Transport Canada Navigational Study of the Lower Athabasca River – Outcomes and Technical Review

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EXECUTIVE SUMMARY

In 2014, Transport Canada (TC) initiated a four-phase study to establish a navigation profile of the lower Athabasca River between Fort McMurray and Embarras, south of Fort Chipewyan, and use this information to identify potential impacts of oilsands water withdrawals on navigation of this river. TC had become aware that users of the lower Athabasca River were experiencing poor navigability during periods of low flow. Given the interaction between mainstem water surface elevations and channel bathymetry, if water surface elevation is sufficiently altered by water withdrawals then navigation can be impeded leading to a reduced ability to use the river as a travel corridor and lost access to areas important in the exercise of traditional-use activities.

To exercise its legal responsibilities for protecting the navigability of listed Canadian waterways, TC decided to undertake a four-phase navigation study on the mainstem of the lower Athabasca River to assist in it filling the knowledge gap and share the study results with the Province of Alberta for consideration in its Surface Water Quantity Management Framework (SWQMF). In the first two phases of the project, scientific data and historic information are assembled and Indigenous river users engaged to identify the main areas of concern (Golder 2018). In the third and fourth phases, the river was field surveyed at key locations and an analysis conducted at each field site to determine how changing flows affect water levels, channel characteristics and navigability. Dillon (2019) provides the results of the third and fourth phases and the overall project outcomes in a draft report that is reviewed here. A final report was expected for release by Transport Canada in February 2020.

Generally, the study outcomes echo Indigenous knowledge and monitoring results. The validity of the AXF concept is confirmed by the results of the TC Study which shows that, across sites, there is a discharge value that corresponds well with the threshold depth required for traditional hunting and below which water depth declines more rapidly. The study projects large reductions in flow rates by the 2060s, taking the river well below the AXF for weeks or even months at a time. The inadequacy of the SWQMF in managing Indigenous navigability is readily evident from the new field survey information in terms of both the unrecognized river constraints and variability and the inaccuracy of the SWQMF's own index. The new discharge measurements at 11 sites along the river provide an opportunity to better understand longitudinal flow variation among the water intakes and to consider the factors that may shape the measured variability. The TC Study also provides an integrated description of the future river affected by reductions in flow during the open-water season and by a simplified river that is narrower and shallower, with fewer active side channels and back channels.

Improvements in the TC Study could be considered in a number of areas. Both reports generated by the TC Study misrepresent Indigenous navigability requirements to some extent. Correct definitions and the best available science should be applied at all times. Dillon's (2019) mischaracterization of oilsands water withdrawals should be corrected because they may have led the TC Study's authors to misunderstand the potential for oilsands water withdrawals for being responsible for lost navigability opportunities today and in future decades. Also, the site discharge ratios used in Dillon's report suggest "missing water" downstream of the Fort McMurray WSC hydrometric station. This warrants additional analysis to determine why the measured flows at each site were lower than what daily reported flows from the reference gauges would have predicted and to clarify whether oilsands withdrawals are part of the answer. In addition, Dillon (2019) makes the common mistake of comparing the short-term effect of withdrawals with the long-term adjustments from climate change. These two factors are not inter-related so this type of direct comparison is misleading. Instead, future withdrawals should be compared against the future availability of river water.

The TC Study provides Federal Crown validation of Indigenous navigability knowledge and science. It confirms that the AXF concept is valid and that it occurs simultaneously at many sites along the lower Athabasca River. The TC Study confirms the spatial and temporal heterogeneity of river discharge and the necessity of using flow data along the lower Athabasca River, rather than from only a single point upstream of impacts. It also demonstrates that Alberta's SWQMF is irreconcilable with the scientific consensus on river conditions. It demonstrates that Alberta's management regime ineffectively characterizes the requirements of Indigenous navigability and insufficiently assesses the factors that may challenge its continued adequacy for fulfilling traditional-use activities. The TC Study also shows a future with an increased frequency of reduced or lost navigability for traditional-use purposes. As the hydrologic regime of the river evolves and changes in response to a changing climate, there will be an increased need for measures to protect navigation such as adjusting the timing of oilsands water withdrawals to a host of other practices from navigation hazard tracking to channel marking and from local dredging to more severe restrictions on oilsands water withdrawal timing and amounts. To manage and protect Indigenous navigability within the Peace-Athabasca Delta, the role of Peace River will need to be understood and integrated with management of the lower Athabasca River.

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List of Acronyms

AB	Alberta
ABF	Aboriginal base flow
ACFN	Athabasca Chipewyan First Nation
AEA	Aqua Environmental Associates
AEP	Alberta Environment and Parks
AXF	Aboriginal extreme flow
BC	British Columbia
CBM	Community-based monitoring
CEMA	Cumulative Environmental Management Association
DFO	Department of Fisheries and Oceans
GoA	Government of Alberta
HEC	Hydrologic Engineering Center
masl	Metres above sea level
MCFN	Mikisew Cree First Nation
PAD	Peace-Athabasca Delta
RAS	River Analysis System
SWQMF	Surface Water Quantity Management Framework
TK	Traditional (Ecological) Knowledge
WSC	Water Survey of Canada

1.0 INTRODUCTION

1.1 Indigenous Navigability of Lower Athabasca River and Peace-Athabasca Delta

The ability of Athabasca Chipewyan First Nation (ACFN) and Mikisew Cree First Nation (MCFN) to efficiently traverse the waters located throughout their Territories, and in a rhythm reflecting long-standing seasonal-use patterns, lies at the heart of the viability and sustainability of their cultures and economies. During the open-water season, the Athabasca River is the only traditional transportation route linking members living in Fort Chipewyan, Fort McKay and Fort McMurray and providing access to lower cost and sometimes unique goods and services in the larger service centres of Fort McMurray and Fort Smith. The river is also a fundamental element of the Territories that supports ACFN's and MCFN's ability to exercise and enjoy their Treaty and Indigenous Rights, including accessing their lands and resources through tributaries and high-value mainstem side channels.

Seasonal water availability in the channel is the single-most important environmental factor shaping the ability of the river to support riverine opportunities for Traditional use. Water dynamics of the Athabasca River also help shape the navigability of the PAD, particularly in its southern portions. In addition to the navigational opportunities provided by the lower Athabasca River, waterbodies within the PAD provide critical access to further ACFN and MCFN territory (see Carver and Maclean, 2016). Although navigability of the lower Athabasca River is the focus of this report, the interrelated importance of navigation within the PAD cannot be overstated.

In 2014, as part of exercising its legal responsibilities for protecting the navigability of listed Canadian waterways, Transport Canada initiated a four-phase study to establish a navigation profile of the lower Athabasca River and use this information to identify potential impacts of water withdrawals on navigation of this river. It is intended that the study outputs may also inform adaptive management measures within the Surface Water Quantity Management Framework (SWQMF) under the Lower Athabasca Regional Plan. Additionally, deliverables for that study were provided in two stages – the first two phases were completed in 2018 (Golder 2018) with the final two phases being completed in March 2019 (Dillon 2019).

1.2 Objectives of this Report

Aqua Environmental Associates has been retained by ACFN and MCFN to address the following objectives related to the Transport Canada (TC) Navigation Study (TC Study) formulated in PWGSC (2014):

1. Carry out a detailed technical review of the TC Study's four components including Dillon (2019), Golder (2018) and relevant background documents.
2. Identify key outcomes of the TC Study in relation to requirements of Indigenous navigability in lower Athabasca River.
3. Summarize the findings in a brief technical report.

Section 2 summarizes the review's findings, highlighting the key outcomes of the TC Study and how they advance understanding of Indigenous navigability. Section 2 includes additional review comments and potential improvements to the study and its outputs. Section 3 provides six conclusions reached on the basis of review.

1.3 Acknowledgments

I would like to acknowledge the review and input of Bruce Maclean. His contributions have improved the clarity and content of this report.

