for some watersheds of this surface water quantity TDR were assessed and reported in Tetra Tech (2020a, 2020b, 2020c) and K'alo-Stantec Limited (2020a, 2020b, 2022a). Such channel information are provided in Table 3.3. Hydrotechnical assessments are planned for the remainder of the alignment, including channel assessment at the bridge crossings, for engineering design and for fish habitat assessment purposes.

Table 3.3 Channel Assessment

Stream	Width[1] (m)	Slope (m/m)	Dominant Substrate
Hodgson Creek	7–13 (17–42)[5]	0.0087 (0.01–0.02)[5]	Gravel (Gravel and cobble)[5]
Ochre River	23–55	0.011	Boulder and cobble
White Sand Creek	15–24	0.015	Boulder and cobble
Strawberry Creek	(8)[7]	n/a[2]	(Boulder)[7]
Vermillion Creek South	n/a[2]	n/a[2]	n/a[2]
Bob's Canyon	(2–6)[3,7]	(0.076)[3]	(Boulders)[3]
Dam Creek	6–8	0.0003	Silt and boulder
Blackwater River	90–110	0.0044	Boulder and cobble
Steep Creek	5–12	0.018	Boulder and cobble
Devil's Creek	n/a[2]	n/a[2]	n/a[2]
Saline Creek	10–20	0.011	Cobble
Seagrams Creek	9–12	0.017	Cobble
Little Smith Creek	5–10	0.005	Gravel and cobble
Big Smith Creek	30–40	0.0001	Sand and cobble
Gotcha Creek	n/a[2]	n/a[2]	n/a[2]
Four Miles Creek	(3)[7]	n/a[2]	(Sand and Gravel)[7]
No name creek	n/a[2]	n/a[2]	n/a[2]
Bluefish Creek	n/a[2]	n/a[2]	n/a[2]
Jungle Ridge Creek	4–9	0.005	Gravel and silt
Nota Creek	4–7	0.009	Cobble and boulder
Vermillion Creek North	7–14	0.011	Gravel
Prohibition Creek	5–9 (6–30)[6]	0.014 (0.01–0.04)[6]	Gravel and cobble (Cobble and gravel)[6]
Christina Creek	2–3 (4–6)[4,6]	0.015 (0.01–0.02)[4,6]	Gravel (Cobble and gravel)[4,6]
Hellava Creek	2–4 (5–7)[6]	0.012 (0.01–0.03)[6]	Gravel and cobble (Cobble and gravel)[6]
Francis Creek	1.5–3 (5–10)[6]	0.016 (0.01–0.04)[6]	Cobble and gravel (Cobble and gravel)[6]
Canyon Creek	5–12 (8–22)[6]	0.014 (0.01–0.04)[6]	Gravel and cobble (Cobble and gravel)[6]
Bosworth Creek	6–15	0.005	Gravel and cobble

Notes:

1. Range of values reflects different widths measured.
2. n/a: Channel assessment was not documented by IOVL (2004) or Tetra Tech (2020a, 2020b, 2020c) or K'alo-Stantec Limited (2020a, 2020b, 2022a)
3. Source: Tetra Tech (2020a)
4. Source: Tetra Tech (2020c)
5. Source: K'alo-Stantec Limited (2020a)
6. Source: K'alo-Stantec Limited (2020b)
7. Source: K'alo-Stantec Limited (2022a)

Source: Unless specified otherwise, information is from IORVL (2004). When information is from other sources, they are provided in parentheses and data sources are provided as footnotes.

3.2.5 Exiting Water Uses

3.2.5.1 Municipal

The town of Norman Wells has a water license (S18L3-003) to withdraw up to 250,000 m^3/year from the Mackenzie River. Actual annual water withdrawal volumes in the last 10 years, based on data available via the MVLWB public registry, are summarized in Table 3.4.

The Hamlet of Tulita has a water license (S16L3-001) to withdraw up to 21,300 m^3/year from Great Bear River. Actual annual water withdrawal volumes, based on data available via the MVLWB public registry, are also summarized in Table 3.4.

Table 3.4 Municipal Water Use (m^3/year)

Year	Norman Wells[1] (m^3/year)	Tulita[2] (m^3/year)
Current WL	**250,000**	**21,300**
2010	143,243	n/a[3]
2011	146,794	n/a[3]
2012	110,049	17,686
2013	106,272	14,771
2014	97,384	16,059
2015	93,974	n/a[3]
2016	97,212	n/a[3]
2017	94,226	n/a[3]
2018	95,837	n/a[3]
2019	101,974	n/a[3]

Notes:

1 source of water: Mackenzie River

2 source of water: Great Bear River

3 n/a: data not available in the MVLWB public registry

Source: MVLWB public registry (www. https://mvlwb.com/registry)

3.2.5.2 Winter Road Construction

Potential sources of water for construction and maintenance of the MVH are shown in Table 3.5 and Figure 3.2.

