Context:

Fraser River, Simon Fraser 1808

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Errors and omissions:

None.

Earlier reference:

The earlier paper was Simon Fraser's latitudes - where was the Chief's village?

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20 nautical miles upstream from Steveston
north arm Fraser River
Sapperton
New Westminster
Port Hammond
Musqueam
Old Fort Langley
Barnston Island
Silverdale
Salmon River
Mission
Steveston
south arm Fraser River
Hatzic Slough
Google earth
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
10 mi
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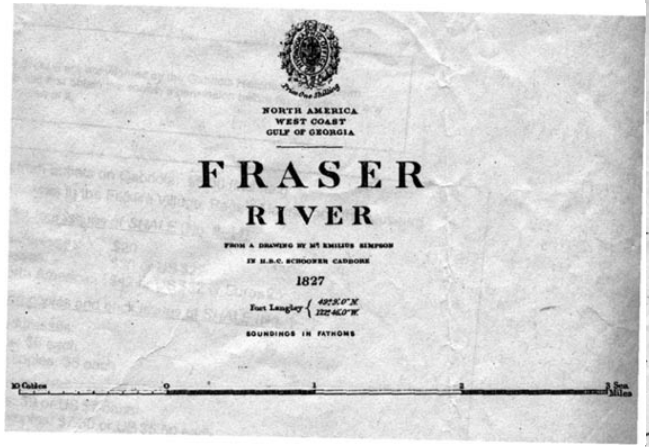
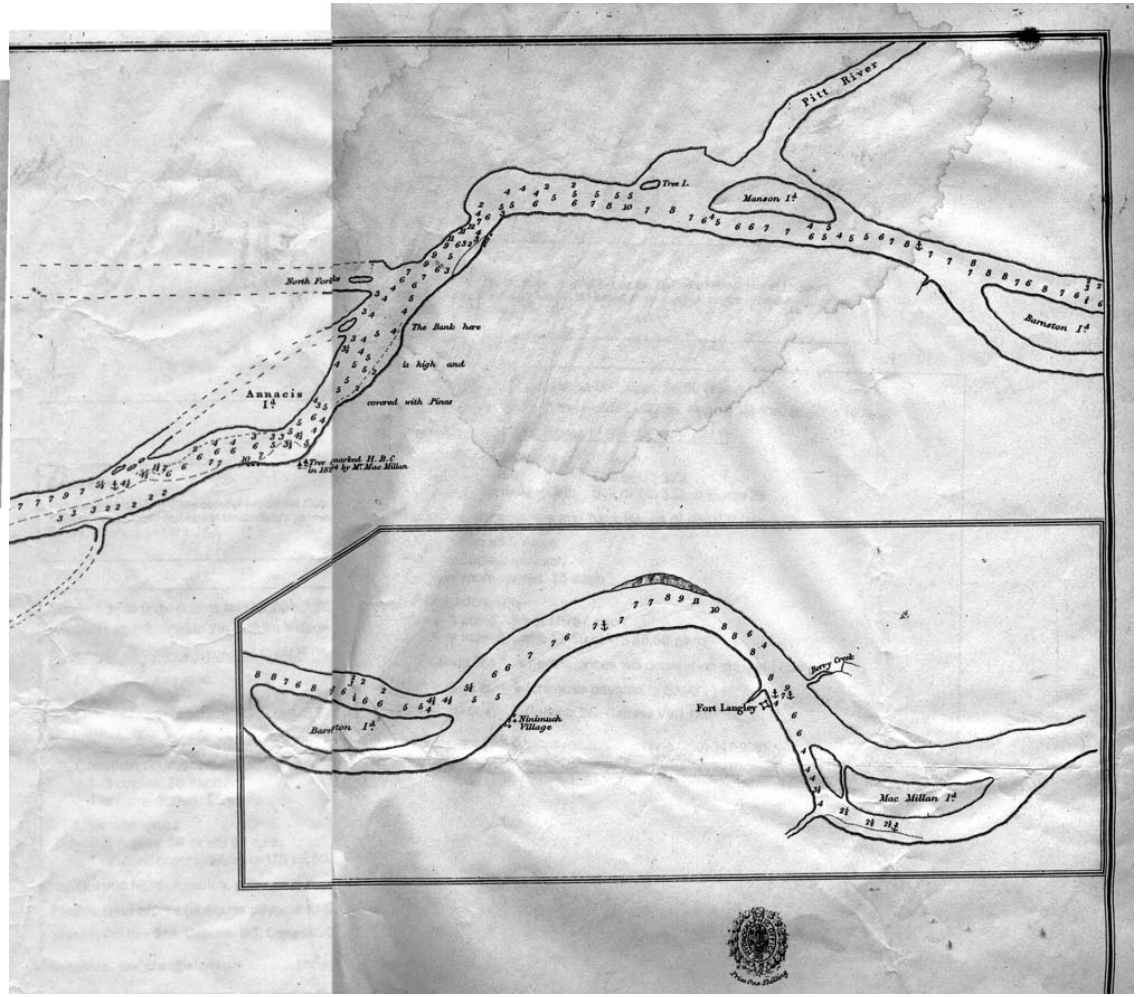
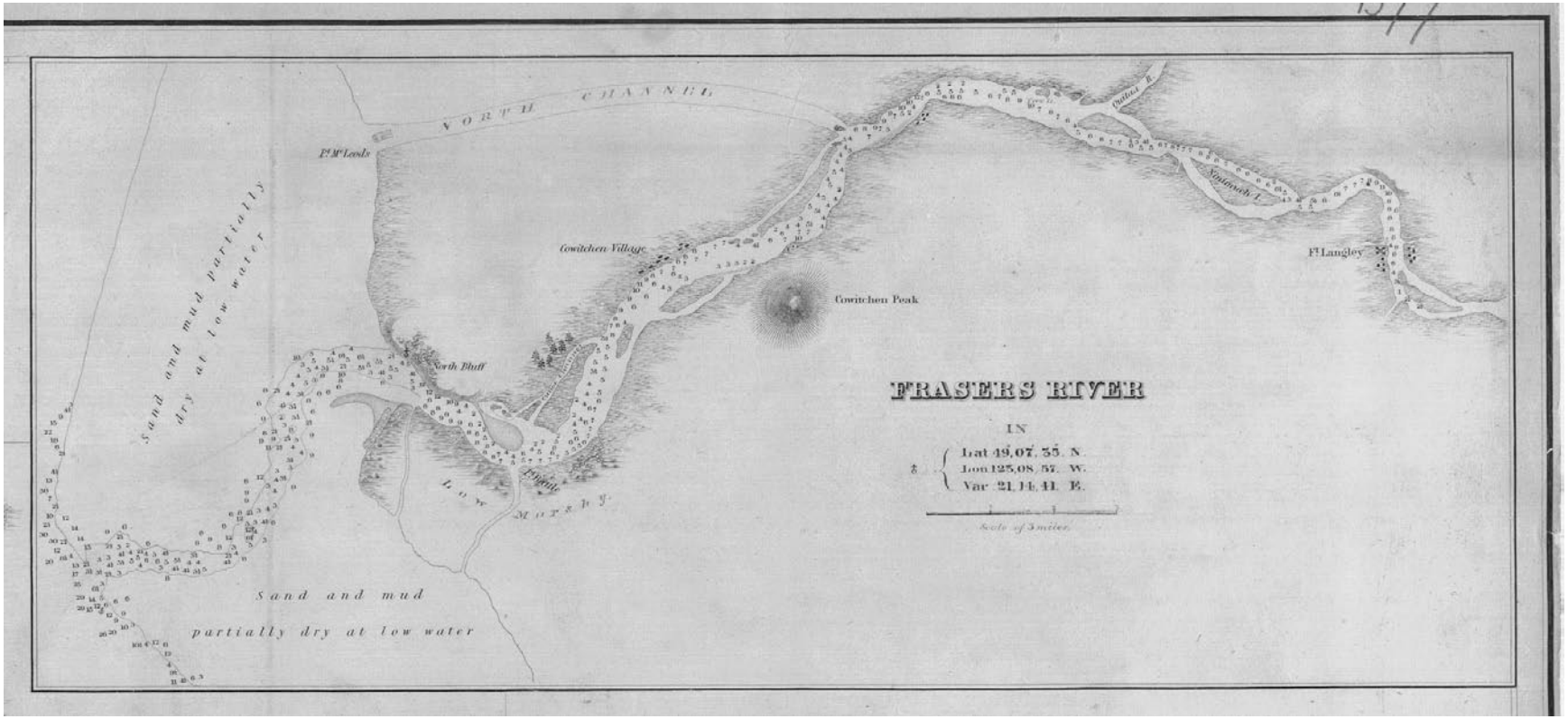


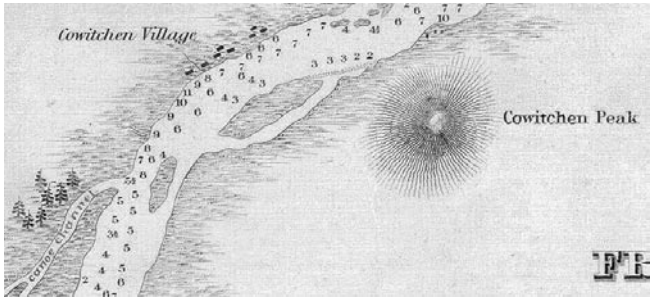


Parts of a chart based on a sketch by Æmilius Simpson, captain of the *Cadboro(e)* in 1827.

The original sketch arrived in London in 1829, but has since been lost (HBC Archive ref: A64/52 #133 B 187); however, the Hydrographic Office has a copy: L3969/Ac2 1827, first published as an official chart in 1849 (*shown here*). This chart was the first in a series published between 1849 and 1858 when it was superseded by the 1859–1860 chart of Captain Richards.

Despite its late date, it shows Fort Langley at its original pre-1839 location. This and other details suggest it is a fairly faithful copy of Simpson's now-lost 1827 sketch. The scale is "sea miles".





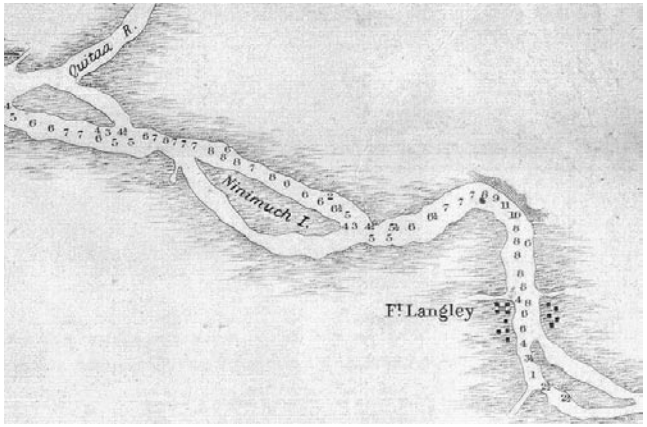


Chart based on a sketch by Æmilius Simpson, captain of the *Cadboro* in 1827.

The Hydrographic Office also has a copy L4226 Ac2 1844 (*shown here*) which is likely an adaptation of an updated version acquired from the HBC by the Wilkes Expedition in 1841. It shows Fort Langley in its post-1839 location. "Cowitchen Peak" seems to be an imaginative interpretation of "the bank here is high and covered with pines".

Simon Fraser's Longitudes, 1808

Where was the Chief's Village?—PART 2

Nick Doe

Simon Fraser's visit to the Greater Vancouver area in the summer of 1808 was for him a disappointment. Although he was the first non-native to have reached the mouth of the river that now bears his name, he had been expecting to reach the mouth of the Columbia River, about 200 miles further south. He had also hoped to find a route to the Pacific Ocean that could be used on a regular basis by the fur traders. Instead, he had found a river where, in the upper reaches at least, unnavigable rapids seemed to be the norm. His disappointment was compounded by the fact that his visit to the Fraser delta coincided with the beginning of the salmon-fishing season, a time when relationships between the several First Nations that shared the resource were particularly sensitive, and people did not need the disruptive and unexpected presence of a group of total strangers in their midst.

Fraser's disappointment is reflected in his own words. When he returned from his sortie down the North Arm of the river to Musqueam (*X^{w}méthk^{w}iyem*), he recorded early in the morning of July 3, 1808:

> "...Still [despite the hostility of the people lower down the river] we were bent on accomplishing our enterprise, to have a sight of the main [ocean] which was but a short distance from whence we had returned; but unfortunately we could not procure a morsel of provisions, & besides the Chief insisted upon having his canoe restored to him immediately...." [1]

And later that same day:

> "...Here I must again acknowledge my great disappointment in not seeing the main ocean, having gone so near it as to be almost within view. For we wished very much to settle the situation by an observation for the longitude...." [2]

Exactly where Fraser and his party were when they "relinquished [their] design and directed [their] thoughts towards home" is not known. Fraser in his journal calls the Native village, the "Chief's Village", the chief being the one who had lent them the large dugout canoe that they had used for their downriver excursion the previous day. The village must have been remarkable; certainly something more than a summer fishing camp, as Fraser describes it as having a large plank house 640 ft. [195 m] long, a population of 200, carvings of beasts and birds, and several tombs. He also describes the custom of the inhabitants of using white paint as a cosmetic.[3]

The site of the Chief's Village is often taken to be "somewhere" between Mission and Barnston Island, but an analysis of the astronomical observations at the village by one of Fraser's clerks, John Stuart, shows that the village is most unlikely to have been further upriver than Silverdale. The purpose of this note is to argue that the village was actually at Port Hammond (*Ts'í:x^{w}t*). There are several separate reasons for believing this to be so. Although no one reason by itself

[1] *The Letters and Journals of Simon Fraser 1806–1808*, edited by W. Kaye Lamb, McMillan Company, Canada 1960, p.108.

[2] Lamb, p.109.

[3] Lamb, pp.102–104.

provides conclusive proof that the Port Hammond identification is correct, all taken together, I would contend, leave little room for any other conclusion.

Village X

After leaving the Chief's Village, the Fraser expedition travelling downstream came across a second village, which they visited. Following Bartroli's notation,[4] I'll call this Village X. It was two miles above where the river divides and where the expedition, on the advice of a guide from the village, entered the North Arm of the Fraser River rather than proceeding down the South Arm.

Locating Village X is an important part of locating the Chief's Village. I will be arguing that it was at the mouth of the Brunette River (*Sk^{w}ek^{w}te'x^{w}qen*) ashore from City Bank.

The astronomical evidence.

The first piece of evidence is the latitude of the site.[5] John Stuart measured its latitude on July 1, 1808, as being 49°10.9' N. The Port Hammond site is at 49°12.3' N, just 1.6 miles further north, and well within the ±2.5 mile uncertainty that must be attributed to Stuart's measurement because of instrument error and the uncertainties generated by atmospheric refraction.