1.4 Limitations

Aqua Environmental Associates (AEA) has prepared this report for ACFN and MCFN to inform their ongoing assessment of navigability within their Territories including the lower Athabasca River and the Peace-Athabasca Delta. AEA is not responsible for any use, interpretations or conclusions that may be made on the basis of the information contained herein if used by other parties and/or outside of this review process. Any such unauthorized use of this report is at the sole risk of the user and is not permitted without the express written consent of the ACFN and MCFN.

2.0 TRANSPORT CANADA'S NAVIGATION STUDY

Through a study undertaken by PWGSC on behalf of TC and taking five years to complete, the Federal government provides the results of a field-based assessment of the navigability of the lower Athabasca River extending from Fort McMurray downstream to Embarras River. As explained in PWGSC (2014), this work was undertaken in the context of Alberta's ongoing development of rules to manage oilsands water withdrawals from the lower Athabasca River. In developing the existing rules, evaluation of water depth was made for only a single "worst case flow value at various locations of a modelled river" (PWGSC 2014, p2) and without field assessment. As also explained in PWGSC (2014), given the interaction between main-stem water surface elevations and channel bathymetry, if water surface elevation is sufficiently altered by withdrawals then navigation can be impeded leading to a reduced ability to use the river as a travel corridor and lost access to areas important in the exercise of traditional-use activities.

Aware that river users have been experiencing poor navigability during periods of low flow, TC initiated this study in 2014 to field assess the effects of water withdrawals on navigation in this river and to complete previous related work. In September 2011, the Cumulative Environmental Management Association (CEMA) had awarded a contract for a navigation study but it was not completed. The TC study "recognized that this was an important piece of information that the Department [TC] was missing and, as such, decided to proceed on its own with a navigation study on the Lower Main Stem of the Athabasca River to assist in filling the knowledge gap identified by CEMA and … share the results of the study with the Province of Alberta for consideration in the Province's water management scheme" (Dillon 2019). In essence, the completion of this study represents the culmination of an eight-year contracting process. The response to the study's findings by the Province of Alberta have not yet been shared with the ACFN or the MCFN.

2.1 Approach and Methodology

The terms of reference for the TC Study provide a number of objectives related to the navigability of the lower Athabasca River (PWGSC 2014). First, the study is to establish a profile of navigation. Second, it is to identify potential impacts of water withdrawals on the river's navigation. The study's findings are also to inform adaptive management measures undertaken through the SWQMF. Lastly, the study is to provide TC with detailed information needed to assist in exercising its responsibilities with respect to environmental impact assessments of future project proposals and under its Federal legislative mandate.

To enable TC to accomplish these objectives, a four-phase project is laid out in PWGSC (2014):

1. Collate and review historical sediment data, hydrologic data, past navigation charts, dredging information, and recent bathymetric data.

2. Identify main areas of concern, including types of vessels, by conferring and discussing with users of the Athabasca River including aboriginal communities.

3. Survey the river bathymetry at key locations identified during the discussion with users of the Athabasca River, and conduct an analysis at each of the sites to determine how changing flows will affect water levels, channel characteristics and navigability.

4. Provide a report summarizing the data, detailed analysis and conclusions.

The first two phases involved assembling office-based information and community knowledge. This work was carried out by Golder Associates and the results provided in a March-2018 report. The third (field study) and fourth (analysis and reporting) phases were carried out by Dillon Consulting and results provided in March 2019 (Dillon 2019). Golder initiated its work in 2014, and in 2015 "the study was put on hold due to delays in the completion of the community consultation process" (Golder 2018, p1) and was not resumed until 2018. Golder (2018) brings together background information some of which was used in the subsequent Dillon (2019) investigation. Golder (2018), including its own two appendices, is presented alongside various background reports and provided in Appendix A of Dillon (2019).

A central output of Golder (2018) is a compilation of field information provided by Indigenous community members identifying the location, degree and extent of navigational concerns. Covering a total of 35 locations, sites of concern are shown spatially in Figure 1. Golder (2018) also summarizes navigability information, hydrometric data, oilsands water withdrawals and climate projections. Although the navigability criteria presented in Golder (2018) have serious shortcomings (see section 2.3.3), it appears that these have largely not been repeated in Dillon (2019) and have not compromised the outcomes of the overall study.

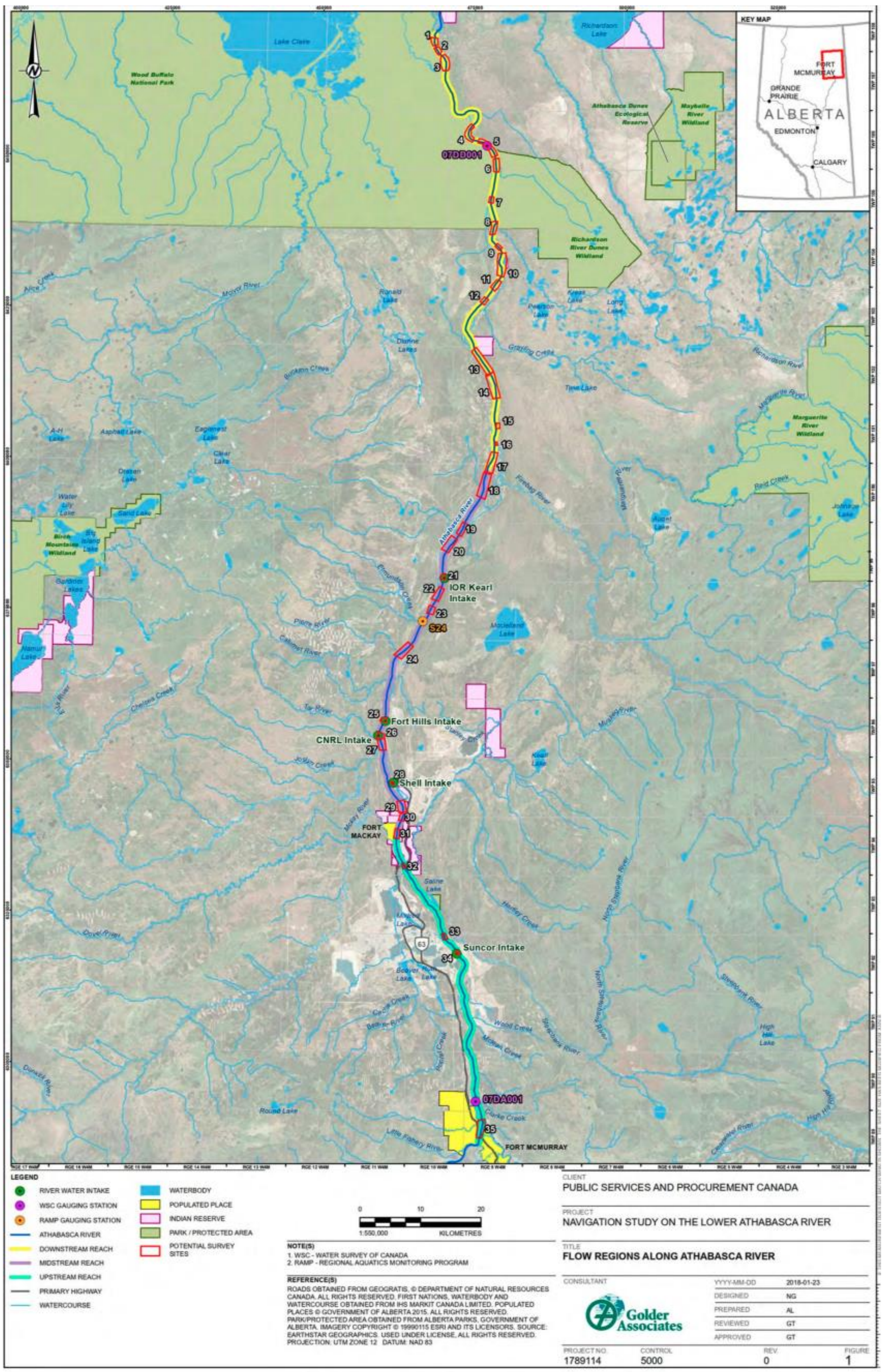
Golder (2018) includes descriptive data summaries from the three hydrometric stations located within the lower Athabasca River[1] (mean hydrographs and cumulative frequency distributions). These focus on mean conditions and do not include extremes thus are of limited value to the discussion of navigability. These means do not appear to be used further in the TC Study. Golder (2018) also tabulates monthly mean flows based on climate projections (for an unspecified decade) using data provided in Teck (2013). In cumulative frequency plots of river discharge, it contrasts the change due to climate with that due to oilsands withdrawals. The plots are of limited value because the timeframe is not provided and because the cumulative frequency plots do not provide an effective basis for assessing impact importance.

