Golder Associates Ltd.

Fort McMurray River Hazard Study

Report on 1875 Ice Jam Flood Assessment

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Date	**Rev.**	**Status**	**Prepared By**	**Checked By**	**Approved By**	**Approved By**
			HATCH			**Client**

Executive Summary:

The 1875 flood event is the largest ice event in recorded history on the Athabasca River at Fort McMurray. The event was noted to have occurred in late April, and produced a peak water level at the Hudson's Bay Company (HBC) post that has been estimated to be between el. 251.5 m (825 ft.) and 253.0 m (830 ft.) (Blench, 1964). Given the considerable influence that this event can have on flood frequency estimates for the long return periods, this review was undertaken to look more closely into this event to better understand the context for this flood, to assess the overall plausibility of an ice jam producing these high levels, and to provide a best estimate of the resulting water level at the confluence of the Athabasca and Clearwater Rivers using independent and modern analyses.

The review was conducted based on available historical documentation, and through application of the HEC-RAS model to simulate the physical processes associated with a flood of this magnitude. The findings included:

- The HBC post in 1875 was likely located near the right abutment of the current McEwan Bridge.
- The 1875 flood event is indeed plausible and should not be discounted. It is estimated that the level was likely to be el. 252.5 m at the Fort location. Water levels at the Clearwater confluence were likely to be approximately 0.5 m lower than this, or el. 252.0 m.
- A numerical ice model (HEC-RAS) was applied to determine if the river bathymetry/geometry, and present day ice mechanics, would support observations of such high ice driven levels. The results suggest that flows of 2500 m^3/s with an ice roughness of 0.085 would be sufficient to create the levels estimated for the 1875 event.

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1. Introduction

1.1 General

Alberta Environment and Parks (AEP) retained Golder Associates Ltd. (Golder), in collaboration with SG1 Water Consulting Ltd. (SG1) and Hatch Ltd. (Hatch), in September 2016 to conduct the Fort McMurray River Hazard Study. The primary purpose of the study is to assess and identify river and flood hazards along the Athabasca River, the Clearwater River (including the Snye), and the Hangingstone River through Fort McMurray, AB in the Regional Municipality of Wood Buffalo (RMWB).

The study is being completed under the provincial Flood Hazard Identification Program (FHIP). The goals of this program include enhancement of public safety and reduction of future flood damages through the identification of river and flood hazards. Project stakeholders include the Government of Alberta, the RMWB, and the public.

This memorandum report documents the methodology and results of the 1875 Ice Jam Flood Assessment, which is part of the ice jam flood assessment component of the study. The assessment was conducted in consultation with Mr. David Andres, who provided invaluable guidance and input to the assessment.

1.2 Context

The 1875 flood event is the largest ice event in recorded history on the Athabasca River at Fort McMurray. The event was noted to have occurred in late April, and produced a peak water level at the Hudson's Bay Company (HBC) post that has been estimated to be between el. 251.5 m (825 ft.) and 253.0 m (830 ft.) (Blench, 1964). Given the considerable influence that this event can have on flood frequency estimates for the long return periods, it was necessary to look more closely into this event to better understand the context for this flood, to assess the overall plausibility of an ice jam producing these high levels, and to provide a best estimate of the resulting water level at the confluence of the Athabasca and Clearwater Rivers using independent and modern analyses. This was done through a two-step process:

- A review of historical and archival documents.
- A forensic assessment using the HEC-RAS computer model to simulate ice jam levels for a range of plausible flows during breakup.

The results of each step are briefly summarized below.

2. Historical Review

As a first step in the assessment, the team reviewed existing anecdotal observations and quantitative information on the flood event. Between the dates of February 16 and 17, 2017, a literature and archival review was performed at the HBC Archives in Winnipeg, Manitoba to search for anecdotal evidence supporting claims of ice jam floods at Fort McMurray in 1875. Results of a literature and archival review performed previously are contained in Appendix A

of the 1964 Blench report. Portions of this appendix are reproduced in Appendix B of this report.

The objectives of the current review were to:

- Better understand the antecedent conditions that preceded the flood event, including any information on any significant meteorological events that may have contributed both to spring flows and strength/thickness of the ice floes that comprised the jam;
- Decipher the important causes or contributing factors to the actual event, like the nature of the winter ice cover, the breakup process upstream, and the extent of the ice jam (toe location, etc.);
- Determine/confirm the location of the HBC trading post in 1875;
- Produce an independent estimate of the peak elevation of the flood within the context of the available information, and compare this to previous estimates that have established the elevation of that flood event to be between el. 251.5 m and 253.0 m.

The two best sources of data for the actual event were found to be the 1964 Blench report and the records held at the HBC Archives in Winnipeg. The results of this literature review are summarized below.

2.1 Location of HBC Post in 1875

Over the course of its existence, the HBC post at Fort McMurray has been built and rebuilt in several different locations. According to the Fort McMurray Heritage Society, the original location of the post in 1870 was on the north/east side of the Clearwater River at its confluence with the Athabasca River opposite of MacDonald Island on a point referred to today as Peden's Point. It is understood that after flooding in the first year after being built, the post was moved to what is now the base of Highway 63/Memorial Drive Bridge on the east side of the Athabasca River, where it operated until 1898. The land sat vacant from 1898 to 1907; in 1907 new buildings were built at this location when the HBC returned to Fort McMurray. These buildings were used until 1921 when a new store was built on Franklin Avenue; this store was used until 1945. The different locations of the post are shown in Figure 2-1: Location 1 is the original post location at Peden's Point, Location 2 is at the base of Highway 63/Memorial Drive Bridge, and Location 3 is the most recent location on Franklin Avenue.

An 1876 map (HBC Arch. G.1/246) that shows the location of the second post on the south side of the confluence of the Clearwater and Athabasca Rivers is shown in Figure 2-2. The 1876 map is relatively coarse in its depiction of the location of the post, but the map shows the post to be located on the right bank of the river between what is now River View Heights and the Snye (Clearwater River). The map also appears to identify the Horse River and Hangingstone River, but does not identify them as such. This location fits well with the descriptions provided by H. J. Moberly in his journal entries. Of note:

- The post was located at a point on the Athabasca with a large prairie area located to the rear of the main structure (termed fort in the archives) along the Clearwater River.
- The post had a high ridge of land immediately to the south of the fort. This high ridge of land is specifically noted in Mr. Moberly's letter to have helped protect the fort from the velocities and ice forces associated with the jam by creating an eddy, or shadow in the flow.
- Mr. Moberly notes having to traverse a distance of approximately 100 yards to reach the higher ground of the above mentioned spur once water levels had risen to the point of flooding the post's buildings. In fact, Mr. Moberly reached safety by half wading and half swimming across this gap in the ice filled water.
- The archives also contain a sketch made by Mr. Moberly in 1877 showing the overall layout of the Fort (archive item 11M2, G.1/333). This sketch is shown in Figure 2-2. As shown, the fort was located just to the west of what is shown as a branch of the Clearwater River. This was most likely the Snye channel.

This evidence would place the post at approximately Location 2 as shown in Figure 2-1.

Figure 2-1: Historical HBC Post Locations (map: Google Earth)

The team was able to obtain a telling photo of the HBC post (circa 1920's) from the University of Alberta archives, taken from a vantage point on the Athabasca River as a boat approached the post from downstream. This photo is shown in Figure 2-4. The high ridge immediately behind (and south of) the post is evident – consistent with what is there today. For comparison, an image of that area from a similar vantage point in the DTM developed for this project (collected in 2016) is shown in Figure 2-5. The DTM shown in this image was developed based on the current survey data, but major man made features (such as the Memorial Bridge abutments) have been removed to better represent the topography in 1875. The view is very similar, providing further evidence that Location 2 was the very likely position of the HBC post at the time of the flood.

As part of the review, we also assessed the likely floodplain elevations in this area based on the latest digital terrain models. Although construction of the bridge in the early 60's likely altered local topography, large tracts of land adjacent to the bridge show the floodplain to be quite flat, as it extended upstream along the Clearwater River. This was likely the case even at the turn of the century. The latest DTM data indicates the elevations in this area vary between el. 251.0 m and 252.0 m – very similar to the el. 250.85 m (823 ft.) identified in the Blench (1964) report. To provide further confirmation on these elevations, digital copies of historical construction drawings for the Memorial Drive bridge were obtained, and these drawings show bore holes and bank elevations in this area circa 1964. These drawings have been included in Appendix C of this document. The bank elevations discussed above are very consistent with the data shown on these drawings.

Therefore, in summary, the HBC post was likely located at Location 2 shown in Figure 2-1. The ground elevation of the post was likely close to the level reported in the Blench study, and for the purpose of this assessment can be assumed to have been el. 250.85 m in 1875.