The evidence of Jean-Baptiste Proveau

Most of the men who had travelled with Fraser in 1808 were French-Canadian *voyageurs*, among whom was one Jean-Baptiste Proveau.[6] Proveau returned to the Fraser in December 1824 as an employee of the Hudson's Bay Company (HBC) and a member of the James McMillan expedition. McMillan's journal itself has not survived, but a brief extract from it is to be found in HBC Governor Sir George Simpson's papers.[7] A paragraph from the extract reads:

> "...No question can exist as to the stream we ascended being Frazers River called by the Natives *Cowitchen's* as one of our Men 'Proveau' who accompanied Mess^{s} Frazer [Fraser] and Stewart [Stuart] described several parts of it before reaching them and those parts I recognised afterwards by his description particularly the points [*sic* plural] from whence those Gentlemen returned which is situated about 20 Miles above the entrance of the River....." [8]

I think it is unlikely that Proveau would refer to anywhere upstream of the village that Fraser calls the Chief's Village as being "a point of return"; hence, we can safely conclude that the

[4] Tomàs Bartroli, "Genesis of Vancouver City—Explorations of its site 1791, 1792 & 1808", pp.121–144, Marco Polo Books, Vancouver 1997.

[5] Doe N.A., *Simon Fraser's Latitudes, 1808—Where was the Chief's village?*, 33(2), pp.2-5, British Columbia Historical News, Spring 2000.

[6] Fraser himself does not list the names of the 19 *voyageurs*, but Proveau may have been the "Baptiste" mentioned in the entry for June 8, Lamb, p.155.

[7] Extracts from Mr. Chief Trader MacMillan's, *Report of His Voyage and Survey from the Columbia to Frazer's River*, British Public Records Office F.O. 5/208. Reproduced in *Fur Trade and Empire—George Simpson's Journal 1824–1825*, edited by Frederick Merk, Harvard University Press, 1968, pp.248–250.

[8] Bruce McKelvie in his book *Fort Langley, Outpost of Empire*, 1957, has Proveau on his return, excitedly identifying Golden Ears and other local features (p. 23), but I have looked in the journals of expedition-members John Work and François-Noël Annance for any such references, and have found none. Work does however confirm that Proveau was on the McMillan expedition, without giving him special mention (Washington Historical Quarterly, Vol. III, July 1912, p.200). I can only assume that McKelvie's commentary is an imaginative interpretation of the quoted extract from McMillan's report.

Chief's Village was at least 20 of McMillan's miles above the "entrance" of the river.

McMillan actually arrived at the mouth of the South Arm of the river on the morning of December 24, 1824 when the tide was high, and so was probably unaware of the full extent of Roberts Bank.[9] His "entrance" therefore would be where Steveston is now.

The McMillan expedition had entered the Fraser River from Boundary Bay, following the Nicomekl River, and eventually the Salmon River to the site of the present-day Fort Langley.[10]

In a short journey from there upstream to Hatzic Slough, just beyond Mission, they saw only small settlements of less than thirty inhabitants. We can be sure therefore that the Chief's Village was downstream of the mouth of the Salmon River.

A point 20 "miles" upstream of Steveston puts us just above the present-day city of New Westminster, four or five miles above where the Fraser splits into its two arms. Simon Fraser had only travelled down the North Arm, so of course Proveau would not have recognised the river below that junction. However, as I'll show later, there is a good chance that McMillan's miles were nautical miles, not statute miles, in which case the "points of return" becomes 23 statute miles up the river. This corresponds to Douglas Island at the mouth of the Pitt River, which is significantly upstream from New Westminster. By modern reckoning, Port Hammond is about 28 statute miles, 24.3 nautical miles, up the river above Steveston ("North Bluff" on the 1827 chart).

The evidence of François-Noël Annance

The journal of François-Noël Annance[11] who was on the McMillan expedition of 1824 adds some potentially interesting commentary to events after they left the mouth of the Salmon River and journeyed downstream on the Fraser River.

> "December 19th …here we looked for a place most eligible for a Fort. Having found one, we marked HB on the trees on the water side and pushed off.
>
> "The course of the river from the place we turned to [this place?] is southwest…."

Annance's bearing is odd. There are several ways of interpreting it beside the at-first-obvious one that it is the direction the river runs along Derby Reach. However, a comparison with John Work's data shows that Annance's figures are insufficiently detailed to be reliable.

Nevertheless, he continues:

> "…and now near the mouth of the river it runs west."

Now comes the interesting part.

> "Little below HB we saw a deserted village nearly a mile long. Finding no good place below, we came back to the village to encamp[e]. This is a terrible large village! the natives are scattered about in the small rivers catching salmon.
>
> "This must contain not less than a thousand men. The houses are very high; the roofs horizontal. There are several channels near the mouth of the river and the ground marshy and

[9] The distance between North and South Sand Heads at the outer entrance, and Garry and Pelly Points on the inner entrance, on the HBC *Cadboro* Chart 1827 is about 5 miles. That McMillan missed seeing Roberts Bank at low tide may be the reason why Henry Hanwell in the HBC brig *William and Ann* spent several days in the summer of 1825 fruitlessly attempting to enter the river across the bank from the south.

[10] Moved from the old 1827 site upstream in 1839.

[11] *A Journal of a Voyage from Fort George Columbia River to Fraser River in the winter of 1824 and 1825*, Francis N. Annance, HBC Archive B 76/a/1.

full of little ponds and small trees. Near the village, there is a beautiful forest of cypress trees."

Despite the fact that the village is described as being several times larger than was the Chief's Village in 1808, it does seem to be a good candidate. Alas, as Work shows, Annance is actually describing the Cowichan Village opposite Tilbury Island, way down on the South Arm.

Evidently the Chief's Village was too small to merit comment from Annance. Either that, or it was no longer there.

The evidence of John Work

The journal of John Work on the 1824 expedition provides lots of navigational detail, and so it is useful to look at it for that reason alone.[12] Understanding the techniques the fur-traders' used is an essential part of learning how to interpret Simon Fraser's 1808 journal. His journal entry for Sunday, December 19th, reads as follows:

"Cloudy fair weather, wind SE blowing fresh in the evening. Poured down rain all night.

"Embarked at 7 o'clock [from their campsite upstream of the Salmon River confluence] and proceeded down the river about 27 miles,[13] viz., W 4 miles down the N. channel formed by the island opposite where we entered the [Fraser] river on the 16th.

"Another small island is at the lower end of this one [Brae Island now an integral part of McMillan Island, the starting point for the plots shown in the accompanying map], then WNW 2 miles, SW by W 2 miles, W by N 2 miles, along the N side of an island [Bishop's Reach and Barnston Island], 4 mile W by S.

"At the lower end of this course there is a bay with an island in its entrance [Confluence of the Pitt River, popularly supposed to be Douglas Island, but my plot favours this being Tree Island. The head of Douglas Island, Sebastian Point, by my reckoning is half way down the W by S course].

"On the N side of the river WSW 3 miles [Queen's Reach], a small island is in the N side of the river just below the bay [Popularly supposed to be Tree Island, but my plot favours this being City Bank near the entrance of the Brunette River].

"S by W 3 miles about the middle of this course there is a bay and an island on the W side of the river [Poplar Island in the entrance to the North Arm], and immediately below the river is divided into two channels by an island [Annacis Island], proceeded down the E one.

"1 mile SW by S and 4 miles WSW. During the day, the river maintained its wideness till towards evening when its breadth considerably increased.

"Some places the banks are elevated at the water's edge, but in general they are low and the land rising into hills a short distance from the shore, towards evening the shores on both side of the river became low and swampy.

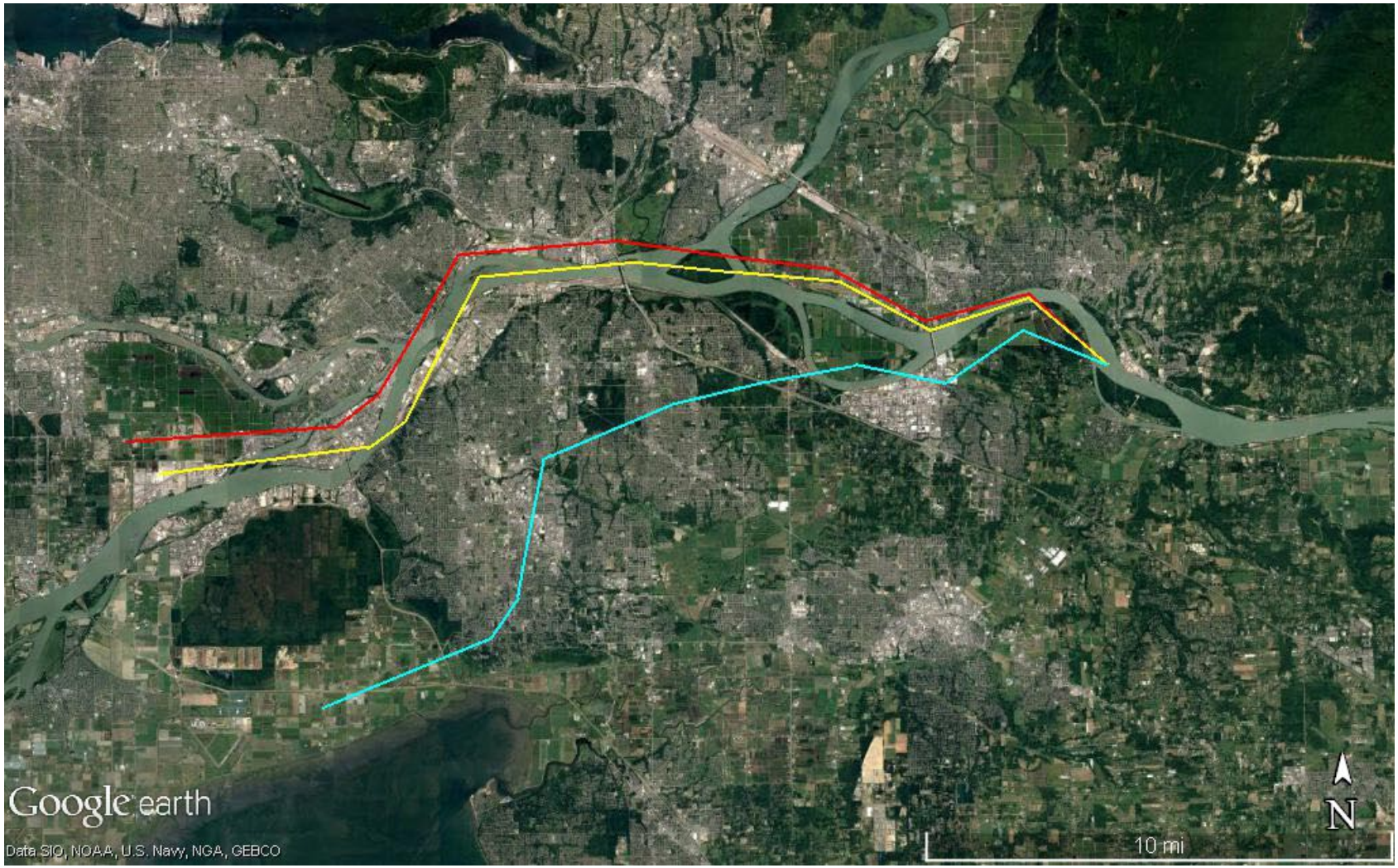
"The trees observed on the shore are pine [fir], cedar, plane, alder and some others, the alder principally occupies the low ground.

"Where we are now encamped is not far from the entrance of the river, the country is so very swampy and liable to be overflowed with the tide that we had to turn back some distance to our present situation which, though the site of an old village [Annance's 'terrible large village'],[14] is a quagmire [the end point for the plots shown in the following map]. "

[12] *Journal of John Work, November and December 1824*, Edited by T.C. Elliot, Washington Historical Quarterly, Vol. III, July 1912, pp.198–228.

[13] Work says 27 miles, yet the total of his courses is only 25 miles. However, 25 nautical miles are 27.3 statute miles.

[14] Work goes on to describe the village as did Annance.



Three plots of the navigational data in John Work's journal from the downstream end of McMillan Island by present-day Fort Langley, down to an area where there used to be a large seasonal Cowitchen Village, opposite Tilbury Island in the South Arm of the Fraser River.

The blue line shows the unedited data in the journal with statute miles (1609m/mile), and true bearings. The red line shows the data taken as nautical miles (1852m/mile) and bearings magnetic requiring +19° rotation. The yellow line shows the data scaled and rotated in such a way as to minimize differences between several plotted and known locations. The optimal scaling (1787m/mile, +17°) is close enough to the red line interpretation to indicate that Work's miles are nautical miles, and his bearings are compass bearings.

As demonstrated in the map (previous page), to make sense of the navigational data, all distances have to be taken as nautical miles (1852 m/mile),[15] and all bearings have to be taken with reference to magnetic north, not geographic north, which involves adding 19º to the bearings.[16]

Evidence for the location of Village X

Although there is no direct evidence of the location of the Chief's Village in the journals of Work and Annance, there are perhaps several threads, rather tenuous I will admit, that point to the location of Village X.

Annance in his entry for December 19 says:

> "…about midday we fell in with the natives on an island opposite to their village on a little river...".

From its place in the text, this was a short distance above where they stopped to select a possible site for a fort and carved HB on the trees opposite Annacis Island.

Work too describes this meeting in similar detail:

> "Four canoes containing 17 Indians of the Cahoot tribe met us, among them was – the principal chief of the tribe…. We put ashore went ashore…. …This [Their] village was at some distance up a river which falls into the bay."

Frustratingly, it is unclear which "bay" Work is meaning, but one possibility is the one at the mouth of the Brunette River.

From Fraser's account, we know that the inhabitants of Village X were not "islanders", meaning not from Vancouver Island, making it quite possible that they were Kwantlen [*Q^{w}'óntl'en*] people.

In an entry for Thursday, August 25, 1825, in the journal of Alexander McKenzie who was on the HBC brig William and Ann, we find they were paid a visit while off Roberts Bank by a chief "…of the first Consequence residing some distance up Frazer River":[17]

"…this chief name is Whotleakenum and appears to be the same our party fell in with last winter ... [he] wished we would Consider him as entirely distance from the Cowitchen who he said have pa ve[?] no business with the Quatlin River."