Table 3.5 Potential Sources of Water Withdrawal for the MVH

Potential Source	Coordinates		Winter Volume (m³)[1]	Watershed[2]
	Latitude	Longitude		
Lake Sources				
WR2	63.275341	123.557336	n/a[3]	Mackenzie River
WR3	63.420145	123.599667	n/a[3]	Ochre River
WR4	63.442750	123.635704	n/a[3]	Mackenzie River
Unlisted	63.986730	124.214965	n/a[3]	Mackenzie River
WR5	64.039404	124.291238	n/a[3]	Mackenzie River
WR6	64.086078	124.305009	n/a[3]	Mackenzie River
WR7	64.135345	124.337608	n/a[3]	Mackenzie River
WR8	64.205625	124.366274	1,265,354	Mackenzie River
WR9	64.263546	124.422416	n/a[3]	Mackenzie River
WR10	64.308888	124.532090	30,844	Mackenzie River
WR11	64.347861	124.590955	n/a[3]	Mackenzie River
WR12	64.517247	124.818424	987,269	Big Smith Creek
WR13	64.615688	124.853169	n/a[3]	Mackenzie River
WR14	64.626953	124.803118	39	Mackenzie River
WR16	64.659051	124.849634	48,991	Mackenzie River
WR18	64.727041	124.932269	229,369	Mackenzie River
Unlisted	64.733542	124.948591	n/a[3]	Mackenzie River
WR19	64.810597	125.005113	11,811	Gotcha Creek
WR20	64.854876	125.033013	n/a[3]	Gotcha Creek
WR22	64.904004	125.153103	n/a[3]	Mackenzie River
WR21	64.898394	125.268561	n/a[3]	Mackenzie River
WR23	64.905544	125.339083	n/a[3]	Mackenzie River
WR25	64.973830	125.677098	3,163,813	No Name Creek
WR26	64.983848	125.675238	n/a[3]	Great Bear River
Unlisted	64.989632	125.715442	n/a[3]	Bluefish Creek
WR28	64.992169	125.756327	n/a[3]	Bluefish Creek
WR31	65.230104	126.556707	n/a[3]	Mackenzie River
Stream Sources				
Blackwater River	63.942657	124.166387	n/ap[4]	Blackwater River
Steep Creek	64.183409	124.390230	n/ap[4]	Steep Creek
Mackenzie River	64.293336	124.537820	n/ap[4]	Mackenzie River
Little Smith Creek	64.435138	124.741597	n/ap[4]	Little Smith Creek

Potential Source	Coordinates		Winter Volume (m^3)[1]	Watershed[2]
	Latitude	Longitude		
Big Smith Creek	64.589887	124.810756	n/ap[4]	Big Smith Creek
Unnamed	64.686122	124.856868	n/ap[4]	Mackenzie River
Gotcha Creek	64.877619	125.103641	n/ap[4]	Gotcha Creek
Mackenzie River	64.899480	125.620172	n/ap[4]	Mackenzie River
Vermillion Creek	65.097815	126.130088	n/ap[4]	Vermilion Creek
Prohibition Creek	65.149557	126.302291	n/ap[4]	Prohibition Creek
Christina Creek	65.186854	126.401435	n/ap[4]	Christina Creek

Notes:

[1] Bathymetric surveys based on Golder (2008)