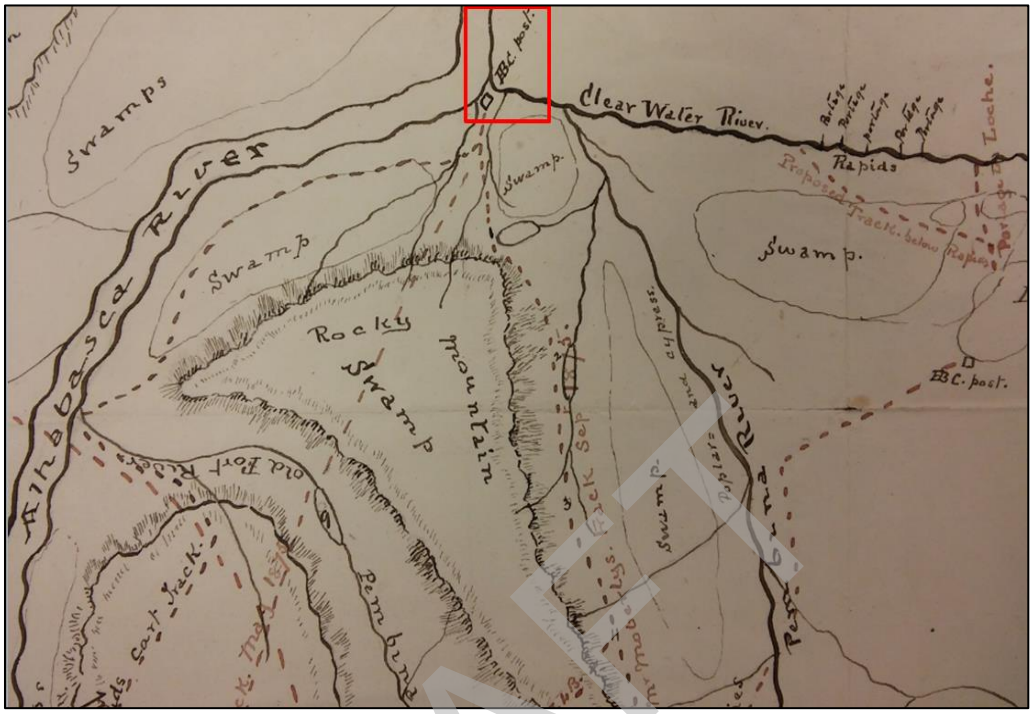

Figure 2-2: Map of HBC Post circa 1876 (HBC Arch. G.1/246)

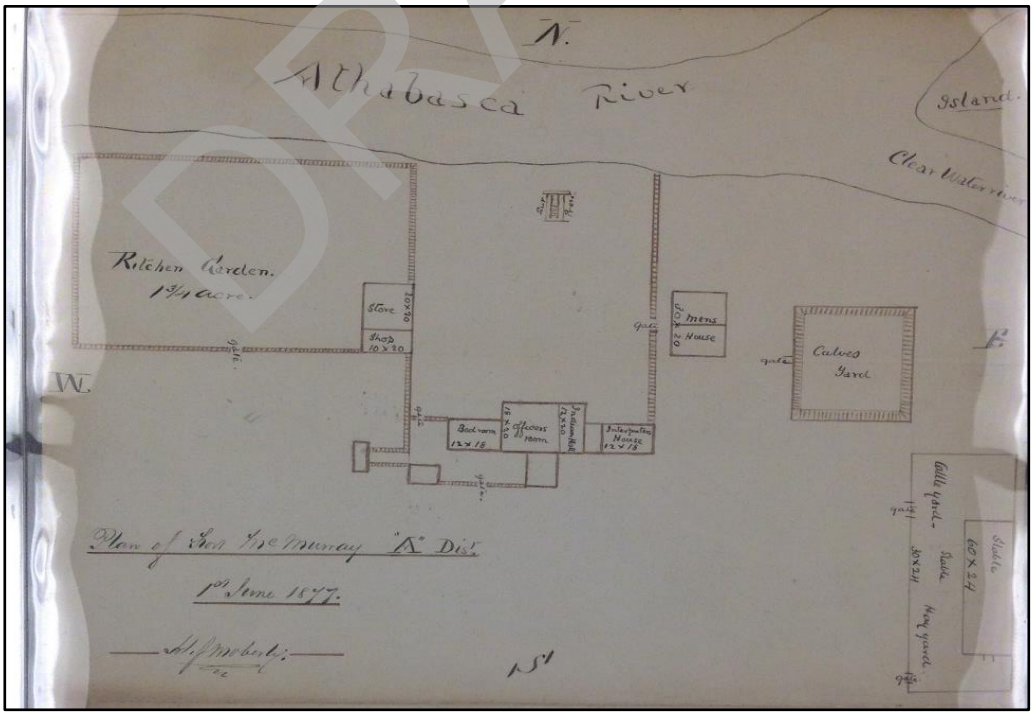

Figure 2-3: **Layout of HBC Post circa 1877 (HBC Arch. G.1/333)**

Figure 2-4: **Photo of HBC Post in early 1920s (U of A Archives)**

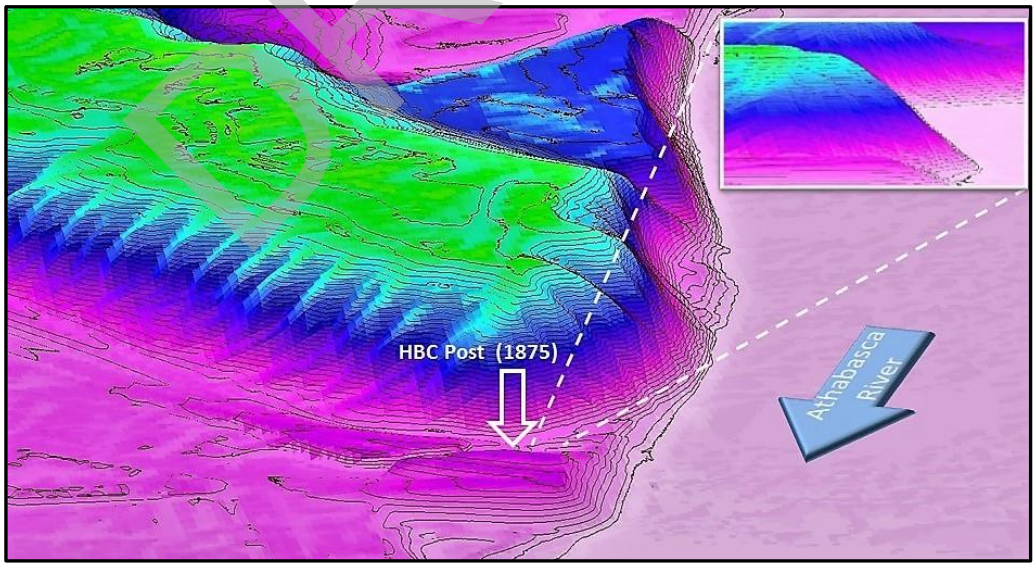

Figure 2-5: **DTM Image From Similar Vantage Point as Photo. Note the flat plain and high ridge in behind the post location.**

2.2 1875 Flood Event

The majority of details associated with the 1875 ice jam event were contained in three short letters that were previously reviewed and reported on in the 1964 Blench report. For convenience, excerpts from these letters have been included in Appendix A of this report. A further search of records at the archives did not reveal any additional information or correspondence related to the flood. Daily journals from the post for the 1875 period do not exist, either having never been written or not surviving to present day.

Daily journals from the HBC post at Fort Chipewyan were reviewed to get a sense of the 1874-75 winter severity. Fort Chipewyan was situated downstream of Fort McMurray at Lake Athabasca. Although ice conditions at Fort Chipewyan would not mirror those at Fort McMurray, weather conditions could likely be similar at the two posts. Excerpts from the daily journals at Fort Chipewyan from the fall of 1874 through to the spring of 1875 describing weather and ice conditions are provided in Appendix B.

Based on these descriptions, the following can be inferred.

- The winter preceding the 1875 flood event was quite cold. There were some short periods of warm temperatures, but overall, it was characterized as a long, bitter winter. Temperatures remained cool until mid-April. The Fort Chipewyan records indicate temperatures increased quite significantly around April 16th – just days before the ice jam occurred.
- Snow depths seemed to be quite large based on Mr. Moberly's descriptions. This, combined with the cool spring prior to the ice jam event, could indicate that spring runoff was more concentrated in 1875, resulting in unusually large flows during the spring freshet.
- The ice sheets on the Athabasca River were likely quite thick and competent prior to breakup. Because of the cold winter, and late spring, this river ice would likely have remained quite strong with little deterioration prior to the arrival of the spring freshet.
- Mr. Moberly reports that at least an 85 mile stretch of the Athabasca River suddenly broke up upstream of Fort McMurray. The volume of ice within this length of river would be more than enough to form a severe jam at Fort McMurray that could attain an equilibrium condition over a considerable length.
- It is noted that on the morning of April 20th, the river ice first broke up and began to run, but then a jam quickly formed with the influx of upstream ice. The jam is noted to have occurred just downstream of the Athabasca and Clearwater confluence, where the river becomes more braided and begins to narrow. This is a typical jam formation point on the Athabasca River.
- Water levels rose quickly, forcing immediate evacuations of the HBC post. Mr. Moberly reports that the water level rose almost 57 ft. (17.4 m) at its peak. Quite literally, this would have resulted in a water level higher than 256.0 m at the post. However, we agree

with the Blench report that this level may have been exaggerated. As noted in the Blench report, it is unlikely that the water level would have been more than 7 ft. (2.1 m) above the floor elevation of the Fort – higher levels would have resulted in considerable damage and/or removal of the Post. As shown in Figure 2-4, the Post infrastructure was not likely particularly robust. As well, Mr. Moberly reports that in escaping the flood, he had to partially wade and partially swim from the Post to the nearby ridge. If the ground elevation was 250.85 m as reported in the Blench report, the peak water level likely would not have been more than 1.5 m higher than this. Considering this, our best estimate of the peak level reached in 1875 was approximately el. 252.5 m.

3. Application of HEC-RAS Model

Following the confirmation of the HBC Post location, and the review of anecdotal data on the flood, the next step in the assessment involved the set up and use of the HEC-RAS hydraulic model to assess the conditions that may have led to the high levels associated with the jam event. This was done to establish the plausibility of reaching these high levels, and to provide a best estimate of what this level may have been not only at the Fort location, but also at the confluence of the Clearwater and Athabasca Rivers.