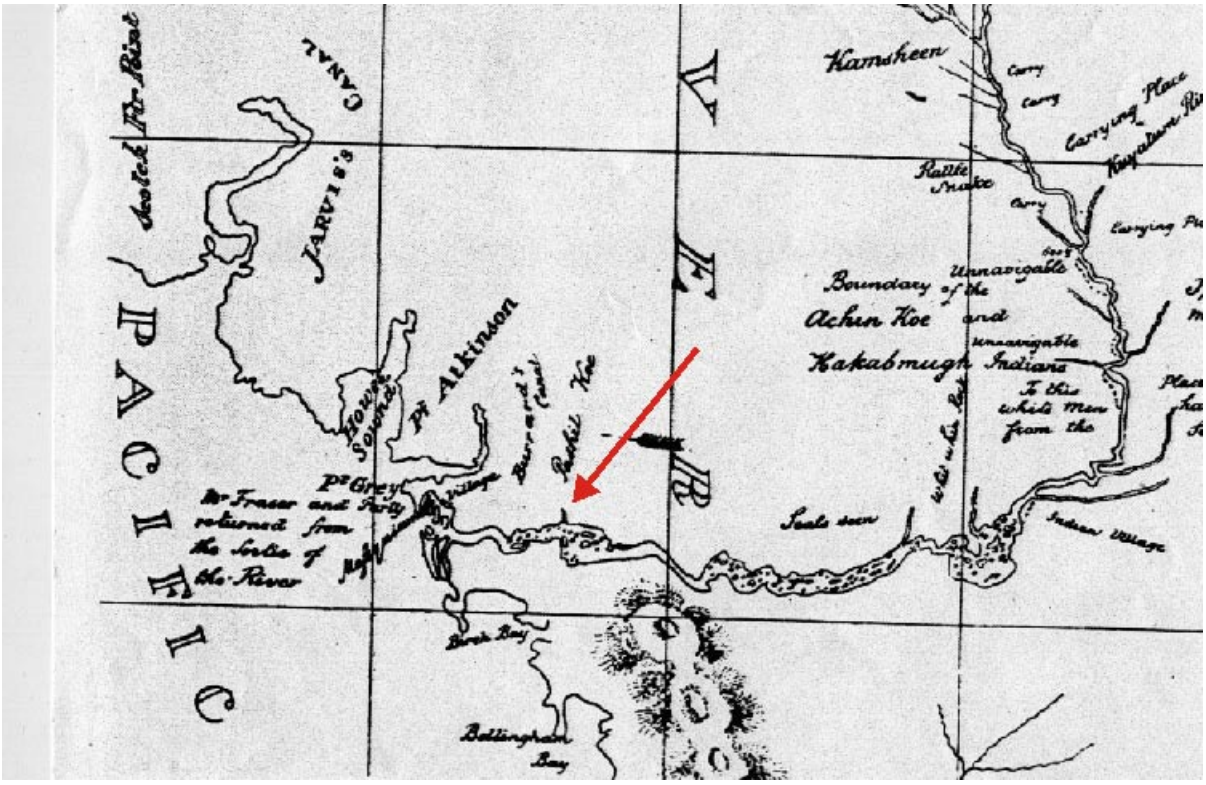
If you think these snippets rather too thin to constitute evidence, wait until you read my final one.

In 1804, the Hudson's Bay Company (HBC) and the North West Company (NWC) agreed to amalgamate; however, they continued to operate separately until 1821. Simon Fraser and David Thompson were both employees of the NWC and held each other in high regard, Fraser having gone so far as to name a major river after his colleague. During 1813 and 1814, Thompson drew the earliest known trustworthy map of the western part of the North American continent entitled, *Map of the*

[15] One could argue that Work's miles are in fact statute miles but an underestimate because of the downstream current. This is simple to disprove by applying the same methodology to the trip they made upstream from the Fort Langley campsite to Hatzic Slough. There are a couple of unrelated errors in his courses, but allowing for these, one still has to use enhanced miles (1754 m/mile) and rotated bearings (+19º) to provide the optimal match to a modern map.

[16] For example, in this part of the world, a compass that is pointing directly north, that is towards magnetic north, means that the compass is pointing in the geographic direction N19ºE (+19º) give or take a degree or two; the value varies with date. So to plot compass readings using the geographic co-ordinates of a map or chart, you have to rotate the compass directions clockwise 19º.

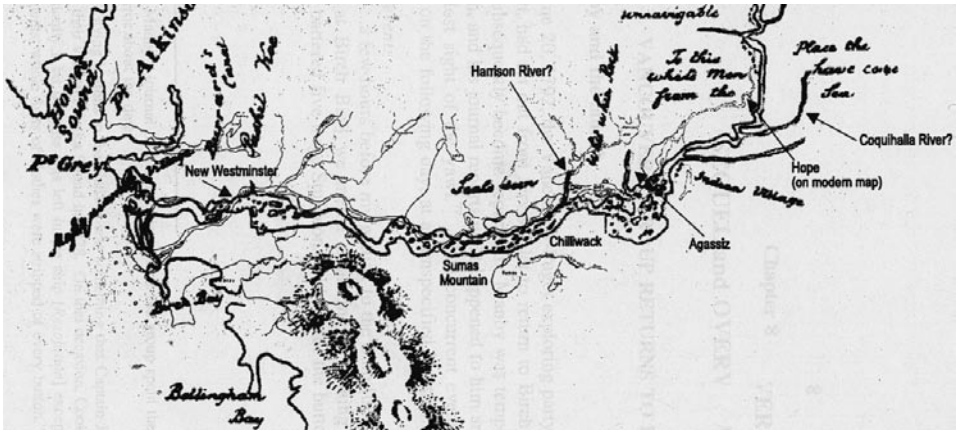
[17] *Remarks on Board the Brig William and Ann, Henry Hanwell Master, From Fort George Columbia River to Observatory Inlet 28 May 1825*, Alexander McKenzie, HBC Archives 1M148, Item B.223/a/1.



North-West Territory of the Province of Canada from actual survey during the years 1792 to 1812.

Thompson must have had access to the log (now lost) of John Stuart, one of the clerks on the Fraser expedition and responsible for keeping navigational and other notes. He must also have had access to Fraser's narrative, and he certainly had Vancouver's 1792 chart to work from.

Although the section of the map that shows the lower Fraser River is very rough and full of extraneous islands added with no regard to actuality, Thompson was an accomplished surveyor and as one might expect, the broad outline of the course of the river corresponds quite closely to its actual course. A match between his map and a modern map is fairly easy to make, and if one does this (*shown below*), the little appendix, marked by the large red arrow in the extract shown above, can be interpreted as being a small river just above New Westminster but below the Pitt River making it the Brunette or Coquitlam River. The inference being that



this small river was indicated in the documents of the Fraser expedition that we no longer have, and that it had for them some special significance.

The tidal evidence for fixing longitude

In the early 1800s, before the advent of affordable and reliable chronometers, the favoured method of measuring longitude was the so-called "lunar-distance" method. Although developed for the purposes of finding longitude at sea, it was also commonly used by the early fur traders (including David Thompson) in their journeys of exploration in what is now western Canada and the northwestern United States.

Very simply, the method involved determining local time by observing when the sun was due south at noon, and comparing this with Greenwich time, which was determined by measuring the angular distance between the moon and either a star or the sun. The observers had pre-calculated tables with them (Nautical Almanacs) which recorded these angular distances at various dates and times of the day. There were a lot of fiddly corrections to be done, but roughly speaking, the angular distances observed were the same everywhere in the world, so the tables gave a method of determining the time at Greenwich.

Simon Fraser appears to have had the instruments and tables for a lunar-distance measurement—"… we wished very much to settle the situation by an observation for the longitude…". That no such measurement was made, for good reasons, is however not quite the disaster he contemplated. Although I have never heard or read of anyone attempting to determine longitude from tides, it is, in principle, not such a crazy idea in that the angular distance between the moon and the sun play a large role in determining the rhythm of the tides. It is a very crude method of course, but way back in the late-1990s when I was doing the research, I decided to give it a go.

The range of the tide

On July 1, 1808, when the expedition had reached the Chief's Village, somebody, likely John Stuart, observed that:

> "The tide now about 2½ feet. … We cast our nets into the water, but took no fish, the current being to strong."

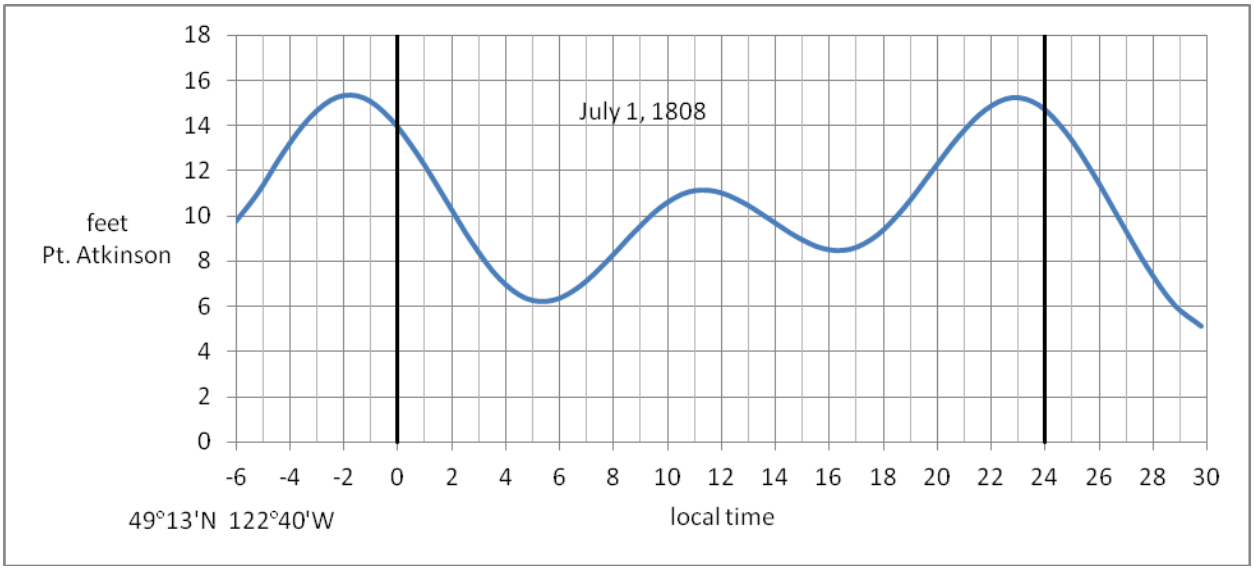
The tidal range at various distances up the Fraser River depends, not only on the state of the tide at the river's estuary, but on the flow of the river. The greater the flow, the smaller the influence of the tide.

The steps I went through to make use of this observation are calculate the tide on July 1, 1808;[18] look for a similar tide in 21st-century tide tables; at this time, use modern DFO software[19] to estimate the tide at Port Hammond for various (volumetric) flows of the river at Hope; select the flow at Hope which gave a tidal range of 2½ feet on the day in question at Port Hammond.

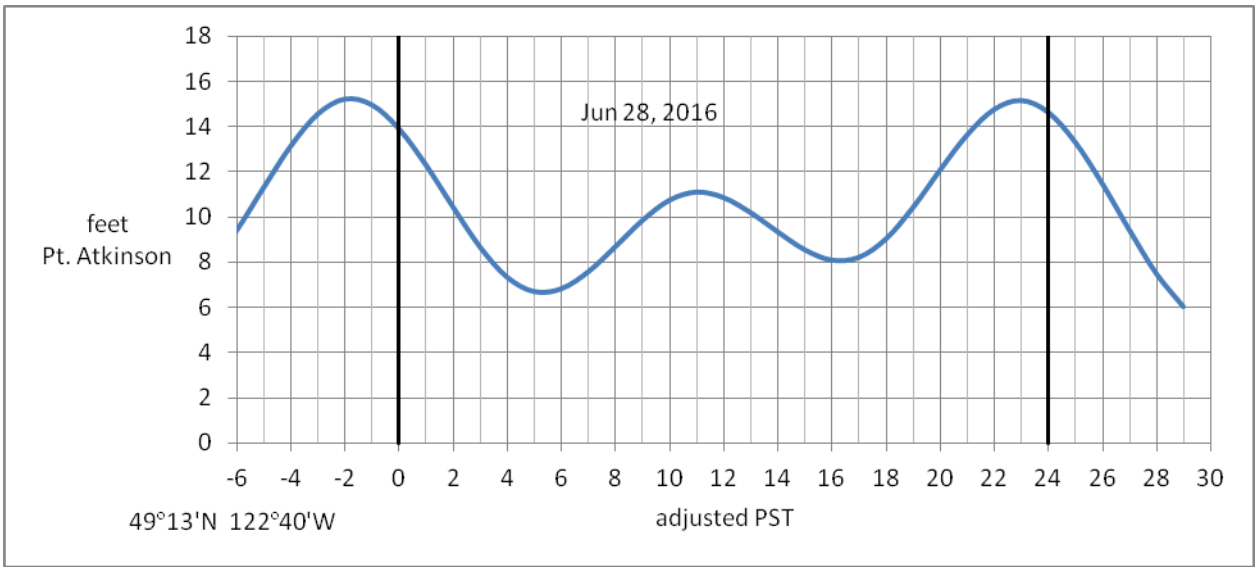
The answer was 5800 m^3/s at Hope, which was very encouraging as the modern tide tables (2016) quote 8500 m^3/s to be normal for June, and 5700 m^3/s to be normal for May and July. The answer was thus in the range of "normal".

[18] I use my own software for these sorts of calculations, but the program uses the same tidal constants that are used by the CHS in computing modern tables. Mine just goes back in time a lot further than theirs.

[19] When I was researching this in 1998, the software model of the flow in the Fraser was still being developed and I am grateful to Anne Woollard of the CHS Institute of Ocean Sciences for her help in making use of it. Since then, the software Avadepth has become available online, which has enabled me to re-work the 1998 data in more detail.