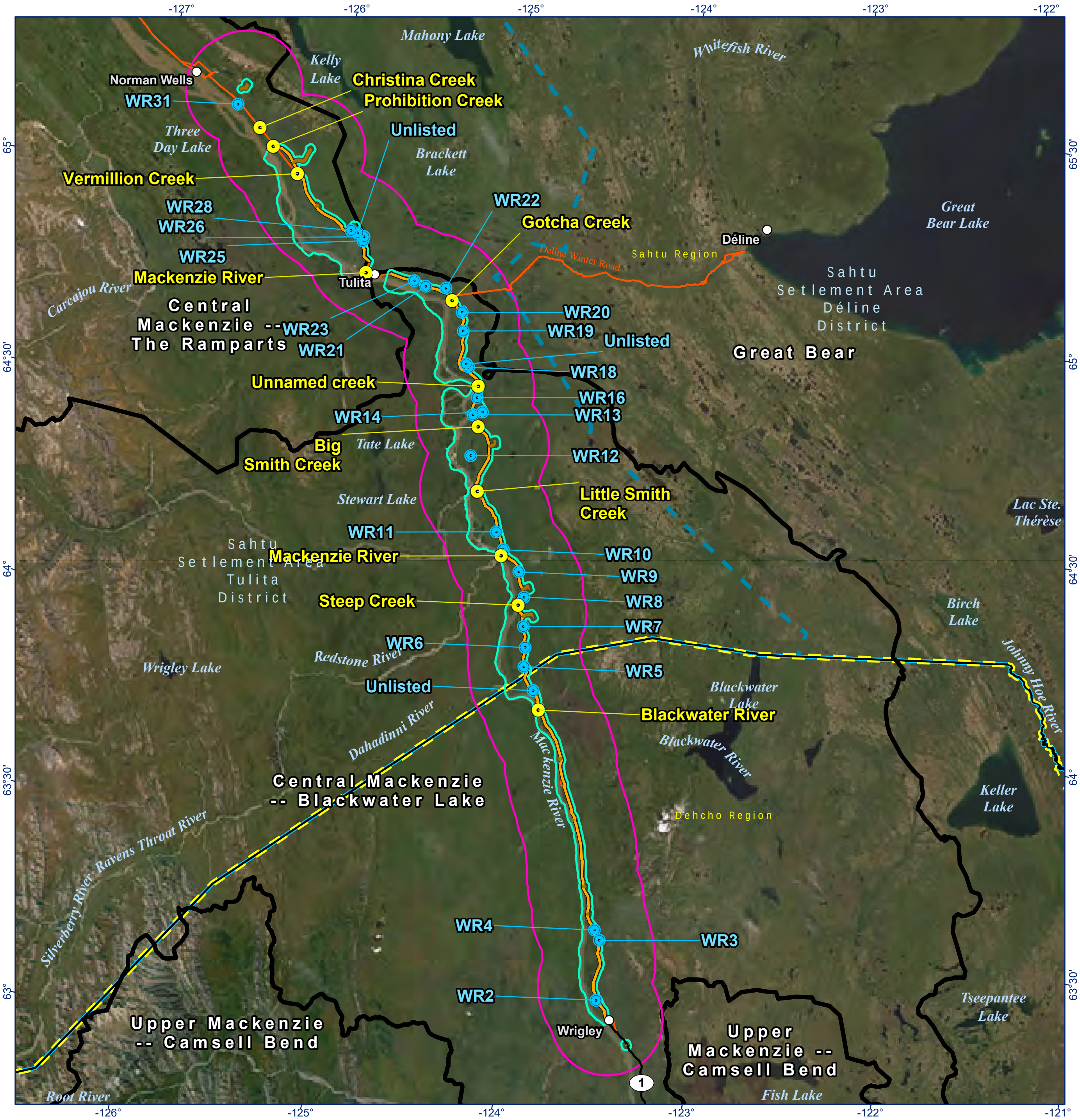
[2] All potential water sources are within the LSA. The water sources which are not within the identified watersheds (Table 3.1; Figure 3.1) are marked as within Mackenzie River watershed.

[3] n/a: Not available in Golder (2008)

[4] n/ap: Not applicable – Stream source

A preliminary assessment of water availability from stream and lake sources is provided in DAR Appendix 15C (K'alo-Stantec, 2022b). Final list of sources will be identified in the project description and updated in future revisions of this TDR.

Source: GNWT (2020, pers. comm.)



Potential Water Source
- Lake
- Stream
- Proposed Mackenzie Valley Highway Alignment - Issued for EA 2022
- Granular Borrow / Rock Quarry Site and Access
- Local Study Area
- Regional Study Area
- Community
- All-Season Road
- Winter Road
- District Boundary
- Region Boundary
- Settlement Area Boundary
- Sub-Basin

0 10 20 Kilometres
(At original document size of 8.5x11)
1:600,000

Kalo-Stantec

Project Location: Wrigley to Norman Wells, NWT
Prepared by AT on 2023-03-07
TR by AJ on 2023-03-07
Client/Project: 144903025-0068 REVB
Government of Northwest Territories
Mackenzie Valley Highway Project
Figure No. **3.2**
Title
Potential Sources of Water Withdrawal for Winter Road Construction

Notes
1. Coordinate System: NAD 1983 Northwest Territories Lambert
2. Data Sources: Centre for Geomatics Government of NWT, Government of Canada, Stantec
3. Background: World Topographic Map: Esri, FAO, NOAA, USGS, NRCan
World Imagery: Earthstar Geographics
World Hillshade: Esri, USGS

4 Hydrologic Indices

4.1 Annual and Monthly Runoff

Annual runoff (a normalized representation of streamflow expressed as depth; millimetre [mm]) is the volume of water passing through a stream's cross section per year divided by the watershed area drained to that cross section. Because annual runoff is normalized by watershed area, it is a useful index for comparing the hydrologic response of watersheds of different sizes.