The assessment involved the following steps:

- An open water, HEC-RAS model for the Athabasca and Clearwater Rivers at Fort McMurray was created from river survey data collected in October 2016 and 2016 LiDAR data. The model was calibrated for the low-flow, open water condition and is considered to be appropriate for this assessment. Based on the composition of the bed in this area, it is unlikely that the bed geometry of the river has changed significantly since 1875, and it is therefore a good representation of the river's bathymetric character. The Manning's bed roughness (n) in the model was 0.030 for the Athabasca River main channel, and it varied spatially between 0.050 and 0.150 on the floodplain. It should be noted that the model was not calibrated against historical ice jam events, but is considered sufficient for a forensic analysis of the 1875 ice jam level.
- The model was then modified to try to emulate conditions as they would have been during the 1875 jam event. To do this, all obvious dikes, bridge abutments, and other features that may have been added to the local topography since then were eliminated from the dataset. However, the bathymetry was assumed to remain unchanged, as noted earlier.
- Ice parameters were then added to the model. Parameters to be entered included the initial sheet ice thickness, the roughness of the cover (main channel and floodplains), the porosity of the jam, the internal strength of the jam, the longitudinal to lateral ratio of internal forces, the maximum velocity under the jam, and the nature of the cover (jam vs ice sheet). Of these, most parameters were initially assigned values based on the judgement of our modellers, and on the experience gained from past model applications

on the river. However, a range of key parameters was also selected for testing. The key parameters tested included:

- Location of jam toe: Two locations were tested: one located approximately 9.5 Km downstream of the proposed for location- 7.5 km downstream of the Clearwater confluence (Toe Location 1), and the other located approximately 5.5 km downstream of the proposed fort location - 3.5 km downstream of the confluence (Toe Location 2). Ice jams occur at various locations within this reach given the braided nature of the channel. These two locations were selected to test the sensitivity in water level at the Fort location to the toe location of the jam. The further downstream the toe is, the more likely the jam would have reached an equilibrium thickness at the Fort location.
- Discharge: Steady state discharges ranging from 2500 m^3/s to 4000 m^3/s were tested. This range of discharges represents an extreme upper end of the expected the spring freshet hydrology. Steady state discharges were utilized since the shape and nature of the incoming hydrograph would be almost impossible to predict. This is standard practice for most ice jam assessments.
- Roughness of ice cover: Ice roughness values ranging from 0.065 up to 0.085 were tested. These values were selected based on the findings of past investigations on the Athabasca River (Andres, 1977-1979, 1983-1986). It is expected that the actual value would likely lie between these ranges. The composite roughness is then calculated for each simulation cross section within the model based on the Belkon-Sabaneev equation.

- Following this, a series of runs were undertaken in which different combinations of these key parameters were tested.

The results were then plotted on a series of profiles and rating curves to assess the likely water levels that may have occurred at the HBC location. Figure 3-1 to Figure 3-10 summarize the results of these runs.

Figure 3-1, Figure 3-2, Figure 3-3 and Figure 3-4 illustrate the resulting water surface profiles for flows of 2500 m^3/s, 3000 m^3/s, 3500 m^3/s, and 4000 m^3/s respectively for a case in which the toe of the jam is at the most downstream location. In each Figure, for context, the red box shown represents the range in water levels previously estimated in the Blench report.

Figure 3-5, Figure 3-6, Figure 3-7 and Figure 3-8 illustrate the resulting water surface profiles for flows of 2500 m^3/s, 3000 m^3/s 3500 m^3/s, and 4000 m^3/s respectively for a case in which the toe of the jam is at the more upstream location (3 km downstream of the confluence).

Figure 3-9 illustrates the stage-discharge rating curve at the HBC location for the most downstream toe location, while Figure 3-10 illustrates the stage-discharge rating curve at the HBC location for the second, more upstream toe location.

In reviewing these charts, the ice jam appears to have reached an equilibrium thickness at the post location for either of the assumed jam initiation points. The equilibrium jam thickness for these runs was approximately 5 m. Where the jam covered areas of the floodplain, the thickness of the jam restricted flow movement on the floodplains, and therefore almost all conveyance continued to be in the main channel of the river. The findings of this preliminary study indicate that the model predictions are consistent with the water surface elevation range established through our review of the archival record. Ice jam formation at either toe location could have led to these types of levels for various combinations of assumed ice jam roughness and river flows.

However, it is our opinion that the most probable combination of parameters creating the 1875 event would involve a scenario involving higher than normal river flows, the higher end of the roughness range (based on an assumption that the ice was not significantly deteriorated at breakup), and formation at a downstream toe location (resulting in an equilibrium thickness and water surface profile at both the Fort location and the Clearwater confluence). Considering a "best estimate" water level at the Fort location of approximately el. 252.5 m (based on historical data), this would mean that flows at the time of the event may have been approximately 2500 m^3/s at the peak of the event (based on Figure 3-9). Given the expected slope of the ice jam, the water level at the Athabasca-Clearwater confluence would be approximately 0.5 m lower, at el. 252.0 m.

It should be noted that these estimates of the 1875 event have been based on the team's best judgment in terms of ice parameters and driving mechanisms.

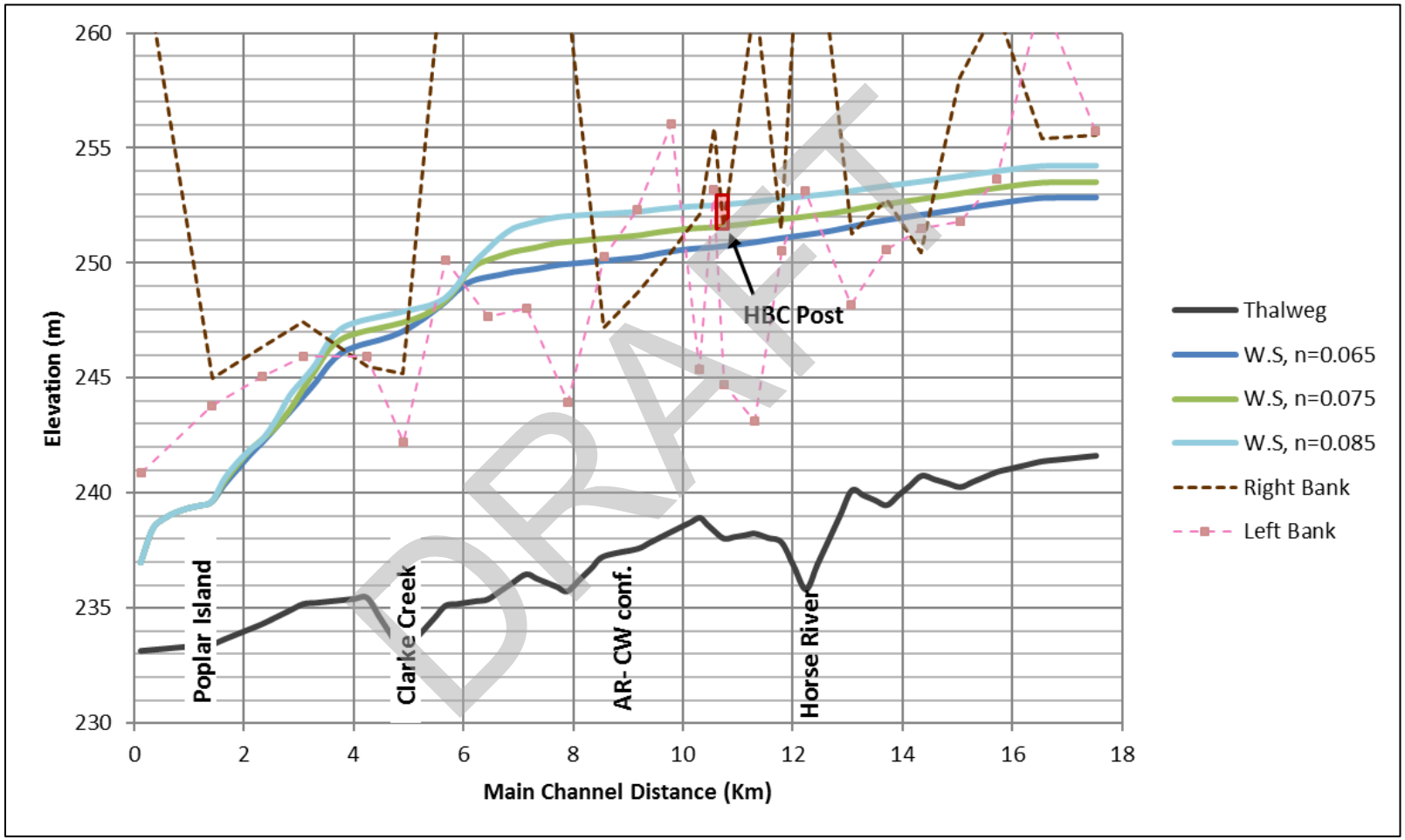

Figure 3-1: WSE Profile for Toe Location 1 (9.5 km downstream of fort location), Q = 2500 m^3/s

