memorandum

to: Joe Donohue, Project Coordinator
Department of Natural Resources
Division of Coastal and Ocean Management

Jackie Timothy, Habitat Biologist
Department of Natural Resources
Office of Habitat Management and Permitting

from: Tim Davies,
Manager, Environmental and Regulatory Affairs
Redfern Resources Ltd.

date: 25 June, 2008

ref: 82647

re: **Tulsequah Chief Mine – Proposed Air Cushion Barge Transportation System**
State Request for Additional Information dated February 14th 2008

Request for Additional Information

The State of Alaska has requested certain additional information related to the proposed Air Cushion Barge transportation system in its letter to Redfern Resources dated February 14, 2008. The purpose of the State's letter was to inform Redfern that portions of the Company's response to the original RFAI (dated December 21, 2007) were inadequate, and that the State is requesting additional information to satisfy the original request. This memorandum provides Redfern's response to these additional requests for information in order to satisfy the information requirements for permitting of this project. It is understood that the project is being reviewed for consistency with the ACMP against the Habitats and Transportation Standards, specifically 11 AAC 112.300 Habitats, and 11AAC 112.280 Transportation Routes and Facilities.

Shortly after the February 14th RFAI was received, Redfern proposed a modification to the project and operations plan. Briefly, the modification involved replacement of the amphitrac tow vessel with amphibious tractors similar to the tracked or wheeled vehicles used on Alaska's north slope (Rolligon, CAVs, and similar vehicles). These vehicles would replace the amphitrac for winter operations. The aquatic operations would remain unchanged, and use shallow-draft tugs as the tow vessel for the ACB. The proposed modification to the original Project Description and Operations Plan is described in detail in Attachment 1, *Air Cushion Barge Transportation System Update, June 2008 (the System Update).*

The responses to the RFAI are set out below. Where applicable, information that was requested regarding the amphitrac has been replaced with comparable information pertaining to the modified equipment and/or operations.

1. *The gross tonnage of the amphitrac is required to complete the review of the proposed transportation plan*.

   The specifications of the proposed equipment are included in the *System Update*. The gross tonnage of the vehicles is as follows (amphitrac is included for comparison purposes only):

Vehicle Type	Gross Tonnage
Tracked Articulated Vehicle	32187 lbs (14.6 tonnes)
Rolligon 4x4 – wheeled	27999 lbs (12.7 tonnes)
Ancillary Vehicles: Hagglunds BV-206	14330 lbs. (6.5 tonnes)
Amphitrac	136,686 lbs (62 tonnes)

2. *Redfern will test the footprint of both the amphitrac and ACB, the wake from the ACB at various distances and speeds, underwater and above surface noise of the amphitrac and ACB at various distances and hover heights, the wind effect under the ACB as it moves from water onto land, and the effect of the ACB keel. Please provide the methods the third-party contractor will use to gather this data. Additionally, please provide the methods the third-party contractor will use to determine the disturbance below the amphitrac and ACB in the water column, the disturbance caused by the Archimedes screws and retractable metal wheels in silt, mud, sand, gravel and cobble, and the disturbance caused in silt, mud, sand, gravel and cobble by anchoring the amphitrac to winch a fully loaded ACB out of the water and onto the land.*

   Commissioning Tests for the ACB:
   In January and February 2008, Redfern engaged Offshore Research Ltd. to attend the test lift and trials of the ACB *Siberian* at Port Glasgow, on the Clyde River in Scotland. Observations and measurements were taken during the tow from the ship builder's yard to Holy Loch, Scotland, where further trials were performed. The *Siberian* is similar to the ACB purchased by Redfern (the *Monty*). While the *Siberian* is smaller than the Monty (200 tonne payload) the performance of the *Siberian* during its commissioning in Scotland provided very useful data. Given the very similar design features of the two ACBs, the performance of the *Siberian* demonstrates that the ACB (*Monty*) will perform comparably under similar conditions. Unfortunately, poor weather conditions during commissioning delayed empirical measurement of wave and wake, although visual observations obtained during these trials indicated minimal wake generated while under tow.

Above Water Noise:
The following tables provide measurements of sound obtained during the commissioning of the *Siberian*.