Two appendices are included in Golder (2018). The first is a survey plan for the lower Athabasca River with an overview map and detailed survey plan maps of each potential site along the Athabasca River. The maps include figures identifying potential study reaches, proposed cross-sections, and set up locations for survey instrumentation. The second provides a ranking of the reaches based on criteria in the report. Also included in the second appendix is a memorandum from Golder Associates providing history and context to this work followed by a tabulated account of field information shared during March 2018 by Indigenous land users with experience of the river.

Dillon (2019) reports on field measurements, data analysis and overall project outcomes. Eleven of the 35 identified sites were chosen for detailed field survey carried out September 17-23, 2018. The site work included channel bathymetry and velocity transects, assessment of local depositional features, and topographic survey of shoreline features, water levels and shallow bathymetry. Semi-permanent cross-sections were established at each site. They were stream gauged during the survey period and aerial and ground-level photographs were taken. (An Acoustic Doppler Profiler (ADP) and a Hemisphere and Sokia RTK GPS survey instruments were used to collect topographic, bathymetric, and river discharges data for each of the 11 survey sites.) Using the survey data, Dillon developed digital surfaces for each site. ARCGIS was used to prepare reference cross-section geometry and base contour plans. River discharge was determined for each site.

[1] Two stations are managed by the Water Survey of Canada (07DA001, 07DD001). The third station is situated between these two and is managed by the Alberta Environmental, Monitoring, Evaluation and Reporting Agency (AEMERA). This third station was formerly created and managed under the Regional Aquatics Monitoring Program (RAMP station S24) - see Table 7 in Golder (2018, p12).

Figure 1. 35 sites from Golder (2018). (reproduced from Golder 2018, p5).



Dillon (2019) compares agency data to the newly-measured discharge data "with the goal of developing an approach to data transfer statistical flow estimates determined at the primary gauge sites to the 11 previously described survey sites" (Dillon 2019, p12). The relative size of the drainage areas at the 11 sites in comparison with that of the Fort McMurray and Embarras Airport hydrometric stations is determined and compared to the relative size of the discharge at each pairing of monitoring locations. The measured flow ratios are calculated by dividing the instantaneous measured flows from Dillon's field work at each survey site by the WSC daily reported flows. They report that the "[m]easured flow ratios tended to be lower than drainage flow ratios, indicating that measured flows at each site were lower than what daily reported flows from the reference gauges would have predicted" (Dillon 2019, p13). Put another way, comparisons based on drainage area alone suggest that the flow that Dillon determined at the survey sites based on its field measurements was lower than would be expected based on area alone. The reason for this discrepancy is not examined by Dillon (2019). Potential causes are discussed further in section 2.3.3 below.

A hydraulic model (HEC-RAS) was constructed using the survey data and preliminary simulations were run. Because "channel features did not tend to change appreciably through the study area" (p20), a single Manning roughness coefficient was used everywhere. The "simulation of water levels … demonstrated a strong alignment with the observed measurements" providing confidence that the model as calibrated could be used to assess the hydraulic characteristics of the river for the range of withdrawal and climate change discharge estimates scoped into the study. For the calibration step, the measured discharges were not corrected for oilsands withdrawals occurring during the period of field measurements. Additional calibrations that include corrections for assumed and maximum potential oilsands withdrawals would be appropriate to clarify whether model calibration can be improved.

With the calibration complete, to assess the relative impact of oilsands water withdrawals on water levels within the Athabasca River, the river model is used to simulate a series of discharges covering the range of flows expected to occur during the navigability period (defined as August 1 through October 31). The simulations were carried out at flow rates of 200, 400, 500, 1000 and 1600 m^3/s to bracket the known range of useful navigability and to include a discharge value known to be much lower than the AXF and relevant under future climates. (See next section for definition of AXF and ABF.) These simulations also include the preliminary estimates of the AXF (400) and ABF (1600) and the revised estimate of the AXF (500) as provided by Carver and Maclean (2016). Each simulation was undertaken for conditions both with and without the influence of water withdrawals. Five magnitudes of withdrawals are applied - 4, 8, 16, 20 and 29 m^3/s.

Dillon (2019) describes flows of the future Athabasca River in the 2060s based on projected climates taken from the Frontier Mine application (Teck Resources 2013). Of the future conditions in that assessment, Dillon (2019) emphasizes those that align best with the Province of Alberta's most current assessment outlook[2]. The future climates are used to determine the river's mean and low monthly discharges during each of August, September and October. Dillon (2019) also describe changes in the timing of the lowest monthly discharge. Use of monthly means is problematic because periods much shorter than a month can be deleterious to carrying out traditional-use activities. Water depths during these shorter and more extreme periods are lower than the monthly averages yet this information is not made available in Dillon's analysis.

[2] https://www.alberta.ca/climate-change-alberta.aspx

2.2 Key Findings and Overall Contributions

A decade of Indigenous activity in describing and communicating navigability within the PAD and lower Athabasca River has laid the foundation for the TC Study. This study's design and outputs largely build on this existing knowledge and previous investigation. The outputs are discussed in three themes.

2.2.1 Study outcomes echo Indigenous knowledge and monitoring results

Candler *et al.* (2010) identify two discharge thresholds of Athabasca River defining limits to ACFN and MCFN access to traditional use in their territories. These thresholds refer to the discharge of the Athabasca River as measured at Water Survey of Canada station 07DA001, also called *Athabasca River below McMurray* (Q_{FM}), and are defined as follows:

- The **Aboriginal Base Flow** (ABF) is the Athabasca River discharge above which water levels are unlikely to cause an impediment to the ability of ACFN and MCFN members to practise their rights and access harvesting areas. In Candler *et al.* (2010), community members indicated that, until recent decades, the ABF level was reached frequently and would last for much of the summer.
- The **Aboriginal Extreme Flow** (AXF) is the Athabasca River discharge below which widespread and extreme disruption of traditional use occurs for the ACFN and MCFN due to loss of access to prime/essential seasonal harvesting areas and key travel routes related to low waters. Lost access may occur at pinch points defined as channel locations where low water restricts access to large areas of traditional use. Lost access occurs in both the Athabasca River and within the PAD.

In between these limits, access varies with discharge. Along the lower Athabasca River, access is closely tied to Q_{FM}. Within the PAD, Peace River discharge affects water depths both directly and through interactions with Athabasca River discharge and prevailing water levels. Extent of hydrologic recharge from recent years has an additional effect, as do location, site-specific deltaic processes, and seiche events.

Access loss and boating safety risks associated with the AXF focus attention on that threshold. Based on direct experience of land users, Candler *et al.* (2010) identified a preliminary AXF of 400 m^3/s. Following the publication of *As Long as the Rivers Flow* (Candler *et al.* 2010), ACFN and MCFN collaborated to broaden their existing water monitoring efforts. They undertook a program of community-based water monitoring (CBM) to quantitatively assess the status of water resources within their territories. Years of falling water levels precipitated that action to address gaps left by agencies and upstream industry which have lacked initiative to quantify the depth declines and their potential linkage to declines in Athabasca River (and Peace River) hydrographs and industrial water withdrawals. Based on this field program, the AXF has been revised to 500 m^3/s (Carver and Maclean 2016). CBM field measurements have also demonstrated that in the vicinity of the AXF, water depth drops quickly with declining Q_{FM}.

Dillon (2019) reflects this existing science in its study design. Although Golder (2018) is not up to date with these existing studies and traditional knowledge, those gaps (see section 2.3.2) do not appear to have been carried forward into Dillon (2019). Dillon (2019) correctly understands the AXF and ABF thresholds and uses their current values. It also expands on this knowledge in its detailed description of 11 identified sites along the Athabasca River, informed by hydrologic modelling calibrated using its own site-specific data.