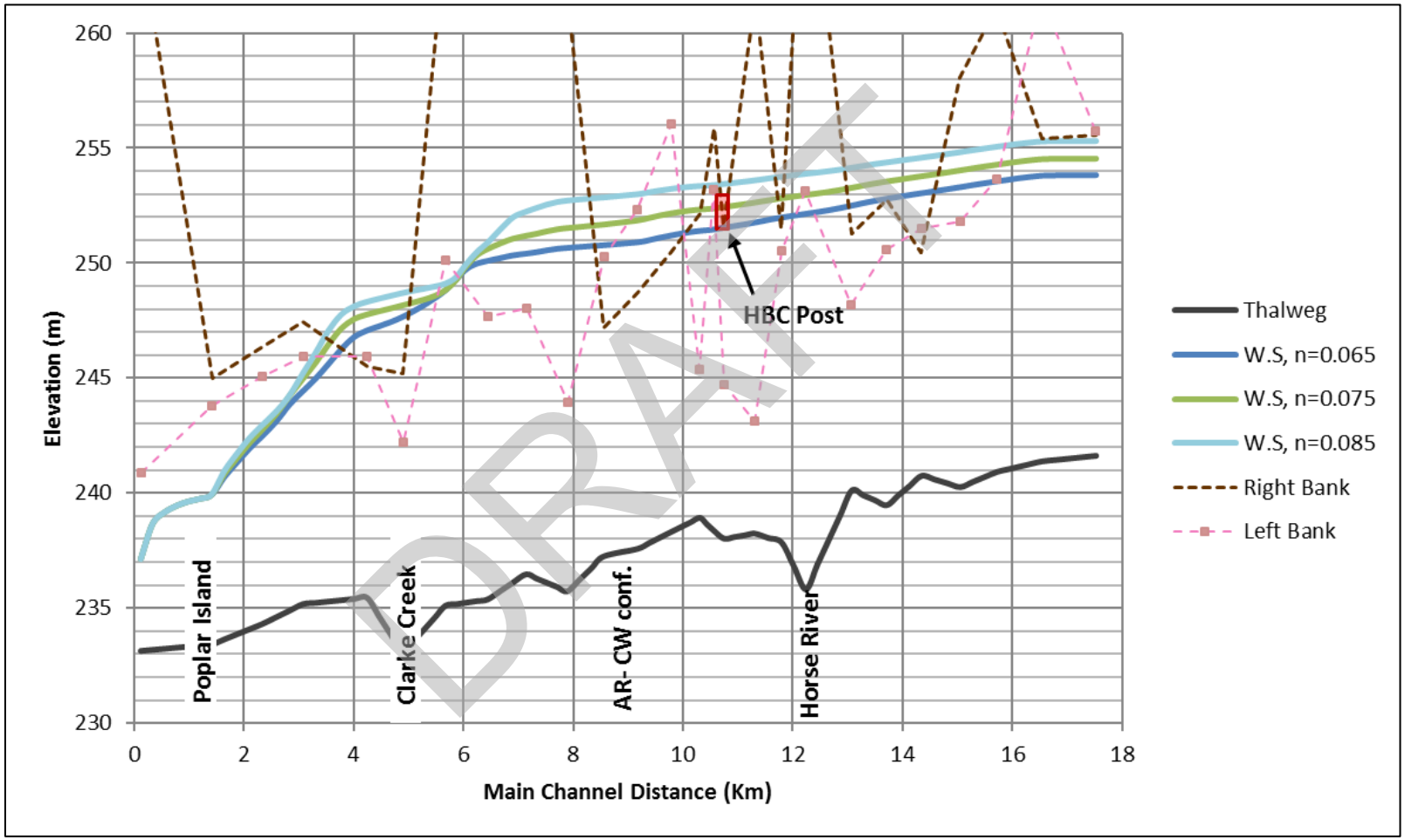

Figure 3-2: WSE Profile for Toe Location 1 (9.5 km downstream of fort location), Q = 3000 m³/s

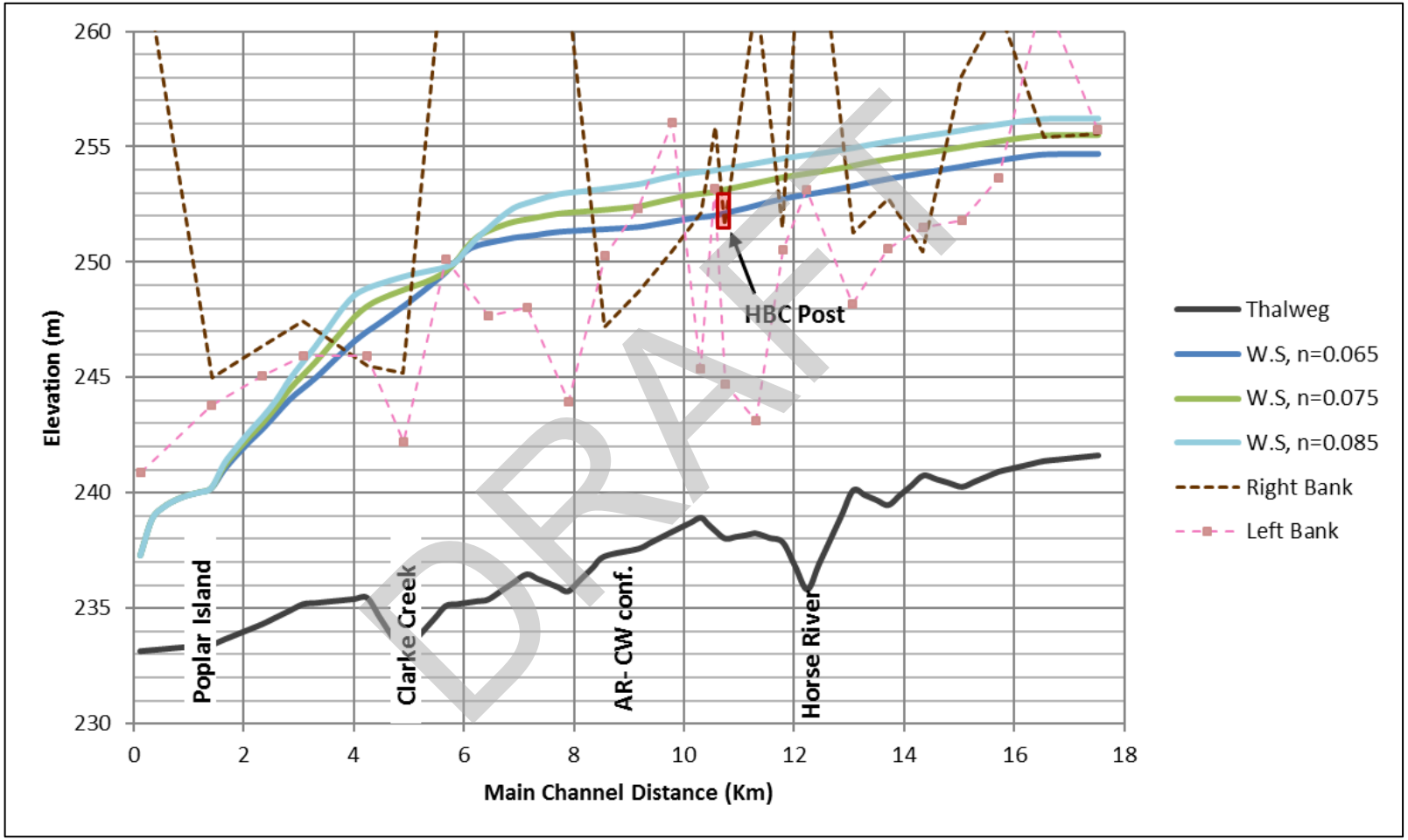

Figure 3-3: WSE Profile for Toe Location 1 (9.5 km downstream of fort location), Q = 3500 m^3/s

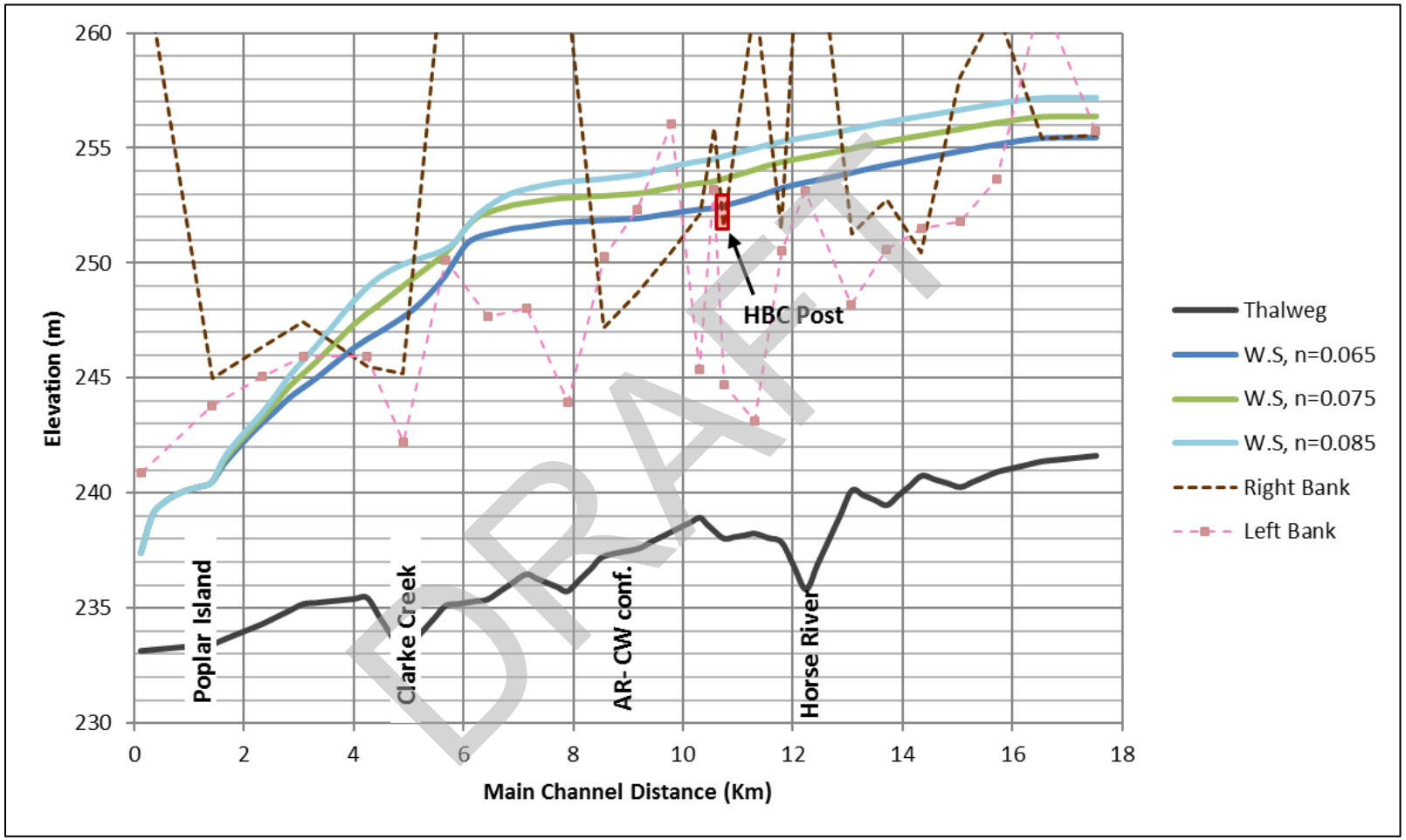

Figure 3-4: WSE Profile for Toe Location 1 (9.5 km downstream of fort location), Q = 4000 m³/s