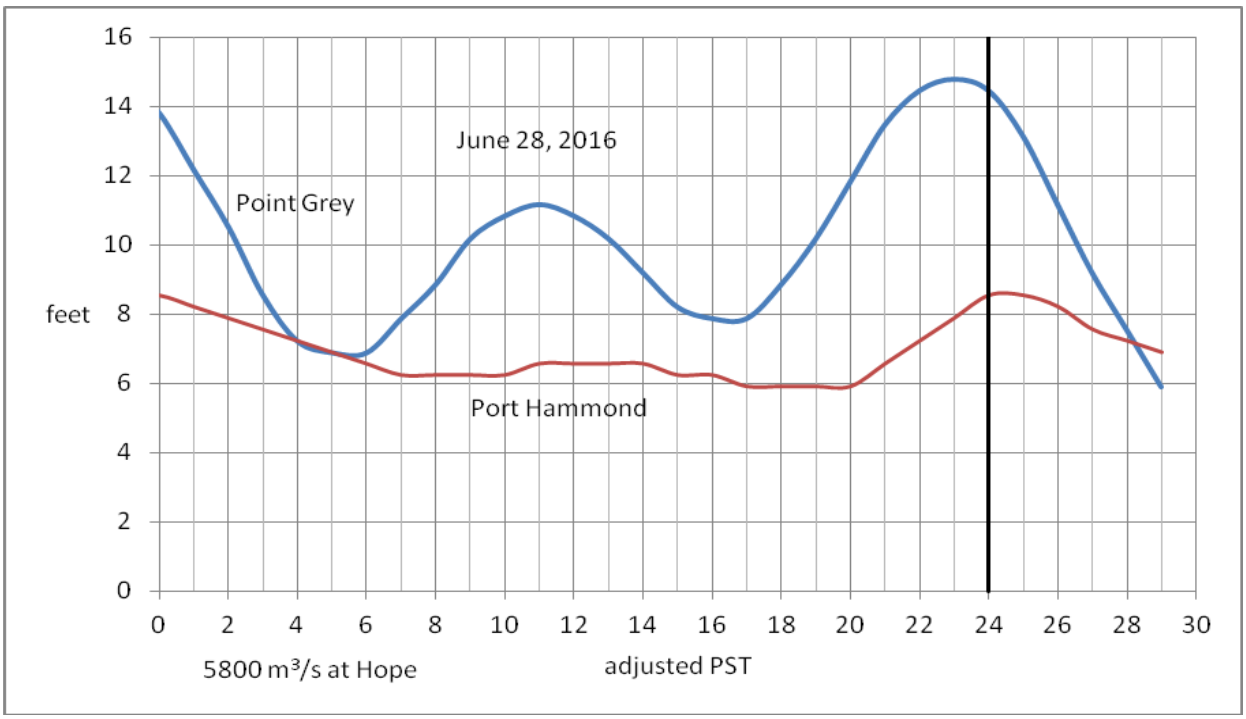


The tide at Point Atkinson on July 1, 1808. The time scale is local time, that is the time that would have been established by an observation of the sun at noon on July 1, 1808. It is equal to PST corrected for longitude west of 120°W and corrected for the equation of time, which factors in the varying position of the sun in the sky due to the Earth's slightly elliptical annual orbit.



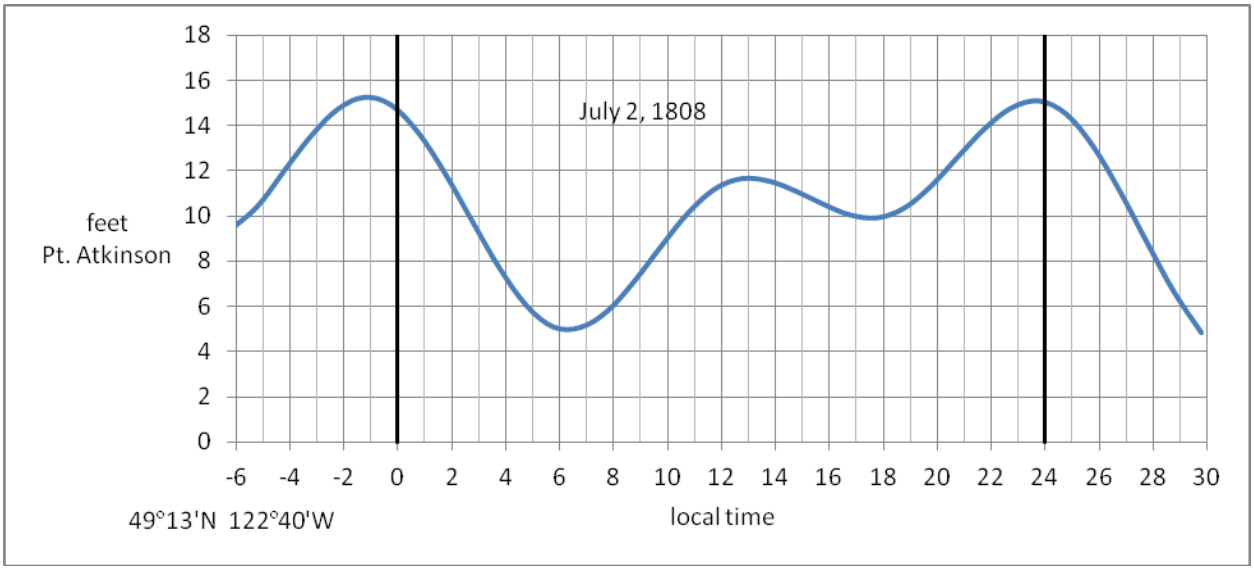
The tide at Point Atkinson on June 28, 2016. The time scale is PST adjusted by subtracting one hour so as to match the tide in 1808. This match is required so that flows in the lower Fraser River in 1808 can be estimated using modern software that does not go back that far in time.

With this figure, I could estimate the velocity of the flow at various points in the river, an essential step in being able to compute where the 1808 expedition probably was at various times of the day.

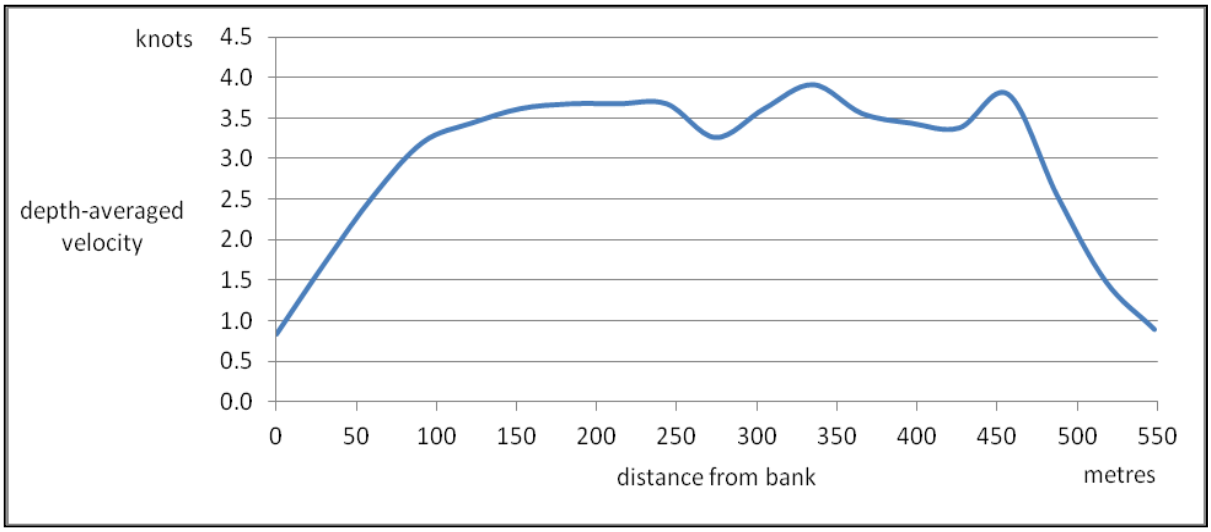


The tide at Point Grey and Port Hammond on June 28, 2016. The time scale is PST adjusted to match the tide in 1808. The flow of the river at Hope has been adjusted so as to make the range of the tide at Port Hammond equal to the 2.5 feet observed in 1808.

Calculated using the DFO Avadepth software



The tide at Point Atkinson on July 2, 1808. It matches that of June 29, 2016 after time adjustment.



An example profile of the variation of depth-averaged velocity with distance from the bank. An illustration of points 3a and 5a in the text. Taking advantage of the current while travelling downstream is not critically dependent on maintaining position in the middle of the river, and there is considerable advantage to be gained by sticking close to the bank when travelling upstream.

Adapted from BC Ministry of Environment, *Fraser River Hydraulic Model Update*, Appendix C: *Roughness from ADCP data*, p.4, northwest hydraulic consultants, March 2008.

Adapting modern data for use in 1808

Before constructing a timeline of Simon Fraser's activities on July 2, 1808, I first need to address the question of the justification of using modern data to assess the state of the river in 1808. Considerations are as follows:

1. Reasons why the DFO Avadepth model figures might be underestimates of the surface velocity regardless of direction of travel in 1808:

(a) **t**hey are the transverse depth-averaged velocities, not the depth-averaged velocities at particular points across the river

[Comment: There are two considerations involved here.

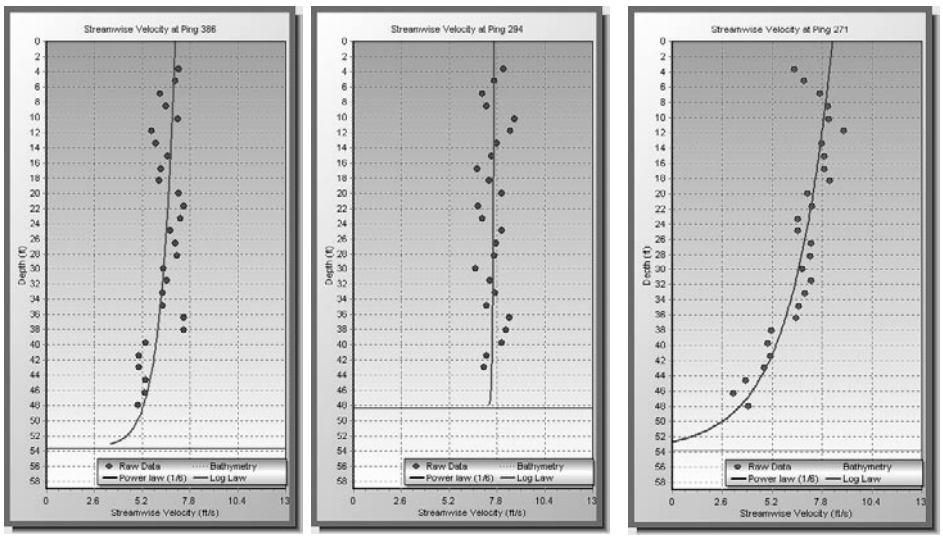
The first consideration is the conversion of the average depth-averaged velocity for the cross-section to the mid-stream depth-averaged velocity.

If we look at the Mission example above, the ratio of the mid-stream depth-averaged velocity to the average depth-averaged velocity for the whole of the cross-section is about 1.22. This is however not the value that would be be given by the DFO Avadepth software. In computing the average for the whole section, the value at each distance from the bank would have to be weighted by the depth of the river at that distance. If we use the profile of the river at Mission to do this,[20] the ratio of the mid-stream depth-averaged velocity to the average depth-averaged velocity for the cross-section becomes about 1.10.

The second consideration is that the depth-averaged velocity is not the surface velocity. The ratio of the depth-averaged velocity to surface velocity varies with distance from the bank and so is influenced by whether travel is with or against the flow because the courses taken would be different. Hence not considered as part of 1(a), but 3(a) and 5(a).

(b) the volumetric flow was estimated by making the adjustment necessary to produce a 2½ foot tidal range at the Chief's Village. Since 1808 however, changes to the river's

[20] A transverse profile of the river at Mission useful as a rough generic guide is available at BC Ministry of Environment, *Fraser River Hydraulic Model Update*, Figure 3.14, northwest hydraulic consultants, March 2008.



Examples of vertical velocity profiles of Fraser River. These examples are for Mission. The surface velocity in these examples is somewhat greater than the depth-averaged velocity, an illustration of point 2(a) in the text.

Adapted from BC Ministry of Environment, *Fraser River Hydraulic Model Update*, Appendix C: *Roughness from ADCP data*, p.4, northwest hydraulic consultants, March 2008

bathymetry will have increased the velocity in the lower reaches, and will in turn caused the upper reach tidal ranges to be less than they were in 1808. To restore the tidal range, the estimate of volumetric flow has to be weakened, which would lead in turn to an underestimate of the upper reach velocity in 1808.

[Comment: A lower volumetric flow lowers the depth of the river and this partially offsets any lowering in its average velocity, but this effect appears to be small. Lowering the volumetric flow roughly decreases the flow velocity by the same amount at New Westminster; hence this requirement is nullified by 4(a) below.]

2. Reasons why the DFO Avadepth model figures might be <u>underestimates</u> of the surface velocities while travelling <u>downstream</u> in 1808:

(a) as noted in 1(a) the depth-averaged velocity is not the surface velocity.

[Comment: A value commonly taken for the ratio of the depth-averaged velocity to surface velocity at the thalweg is 0.85.[21] This figure would imply that to convert depth-averaged velocity to surface velocity at the thalweg, we should multiply by 1/0.85 = 1.18.]

3. Reasons why the DFO Avadepth model figures might be <u>overestimates</u> of the surface velocities while travelling <u>downstream</u> in 1808:

(a) the canoe might not have kept to midstream away from the banks where the canoe could take full advantage of the current.

[Comment: While in general, straying away from the thalweg decreases the speed of a canoe heading downstream, this is unlikely to be a significant factor on the Fraser River.

The transverse depth-averaged velocity of the lower Fraser River tends to be pretty flat, only falling off near the banks, which the 1808 expedition would only occasionally have been approaching as they progressed downstream.]

4. Reasons why the DFO Avadepth model figures might be <u>overestimates</u> of the surface velocities regardless of direction of travel in 1808:

(a) modern dredging, diking, river training, blockage of side-channels and sloughs, and the reclamation of Sumas Lake ca.1920 have served to increase the river velocity.

[Comment: Dredging in the lower river has increased the river's gradient; and diking and river training have decreased its flood plain. Both have increased the river's velocity as it nears the sea.

[21] There's a discussion on this in Doe, Nick, *A simple method of measuring the volumetric flow of a stream*, *SILT* 14, April 2015.

However, this increase will match the decrease required by 1(b); the two cancel out.]

5. Reasons why the DFO Avadepth model figures might be overestimates of the surface velocity while travelling upstream in 1808:

(a) the canoe would be travelling near the bank where the current is weaker.

[Comment: Experienced paddlers know that when going upstream, it's best to keep close to the shore where the current is weaker.

The benefit of doing this can be substantial if there are back eddies along the shore such that, with short bursts of energy, one can round the rocky points separating one eddy from the next as one progresses upstream. However, while such a series of back eddies is commonly available in tidal passages on the coast, they occur less often along the lower parts of the the Fraser. This is because the river flows through easily-eroded sediments and consequently has banks that tend to run parallel to the flow without creating back eddies. There can however be an advantage along the river gained by using side channels where the flow is weaker.

Some indication of the relationship between 3(a) and 5(a) — the apparent decrease in the velocity of the current due to steering away from the bank going downstream and then steering close to the bank while going upstream — can be gleaned from Simon Fraser's data. On July 2, he traversed both up and down the same part of the river and he naturally would have steered the courses demanding the least work from his crew.]

(b) as noted in 1(a) the depth-averaged velocity is not the surface velocity.