The validity of the AXF concept and its quantification as 500 m^3/s are confirmed by the results of the TC Study which show that, across sites, there is a discharge value (just less than 500) below which water depth declines more rapidly and that the value of this threshold corresponds well with the depth required for traditional hunting. (MCFN concluded similarly in its submission to the Joint Review Panel for the

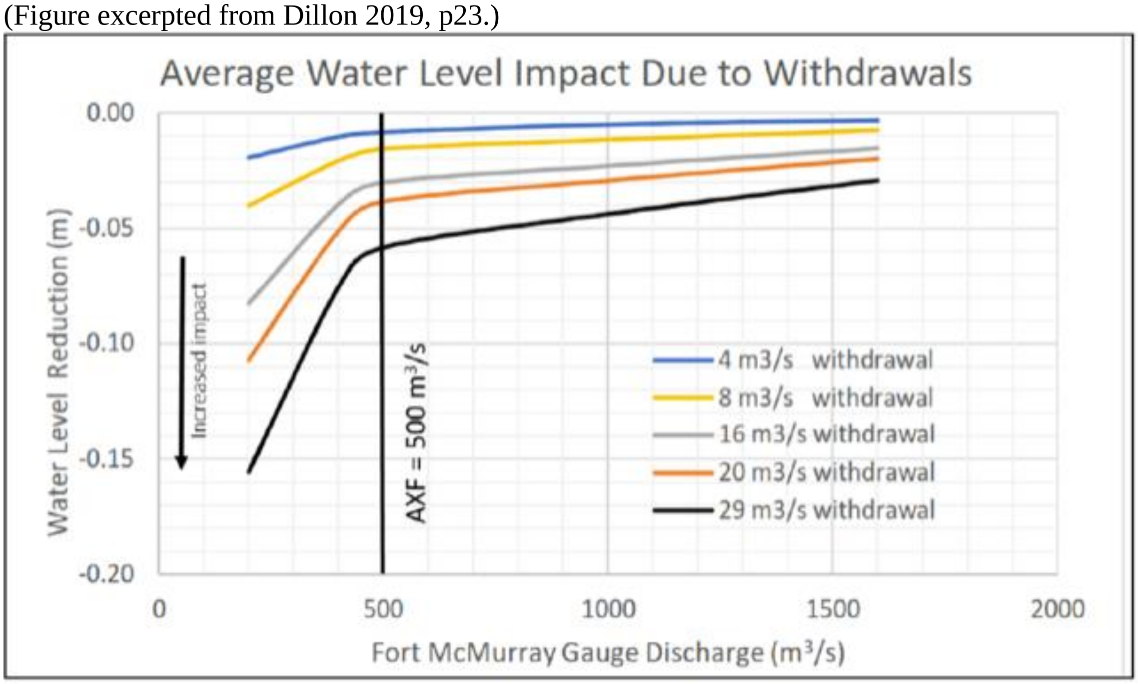
Frontier Mine – see Carver, 2018a.) The depth classes chosen, the discharges simulated, and the magnitude of the applied water withdrawals all appropriately represent and bracket the range of concern related to the navigability threshold. Dillon (2019) appropriately recognizes the water-depth requirements of Indigenous navigability (1.2 m). This application of up-to-date information contrasts with Golder (2018) and the SWQMF both of which make mistaken reference to inapplicable values of the threshold (AXF) magnitude – see section 2.3.2. Dillon's use of up-to-date information and a complete and accurate methodological framing support the efficient and successful ability of the study to address TC's overall objectives.

Dillon (2019) calibrates a hydraulic model using its field measurements at 11 sites to estimate the river's average water level (masl) at those sites for a flow of 500 m^3/s (AXF) as measured at the WSC station in Fort McMurray. Using the calibrated model, it determines that when that flow rate occurs at the Fort McMurray hydrometric station, the discharge at the 11 sites varies from 340 to 527 m^3/s and depth varies from 1.9 to 4.4 m. This variability highlights the limitation in managing navigability (and the impacts of oilsands withdrawals) using flow measurements at one point in the river, particularly a point that is upstream of the industry. The wide range in discharge along the river would be expected to reflect a wide range in navigability limitations. Whereas it is attractive to use a single indicator such as the AXF to reflect access loss overall, there are limitations to such an approach. Notwithstanding the concept's validity, the variability in flow and navigability at the AXF indicates the need to be better apprised of true river variability so that navigability can be adequately managed.

Using the survey information and rating curves for each of its field sites, Dillon (2019) generates a plot (Figure 8, p23) that shows that across its survey sites, water depth declines more rapidly below a value of Q_{FM} of 500 m^3/s. See Figure 2. This accelerated loss in water depth just below the AXF means that the effect of water withdrawals increases more rapidly under these low river discharges. For example, the water level impact of 29 m^3/s withdrawal rate increases to 250% of this value under more extreme low discharges. This echoes the finding provided by MCFN to the Joint Review Panel for the proposed Teck Frontier Mine (Carver 2018a), underscoring its validity.

Figure 2. Mean water-level reduction across Dillon's 11 surveyed sites due to water withdrawals of 4, 8, 16, 20 and 29 m^3/s for the full range of river discharges ranging from 200 m^3/s to 1600 m^3/s.

(Figure excerpted from Dillon 2019, p23.)



Dillon (2019) also presents projections of mean monthly flow and low monthly flow associated with the projected climates presented by Golder (2018). The findings are broadly consistent with those presented earlier by MCFN (Carver 2018a) though Dillon does not determine extreme flows, focusing instead on mean monthly flows. Dillon (2019) also combines these projections with the changes due to oilsands withdrawals (8 m^3/s and 29 m^3/s) to determine average monthly water level reductions, also averaged over the 11 sites. Despite the different metrics and presentations of results, the findings appear consistent with those previously developed by MCFN (Carver 2018a) in that large reductions are projected in flow rates taking the river well below the AXF for weeks or even months at a time. Additional details are provided by the TC Study as discussed in the next section.

These consistent results from scientific studies (including the TC Study) and Indigenous knowledge are at odds with Alberta's perspectives about Indigenous navigability and the requirements it maintains are sufficient to manage it effectively. In the SWQMF, Alberta maintains that a depth calculation, made at one location and based on bathymetry taken in the past at one point in time, is sufficient as a threshold characterizing navigability through the entire Athabasca River and over many years. Alberta also assumes without evidence that Indigenous navigability persists to flows as low as 300 m^3/s (Alberta 2015). This value of 300 m^3/s is provided based on an office-based opinion of staff about what is suitable for Indigenous navigability. (See section 2.3.2.) Through the TC Study, the Federal Crown confirms that the Provincial Crown is mistaken in its characterization of Indigenous navigability of the Athabasca River.

2.2.2 Expanded scale understanding of navigability limitations

ACFN and MCFN have previously described variability aspects of Indigenous navigability. Anecdotal accounts have been compiled to illustrate the diverse and distributed nature of navigability constraints in the lower Athabasca River and in the PAD (Candler *et al.* 2010). Almost a decade of water-depth CBM measurements have shown at numerous pinch points[3] how navigability is reduced and eventually lost with declining discharge. Using maps illustrating water depth at flows of 250, 300, 350, 400, 450, 500, 600 and 800 m^3/s (as measured at WSC 07DA001) and for sections of the Athabasca River covering 30 km, ACFN and MCFN have illustrated the diverse and distributed nature of navigability limitations in the lower Athabasca River including lost access to side channels and tributaries to Athabasca River at flow rates well above the AXF (Carver 2018a). MCFN has also shown that water-depth impacts of water withdrawals increase with decreasing depth (Carver 2018a).

The TC Study adds to the understanding of spatial and temporal variability of navigability. It quantifies river flow and depth variation at 11 sites, well distributed along the river, during the same period of the fall low-flow season (mid-September). The data granularity reveals that the flow at the Fort McMurray reference gauge is generally higher than at other locations downstream, this despite the inflow of major tributaries. The catchment areas below Fort McMurray include large areas where the groundwater and surface water have been modified by industrial activity. The TC Study's distributed downriver measurements shed light on potential consequences for river flow of these watershed modifications. They also suggest that the measurements at WSC 07DD001 are reliable at least over the range of flows relevant to the TC Study.