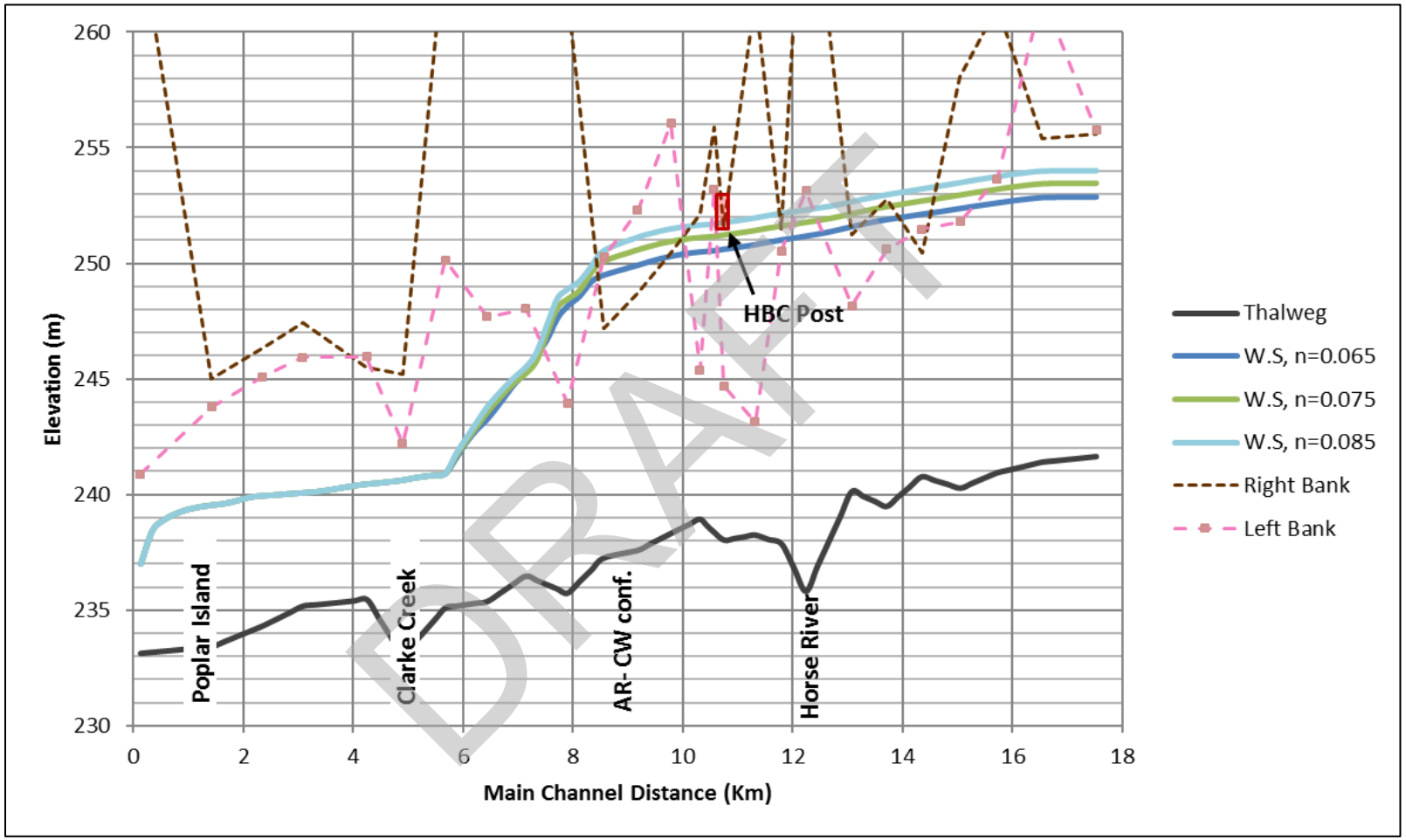

Figure 3-5: Toe Location 2 (5.5 km downstream of fort location), Q = 2500 m³/s

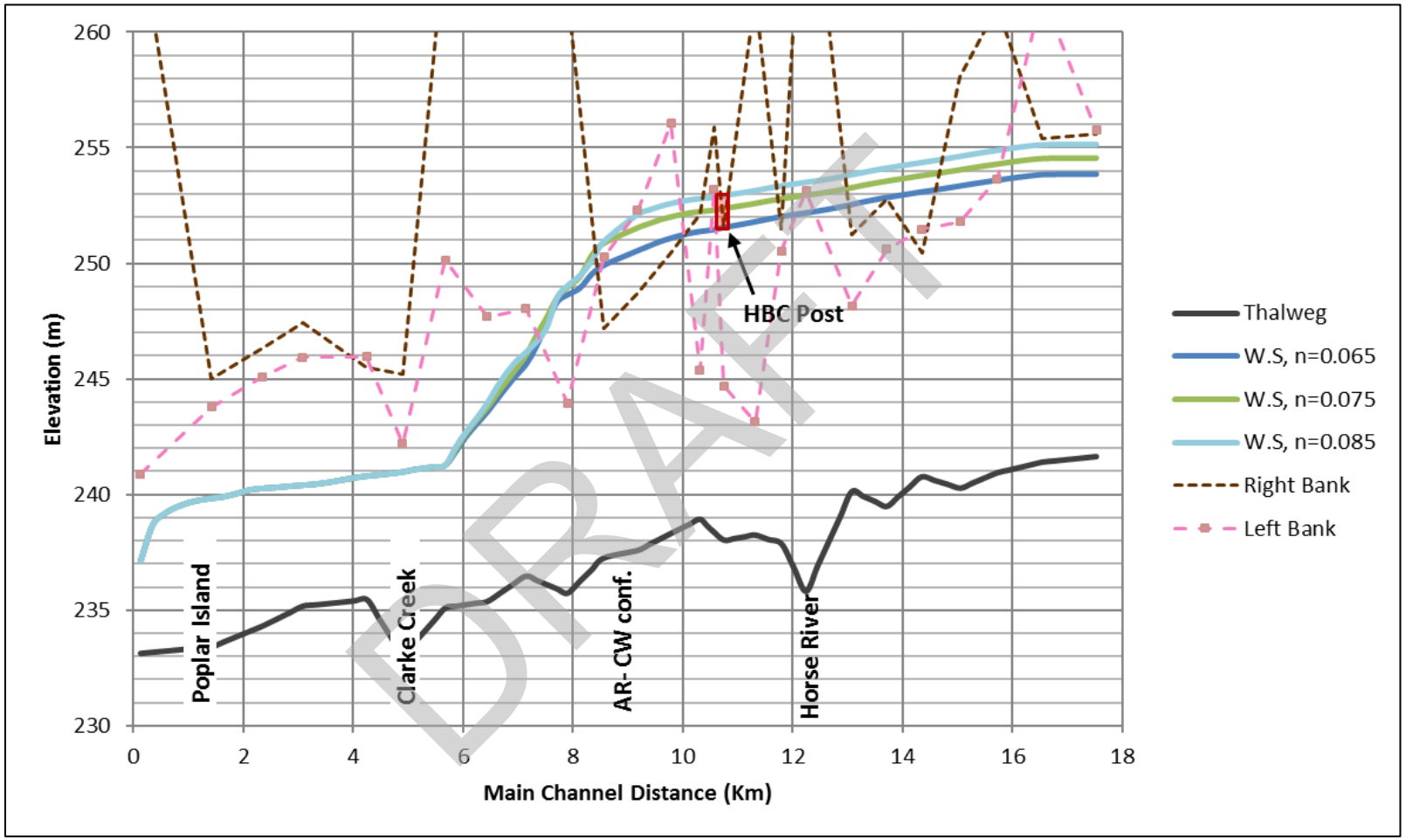

Figure 3-6 : Toe Location 2 (5.5 km downstream of fort location), Q = 3000 m^3/s

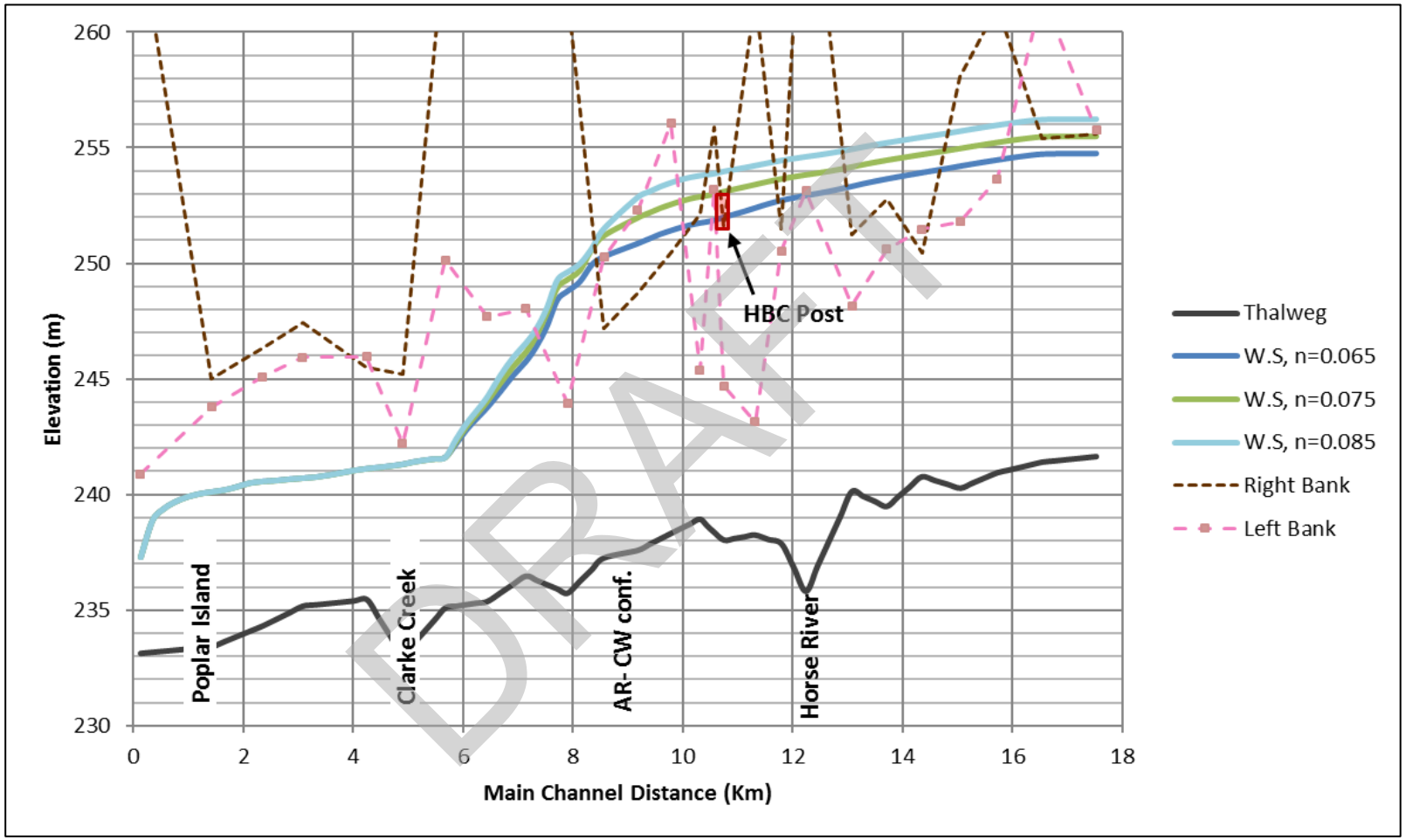