[Comment: Although the value commonly taken for the ratio of the depth-averaged velocity to surface velocity at the thalweg is 0.85, this ratio rises towards 1.0 as the water shallows.[22] The multiplier of 1/0.85 = 1.18 in 2(a) should therefore not be applied when the canoe is travelling upstream.]

To sum up:

While travelling downstream, the velocity may be underestimated due to 1(a) and 2(a); and overestimated due to 3(a).

While travelling upstream, the velocity may be underestimated due to 1(a); and overestimated due to 5(a) and 5(b).

If we make, just a little more than guessing, the correction factors to be:
1(a) = 1.10; transverse velocity
1(b) not needed = 1/4(a)
2(a) = 1.18; average to surface;
3(a) = 1.00; not mid-stream (negligible)
4(a) not needed = 1/1(b)
5(a) = 0.67; near bank. An empirical estimate that nevertheless fits well with the timeline;
5 (b) = 1.0; average to surface (negligible).

Going downstream, the velocity multiplier is:
$\alpha = 1(a) \times 2(a) \times 3(a) = 1.30$.

Going upstream, the velocity multiplier is:
$\beta = 1(a) \times 5(a) \times 5(b) = 0.74$.

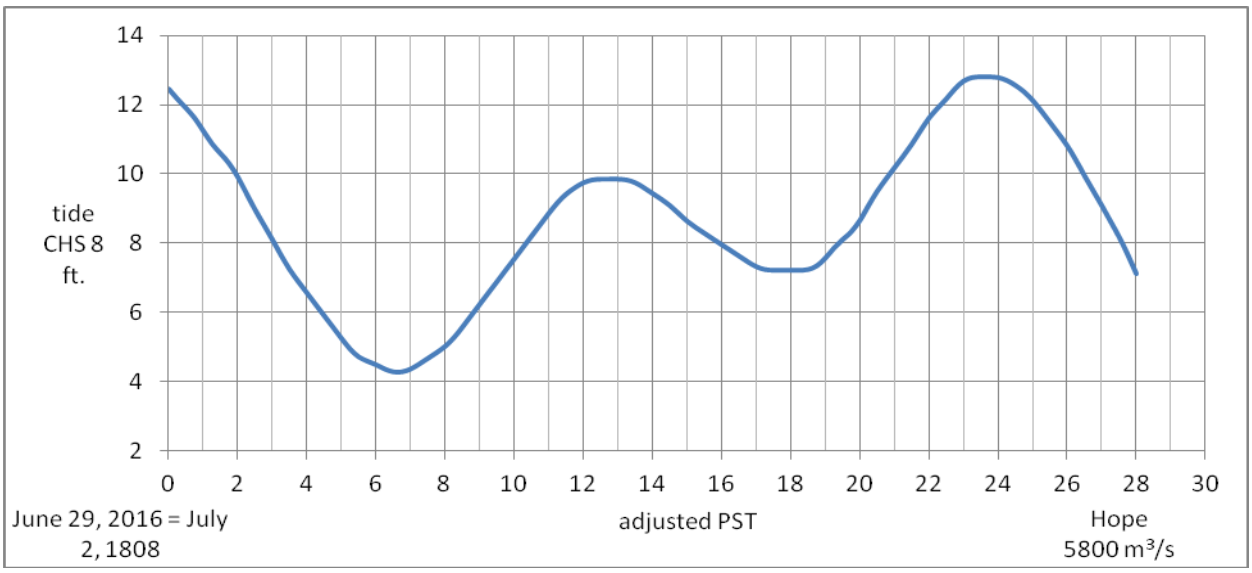
These values correspond closely to those determined from the timeline based on Fraser's data, and to a certain extent, of course, have been designed to do so. We are dealing with too many unknown variables over known variables to be rigorously dispassionate. But although it is possible to come up with alternative solutions that match the constraints imposed by Fraser's data, there are more of these constraints than a casual reading of his journal would suggest. Which introduces the next topic.

The tide at Musqueam

One of the key pieces of information needed to construct a timeline for the events of July 2, 1808, is the time that Simon Fraser and his crew turned their borrowed canoe around and headed back upstream. We can work on estimates of the time that they started downstream because he says they arrived at Village X at 11 am[23] and that this was two

[22] Doe, Nick, ibid.

[23] This would not of course been 11 am PST. Pacific Standard Time hadn't been invented back then. Fraser would have been using noon as determined by Stuart's



The tide at CHS 8 close to Musqueam on June 29, 2016 with a flow at Hope of 5800 m^3/s. The time scale is PST adjusted to match local (apparent) time on July 2, 1808 as observed on July1.

Calculated using the DFO Avadepth software

miles above the North/South Arm split.[24] We also know that they camped that night at 11 pm when six miles short of the Chief's Village. If we knew when they turned around, we can, if we know the strength of the current, work out their average velocity relative to the water, which we can reasonably assume was the same going down river as it was going up.[25]

Fortunately, we can make a good estimate of the time that Fraser left Musqueam, which he doesn't tell us, from the tidal information.

Fraser says"

> "…having spent one hour about this place [Musqueam] we went to embark, [when] we found the tide had ebbed, and left our canoe on dry land. We had, therefore to drag it out to the water some distance.…"

Now had the tide been falling steadily that afternoon, this wouldn't have told us much, but as it happened, it hadn't. There was a LHW (low high-water) at around 1 pm and a HLW (high low-water) at around 6 pm, and only a significant falling tide between about 2:00 and 5:30 pm. This we can narrow even further using the timeline because if we estimate that they left too early, the current

observations the previous day. His longitude was west of 120ºW, so his noon was 10.7 minutes after 12 PST for this reason alone. The earth was also close to aphelion, the point in its elliptical orbit when it is moving slowest, and this caused Stuart's noon on July 1 to appear an additional 3.3 minutes late. All of Fraser's local times are therefore PST – 0.23 hrs. Something you need to know when timing the tides.

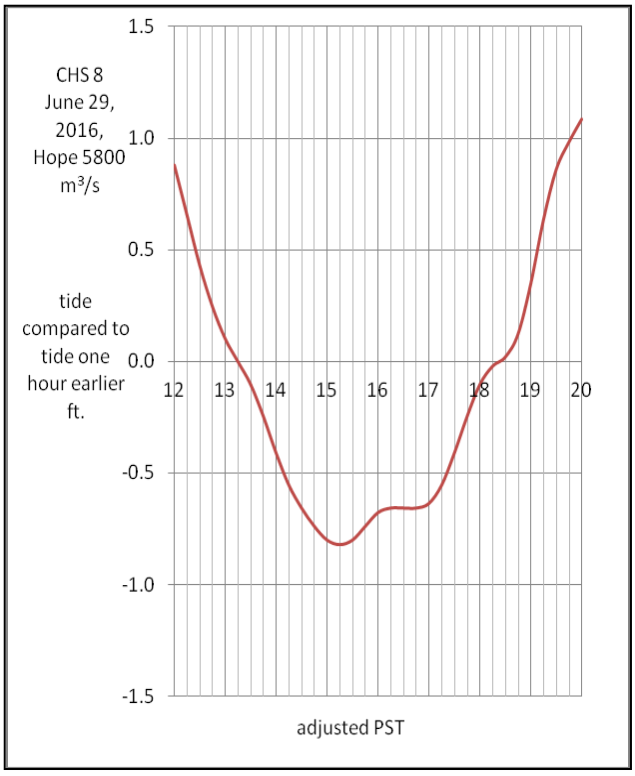
[24] Following Work's usage, I take "miles" to mean mean nautical miles, and speeds I shall be expressing in knots (nautical miles per hour). If instead you use statute miles and miles per hour, it creates difficulties in the timeline, which I will deal with later.

[25] It is not possible to factor in the fact that the crew must have been getting tired at the end of the day. We have too many unknowns already.

By velocity of the canoe, I'm meaning the average velocity with no allowance made for the short "smoke breaks" they probably took now and then.
The canoe was new to the crew, probably larger and heavier than usual, so their accustomed velocity can't be figured out from travel times before they reached the Chief's Village.

will need to be reckoned as being too strong (a shorter journey time downstream but a longer journey time upstream), and conversely if we estimate that they left too late, the current will need to be reckoned as being too weak (a longer journey time downstream but a shorter journey time upstream).

A good balance of the tidal information (*right*) and the timeline is to have the Musqueam leaving time at 4:00 pm (1600 on the graph). The timeline values of the current factors $\alpha = 1.31$ (downstream) and $\beta = 0.73$ (upstream) are then the practically the same as estimated independently above. At 4:00 pm the tide was about 0.68 ft. lower than it had been when they arrived at 3:00 pm. At an intertidal beach slope of 2–5°, this would be at least eight sloping ft., and perhaps as much as twenty feet, enough to cause Fraser and his crew the difficulty they experienced with a stranded, heavy, dug-out canoe.

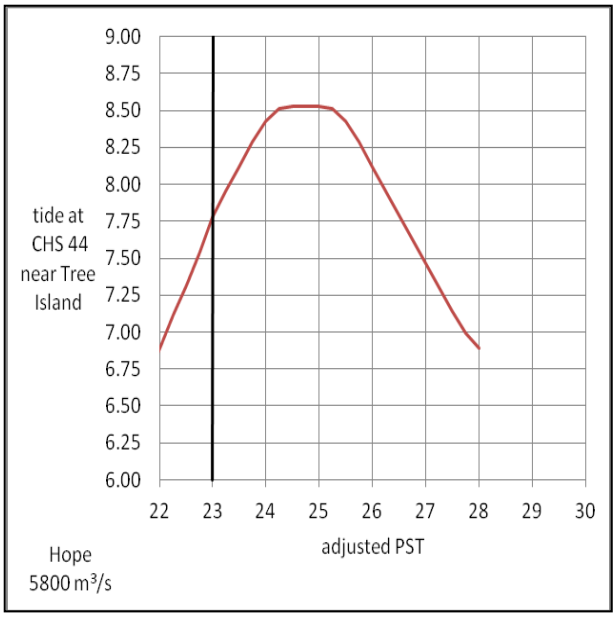


The height of the tide at Musqueam at time and date adjusted to be local (apparent) time on July 2, 1808, compared to what the tide was one hour earlier. If Fraser and his crew found their canoe stranded when they returned after their one hour inspection of the village, they must have left when this difference was significantly negative.

Calculated using data from the DFO Avadepth software

The flooded campsite

Just one more snippet of tidal information in Fraser's journal is that when they camped for the night at the end of a very busy day, they were six miles down from the Chief's Village. They had arrived at 11:00 pm, but "…the men being extremely tired, went to rest; but they were not long in bed before the tide rushed upon the beds and roused them up."



One of the characteristics of tides on rivers like the Fraser River is that the tide (high or low), besides growing weaker, also occurs increasingly later as it moves upstream. Delays at New Westminster vary between 45 minutes to over two hours. So any suggestion we have for the location of the Chief's Village

The tide at or near Tree Island in the late evening of July 2, 1808 was rising. If they arrived at 11:00 pm, as Fraser said they did, the tide still had 9 inches to go. On a gently sloping beach (5°) that would be over eight feet from the strand. It peaked at just after mid-night.

Calculated using data from the DFO Avadepth software

has to pass the test that high tide, six miles down river from the village, was, in the late evening of July 2, 1808, fairly soon *after* 11:00 pm. Unfortunately, the effect at HHW (high high-water) on this day was not strong enough by itself to pinpoint the location of the camp site with any accuracy; but nevertheless, it has to be shown that it passes the test.

And it does. The HHW at Tree Island was shortly before 1:00 am on July 3, 1808.

Tree Island looking upstream. Choice of camping site here seems to be the forest understory or out on the tidal flats.

Dave's Firsts Blog, ChangLooGrace, Aug.16, 2015.

The timeline of events on July 2, 1808

Fraser journal constraints

Arrive at Village X: 11:00 am
Timeline: 11:00 am (imposed)

Miles to split: 2
Timeline: 2.12 nm (deduced)

Stay at Musqueam: 1 hour
Timeline: 1 hour (imposed)

The weather was "fine"; no wind to complicate matters.

Arrive at camp: 11:00 pm
Timeline: 11:00 pm (imposed)

Miles camp to Chief's: 6
Timeline: 6.49 nm (deduced)

Arrive at Chief's: 5:00 am
Timeline: 5.00 am (imposed)

Additional imposed constraints

Time spent at Village X: 1hr.2 min. (deduced from timing of other events)

Pause at split: 12 min. (conjecture)

Leave Musqueam: 4:12 pm (deduced from tide and effect on current multipliers)

Stay at Mahli: 7 min. (conjecture)

Timeline deduced values within constraints

Canoe still-water speed: 3.63 knots (6.7 km/h)

Current downstream multiplier α: 1.30 (estimated independently as 1.30).

Current upstream multiplier β: 0.74 (estimated independently as 0.74).

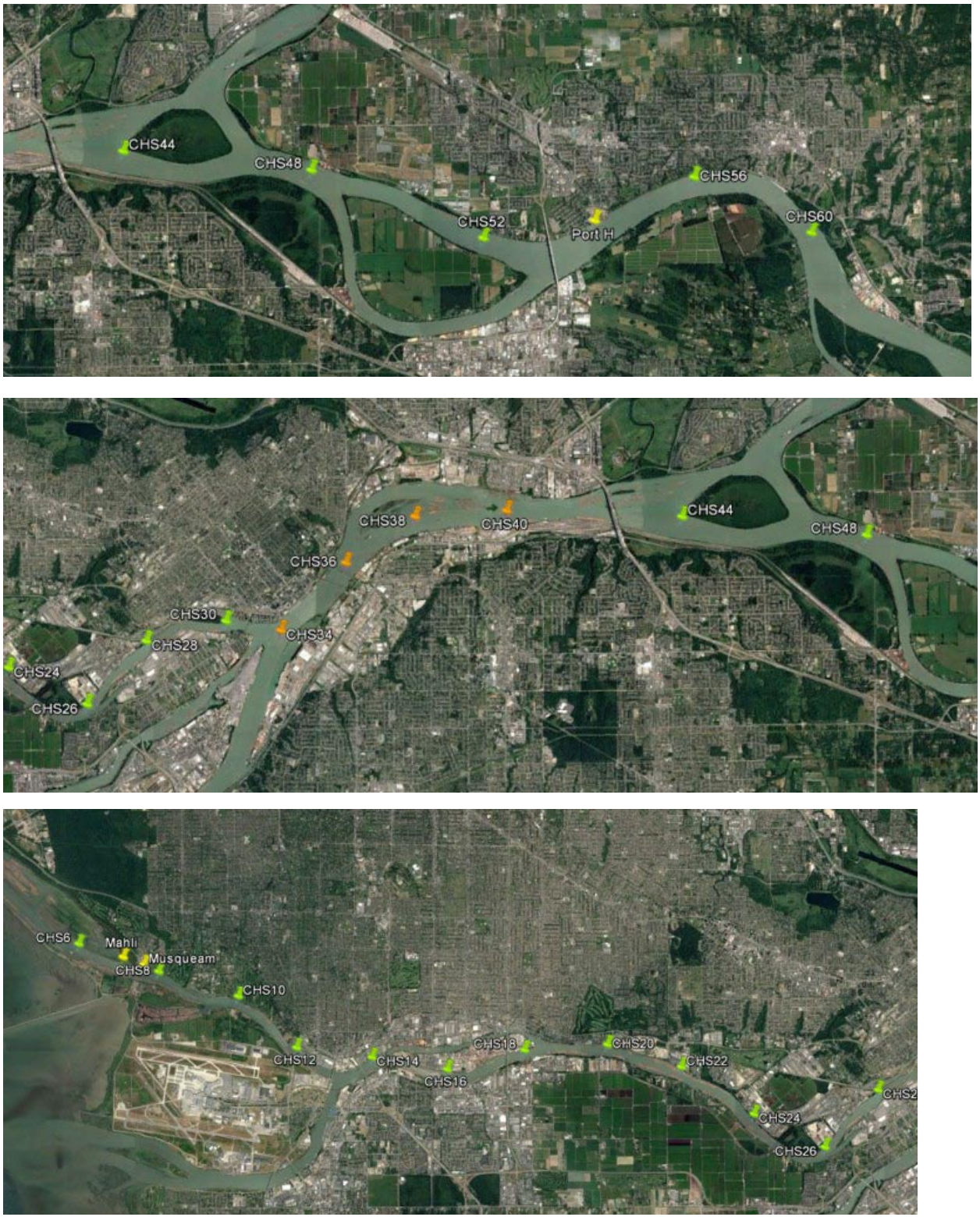
Left Chief's Village (late): 9:36 am.