Historical monthly streamflow data from the WSC hydrometric stations (Table 3.2) during their period of record were downloaded from WSC (2021) and used to estimate the mean annual runoff (MAR), as well as monthly distribution of runoff at these WSC hydrometric stations (Table 4.1).

The MAR estimate for the watersheds with WSC stations are between 151 mm and 220 mm (Table 4.2). For ungauged watersheds, the MAR within this range is recommended for surface water quantity effects assessment.

Monthly distribution of runoff for the watersheds with WSC stations are presented in Table 4.1, and those of perennial and seasonal ungauged watersheds are shown in Table 4.2. As explained in Section 3.2.1, watersheds with drainage areas of greater than 100 km^2 are assumed to be perennial, and those with drainage areas of less than 100 km^2 may be perennial or seasonal.

Table 4.1 Mean Annual Runoff and Monthly Distribution of Runoff at the WSC Hydrometric Stations

WSC Station ID	WSC Station Name	Drainage Area (km^2)	Monthly Runoff (% of Annual Runoff)												MAR[1] (mm)
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
10HC007	Hodgson Creek	358	1.2%	0.9%	0.8%	2.2%	39.9%	11.7%	12.3%	11.0%	9.0%	6.1%	3.0%	1.9%	**151**
10HC008	Ochre River	1,207	0.5%	0.3%	0.3%	2.8%	44.0%	10.0%	11.0%	11.8%	12.7%	4.8%	1.3%	0.6%	**220**
10HC006	Blackwater River	7,850	0.7%	0.4%	0.4%	0.6%	28.9%	29.8%	15.9%	8.0%	6.9%	5.0%	2.1%	1.3%	**187**
10HC003	Big Smith Creek	980	0.4%	0.3%	0.3%	0.6%	44.5%	22.4%	7.1%	8.5%	9.7%	4.1%	1.4%	0.7%	**188**
10KA006	Jungle Ridge Creek	60	0.0%	0.0%	0.0%	0.7%	54.6%	17.2%	6.0%	7.9%	8.7%	4.0%	0.9%	0.1%	**213**
10KA009	Canyon Creek	53	3.0%	2.4%	2.2%	2.9%	38.8%	8.1%	9.3%	7.8%	9.4%	6.6%	4.8%	4.6%	**219**
10KA005	Seepage Creek	31	0.0%	0.0%	0.0%	1.1%	66.4%	10.3%	3.4%	15.4%	3.4%	0.0%	0.0%	0.0%	**n/a[2]**
10KA007	Bosworth Creek	125	3.0%	2.3%	2.1%	4.0%	40.4%	12.6%	7.4%	6.4%	7.8%	6.4%	4.0%	3.3%	**166**
10KA001	Mackenzie River	1,590,000	3.8%	3.1%	3.3%	3.5%	13.5%	16.8%	15.5%	12.4%	10.2%	8.8%	4.9%	4.2%	**168**
10LD002	Jackfish Creek	63	0.0%	0.0%	0.0%	0.0%	43.1%	27.0%	6.5%	6.4%	11.6%	5.3%	0.1%	0.0%	**n/a[2]**

Notes:

[1] Mean Annual Runoff

[2] Sufficient data was not available to estimate the MAR

Source: WSC (2021)

Table 4.2 Monthly Distribution of Runoff for Ungauged Streams

Streams	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Perennial Streams[1]	1.6%	1.2%	1.1%	2.5%	42%	13%	9.4%	9.1%	9.7%	5.6%	2.9%	2.2%
Seasonal Streams[2]	0.0%	0.0%	0.0%	0.6%	55%	18%	5.3%	9.9%	7.9%	3.1%	0.3%	0.0%

Notes:

[1] based on the average of data from WSC stations with drainage area of equal to or less than 1,207 km^2 in Table 4.2

[2] based on the average of data from WSC stations with seasonal flow and drainage area of equal to or less than 63 km^2 in Table 4.2

4.2 Peak Flows

Tetra Tech (2020a, 2020b, 2020c) performed hydrotechnical assessments along segments of the project highway alignment. As part of these assessments, Tetra Tech (2020a, 2020b, 2020c) derived the following regression-based equations for instantaneous peak flow with 2-year and 100-year return periods:

$Q_{100} = 0.7685\ DA^{0.7638}$; ($R^2$=0.78) and $Q_2 = 0.2893\ DA^{0.7458}$; ($R^2$=0.68) *Equation 4-1*

where

Q_{100} = Instantaneous peak with 100-year return period (m^3/s)

Q_2 = Instantaneous peak with 2-year return period (m^3/s)

DA = Drainage area (km^2)

R^2 = Coefficient of determination

These peak flow equations will be used in the surface water quantity effects assessment. These equations may be updated and similar equations may be developed for other return periods as further hydrotechnical assessment for other segments of the project highway alignment become available and as engineering design for new crossings become available.