Figure 3-7: Toe Location 2 (5.5 km downstream of fort location), Q = 3500 m^3/s

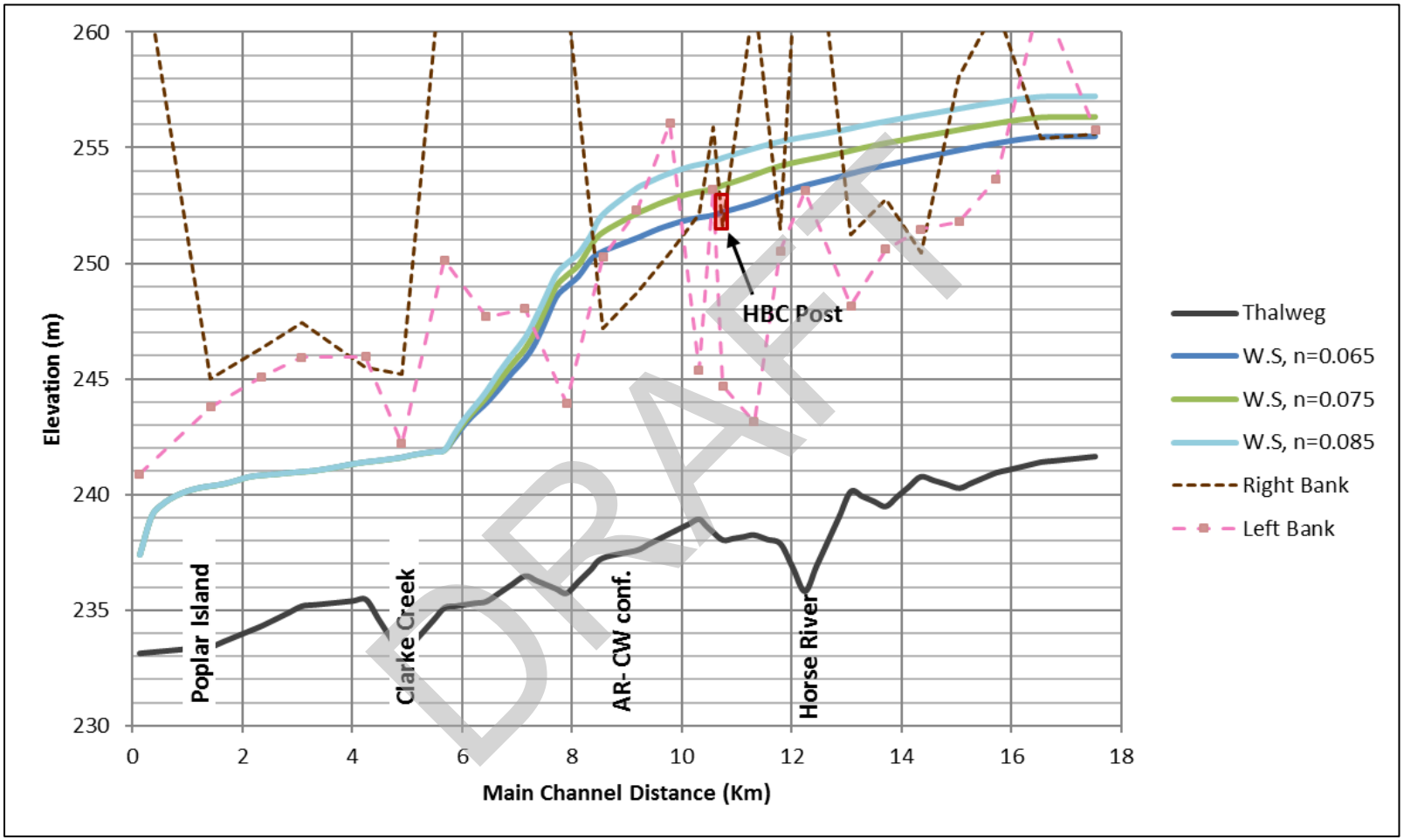

Figure 3-8: **Toe Location 2 (5.5 km downstream of fort location), Q = 4000 m³/s**

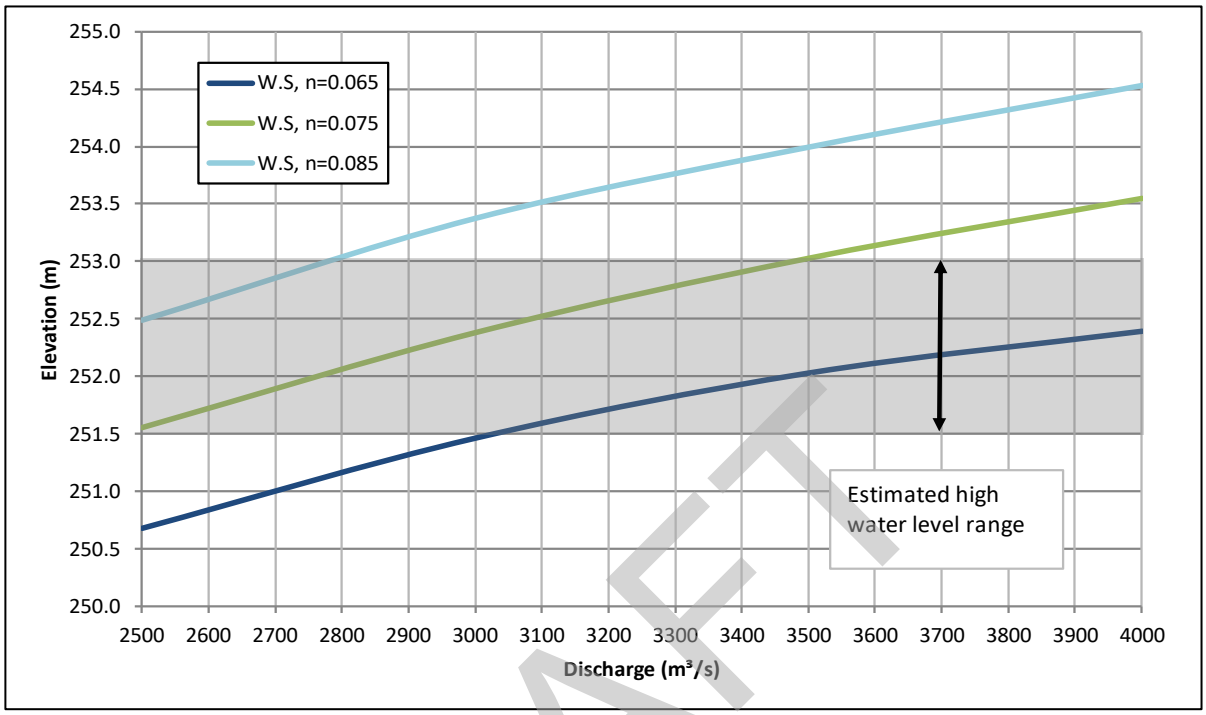

Figure 3-9: Stage-Discharge Rating Curve at HBC Location 2 – Toe Location 1 (9.5 km downstream)