Village X was at or near Brunette River site

Camp was at or near Tree Island (distance and tide)

Left camp early on July 3 (tide): 1:59 am (3 hours rest)

Chief's Village was at or near Port Hammond.



Positions of the CHS Avadepth waypoints, which are in three sections: North Arm CHS 6-30; South Arm CHS 34-40; and Main CHS 44-60. Musqueam and Mahli are between CHS 6 and 8; suspected Village X is at CHS 38; suspected Chief's Village is at Port Hamond between CHS 52 and 56. The suspected overnight campsite, Tree Island or Essondale Islet, is between CHS 40 and 44.

1. Leave Chief's Village

left: 9:36 am
current on leaving: 3.42 knots
cumulative distance: 0.00 nm.

We can't be sure when Fraser left, but it was certainly after their usual start time at dawn around 4:00 am. He had to negotiate the loan of a canoe that they could use for the downstream journey. The above conjecture is deduced from the river current and the canoe velocity determined later in the journey.

2. Waypoint CHS 52

passed 9:48 am
distance made: 1.39 nm
current en route: 3.35 knots
effective velocity: 6.98 knots
cumulative distance: 1.39 nm.

In Bishop's Reach, north side of Barnston Island.

3. Waypoint CHS 48

passed 10:08 am
distance made: 2.14 nm
current for the course: 2.89 knots
effective velocity: 6.52 knots
cumulative distance: 3.54 nm.

Between Barnston and Douglas Islands.

4. Waypoint CHS 44

passed 10:29 am
distance made: 2.23 nm
current en route: 2.70 knots
effective velocity: 6.34 knots
cumulative distance: 5.77 nm.

Helmcken Point, downstream end of Douglas Island.

5. Waypoint CHS 40

passed 10:49 am
distance made: 2.21 nm
current en route: 2.76 knots
effective velocity: 6.40 knots
cumulative distance: 7.98 nm.

Queen's Reach.

6. Arrive Village X (CHS 38)

arrive 11:00 am
distance made: 1.10 nm
current en route: 2.57 knots
effective velocity: 6.21 knots
cumulative distance: 9.08 nm.

City Bank at the mouth of the Brunette River. Site NS20 in Appendix A.

7. Leave Village X (CHS 38)

left 12:03 am
current on leaving: 2.00 knots.

The deduced time for their stay at Village X is about an hour. Extra time could be allowed if α is increased (they had more help from the current while going downstream) and β was decreased (they had less opposition going upstream), but the values of α and β would no longer match independent estimates, although timeline changes would be insignificant.

8. Waypoint CHS 36

arrive 12:13 am
distance made: 1.00 nm
current en route: 2.01 knots
effective velocity: 5.65 knots
cumulative distance: 10.07 nm.

Pattullo Bridge, New Westminster.

9. Arrive at split (CHS 34)

passed 12:25 am
distance made: 1.12 nm
current en route: 2.02 knots
effective velocity: 5.66 knots
cumulative distance: 11.19 nm.

Here they waited to allow the canoe following them to catch up and there was subsequently some discussion as to which fork they should take. I've allowed 12 minutes for this.

10. Leave split (CHS 34)

left 12:37 pm
current on leaving: 2.02 knots.

11. Waypoint CHS 30

passed 12:45 pm
distance made: 0.67 nm
current en route: 1.77 knots
effective velocity: 5.40 knots
cumulative distance: 11.86 nm.

Head of Poplar Island.

12. Waypoint CHS 28

passed 12:57 am
distance made: 1.04 nm
current en route: 1.52 knots
effective velocity: 5.15 knots
cumulative distance: 12.90 nm.

North Arm.

13. Waypoint CHS 26

passed 1:09 pm
distance made: 1.04 nm
current en route: 1.52 knots
effective velocity: 5.15 knots
cumulative distance: 13.93 nm.

North Arm.

14. Waypoint CHS 24

passed 1:22 pm
distance made: 1.12 nm
current en route: 1.39 knots
effective velocity: 5.02 knots
cumulative distance: 15.06 nm.

North Arm.

15. Waypoint CHS 22

passed 1:37 pm
distance made: 1.15 nm
current en route: 1.14 knots
effective velocity: 4.77 knots
cumulative distance: 16.20 nm.

North Arm.

16. Waypoint CHS 20

passed 1:49 pm
distance made: 1.02 nm
current en route: 1.11 knots
effective velocity: 4.75 knots
cumulative distance: 17.22 nm.

North Arm.

17. Waypoint CHS 18

passed 2:03 pm
distance made: 1.10 nm
current en route: 1.25 knots
effective velocity: 4.88 knots
cumulative distance: 18.32 nm.

Mitchell Island. South channel.

18. Waypoint CHS 16

passed 2:16 pm
distance made: 1.09 nm
current en route: 1.30 knots
effective velocity: 4.94 knots
cumulative distance: 19.41 nm.

Mitchell Island. South channel.

19. Waypoint CHS 14

passed 2:29 pm
distance made: 1.04 nm
current en route: 1.17 knots
effective velocity: 4.81 knots
cumulative distance: 20.45 nm.

Oak Street Bridge.

20. Waypoint CHS 12

passed 2:43 pm
distance made: 1.09 nm
current en route: 1.10 knots
effective velocity: 4.74 knots
cumulative distance: 21.54 nm.

North Arm, north of Sea Island, below split with the Middle Arm.

21. Waypoint CHS 10

passed 2:56 pm
distance made: 1.04 nm
current en route: 1.22 knots
effective velocity: 4.85 knots
cumulative distance: 22.58 nm.

Approaching McDonald Slough, north side of Sea Island.

22. Waypoint CHS 8

passed 3:09 pm
distance made: 1.11 nm
current en route: 1.27 knots
effective velocity: 4.91 knots
cumulative distance: 23.69 nm.

Just short of Musqueam. North side of Iona Island.

23. Arrive Musqueam

arrive 3:12 pm
distance made: 0.21 nm
current en route: 1.31 knots
effective velocity: 4.94 knots
cumulative distance: 23.91 nm.

24. Leave Musqueam

left 4:12 pm
current on leaving: 1.52 knots.

Leave time determined in part by the tide.

25. Arrive Mahli

arrive 4:15 pm
distance made: 0.30 nm
current en route: 1.52 knots
effective velocity: 5.15 knots
cumulative distance: 24.20 nm.

Only a short distance downriver. Decision to turn around probably made pretty swiftly as they had no provisions and were facing a long paddle back to the Chief's Village. Allowed about 7 minutes.

26. Leave Malhi

left 4:22 pm
current on leaving: –1.52 knots.

Now working against the current.

27. Waypoint CHS 8

passed 4:37 pm
distance made: 0.51 nm
current en route: –1.52 knots
effective velocity: 2.12 knots
cumulative distance: 23.69 nm.

Just up from Musqueam. Cumulative distance from Chief's Village now decreasing.

28. Waypoint CHS 10

passed 5:04 pm
distance made: 1.11 nm
current en route: –1.19 knots
effective velocity: 2.44 knots
cumulative distance: 22.58 nm.

North side of Sea Island.

29. Waypoint CHS 12

passed 5:26 pm
distance made: 1.04 nm
current en route: –0.83 knots
effective velocity: 2.80 knots
cumulative distance: 21.54 nm.

North Arm.

30. Waypoint CHS 14

passed 5:49 pm
distance made: 1.09 nm
current en route: –0.76 knots
effective velocity: 2.87 knots
cumulative distance: 20.45 nm.

North Arm.

31. Waypoint CHS 16

passed 6:11 pm
distance made: –1.04 nm
current en route: –0.85 knots
effective velocity: 2.78 knots
cumulative distance: 19.41 nm.

North Arm.

32. Waypoint CHS 18

passed 6:36 pm
distance made: 1.09 nm
current en route: –0.92 knots
effective velocity: 2.71 knots
cumulative distance: 18.32 nm.

North Arm.

33. Waypoint CHS 20

passed 6:59 pm
distance made: 1.02 nm
current en route: –0.86 knots
effective velocity: 2.77 knots
cumulative distance: 17.22 nm.

North Arm.

34. Waypoint CHS 22

passed 7:21 pm
distance made: 1.02 nm
current en route: –0.86 knots
effective velocity: 2.77 knots
cumulative distance: 16.20 nm.

North Arm.

35. Waypoint CHS 24

passed 7:46 pm
distance made: 1.15 nm
current en route: –0.88 knots
effective velocity: 2.75 knots
cumulative distance: 15.06 nm.

North Arm.

36. Waypoint CHS 26

passed 8:12 pm
distance made: 1.12 nm
current en route: –0.99 knots
effective velocity: 2.64 knots
cumulative distance: 13.93 nm.

North Arm.

37. Waypoint CHS 28

passed 8:36 am
distance made: 1.04 nm
current en route: –1.04 knots
effective velocity: 2.60 knots
cumulative distance: 12.90 nm.

North Arm.

38. Waypoint CHS 30

passed 8:59 pm
distance made: 1.04 nm
current en route: –0.99 knots
effective velocity: 2.64 knots
cumulative distance: 11.86 nm.

North Arm.

39. Split (CHS 34)

passed 9:15 am
distance made: 0.67 nm
current en route: –1.04 knots
effective velocity: 2.59 knots
cumulative distance: 11.19 nm.

Back in the CHS South Arm.

40. Waypoint CHS 36

passed 9:41 pm
distance made: 1.12 nm
current en route: –1.04 knots
effective velocity: 2.59 knots
cumulative distance: 10.07 nm.

Pattullo Bridge, New Westminster.

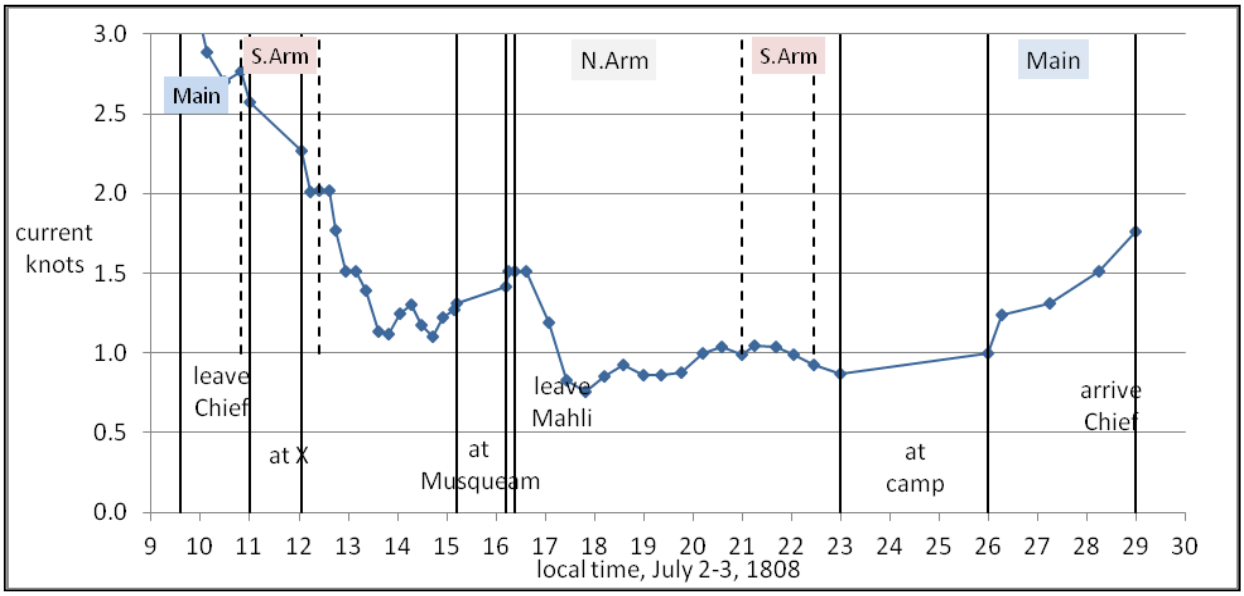
41. Passed Village X (CHS 38)

passed 10:03 am
distance made: 1.00 nm
current en route: –0.99 knots
effective velocity: 2.64 knots
cumulative distance: 9.08 nm

42. Waypoint CHS 40

passed 10:28 am
distance made: 1.10 nm
current en route: –0.93 knots
effective velocity: 2.71 knots
cumulative distance: 7.98 nm.

Queen's Reach. 1.26 nautical miles below the Port Mann Bridge.



Fraser's crew made good use of the current (shown is the conjectured surface current they experienced). On their return from Musqueam and Mahli, Fraser notes: "…the tide was now in our favour, the evening fine, and we continued our course with great speed." It seems very unlikely though that the current was strong enough to reverse the flow of the river. The tide was flooding, but it was also being opposed by the increasing velocity of the river as they moved upstream.

43. Arrive at camp (Tree Island)

arrive 11:00 am
distance made: 1.49 nm
current en route: –0.87 knots
effective velocity: 2.77 knots
cumulative distance: 6.49 nm.