The site discharge measurements provided in the TC Study provide an opportunity to better understand longitudinal flow variation among the water intakes and to consider the factors that may shape this measured variability. See section 2.3.4 for additional discussion.

[3] Pinch points are defined as channel locations where low water restricts access to large areas of traditional use, or where access to traditional hunting, fishing and trapping is restricted when water levels reach lower than 1.2 m.

During the field work period, measured discharge at the cross-sections varied from 415 to 620 m^3/s and “[r]epresentative surveyed channel cross-section depth” varied from 1.9 to 4.4 m. The AXF had been established based on the discharge at WSC 07DA001, upstream of all but one of the field sites. Despite this variability in flow rate, the TC data set indicates that when discharge at Fort McMurray reaches the AXF, depth at most of the field sites (1, 3, 10, 11, 14, 22, 29 and 35) is below the minimum required to maintain Indigenous navigability. See Table 1. At the other three sites, (2, 18, and 20), the calculated depth was above 1.22 m. Dillon (2019, p36) emphasizes that these depths are determined along “an idealistic route based on the assumption that an operator can identify this route while navigating the vessel through these challenging conditions” and that “this route may not be readily identifiable from the surface by a boat operator, as it would imply preknowledge of existing channel bathymetry by the operator during navigation.” In other words, it would be expected that navigability would be lost at a depth greater than 1.2 m in practical situations given the idealized nature of the modelling. This high degree of validation given the idealized nature of the modelling provides significant added confidence in the value of the AXF threshold concept and reinforces the magnitude that ACFN and MCFN have determined it to be (Carver and Maclean 2016).

Table 1. Water depth limitation at the eleven surveyed sites, modelled based on Q_{FM} = 500 m^3/s (excerpted from Dillon, 2019, Table 14).

Survey Site Number	Depth of Water Above Critical Bed Elevation (m)
1	0.97
2	2.18
3	0.82
10	0.65
11	0.69
14	1.21
18	1.68
20	2.64
22	0.42
29	0.49
35	0.95

This added information is also helpful in explaining where Alberta’s management framework is deficient in defining and protecting Indigenous navigability. Alberta’s SWQMF relies solely on the discharge measurements carried out at Fort McMurray. See section 2.3.3 for further discussion. This progress in describing spatial and temporal variabilities of navigability requirements is also at odds with the SWQMF which uses an indicator based on only one location in the river as a surrogate for all navigability limitations in this system, no matter when or where they occur. That single point is located in site 13 which is just downstream of site 14, included in the surveyed sites. The model outputs reproduced in Table 1 reveal that, at the AXF, the surveyed sites are at or well below the minimum depth (1.22 m) required for Indigenous navigability able to support traditional use. This was also discussed in the previous section. Additionally, the significant differences in amount of flow at each site suggests that a lot of information is lost longitudinally in the river when only one measurement point is utilized, particularly when it is upstream of all the oilsands water intakes. Discharge measurements at the eleven sites ranged between 319 to 550 during Sept 17-23, 2018 when Q_{FM}[4] ranged between 555 and 612 m^3/s, indicating a noteworthy downstream decline in river flow. Alberta has rejected using the ongoing measurements at Embarras because it considers them to be unreliable for its purposes because the measurement cross-section is in a shifting sand-bed river. The TC Study reveals the limitation of this perspective: at these lower flow rates, discharge measurement in these study sites appears to be reliable.

2.2.3 Integrated description of the future Athabasca River

The Athabasca River is changing and human opportunities to benefit from the river are evolving as a result. Like other rivers, Athabasca River responds to fluctuations in the controls on its discharge, sediment loads and other factors. As particular controls move outside their usual range of variability, river characteristics can be affected. Depending on the magnitude of the adjustments, they can lead to changes in the services provided by the river including surpluses that have been allocated for industrial use based on past hydrographs.

Changes in climate dating back to the 1900s are creating adjustments in the mean annual hydrograph of the lower Athabasca River. These are expected to continue through the coming decades and centuries as greenhouse gas emissions evolve and potentially stabilize. Using hydrologic modelling based on new field data, the TC Study estimates river flow and water depth under climates projected to the 2060s. Adjustments during the open-water navigation season include reported mean monthly flow reductions of 18%, declines in low mean monthly flow of 13% and a potential shift in timing from October to August of extreme monthly low flows (Dillon 2019, p18). These quoted reductions likely underestimate the expected declines because the projected flows, although unstated in the report, may have an annual return period, whereas the historic baseline is statistically determined from the long-term record from WSC data and thus is associated with a far less frequent return period (about 60 years). In any case, these changes point to an expanded duration of the annual open-water low-flow season and including annual extreme low flows expected to be significantly more severe in magnitude.

In an alluvial river, projected changes in climate and hydrology of this magnitude would also typically be accompanied by geomorphological changes due to altered river velocities, bedforms and sediment loads among other characteristics. For example, Dillon (2019) projects reduced velocities of about 5-10% associated with lower water levels (p30). Prolonged periods of low flow and reduced fluvial energy and activity are associated with a simplified river that is narrower and shallower, with fewer active side channels and back channels, particularly if the peak-flow freshet regime of the river also declines as the cryosphere declines. The diminished activity and modified morphology would be associated with reductions in the river's capacity to provide "surplus" removable water during the key navigation seasons without jeopardizing Traditional-use opportunities. These changes would also impact the PAD's structure and function vis-à-vis navigability.

These combined changes in hydrology and geomorphology impact the Athabasca River's ability to provide benefits to river users. For example, Alberta's oilsands industry is a long-term undertaking, including long-term projected demands for river water withdrawals, and intended to be sustained (and expanded) for decades. The industry's projected withdrawals will be from a river with very different morphology and hydrology to that of today. The pattern of water withdrawals that are designed for the 2010s river will not be available from the simplified 2060s river without harming river ecology and affecting pre-existing Traditional uses. The reduced availability of water "suggests an increased

[4] Measured September-2018 daily flows (m^3/s) at WSC 07DA001: 17th–612; 18th-610; 19th-603; 20th-606; 21st-591; 22nd-564; 23rd–555.

frequency of challenging navigational conditions in the future." (Dillon 2019, p42). As the TC Study demonstrates, the new hydrograph, a seasonal decline in flow velocity, and seasonal changes in sedimentation patterns will lead to a river less dynamic than today, with less capacity for withdrawals and, all other things being equal, a greater impact of withdrawals on navigability. The TC Study also shows that downstream of Fort McMurray, navigability impacts on the Athabasca River would be greater in the lower reaches than the upper reaches (Dillon 2019, p36).

The TC Study introduces these elements of an improved framework for understanding navigability impacts of oilsands withdrawals in future decades. The TC Study makes it clear that if oilsands withdrawals continue, they will occur from a very different river come the 2060s. If the present rules (SWQMF) are maintained in place, future oilsands water withdrawals will take place under conditions in which navigability is already compromised and in which their incremental navigability impact will be of heightened concern.

In addition, the TC Study's improved and integrated narrative of the future river remains incomplete in several respects. The navigability of the lower Athabasca River remains focused on mainstem through-travel and does not consider lost access to side and back channels and to tributaries, as river discharge declines from the ABF to the AXF and to depths below this threshold. Navigability of these locations is critical for the exercise of Traditional-use rights. The TC Study quantifies river flow in terms of monthly averages rather than daily extreme flows (*e.g.*, see Carver 2018a) which should be provided in any meaningful navigability impact assessment. Additionally, the PAD continues to be excluded from the navigability analysis and the Peace River's role in shaping PAD navigability remains unconsidered.