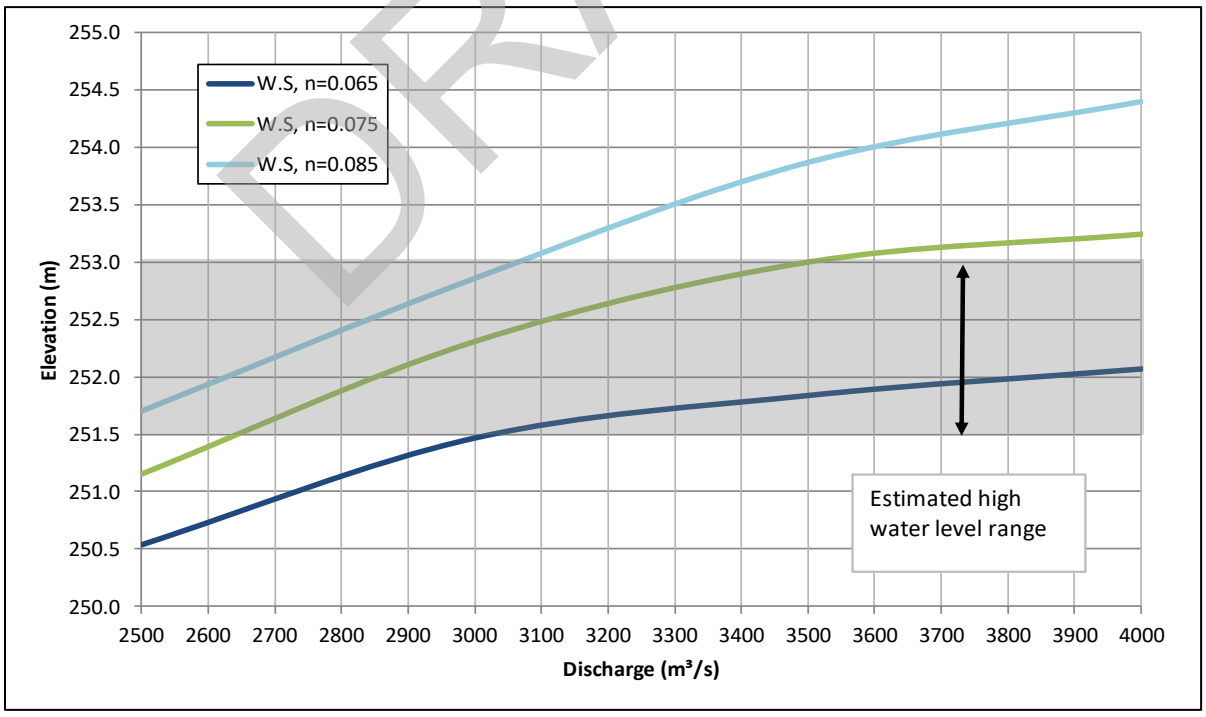

Figure 3-10: Stage-Discharge Rating Curve at HBC Location 2 – Toe Location 2 (5.5 km downstream)

4. Summary

The 1875 flood event has been reviewed based on available historical documentation, and through application of the HEC-RAS model. The assessment has resulted in the following findings:

- The HBC post was likely located at Location 2 of Figure 2-1 in 1875. This position has been established independently through a review of Mr. Moberly's letters, discussions with staff at the Fort McMurray Heritage Society and the staff at the HBC Archives, an archived map showing the post location, and an historical photo of the post.
- The conclusion of this assessment is that the peak water level during the 1875 ice jam event was likely to be at el. 252.5 m at the HBC Fort location. Water levels at the Clearwater confluence were likely to be approximately 0.5 m lower than this, or el. 252.0 m. This independent assessment therefore suggests that the levels reported in the 1964 Blench report are reasonable estimates of the peak levels reached - historical estimates of the peak level reached range between the elevations of el. 251.5 m and el. 253.0 m.
- Anecdotal information suggests that conditions were favorable for the development of a more severe than usual ice run that year. Snowpacks were characterized as being high, the winter was described as being bitterly cold, and extending into mid April before temperatures began to rise.
- A numerical ice model was applied to determine if the river bathymetry/geometry, and present day ice mechanics, would support observations of such high ice driven levels. The results of this modelling exercise suggests that ice jam formation, with a toe that is within 5 km downstream of the post location, could have led to these types of levels for various combinations of assumed ice jam roughness and river flow. The results suggest that flows of 2500 m^3/s with an ice roughness of 0.085 would be sufficient to create the levels estimated for the 1875 event.

It should be noted that these estimates of the 1875 event have been based on the team's best judgment in terms of ice parameters and driving mechanisms.

Appendix A: Excerpts from 1964 Blench Report on 1875 Ice Jam Flood

APPENDIX A

ICE JAM FLOOD DATA

1875 Flood.

The following is a quotation from page 151, H.J. Moberly's account of this flood (Ref. 2):

"The winter of 1874-75 was a bitter one, with deep snow and never a thaw until April. On the 2nd or 3rd of that month, however, a further heavy fall of snow was followed by a sudden rise in temperature. The change of weather and weight of the melting snow caused the ice for the eighty-five-mile stretch of rapids above the fort to break up, and it came down the Athabasca with terrific force. On striking the turn in the stream at the post it blocked the river and drove the ice two miles up the Clearwater in piles forty or fifty feet high. In less than an hour the water rose fifty-seven feet, flooding the whole flat and mowing down trees, some three feet in diameter, like grass.

Fortunately, the spur of the hill just above the fort sloped to the river, forming an eddy. The flood caught only one of the houses, but this was at once swept away. When the water had mounted almost to the bank I ordered everyone back to the high ground, but fearing that if the rise reached the house its contents would be damaged, I stayed behind and, shutting the doors, commenced to carry what articles I could to the upper rooms.

Presently I noticed water trickling in under the doors. I was too much occupied, however, to take the time to look out, until a large tree dashed in at the window. I knew now that I was in for a cold bath.

After I had with great difficulty got out of the trap a hundred yards of water five to ten feet deep still separated me from dry land. When, at times wading and again swimming, I at length reach it and safety no one with ague ever shook harder than did I after my ducking.

We cleared away the snow and made a comfortable camp, and here we remained for five days before we could re-occupy the houses. Out of thirty-seven oxen for the transport service one only escaped. The rest were drowned".

On April 1st, 1964, Mr. Joseph Shott, age 78, pointed out the site of the original Hudson's Bay Co. post located as shown on Fig. 14. The elevation of the ground surface at this point is about 823. The site is about 100 yards from a steep rise or terrace in the ground roughly parallel to the 825 contour at the west end of Franklin Avenue. The post was a log structure and would have been carried away had the water risen 57 ft. (to about elev. 847 or 24 ft. above the ground) as stated in the above quotation. While the dimensions of the buildings are not available, it is likely that they would have floated had the water depth reached more than about 7 feet. The maximum water level must therefore have been no more than 830. The lowest possible maximum level was about 2 ft. above the ground or elevation 825.

Mr. Shott's comments on his father's stories of the "big flood" in which many cattle died in the "Prairies" area, were in agreement with other available accounts of the incident.

Extracts from the Hudson's Bay Co. files, included in this Appendix, provide further details of this flood. The second paragraph of Enclosure 1 locates the fort on the left bank of the Athabasca. Since the location

described, "A beautiful Prairie .....", exists only near the right bank, it would appear that Mr. Moberly was facing upstream when he gave the description.

It should be noted that the above quotation states the flood occurred on the 2 or 3rd of the month whereas Moberly's report to the Hudson's Bay Co. gives the date as April 20.

Extract from copy of letter from Chief Trader Roderick MacFarlane to Chief Commissioner James A. Grahame at Fort Garry, dated 'En Route Clear Water River', 14 June 1875.

"I beg to transmit to you herewith copy of Mr H.J. Moberly's Report to me dated 25 April 1875*...

Fort McMurray is situated on the left bank of the Athabasca River at its confluence with the 'Clear Water' – the buildings are upwards of 50 feet above the winter level of the water. A beautiful Prairie extends for 2 miles to the rear of the post along the clear water river. On the East it is bounded by a hummock of tall pines and poplars and on the South by a high ridge of land. A supply of excellent hay for 60 head of Cattle can be obtained on this Prairie. For the sake of shelter and convenience of watering the Animals during Winter, the Byres were erected in the midst of said timber, also their keeper's house.

On the morning of 20 April last James Daniel (a) the man in charge on becoming aware that the river was breaking up, immediately liberated the Oxen and began to drive them to the highlands beyond the Woods, but before he could get them through, the water rose so suddenly that he barely escaped with his own life and had to leave the poor animals to their fate. Had the Ice, however, not completely surrounded, as it did, the said woods, all of them would have escaped by swimming; but as the water and ice continued high for 5 or 6 days, it was impossible to render them any assistance from the Fort, and the poor brutes after swimming about and making the most strenuous efforts to escape, at length perished one by one, their bodies being since found scattered at intervals in all directions ... The Athabasca broke up very suddenly and quite unexpected while the water rose higher than was ever before known; and after making full and particular enquiries on the spot, I feel satisfied that no blame can justly attach to any one for this unfortunate and much to be regretted occurrence...

A Flood similar to that of 1875 has probably never before happened, and is not likely to occur again so soon; At all events, after this spring's experience, I think I may safely venture to state that with the precautionary measures to be taken in future, no danger need be apprehended that we shall again lose any Animals or property from this cause ...'.

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* See Enclosure No. 2.

Extract from copy of letter from Henry J. Moberly, clerk in charge of Fort McMurray, to Chief Trader Roderick MacFarlane, officer in charge of Athabasca District at Fort Chipewyan, dated Fort McMurray, 25 April 1875.

'I have now the painful duty to perform of letting you know that we have had a very sudden Inundation here, a few days ago, accompanied by serious loss to the Hudson's Bay Company.