Camped on Tree Island, or, less likely, tail of Barnston Island, or Essondale Islet. Supported by tidal information — their camp was flooded.

The total journey distance that day was about 42 nautical miles, just over 77 kilometres.[26]

44. Break camp

left 1:59 am
current on leaving: –1.14 knots.

45. Waypoint CHS 44

passed 2:17 am
distance made: 0.72 nm
current en route: –1.24 knots
effective velocity: 2.39 knots
cumulative distance: 5.77 nm.

Helmcken Point, downstream end of Douglas Island.

46. Waypoint CHS 48

passed 3:15 am
distance made: 2.23 nm
current en route: –1.31 knots
effective velocity: 2.32 knots
cumulative distance: 3.54 nm.

There is a choice going upstream of going through Parsons Channel on the south side of Barnston Island, or carrying on along Bishops Reach on the north side. The current is weaker on the south side, but the distance is greater. I'm told by experienced paddlers that there's often not much advantage of one route over the other. I assume that Fraser did not risk taking the to-him-unknown southern route.

[26] I was told by RCMP Sgt. Ron Paysen, who participated in a VisionQuest voyage starting on April 14, 1998, in 10-metre canoes down the Salish Sea, that the canoes could travel 30 km/day very comfortably, and that in favourable conditions, they could go up to 100 km/day. He thought that bigger canoes would go even faster; however, Simon Fraser might not have had a full complement of paddlers. Bottom line: the estimated 77 km in one day is quite plausible.

47. Waypoint CHS 52

passed 4:15 am
distance made: 2.14 nm
current en route: –1.51 knots
effective velocity: 2.12 knots
cumulative distance: 1.39 nm.

Bishop's Reach, north side of Barnston Island.

48. Arrive Chief's Village

arrive 5:00 am
distance made: 1.39 nm
current en route: –1.76 knots
effective velocity: 1.87 knots
cumulative distance: 0.00 nm.

Conclusions

The Chief's Village was indeed at Port Hammond. I should probably say, at or near Port Hammond, but Port Hammond was a very old site, dating back to Marpole times or earlier. It appears from the archaeological and ethnographic notes (Appendix A) that by the time Fort Langley was established, the Katzie had moved down from the Pitt River into the Fraser River-side territories.

Village X was a Kwantlen village at the mouth of the Brunette River.

The expedition's flooded campsite was probably on Tree Island.

Timeline calculation notes
(some fine print)

1. Times

Times in the format xx.xx are decimal hours on a 24 hr. clock. Times in the format hh:mm are clock times on a 12 hour clock.

2. Miles are nautical miles.

An assumption that they were statute miles would create difficulties. For example, Village X was 2 miles above the split in the river. There are no plausible sites for Village X that are only 2 statute miles above the split. The distance used in the timeline, assuming the Brunette River site, is 2.12 nautical miles, which is 2.44 statute miles. Similarly, the camp site on the night of July 2 was 6 miles below the Chief's Village. The timeline, based on progress upstream from Musqueam, reckons this to be 6.49 nautical miles below Port Hammond, which is 7.47 statute miles.

3. En route currents are just the average of the leaving and arrival currents. They are surface currents including the factors α and β. The DFO Avadepth tables classify waypoints CHS 44–60 as being in the Main part of the river, waypoints CHS 34–40 as being in the South Arm, and waypoints CHS 6–30 as being in the North Arm.

4. There is a trick to calculating the time to go from one waypoint to the next when the strength of the current, and hence the velocity of the canoe, varies with both time and location.

If the canoe leaves A(D,T), which is a distance D from a chosen reference location, at a clock time T, then knowing D and T, we can look up the current strength J(D,T) and adjust it according to a pre-determined constant γ (α or $-\beta$).

The canoe velocity relative to the shore as it leaves A is then $C_0 + \gamma . J(D,T)$, where C_0 is the assumed constant velocity of the canoe relative to the water.

The canoe arrives at B(D+d,T+t) where and when the current is $\gamma . J(D+d,T+t)$. There is no problem in knowing d, the distance between A and B, that's our choice, but what of t?

The simple procedure for evaluation t was as follows:
1. Just guess a value for $t = t_0$
2. Calculate the mean course current velocity:
$J_{ABT} = ½ [J(D,T) + J(D+d,T+t_0)]$
3. Calculate the travel time $t_1 = d /[C_0 + \gamma . J_{ABT}]$
4. If $t_1 = t_0$ then this is the value of t; however, if $t_1 \neq t_0$, then repeat step 2 using t_1 instead of t_0.
5. Continue doing this until after n trials, $t_{n+1} = t_n = t$.

This is easy to code in a program to avoid having to look up values of J () in a printed table, but in practice the number of iterations needed is very small as the distances between points have been kept small.

Many locations required timewise interpolation of table entries, and a few also require location interpolation for which I used, in terms of the 4 table entries:
$J(D_{X+x},T_{T+t}) =$
$J(D_X,T_T) (1 – (t/\Delta T)) (1 – (x/\Delta X)) +$
$J(D_X,T_{T+\Delta T}) (t/\Delta T) (1 – (x/\Delta X)) +$
$J(D_{X+\Delta X},T_T) (x/\Delta X) (1 – (t/\Delta T)) +$
$J(D_{X+\Delta X},T_{T+\Delta T}) (t/\Delta T) (x/\Delta X).$

In the version of the tables used, ΔT was 1 hour. Distances ΔX were measured on Google Earth to roughly correspond to the actual travel distance, not the distance as the crow flies. ◊

Appendix A

Archaeological and historical sites

Note: These notes were compiled *ca.*1998 and are reproduced here without revision.

Initialisms

AM = Archie Miller, City of New Westminster Curator (*personal communications*).

BR = Barbara Rogers (*personal communications*).

NS = Native settlement or resource area. *Fraser River Estuary Heritage Resource Inventory*, Ministry of Provincial Secretary and Government Services, May 1981.

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Sites

NS45 Brownsville site [Stéqwó:thel]

10 U 507782 E, 5450156 N
South bank, 0.93 nautical miles above the North/South Arm split.

Name: "*across from, but facing you*".

Across from New Westminster. West of Pattullo Bridge near foot of Old Yale Road. Listed as "Brownsville", Semiahmoo(?)/Musqueam Band, potential archaeological content, fishing camp.

This site was important enough to be the only New Westminster site to be marked as a village on the 1827 Cadboro chart. George Barnston in the Fort Langley Journal however says only "past a few tents on the south side".

This site may also be one of the villages referred to by the 1824 expedition after meeting with the chief of NS20. Annance says after visiting the chief "saw the site of several villages, we come to the beginning of the marshy ground [where they carved HBC on the trees, opposite Annacis Island - near NS48 the St. Mungo & Glenrose Cannery sites]". Work says "we passed the site of several old villages". No sites listed on the south side other than this one between NS48 opposite Annacis Island and the bend in the river at Sapperton, NS20.

The only one of the five sites not listed as Langley Band (Kwantlen).

Site originally called "Brown's Landing". There were hotels, livery stables, and stores here in the 1870s. Crossing the river until 1884 by canoes, then steam ferry, Fraser River Bridge 1904, Pattullo Bridge 1937.

NS44 Kikait (Liverpool) [Qiqá:yt]

10 U 508759 E, 5451114 N
South bank, 1.71 nautical miles above the North/South Arm split.

Name: "*resting place*".

Opposite Sapperton, east of the Pattullo Bridge.

Listed as Langley Band, potential archaeological content, fishing camp, was once a four-acre Langley Indian Reserve, but has been sold.

This site is often listed in popular history books as being at "Brownsville" but this is wrong. It is at the site of a planned town called Liverpool which is east of the former Brownsville. Both Liverpool and Brownsville once had railway stations (*Key Plan…*).

Listed as sold in *You are asked...*p.198.

BR says "fishing village with plain houses and in two rows".

Confirmed that Bartroli p. 143, "...summer camp where the Liverpool cannery was later sited..." .

McKelvie pp. 1–6, also tells story of Fraser's visit supposedly to NS44. Similar to Bartroli's.

Gypsum Bar (in *Explore the Fraser…* p.85) Gyproc Bar (on topo map) is reachable from the end of 124th St., not sure if this is Kikait site exactly. NS44 is just a fraction to the west of the end of 124th St.

NS18 Creek down from BC Penitentiary Site [Stá'telu]

10 U 507720 E, 5451317 N
North bank, 1.50 nautical miles above the North/South Arm split.

Name: "--".

A second BC Penitentiary site at the mouth of the creek just downstream from NS19. Listed as Langley Band, potential archaeological content, village site (fishing).

The creek is now underground for a few hundred metres above where it joins the Fraser. The canyon is called "Glenbrook Ravine Park", probably a real estate agent's name, but I'm not sure. Not sure either if the site survived or not. Nice walk.

Found an 1897 New Westminster Fire Atlas which marks the creek as "The Glen Stream". Most maps of this period (all of SFU's collection) show but do not name the creek (Stótelō "little creek").

Talked to Archie Miller about this site also. He says something may be preserved under the roadway where it is culverted, but it too has probably been too badly disturbed to be of much interest archaeologically. Archie says the name "the Glen" is definitely not a recently invented name.

NS19 BC Penitentiary Site [Schech:les]

10 U 507782 E, 5451794 N
North bank, 1.78 nautical miles above the North/South Arm split.

Name: "strong lungs".

Main B.C. Penitentiary site.

Listed as Langley Band, potential archaeological content, fishing camp & village site. Archaeological investigation recommended.

The site is now occupied by "Fraserview Park" a housing development. Not sure if the site survived or not. There is a monument to the Royal Engineers outside a restaurant there.

Have searched through several popular history books on the foundation of New Westminster in 1858–9, but none give any description of pre-existing Indian sites. Local history books mostly just mention *Skaimametl* [Sxwóymelh? a cemetery near NS18] saying it was from here that the Kwantlen moved to Kanaka Creek when Fort Langley was founded. Cole Harris says the best source of early New Westminster history is an MA thesis by Margaret McDonald, UBC 1947.

Some say (McKelvie, p. 88 for example) that the site of *Skaimametl* was renamed Sapperton by the Royal Engineers. All a bit murky.

Talked to Archie Miller about this site and he reckons it is so disturbed as to be of no archaeological interest anymore. Should check with UBC and SFU archaeology departments.

NS20 Mouth of Brunette [Sk^{w}ek^{w}te'x^{w}qen]

10 U 508016 E, 5452104 N
North bank, 1.94 nautical miles above the North/South Arm split.

Name: "island".

Listed as Musqueam/Langley Band, potential archaeological content, fishing camp & village site, site occupied by Brunette Sawmill.

I'm pretty sure this village is identified by the McMillan expedition December 19, 1824, (it was on a small river) so it was not just a summer fishing camp. The chief also met the 1825 *William & Ann* expedition. Work says the village "was at some distance up a river which falls into the bay". Annance said that they "fell in with the Natives again on an Island opposite their Village on a little river".

Archie Miller pointed out that references to this site can be confused to the one on the Coquitlam River. Should check for archaeological investigations at Riverview and Colony Farm.

This site is the closest to being two (nautical) miles above the split.

NS21 Coquitlam IR #1 [Miss-kew-um and **K^{w}ik^{w}etl'em]**

10 U 514190 E, 5453108 N
North bank, 4.83 nautical miles above the North/South Arm split.

Name: "--" and "smelly fish slime" a name given by the Kwantlen to the Coquitlams there.

Also a fishing site a short distance downstream, Kwikwel'emn

Near mouth of Coquitlam River. Occupied village site. Too far from the split to be Village X.

NS43 Barnston Island IR #3

This one is unfavourable as to get to it you have to use Parsons Channel on the south side of Barnston. Not the main route.

Listed as Katzie, known archaeological content, fishing camp, present fishing grounds and small village.

No name in inventory.

Not named in map from BR. East tip of island (Mann Point) is called *Qeloslhep* "water swift'.

NS38 Katzie IR #1 [Q'eytsi'i]

10 U 523779 E, 5449743 N
North bank, 10.2 nautical miles above the North/South Arm split.

Name: "moss, many colours".

Level with Mann Point, the eastern tip of Barnston Island.

Listed as Katzie, known archaeological content, main winter village, presently occupied by the band.

Historical Story of Pitt Meadows…, p.8, says "The original village was at Port Hammond which is about a mile east of the present reserve". [not that reliable a source but interesting - archaeological evidence would suggest that NS38 is not an entirely new site as suggested].

NS39 Port Hammond mill site [Ts'í:x^{w}t]

10 U 525219 E, 5449966 N
North bank, 11.2 nautical miles above the North/South Arm split.

Name: "dry it".

Listed as Katzie, known archaeological content, village site & burial grounds, human remains still being found under the mill. DhRp-17.

Mill is marked on Chart 3489 as Fletcher Challenge (still right?). It's southwest of the foot of 207th Street.

Wayne Suttles reports, "the original village at Port Hammond (cx^{w}i't) consisted of two sections, one on the hillside extending both east and northwest from the present corner of Second and Maple Streets, and another down on the lower land

parallel to the river extending from the present mill-site to the Katzie Reserve".

NS? Haney site [Thexwoneq'?]

No information, not shown in inventory.

Shown in map from BR as *Shxwleqwén'e*.

NS42 Katzie IR #2 [X^{w}th'exth'exem]

10 U 525151 E, 5449216 N
South bank, 10.9 nautical miles above the North/South Arm split.

Name: "nettle place".

Mouth of Yorkson Creek.

1827 chart has the village as "Ninimuch" (Nanaimo, Snunéymux^{w}).

Listed as Katzie, known archaeological content, village & fishing grounds, present fishing grounds and small village.

Legends of Langley…, has some interesting comments. P.137 says it is doubtful that the Katzie occupied any area along the banks of the Fraser River. This would certainly tie in with the fact that the present-day Katzie IR #2 was not a Katzie site in 1827.

NS41 Derby site [Snák^{w}aya]

Name: "--".

South bank. McKelvie [p. 93] says the bend in the river was known as *Slikwhinna* (Big Horn). The original Fort Langley site.

NS40 Kanaka creek site [Ts'elex^{w}á:yel]

10 U 530296 E, 5449744 N
North bank, 14.0 nautical miles above the North/South Arm split.

Name: "--".

Legends of Langley… p.137 says it was to this site that the Kwantlen at New Westminster moved after the founding of Fort Langley. This ties in well with several other reports I've seen and is undoubtedly true. Called Kanaka because the Hawaiians at the fort took Indian wives and were subsequently not allowed to stay in the fort. Seems like this site was probably unoccupied in Fraser's time, possibly de-populated in the 1780s along with NS41? (my speculation only).

Appendix B

DFO Avadepth current velocity tables. These are transverse averaged depth-averaged velocities in metres/second.