4.3 Low Flows

The minimum seven-day average flow, calculated by averaging flows over a seven-day period and calculating the minimum seven-day average flow over a period of time (annual or June to September) was used for low flow characterization.

Minimum annual seven-day average flow with a 10-year return period (7Q10a) and minimum June to September seven-day average flow with a 10-year return period (7Q10s) are used as indicators of extreme low flow conditions in this study.

Historical daily streamflow data from the WSC hydrometric stations (Table 3.2) during their period of record were downloaded from WSC (2021). The Hyfran Plus software package was used to conduct frequency analyses on the annual and June to September 7-day low flows. The timeseries were evaluated with the independence, stationary, and homogeneity tests and probability distribution functions were fitted to these timeseries to estimate the 7Q10a and 7Q10s for each WSC hydrometric station (Table 4.3).

For each of the 7Q10a and 7Q10s, a regression analysis was conducted with drainage area being the independent variable. The regression analysis did not find a correlation between 7Q10a and drainage area, but identified a strong correlation between 7Q10s and drainage area in the form of:

$7Q10s = 0.0028\, DA^{0.8189}$; ($R^2$=0.87) *Equation 4-2*

where

7Q10s	=	June to September 7-day low flow with 10-year return period (m^3/s)
DA	=	Drainage area (km^2)
R^2	=	Coefficient of determination

Table 4.3 Low Flow Estimates for Water Survey of Canada (WSC) Hydrometric Stations

WSC Station ID	WSC Station Name	Drainage Area (km^2)	7Q10a[1] (m^3/s)	7Q10s[2] (m^3/s)
10HC007	Hodgson Creek	358	0.053	0.510
10HC008	Ochre River	1,207	0.069	0.966
10HC006	Blackwater River	7,850	0.525	7.92
10HC003	Big Smith Creek	980	n/a[3]	0.600
10KA006	Jungle Ridge Creek	60	0	0.040
10KA009	Canyon Creek	53	n/a[4]	0.115
10KA005	Seepage Creek	31	0	0
10KA007	Bosworth Creek	125	0.059	0.164
10KA001	Mackenzie River	1,590,000	2,050	8,100
10LD002	Jackfish Creek	63	0	n/a[4]

Notes:
[1] annual seven-day low flow with 10-year return period
[2] June through September seven-day low flow with 10-year return period
[3] available data did not pass the independence, stationarity, and homogeneity tests
[4] sufficient data was not available to estimate 7Q10
Source: data downloaded from WSC (2021)

While Table 4.3 can be used for the 7Q10a and 7Q10s estimate for the watersheds with WSC stations, the 7Q10s for ungauged watersheds can be estimated with the regression-based Equation 4-2.

5 Summary

This TDR presents existing surface water quantity data to support the DAR. Existing data were collected from WSC hydrometric stations in the region, as well as previously published documents. Hydrologic indices (i.e., MAR, monthly distribution of annual runoff, peak flows, and low flows) were characterized for ten watersheds identified within the RSA. These watersheds contain the major streams (i.e., tributaries of the Mackenzie River) that the project highway alignment will cross.

The MAR identified is 151 mm to 220 mm. Likewise, although it is known that the watersheds with drainage area of greater than 100 km^2 are assumed to be perennial, it is not known with certainty what watersheds with drainage areas of less than 100 km^2 are perennial and which ones are seasonal. It is anticipated that surface water quantity effects assessment will not be sensitive to these uncertainties.

Data presented in this TDR are intended for surface water quantity effects assessment of the DAR and do not provide engineering design parameters. Engineering design and analysis of crossings (e.g., conveyance capacity and channel stability) will require a separate study tailored for such purposes.

The Terms of Reference (MVEIRB, 2015) requires a description of water courses that have year-round flow. This information will also support the cumulative effects assessment of the Project.

6 Closure

This TDR was prepared for the sole benefit of GNWT to describe existing conditions related to surface water quantity within the Project LSA and RSA. If you have any questions, please do not hesitate to contact the undersigned.

Respectfully submitted,

K'alo-Stantec Limited

7 References

7.1 Literature Cited

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7.2 Personal Communication

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