On the 20 Instant about 2 hours after daylight, the river suddenly gave signs of breaking up and in half an hour from that time the water had risen about 60 feet, and the whole place was flooded - the water and ice passing with fearful rapidity and carrying off everything before them. We had just time to escape to the hill, in our immediate vicinity, with the families, bedding and a little Provisions and Ammunition, and to throw up stairs the Furs and most of the valuable property, when the water was already rushing through the Fort. From the time the river first gave signs of starting hardly half an hour elapsed before there was 5 feet of water in the highest building in the Fort, and the Interpreter's house was carried bodily away and dashed to pieces in the Woods; the Workshop and Men's houses have been almost destroyed.

As soon as the river appeared bad, I gave immediate orders to have the Cattle driven to the high lands; and altho' their Keeper James Daniel did all that could be done and even risked his life to save them, still there was no time, as the water rose so suddenly, and I regret to say they all perished ... I had been expecting high water this spring, altho' nothing like what has happened: But the Weather was still very cold - the snow had hardly melted any, and the Ice on the river to all appearance as solid as in Winter - and no one expected the river to break up for 10 days, and then only if the Weather changed and got warm ...

The Ice and Water swept clean over the Prairie up the Clear Water River, which accounts for all the Cattle being drowned as they could not hold against such a torrent ... It may take 2 weeks before the Ice, which is now piled up at least 80 or 100 feet in the Athabasca and Clear Water Rivers, clears off ...'.

(H.B.C. Arch. B.39/c/2)

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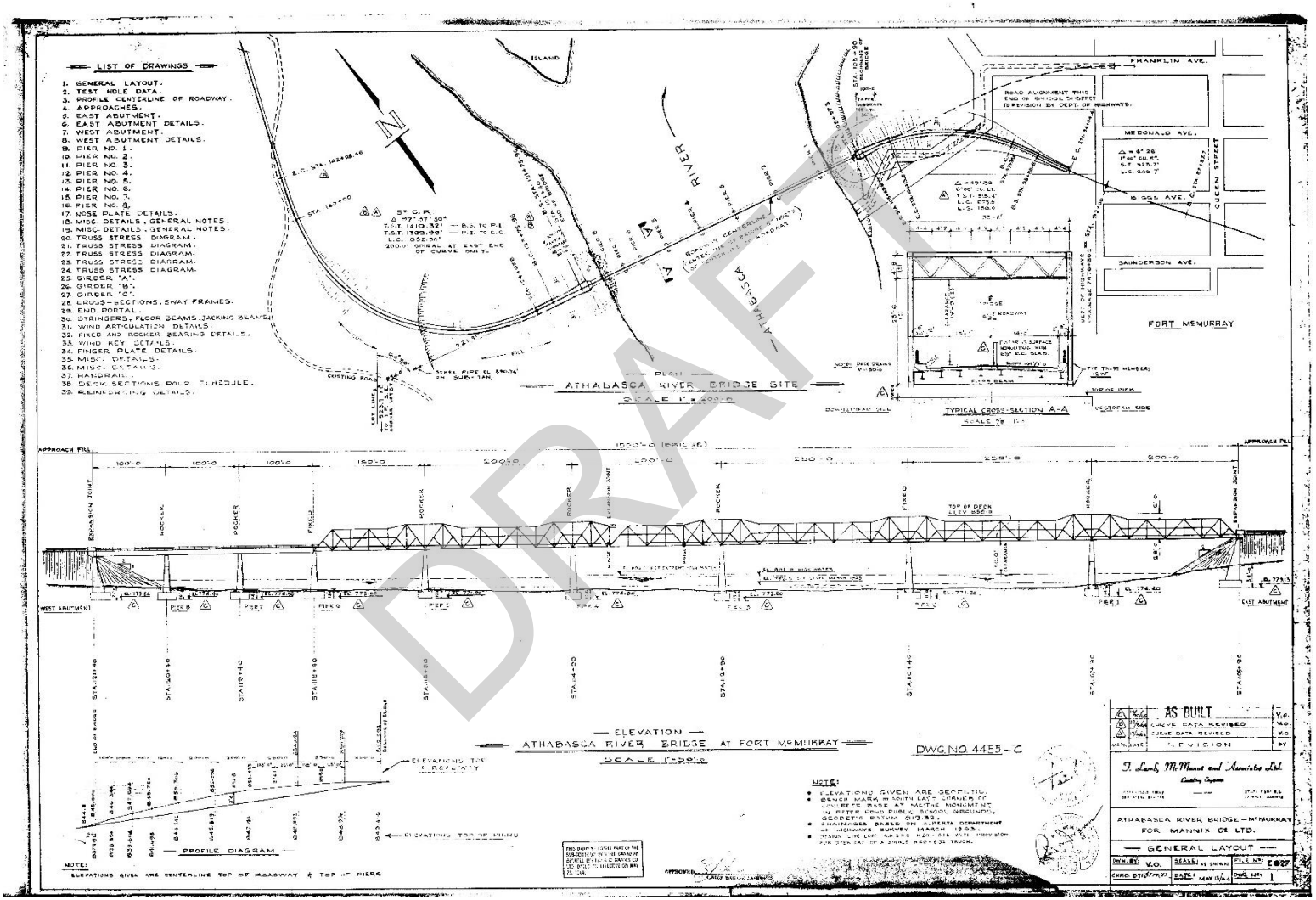
Appendix B: Daily Meteorological Observations, Winter of 1874/75

Excerpts from Daily Journals at Fort Chipewyan Describing Weather and Ice Conditions (HBC Arch. B.39/a/50)

Date	Comment
2-6 Oct 1874	Fine and calm.
7-8 Oct 1874	Cloudy and colder than usual.
9-18 Oct 1784	Fine day.
22 Oct 1874	Clouds and wind.
24 Oct 1874	Cold with showers of snow and ice.
27 Oct 1874	Wind north, slight fall of snow, William Charles came back owing to ice drifting.
28 Oct 1874	Weather overcast, Willian Charles gathering up hay on the land.
30-31 Oct 1874	Weather fine, no appearance of cold weather.
2 Nov 1874	Wind, overcast, slight fall of snow.
3-9 Nov 1874	Wind, no appearance of cold.
10 Nov 1874	Wind, small cold, slight fall of snow.
12 Nov 1874	Cold, the weather has now changed.
13-15 Nov 1874	Cold weather, wind.
16 Nov 1874	Clear weather, small cold.
19 Nov 1874	Weather milder than usual, slight fall of snow.
20-21 Nov 1874	Weather overcast.
22 Nov 1874	Weather cold.
23 Nov 1874	Clear weather.
24 Nov 1874	Nice weather.
28-29 Nov 1874	Clear cold weather.
30 Nov 1874	Slight fall of snow.
1 Dec 1874	Fine clear weather.
2-5 Dec 1874	Mild weather.
7 Dec 1874	Shower of rain last night, by the afternoon blowing storm and snowing, ice dangerous, horses unfit to cross to the fishery owing to the weather being so mild.
10 Dec 1874	Coldest day this winter, clear weather.
11-12 Dec 1874	Weather cold.
13 Dec 1874	Overcast, weather mild.
14 Dec 1874	Snowing and drifting.
17-18 Dec 1874	Weather much milder.
21 Dec 1874	Beautiful clear day.
22-23 Dec 1874	Mild weather, beautiful.
24 Dec 1874	Overcast, snowing.
25 Dec 1874	Overcast.
26-28 Dec 1874	Weather cold.
1 Jan 1875	Weather milder than usual.
7 Jan 1875	Clear, cold.
8 Jan 1875	Clear.
9 Jan 1875	34 below zero at sunrise, clear.
12 Jan 1875	Weather cold.
13 Jan 1875	Weather much milder than usual.
15-19 Jan 1875	Weather not so cold.

20 Jan 1875	Strong wind from north. Snowing and drifting. MacKlin, McKay, Flett, and Beechaw commenced to chop ice for summer's use.
21 Jan 1875	Strong wind from north. Snowing and drifting.
22-25 Jan 1875	Weather much milder.
26 Jan 1875	Weather clear and bright.
27 Jan 1875	Clear cold day.
28-30 Jan 1875	Mild weather.
1-2 Feb 1875	Fine clear day, but cold.
3-4 Feb 1875	Weather cold.
6 Feb 1875	A beautiful day.
8 Feb 1875	Mild weather.
10 Feb 1875	29 below zero, rather cold and clear.
11 Feb 1875	Rather cold, weather clear.
12-14 Feb 1875	Fine clear day.
15 Feb 1875	Storming in first part of day then clear.
16-20 Feb 1875	Mild weather.
21 Feb 1875	Weather cold.
22 Feb 1875	Clear cold day, 35 below zero.
23-26 Feb 1875	Weather cold.
1 Mar 1875	First part of the day mild, but after dark blowing, snowing, and drifting.
4-6 Mar 1875	Snow.
8 Mar 1875	Weather mild.
11 Mar 1875	Snowing and drifting.
13-14 Mar 1875	Weather cold for this time of the season.
19 Mar 1875	Weather mild, snowing.
20 Mar 1875	Mild weather.
21-22 Mar 1875	Weather cold.
23-24 Mar 1875	Much milder today.
27 Mar 1875	Blowing and drifting.
28 Mar 1875	Mild, blowing slightly.
29 Mar 1875	Overcast, mild.
30-31 Mar 1875	First mild day of the season.
1 Apr 1875	A beautiful day, thawing slightly.
3 Apr 1875	Weather clear.
4 Apr 1875	Weather clear, but cold.
6 Apr 1875	Weather mild.
8 Apr 1875	Appearance of spring, thawing slightly.
10 Apr 1875	Slight fall of snow toward sundown, fine and clear.
13 Apr 1875	A beautiful day, thawing.
16 Apr 1875	Warmest day of the season.
22 Apr 1875	Thawing but little.
23-26 Apr 1875	Thawing a great deal today.
27-29 Apr 1875	Weather cold, thawing but little.
3 May 1875	Water commencing to make its appearance on the ice.

Appendix C: McEwan Bridge Drawings



Appendix C