In the timeline, factors α and β have been used to convert the table figures to the surface velocities that would have been experienced by a canoe being steered to take advantage of the current, or to avoid its full force. These surface velocities have been converted to knots.

Predicted Water Levels & Velocities

For Jun 29, 2016 at 1 Hour Intervals
River Discharge @ Hope 5800 m³/s (User-defined)
taken to apply to July 2, 1808 after time adjustment

MAIN

PST	m/s	Location Port Mann to Mission												
	40	44	48	52	56	60	64	68	72	76	80	84	88	92
00:00	0.3	0.6	0.7	0.9	1.1	1.1	1.0	1.0	1.1	1.1	1.3	1.1	1.1	1.1
01:00	0.3	0.7	0.7	0.9	1.1	1.1	1.0	1.0	1.1	1.1	1.2	1.1	1.1	1.1
02:00	0.6	0.9	0.8	1.0	1.1	1.1	1.0	1.0	1.1	1.1	1.2	1.1	1.0	1.1
03:00	0.8	1.0	0.9	1.1	1.2	1.2	1.1	1.0	1.1	1.1	1.2	1.1	1.0	1.1
04:00	0.9	1.1	0.9	1.2	1.3	1.3	1.1	1.1	1.2	1.2	1.3	1.1	1.1	1.1
05:00	1.1	1.2	1.0	1.2	1.3	1.3	1.2	1.1	1.2	1.2	1.3	1.1	1.1	1.1
06:00	1.2	1.2	1.0	1.3	1.4	1.3	1.2	1.1	1.2	1.2	1.3	1.1	1.1	1.1
07:00	1.3	1.3	1.0	1.3	1.4	1.3	1.2	1.1	1.2	1.2	1.3	1.1	1.1	1.1
08:00	1.3	1.3	1.0	1.3	1.4	1.3	1.2	1.1	1.3	1.2	1.3	1.2	1.1	1.1
09:00	1.3	1.3	1.0	1.3	1.4	1.4	1.2	1.1	1.3	1.2	1.3	1.2	1.1	1.2
10:00	1.2	1.3	1.0	1.3	1.4	1.4	1.2	1.1	1.3	1.2	1.4	1.2	1.1	1.2
11:00	1.1	1.2	1.0	1.3	1.4	1.3	1.2	1.1	1.3	1.2	1.4	1.2	1.1	1.2
12:00	0.9	1.1	0.9	1.2	1.3	1.3	1.2	1.1	1.3	1.2	1.3	1.2	1.1	1.2
13:00	0.8	1.0	0.9	1.2	1.3	1.3	1.2	1.1	1.2	1.2	1.3	1.2	1.1	1.2
14:00	0.7	0.9	0.9	1.1	1.2	1.2	1.1	1.1	1.2	1.2	1.3	1.1	1.1	1.2
15:00	0.7	0.9	0.9	1.1	1.2	1.2	1.1	1.1	1.2	1.2	1.3	1.1	1.1	1.2
16:00	0.8	1.0	0.9	1.2	1.3	1.2	1.1	1.1	1.2	1.2	1.3	1.1	1.1	1.1
17:00	0.9	1.1	0.9	1.2	1.3	1.3	1.1	1.1	1.2	1.2	1.3	1.1	1.1	1.1
18:00	1.0	1.1	0.9	1.2	1.3	1.3	1.2	1.1	1.2	1.2	1.3	1.1	1.1	1.1
19:00	1.0	1.1	1.0	1.2	1.3	1.3	1.2	1.1	1.2	1.2	1.3	1.1	1.1	1.2
20:00	1.0	1.1	1.0	1.2	1.3	1.3	1.2	1.1	1.2	1.2	1.3	1.1	1.1	1.2
21:00	1.0	1.1	0.9	1.2	1.3	1.3	1.2	1.1	1.2	1.2	1.3	1.2	1.1	1.2
22:00	0.9	1.0	0.9	1.2	1.3	1.3	1.2	1.1	1.2	1.2	1.3	1.1	1.1	1.2
23:00	0.6	0.9	0.8	1.1	1.2	1.2	1.1	1.1	1.2	1.2	1.3	1.1	1.1	1.2
24:00	0.4	0.7	0.8	1.0	1.2	1.2	1.1	1.0	1.2	1.2	1.3	1.1	1.1	1.1

Predicted Water Levels & Velocities

For Jun 29, 2016 at 1 Hour Intervals

River Discharge @ Hope 5800 m³/s (User-defined)
taken to apply to July 2, 1808 after time adjustment

SOUTH ARM

PST	m/s	Location Sandheads to Port Mann																			
	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
00	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3
01	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4
02	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.7	0.6	0.6	0.6	0.6	0.8	0.5	0.6	0.6	0.6	0.7	0.6	0.6	0.6
03	0.9	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.8	1.0	0.7	0.8	0.9	0.8	0.9	0.8	0.8	0.8
04	1.3	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.3	0.9	1.0	1.1	1.1	1.1	1.0	1.0	1.0
05	1.5	1.5	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.1	1.5	1.0	1.2	1.3	1.2	1.3	1.2	1.1	1.1
06	1.6	1.6	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.3	1.4	1.3	1.6	1.1	1.3	1.4	1.4	1.4	1.3	1.3	1.3
07	1.5	1.5	1.3	1.4	1.4	1.4	1.4	1.4	1.5	1.4	1.4	1.3	1.7	1.2	1.4	1.5	1.5	1.5	1.4	1.4	1.3
08	1.2	1.2	1.1	1.3	1.3	1.3	1.4	1.3	1.4	1.3	1.4	1.3	1.6	1.2	1.4	1.5	1.5	1.5	1.4	1.4	1.4
09	0.8	0.8	0.8	1.1	1.1	1.1	1.2	1.2	1.3	1.2	1.3	1.2	1.5	1.1	1.3	1.5	1.4	1.5	1.4	1.4	1.3
10	0.4	0.4	0.5	0.7	0.7	0.8	1.0	1.0	1.1	1.1	1.1	1.1	1.4	1.0	1.2	1.4	1.3	1.4	1.3	1.3	1.3
11	0.1	0.1	0.2	0.4	0.4	0.5	0.7	0.7	0.8	0.8	0.9	0.9	1.1	0.9	1.0	1.2	1.2	1.2	1.2	1.2	1.2
12	0.0	0.0	0.1	0.3	0.3	0.3	0.5	0.5	0.5	0.6	0.6	0.6	0.9	0.6	0.8	0.9	1.0	1.0	1.0	1.0	1.0
13	0.2	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.8	0.5	0.7	0.8	0.8	0.8	0.8	0.8	0.8
14	0.3	0.3	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.8	0.6	0.7	0.8	0.8	0.8	0.8	0.7	0.8
15	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.9	0.6	0.7	0.8	0.8	0.8	0.8	0.8	0.8
16	0.7	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.0	0.7	0.8	0.9	0.9	0.9	0.9	0.8	0.9
17	0.8	0.8	0.7	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.1	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0
18	0.8	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0	0.9	1.2	0.9	1.0	1.1	1.1	1.1	1.1	1.0	1.0
19	0.7	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.2	0.9	1.0	1.1	1.1	1.2	1.1	1.1	1.1
20	0.5	0.5	0.6	0.7	0.7	0.7	0.8	0.9	0.9	0.9	0.9	0.9	1.2	0.8	1.0	1.1	1.1	1.2	1.1	1.1	1.1
21	0.2	0.2	0.3	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.8	0.8	1.0	0.7	0.9	1.0	1.0	1.1	1.0	1.0	1.0
22	0.0	0.0	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.8	0.6	0.7	0.8	0.8	0.9	0.9	0.9	0.9
23	-01	-01	0.0	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.5	0.4	0.5	0.6	0.6	0.7	0.6	0.7	0.7
24	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.5

Predicted Water Levels & Velocities

For Jun 29, 2016 at 1 Hour Intervals
River Discharge @ Hope 5800 m³/s (User-defined)
taken to apply to July 2, 1808 after time adjustment

NORTH ARM

PST	m/s	Location Point Grey to New Westminster															
	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
00:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
01:00	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.3
02:00	0.1	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.5	0.6	0.5	0.5
03:00	0.1	0.6	0.7	0.7	0.6	0.6	0.6	0.5	0.7	0.6	0.6	0.5	0.6	0.8	0.7	0.7
04:00	0.1	0.8	0.8	0.8	0.8	0.8	0.8	0.6	0.8	0.7	0.7	0.6	0.7	0.9	0.8	0.8
05:00	0.2	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.9	0.8	0.7	0.7	0.8	0.9	0.9	0.9
06:00	0.1	0.9	0.9	1.0	0.9	0.9	0.9	0.7	0.9	0.8	0.8	0.8	0.9	1.0	1.0	1.0
07:00	0.1	0.8	0.8	0.9	0.9	0.9	0.9	0.7	0.9	0.8	0.8	0.8	0.9	1.1	1.1	1.0
08:00	0.1	0.6	0.6	0.7	0.7	0.8	0.8	0.6	0.9	0.8	0.8	0.8	0.9	1.1	1.1	1.0
09:00	0.0	0.4	0.4	0.5	0.6	0.6	0.6	0.5	0.8	0.7	0.7	0.7	0.9	1.0	1.0	1.0
10:00	0.0	0.1	0.2	0.3	0.3	0.4	0.4	0.4	0.7	0.6	0.7	0.7	0.8	1.0	1.0	1.0
11:00	-0.0	-0.0	-0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.5	0.5	0.5	0.7	0.8	0.9	0.9
12:00	-0.0	-0.1	-0.0	-0.0	0.0	0.0	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.7	0.7	0.7
13:00	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.3	0.3	0.3	0.4	0.6	0.6	0.6
14:00	0.0	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.6	0.6	0.6
15:00	0.1	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.4	0.5	0.6	0.6	0.6
16:00	0.1	0.4	0.5	0.5	0.5	0.5	0.5	0.4	0.6	0.5	0.5	0.5	0.6	0.7	0.7	0.7
17:00	0.1	0.5	0.5	0.6	0.6	0.6	0.6	0.5	0.7	0.6	0.6	0.6	0.6	0.8	0.7	0.7
18:00	0.1	0.5	0.5	0.6	0.6	0.6	0.6	0.5	0.7	0.6	0.6	0.6	0.7	0.8	0.8	0.8
19:00	0.1	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.7	0.6	0.6	0.6	0.7	0.9	0.9	0.9
20:00	0.0	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.6	0.6	0.6	0.6	0.7	0.9	0.8	0.9
21:00	-0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.5	0.6	0.8	0.8	0.8
22:00	-0.0	-0.1	-0.1	-0.1	-0.0	0.0	0.1	0.1	0.3	0.3	0.3	0.3	0.4	0.6	0.6	0.7
23:00	-0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.4
24:00	-0.0	-0.1	-0.0	-0.0	-0.0	-0.0	-0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2

Predicted Water Levels & Velocities

For Jun 30, 2016 at 1 Hour Intervals

River Discharge @ Hope 5800 m³/s (User-defined)
taken to apply to July 3, 1808 after time adjustment

MAIN

PST	m/s	Location Port Mann to Mission												
	40	44	48	52	56	60	64	68	72	76	80	84	88	92
00:00	0.4	0.7	0.8	1.0	1.2	1.2	1.1	1.0	1.2	1.2	1.3	1.1	1.1	1.1
01:00	0.3	0.7	0.7	1.0	1.1	1.1	1.0	1.0	1.1	1.1	1.3	1.1	1.1	1.1
02:00	0.4	0.8	0.7	1.0	1.1	1.1	1.0	1.0	1.1	1.1	1.2	1.1	1.1	1.1
03:00	0.6	0.9	0.8	1.1	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.1	1.0	1.1
04:00	0.8	1.0	0.9	1.2	1.3	1.2	1.1	1.0	1.2	1.1	1.2	1.1	1.1	1.1
05:00	1.0	1.1	0.9	1.2	1.3	1.3	1.1	1.1	1.2	1.2	1.3	1.1	1.1	1.1
06:00	1.2	1.2	1.0	1.2	1.3	1.3	1.2	1.1	1.2	1.2	1.3	1.1	1.1	1.1
07:00	1.3	1.3	1.0	1.3	1.4	1.3	1.2	1.1	1.2	1.2	1.3	1.1	1.1	1.1
08:00	1.3	1.3	1.0	1.3	1.4	1.3	1.2	1.1	1.2	1.2	1.3	1.1	1.1	1.1
09:00	1.3	1.4	1.0	1.3	1.4	1.4	1.2	1.1	1.3	1.2	1.3	1.2	1.1	1.2
10:00	1.3	1.4	1.0	1.3	1.4	1.4	1.2	1.1	1.3	1.2	1.4	1.2	1.1	1.2
11:00	1.2	1.3	1.0	1.3	1.4	1.4	1.2	1.1	1.3	1.2	1.4	1.2	1.1	1.2
12:00	1.1	1.2	1.0	1.3	1.4	1.3	1.2	1.1	1.3	1.2	1.4	1.2	1.1	1.2
13:00	0.9	1.1	0.9	1.2	1.3	1.3	1.2	1.1	1.3	1.2	1.4	1.2	1.1	1.2
14:00	0.7	0.9	0.8	1.1	1.3	1.2	1.2	1.1	1.2	1.2	1.3	1.2	1.1	1.2
15:00	0.6	0.8	0.8	1.1	1.2	1.2	1.1	1.1	1.2	1.2	1.3	1.1	1.1	1.2
16:00	0.6	0.9	0.8	1.1	1.2	1.2	1.1	1.0	1.2	1.2	1.3	1.1	1.1	1.1
17:00	0.7	0.9	0.9	1.1	1.2	1.2	1.1	1.0	1.2	1.2	1.3	1.1	1.1	1.1
18:00	0.8	1.0	0.9	1.2	1.3	1.2	1.1	1.1	1.2	1.2	1.3	1.1	1.1	1.1
19:00	0.9	1.1	0.9	1.2	1.3	1.3	1.1	1.1	1.2	1.2	1.3	1.1	1.1	1.1
20:00	1.0	1.1	0.9	1.2	1.3	1.3	1.2	1.1	1.2	1.2	1.3	1.1	1.1	1.1
21:00	1.0	1.1	0.9	1.2	1.3	1.3	1.2	1.1	1.2	1.2	1.3	1.1	1.1	1.1
22:00	1.0	1.1	0.9	1.2	1.3	1.3	1.2	1.1	1.2	1.2	1.3	1.1	1.1	1.2
23:00	0.8	1.0	0.9	1.2	1.3	1.3	1.1	1.1	1.2	1.2	1.3	1.1	1.1	1.2
24:00	0.7	0.9	0.8	1.1	1.3	1.2	1.1	1.1	1.2	1.2	1.3	1.2	1.1	1.2

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