Lastly, both Dillon (2019) and Golder (2018) compare the short-term effect of withdrawals with long-term adjustments from climate change. Rivers commonly have long-term (decadal) changes in their hydrograph but that incremental change, though important to identify and discuss, is inappropriate as the basis of comparison and may lead to misinterpretations about impact significance when evaluating a project effect such as that due to the oilsands industry. Comparison of these two unrelated factors is misleading and does not advance the objectives of either report. Instead, as provided in section 2.4 (#7) below, expected future withdrawals should be considered in light of *projected future availability* of river water, exploring implications for depths, duration, etc.

2.3 Additional Review Comments

Elements of the study that could be improved relate to project timeliness, background science related to Indigenous navigability, analysis of site discharge ratios and characterization of oilsands water demands. Some shortcomings are evident in only one of the reports whereas others can be found in both. In general, where deficiencies may be present in Golder (2018), they do not appear to be repeated in Dillon (2019) thus the TC Study's overall findings may not be affected. In general, where these shortcomings may impact the TC Study's outcomes, correcting them would make only a stronger case for the magnitude of impact from oilsands withdrawals on Indigenous navigability.

2.3.1 Timeliness of project execution

The TC Study spanned eight years from the beginning of CEMA's initial navigation study to the release of Dillon (2019). The TC Study itself spanned five years from the contract award through completion. During the eight-year period, seven new and/or expanded oilsands mines have been reviewed, considered for approval, or approved. It appears likely that the delays in completing the TC Study have deprived review regulatory panels of information about navigability that might influence approval decisions. In addition, these delays have meant that these findings have not been made available to the Government of

Alberta to further guide them in addressing gaps in the SWQMF associated with impacts of oilsands water withdrawals on Indigenous navigability. Fortunately, the administrative shortcomings associated with the TC Study do not appear to have had a material effect on the scientific integrity and outcomes of the study however they have led to the findings being available later than they could have been otherwise.

2.3.2 Information on Indigenous navigability requirements

Golder (2018) and Dillon (2019) show gaps and inconsistencies in their understanding of Indigenous navigation thresholds and dynamics. Several examples are available.

AXF numerical value. ACFN/MCFN publications defining Indigenous navigability requirements (Candler *et al*. 2010; Carver and Maclean 2016) are not referenced by Golder (2018). Candler *et al*. (2010) established the AXF at a preliminary value of 400 m^3/s. Golder provides this early threshold estimate value but does not give a citation. Based on ACFN/MCFN analysis of subsequent CBM data, Carver and Maclean (2016) updated the value of the AXF to 500 m^3/s. Dillon (2019) correctly identifies the AXF as 500 m^3/s but does not indicate the source of its information. (Carver and Maclean is, however, referenced by Carver (2018b) which is provided as one of the background reports given in Appendix A of Dillon (2019).)

Minimum depth needed for navigability. Golder (2018, p9-10) makes references to water-depth requirements, constraints and connectivity unrelated to Indigenous navigability. For example, Golder misapplies water-depth thresholds based on recreational use to the TC Study's investigation of Indigenous navigability, and including information requested from retail outlets. Through its *Survey of Recreational Use Along the Lower Athabasca River* (CEMA contract title awarded to AECOM Canada Ltd.), AECOM (2009) provides depth thresholds for operating recreational craft (jetboats, powerboats, canoes, kayaks) and concludes that "[w]hen water depth exceeds 0.6m, it is anticipated that most recreational craft will be able to navigate the river unabated." This study based its conclusions on the application of thresholds gathered as personal communications from retail outlets (e.g., Formula Sports and Marine Ltd in Fort McMurray – AECOM, 2009, p27) and was not engaged in determining the depth requirements of Indigenous navigability. Despite this different application, Golder (2018) misapplies these recreational threshold values in its component of the TC Study. Instead, as discussed above, Golder should have relied on well-documented and readily-available threshold information related to Indigenous navigability and as provided by Indigenous communities (Candler *et al.* 2010; Carver and Maclean 2016, etc). The thresholds from AECOM (2009) used by Golder (2018) in the TC Study are irrelevant to assessing requirements of Indigenous navigability.

ABF definition. Golder (2018) states that the ABF is an upper boundary to "adequate river navigability" (p8) when it is actually the boundary above which there are no limits to navigability (Candler *et al*. 2010).

Use of Alberta's incorrect information. Alberta (2015, p75) erroneously reports that a Q_{FM} of 300 m^3/s "reflects a depth at which navigation may become impossible with a fully loaded boat." Alberta also establishes the zero value for its navigation indicator at 300 m^3/s to reflect its office-based assumption that flows are adequate for Indigenous navigability at this rate. In addition, Golder (2018, p10) states that the AXF marks the threshold "to poor in terms of providing access to traditional activities along the Athabasca River by First Nations and Metis communities." However, it is known from extensive field data that "widespread and extreme disruption of traditional use occurs" at the AXF and that this threshold occurs at 500 m^3/s, not at 300 m^3/s (also see section 2.2). Golder (2018, p9) repetition of Alberta's faulty information is made without indication that it is, in fact, based on assumptions and is inconsistent with best available science. The significant inadequacy of idealized water depth across the surveyed sites under AXF flow conditions (see above section 2.2.2) reiterates the failings of the SWQMF's one-point approach. The Metis Nation was also not consulted regarding the AXF and it is therefore a further unverified assumption on Golder's part that the AXF is appropriate to define their river use.

In its draft report, Dillon (2019, p19) also states that Candler *et al*. (2010) has identified 700 m^3/s as a flow "yielding a depth of approximately 1.2 m" (ie, the AXF) which is incorrect and is at odds with its correct statements elsewhere that Candler *et al*. (2010) identified 400 m^3/s as the preliminary AXF.

2.3.3 Characterization of oilsands water withdrawals

The TC Study mischaracterizes the scope and management of oilsands water withdrawals. This misrepresentation of the industry's demand profile and its regulation diminishes the breadth of concern suggested by the TC Study for the effects of industrial water withdrawals on Indigenous navigability. Three examples are provided here.

Permitted instantaneous rates of water withdrawal. Dillon (2019, p31) states that the "withdrawal of water from the oil sands developments can potentially be has [sic] much as 29 m^3/s based on existing permits," however, this doesn't full portray the potential capacity for total water withdrawals from oilsands operations. The limit of 29 m^3/s arises in the SWQMF and is implemented through unverified industry reporting carried out to comply with it. Industry operators work together to limit their combined withdrawals so as not to exceed this upper limit. However, the total operator capacity for withdrawing water from the Athabasca River can exceed the 29 m^3/s limit, particularly given the projected expansion of the oilsands industry and its demand for water from the Athabasca River.

29 m3/s and Whereas water authorizations may refer to the SWQMF, the total maximum instantaneous limits specified in authorizations do not add up to.

Assumed/unverified rates of water withdrawal. Dillon (2019, p31) states that "…over the years the actual rate of withdrawal has generally been no more than 5 m^3/s on a monthly basis, 6 m^3/s on a weekly basis, and it has been assumed to be in the order of a maximum of 8 m^3/sec on daily basis." Dillon (p31) Evidence is not provided in support of this assumption. Additionally, independent verification of reported oilsands withdrawals is not undertaken or has not been made available to the public. Given that the second objective of the TC Study is to "identify potential impacts of water withdrawals on the river's navigation" (section 2.1), it is inappropriate to assume that withdrawal rates are limited to these numbers, particularly when there are unexplained discrepancies in the hydrometric data (section 2.3.4).

Future oilsands water withdrawals. Dillon (2019, p23) states that "should current typical withdrawal rates continue in the future the more likely impacts would see water level reductions in the order of 2 cm (0.02 m) under a condition of 500 m^3/s and during extreme low discharges could range to approximately 4 cm (0.04 m)." This musing about the future is not plausible. Given the build out of the oilsands, it is not credible to expect that withdrawal rates could remain at present daily values (which Dillon assumes is at 8 m^3/s) because projected demand includes substantial and sustained withdrawals required to fill end pit lakes.

Whereas these mischaracterizations do not appear to affect the quantitative results of the study, they may have led the TC Study's authors to misunderstand the potential for oilsands water withdrawals to be responsible for lost navigability opportunities today and in future decades. As a result, they may have led the authors to understate the potential effect importance due to oilsands withdrawals.

2.3.4 Analysis of anomalous site discharge ratios

As reviewed in section 2.1, Dillon (2019) compares ratios of agency hydrometric data to its own field discharge data alongside the corresponding area ratios for each of the 11 assessed sites. They report flow ratios lower than drainage ratios, "indicating that measured flows at each site were lower than what daily reported flows from the reference gauges would have predicted" (Dillon 2019, p13). In a similar manner, Golder (2018) encountered lower than expected flows at the AEMERA hydrometric station situated near Eymundson Creek (midway between the two WSC stations). After noting that the differences between the two upper monitoring stations are "outside of the expected range of flow reduction between the two stations due to existing water withdrawal for oil sand operations", Golder (2018, p14) removes the data from further analysis without first determining the extent to which oilsands withdrawals or other effects might have been responsible for the discrepancies. Instead, Golder deems them not representative of the flows that had actually occurred and simply removes those data from its ratio analysis. Given that there is no independent verification of oilsands water withdrawals, it is not possible to assess the accuracy of Golder's assumption.

Although not investigated, Dillon (2019, p13) does suggest potential causes of the discrepancies:

> "These discrepancies generally can be described as being in the order of a relatively moderate degree and may be attributed to a number of causes including the accuracy of reported discharge estimates at the reference gauges (i.e., rating curves reliability), the comparison of daily discharge estimates to single discrete measured observations made by the field crews, and possible systematic errors in surveyed stream discharge estimates, and possibly the local effect of water withdrawals."

As random errors, the first two reasons would not be expected to yield the systematic (negative) difference that is observed. Whereas Dillon suggests that the surveying equipment could be associated with a systematic difference, it does not similarly indicate this for oilsands withdrawals yet these would cause *only* a systematic effect. We know they occur and that they only lower the measured discharge between the two reference sites. Given the capacity of the oilsands intakes to withdraw substantial quantities of water from the Athabasca River (potentially over short periods) and the absence of independent verification of reported withdrawal volumes, this effect warrants additional analysis. Dillon (2019) does not provide such an analysis. Instead, Dillon (2019, p14) sets aside the concern: "While it is undertstood [sic] that the withdrawl [sic] of water for oil sand production can impact the reported discharge estimates for the respective discharge gauges, the magnitude of the withdrawal is generally considered small (typically less than 5%) and is not expected to appreciably [sic] impact the reported discharge charactersitics [sic]."

In its subsequent determination of hydrograph return-frequency statistics, Dillon (2019) states that "…the reported discharges provided by the WSC are considered unregulated or un-nfluenced [sic] by withdrawals and are assumed to reasonably reflect natural flow regimes" and, as a result, Dillon does not naturalize the data sets in relation to reductions due to water withdrawals. The scope for this assumption to affect the study's outcomes is not provided in Dillon (2019) and despite oilsands withdrawals being unverified. Given the uncertainties and inconsistencies noted above in sections 2.3.3 and 2.3.4 regarding oilsands water withdrawals and site discharge ratios, a sensitivity analysis is recommended to ascertain the scope for error associated with the study's assumptions regarding the implications of not naturalizing the measured discharge values. These data are integral to river model calibration and validation and model outputs are central to the findings of the TC Study.

2.3.5 Comparisons and metrics

As discussed above in section 2.1, Dillon (2019) describes flows of the future Athabasca River in the 2060s based on projected climates (taken from the Frontier Mine application; Teck Resources 2013). In describing the future condition, Dillon focuses on metrics that are averaged over an entire month. Such long-term outputs metrics mask shorter-term behaviour related to the true lived experience. Daily and weekly shortfalls in available water for navigability cause losses in Traditional-use opportunities. While it can be beneficial to describe monthly averages, further steps can be taken in the TC Study to elaborate on shorter-term navigability dynamics and avoid having to "compare apples to oranges".

2.4 Suggested Measures to Finalize Study Outputs

In addition to the advances in understanding Indigenous navigability of the Athabasca River, review comments provided above in this section also suggest a number of measures that warrant additional work (information requests) before the TC Study outputs are finalized. These information gaps and correction edits are summarized here in six areas in reference to the two reports – Golder (2018) and Dillon (2019).

1. ***Address the reports' scientific information errors regarding Indigenous navigability***

In each report, correct and complete acknowledgment of previous and best-available science and Traditional knowledge related to Indigenous navigability of the Athabasca River. This includes:

- providing the correct and up-to-date values for the AXF;
- identifying the appropriate publications that give accurate and current information regarding Indigenous navigability;
- defining the ABF appropriately; and
- avoiding application of applying information from other sources in the wrong context – for example, do not use recreational use values for determining Indigenous navigability threshold requirements.

In Dillon (2019), avoid providing information from other sources that is known to be incorrect. For example, the SWQMF provides office-based assumptions regarding minimum requirements of Indigenous navigability that are contrary to the best available science. As a result, it does not represent authoritative science on the subject of Indigenous navigability.

2. ***Revisit modelling calibrations and output metrics of Dillon (2019)***

In addition to the mean monthly and minimum mean-monthly values, determine projected 2060s minimum daily low-flow values. Without these values, the reader cannot make meaningful comparison to the present situation. During an extreme that is calculated as a mean over 30 days, periods of lower flow would occur with durations of the true-lived experience and the weekly, even daily, requirements of a household.

For the calibration step, the measured discharges were not corrected for oilsands withdrawals occurring during the period of measurement. Neither were WSC data naturalized before they were used in model calibration and validation. Additional calibrations that include corrections for assumed and maximum potential oilsands withdrawals would be appropriate to clarify whether model calibration can be improved.

3. ***Correct flawed and unsupported statements about oilsands water withdrawals in Dillon (2019)***

Dillon's mischaracterization of oilsands water withdrawals should be corrected because they may have led to misunderstanding the potential for oilsands water withdrawals for being responsible for lost navigability opportunities today and in future decades. This includes assumptions about current potential daily rates of withdrawals, the individual and summed quantities of licensed withdrawal volumes and comments on projected withdrawals in relation to current levels.

4. ***Investigate inconsistency between discharge and area ratios in Dillon (2019)***

Dillon (2019) determines that the flow it calculates (using field measurements) at its survey sites below Fort McMurray is less than what would be suggested by the ratios of drainage area alone. Although it offers potential explanations, it does not investigate these anomalies and dismisses the concern. However, this concern may be related to oilsands withdrawals which is the subject under study. These shortfalls in expected discharge at the 10 sites warrant additional analysis to determine why the measured flows at each site were lower than what daily reported flows from the reference gauges would have predicted and to clarify whether oilsands withdrawals are part of the answer.

5. ***<u>Reconcile the two main reports that make up the TC Study</u>***

The TC Study would be strengthened by an improved reconciliation between its two main reports. Dillon (2019) should clarify the extent to which it builds upon or rejects the content of Golder (2018). This information would aid in confirming the state-of-the-art understanding of Indigenous navigability of the Athabasca River.

6. ***<u>Remove misleading comparisons of instantaneous water-withdrawal impacts with long-term background changes due to climate</u>***

Both reports compare the short-term effect of withdrawals with long-term adjustments from climate change. Rivers commonly have long-term (decadal) changes in their hydrograph but such changes, though important to identify and discuss, should not form the basis of the comparison when evaluating significance assessment of a project effect such as that due to the oilsands industry. Comparison of these two unrelated factors is misleading and does not advance the objectives of either report. Instead, comparison of expected future withdrawals against the projected future availability of river water should be the basis of the effects discussion, exploring implications for depths, duration, etc.

7. ***<u>Include a new section in the Dillon report that speaks to the PAD and the role of the Peace River</u>***

Indigenous navigability of the Athabasca River is intimately interconnected with that of the PAD. In turn, PAD navigability is shaped by *both* the Athabasca and Peace Rivers and their interaction; the relative significance of these (and other) controls is spatially and temporally variable. The information and conclusions within Dillon (2019) should be considered within the context of this larger navigability system, of which the lower Athabasca River is a part. This consideration could include a discussion of PAD navigability within Dillon (2019) and an additional discussion by TC of its broader consideration of and responsibilities for navigability within the PAD. Although assessing navigability of this larger system is out of scope of the TC Study, setting the TC Study within that larger context remains as an important and missing element to be addressed.

3.0 CONCLUSIONS

Transport Canada's recently completed study on navigation of the lower Athabasca River (Dillon 2019) is a major scientific advance in supporting the Crown's ability to manage potential impacts to Indigenous navigability in this river. The study integrates knowledge of Elders and other Indigenous river users with desktop information and a field-based study of eleven sites where navigation is of concern in this river. This synthesis and analysis has pointed to the growing concern for the impacts of oilsands withdrawals, and the worsening intensity, duration, frequency and spatial distribution of these impacts, particularly as river discharge declines.

Five conclusions are reached in this review and in light of the findings of the TC Study:

- Federal Crown validates Indigenous navigability knowledge and science
- Current river monitoring is insufficient to address scale variability
- Alberta's SWQMF is irreconcilable with scientific consensus on river conditions
- Navigation protection measures are essential in light of evolving river characteristics
- Understanding effect of Peace River is required to manage PAD navigability

These conclusions are discussed below.

3.1 Federal Crown Validates Indigenous Navigability Knowledge and Science

ACFN and MCFN have been putting forth their traditional knowledge and results from their own western scientific programs for many years in relation to navigability around their Territories. This information was generally disregarded by the Crown for a variety of reasons. For example, in its water management rules for the Athabasca River, although the government of Alberta recognized Candler *et al.* (2010) as an important document providing authoritative information from these First Nations, it then disregarded its content. Specifically, AEP Parks (2013) and Province of Alberta (2015) both disregarded the input of ACFN and MCFN regarding the minimum depth requirements for Indigenous navigability instead choosing thresholds that Alberta established arbitrarily.

The outcomes of the TC study establish the veracity of knowledge provided by ACFN and MCFN over the past decade. The legitimacy of the AXF as a minimum threshold for navigability is confirmed (and elaborated) by the Federal government through reference to detailed field bathymetric and stream gauging work at sites distributed along the lower Athabasca River. The accelerated navigability impact of oilsands water withdrawals as river discharge declines is also validated. The spatially distributed nature of the impacts is confirmed. With the Indigenous perspective validated, it may behoove other Federal departments and Crown governments to reconcile their management regimes with this best available science and knowledge, now in their hands.

Further discussion of the compatibility of TEK and western science is provided in Carver and Maclean (2016, p1).

3.2 Current River Monitoring Is Insufficient to Address Scale Variability

Currently in force to regulate oilsands withdrawals in the lower Athabasca River, the SWQMF makes management decisions based on river flow rates determined at only one location in the lower Athabasca

River and at a location that is well upstream of all oilsands water-withdrawal impacts. Other river flow data are *derived* using water-use data provided by industry rather than being generated from independent gauging sources based directly within the river itself. Downstream of Fort McMurray, there is a high degree of hydrologic modification to surface-water and groundwater flows. ACFN and MCFN have long been advocating for the use of increased flow monitoring along the lower Athabasca River within the context of the SWQMF so that actual river discharge informs impact assessment rather than derived values.

The TC Study confirms the spatial and temporal heterogeneity of river discharge and the necessity of using flow data along the lower Athabasca River, rather than from only a single point upstream of impacts. The SQWMF (p75) considers only mainstem navigability and at only one point in the river. The SWQMF does not give consideration to other areas where navigability is needed (back channels, side channels, tributary access points, etc) for fulfilling traditional-use requirements. In addition, the TC Study has begun to quantify the extent of this spatial and temporal variability. Spatial variability arises for various reasons including groundwater modification, withdrawals from tributaries, incomplete or inaccurate reporting of oilsands withdrawals, and other potential causes. Although a longstanding characteristic of the annual hydrograph, temporal variability is generally increasing as the climate changes. In subsequent work, these variabilities – and in particular the spatial variability – should be better quantified and sources partitioned. Improved navigability management would be made possible by gathering this information. Improved Lidar may be helpful. The reader is referred to Carver and Maclean (2016, p18-20) for an expanded discussion of related monitoring and modelling that could be used to better manage Athabasca River (and PAD) navigability.

3.3 Alberta's SWQMF Is Irreconcilable with Scientific Consensus on River Conditions

As explained elsewhere (Carver 2014; Carver and Maclean 2016; Carver 2018b), Alberta assumes that the Athabasca River provides navigability adequate for traditional-use purposes with river discharges as low as 300 m^3/s (as measured at WSC 07DA001; see SWQMF, p75). This assumption has been discredited by ACFN and MCFN for years in various forums. The TC Study provides further confirmation, now by the Federal government, that AEP's assumption is false. The TC Study demonstrates that Alberta's management regime ineffectively characterizes the requirements of Indigenous navigability and insufficiently assesses the factors that may challenge its continued adequacy for fulfilling traditional-use activities. Until Alberta has corrected its management framework, it will be at odds with best available science. It is difficult to understand how a Provincial Crown counterpart to the Federal Crown can maintain a viewpoint that is at odds with a credible scientific study undertaken and published by an agency of the Federal Crown. Given the absence of opposing evidence provided by the Alberta government, Alberta can adopt the findings of this report and use this advanced understanding of Indigenous navigability in its related management frameworks.

Carver and Maclean (2016, p48-50) provide further discussion of the scientific shortcomings of the SWQMF in addressing the requirements of Indigenous navigability along the lower Athabasca River. In addition, the SWQMF does not address PAD navigability. As navigability of the lower Athabasca River becomes better understood, it points to the need to assess PAD navigability dynamics and to better understand its variabilities and causes. This will certainly require consideration of the temporal variation in Peace River discharge.

3.4 Navigation Protection Measures Are Essential in Light of Evolving River Characteristics

The TC Study shows a future with an increased frequency of reduced or lost navigability for traditional-use purposes. Some scenarios see 50% of the time with navigability conditions insufficient to access Territory. As the hydrologic regime of the river evolves and changes in response to a changing climate, there will be an increased need for measures to protect navigation. Initially, it may be sufficient to adjust the timing of oilsands withdrawals from the Athabasca River and of any related practices that may be modifying the mainstem discharge. Navigation hazard tracking and mapping would be used to support successful navigation. As conditions decline further, local dredging may be required to sustain access through critical pinch points essential to sustain traditional use. (Dredging was undertaken in the past in support of mining activities.) Channel marking may be sufficient in some locations. In more difficult years, it may be necessary to limit oilsands water withdrawals to the spring and early summer periods so as to fully avoid their incremental impacts during the late-summer and fall navigability season. For other extreme situations, support may be considered for alternatives to river travel.

3.5 Understanding Effect of Peace River Is Required to Manage PAD Navigability

The PAD is a highly dynamic environment with hydrologic characteristics that have sustained Indigenous life for millennia. Complex interactions between river systems (Athabasca River and Peace River, along with smaller systems such as the Birch River) result in a host of ecological niches sustained by hydrologic recharge and waterways that enable access to them. If able to function, the recharge mechanisms connecting the hydrology of the Peace River to hydrologic recharge of the PAD bring water into the PAD, retain it in lakes and wetlands of various sizes and at various elevations, and lead to myriad opportunities for water-based transportation through reversing rivers, expanded lakes and wetlands, elevated water levels, and changes in deposition patterns.

If the advances made in the TC Study are to be mirrored by similar advances in the PAD, the wider range of influences that shape variation in navigability throughout the PAD need to be considered. This will require that the influence of Peace River on Indigenous navigability be better understood. In some parts of the PAD, Peace River is the dominant factor shaping Indigenous navigability. The interaction between the Peace and Athabasca Rivers is variable both seasonally and spatially. To develop a management regime able to protect ACFN's and MCFN's Indigenous navigability through the coming decades and in the context of an evolving delta and a changing climate, the effects of this interaction on spatial and temporal change in Indigenous navigability need to be better understood using expanded monitoring, field-based assessments, water balance modelling, improved input data (e.g., Lidar) and other approaches.

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