Siberian: Above Water Noise Level Measurement

Distance (m)	Noise (dBA)
Ambient	68
0	110
1	98
5	98
10	97
20	95
30	90

The most significant source of the noise was from the intake of air into the lift fans, which registered at 110 dBA on deck directly in front of the intake. The level diminished to 90 dBA on shore at a distance of 30m. The *Siberian* was not equipped with sound mufflers, and did not have all the panels housing the engines installed at the time.

The *Monty* will have mufflers surrounding the lift fans, as well as housing around each engine to reduce sound levels. The *Monty* will be tested on the Columbia River to ensure that the 70dB specification is achieved as stated.

Underwater Noise:

Siberian: Underwater Noise Level Measurement

Condition	Depth (m)	Noise (dBA)
	Ambient	-12
On hover	0	8
On Hover	3	5
Off Hover	0	-5
Off Hover	3	-8

Underwater noise level measurement was taken during towing from the shipyard to Holy Lock. On hover and stationary, the noise level was measured as 8 dBA immediately below the surface, and 5 dBA 3meters below the water surface. Off hover, with all generators running, - 5dBA was recorded.

No further tests are warranted on the *Monty* as the results from the *Siberian* tests are considered to be indicative of underwater noise levels anticipated for the Monty.

Footprint:
The footprint of the *Siberian*, on full hover, was measured at 0.65 psi, and left no impression on the mud substrate during the towing exercises. Observations taken at that time showed that the air escaping from the skirt was not strong enough to displace most light objects nearby, such as small sticks. The *Monty* is designed for 1psi ground pressure, on full hover, so it is reasonable to conclude that its footprint on comparable substrates (mud, sand) will be very similar to the Siberian.

Tests on the Columbia River or at another site near Juneau will be performed for the *Monty* to confirm its ground pressure. These tests will confirm the ACB ground pressure on full hover and off hover, and will photographically record the impression left on substrate(s) at that time. During this time, it will also be possible to test the effectiveness of the keel wheel on the ACB.

The design objectives for the replacement tow vehicles have been selected to achieve similar or better design specifications than the amphitrac – in this case, a low ground pressure of < 5psi.

Type of Vehicle	Ground Pressure Specification (manufacturer)
Tracked Articulated Vehicle	2.75 psi
Rolligon 4x4 – wheeled	3.16 psi
Ancillary Vehicles: Hagglunds BV-206	1.97 psi
Amphitrac	2-5 psi

Wake:
As mentioned above, it was only possible to observe the wake of the ACB *Siberian* under tow at 4 knots, in relatively calm water as it left the shipbuilders yard. The wake under these conditions was negligible as can be seen from the photograph(s) below. Further out in the river channel, the rough sea state made it impossible to obtain measurements of wake while under tow, and the wake was not visible due to rough sea state.

The measurement of the ACB wake while under tow, at various speeds and hover heights, will be performed on the Columbia River or another site, using a conventional tug as the tow vessel for the ACB. Wave heights will be recorded, using a measuring stick fixed onshore, by a camera mounted on a tripod. As the ACB passes the fixed point, wave heights will be recorded, under various speeds and hover heights, at distances of 50 and 100 m. The water depth will also be recorded.

ACB Siberian – View of Wake from Stern of ACB, January 2008

Sedimentation:
The potential for sedimentation as the ACB transitions between water and land will be assessed during the tests on the Columbia River, assuming that a suitable site for carrying out such tests can be confirmed. Alternative test sites closer to Juneau will also be identified should the Columbia River not be suitable. These observations and measurements will be carried out for the ACB on hover, with and without the keel wheel engaged.

At the start of operations in the fall/winter of 2008, observations of sedimentation, particularly in areas of finer substrate (sand and silt/mud), will be made and recorded photographically. A turbidity meter will record change in turbidity (background; and after the ACB transitions between water and land). In Alaska, there are up to 16 channel crossings (generally perpendicular to the channel) that may be required during early winter operations (see Attachment 1 as shown on *Updated Barge Route Atlas June 2008*). Observations and measurements of sedimentation at up to 10 of these crossings will be performed during initial operations (2008). This information will be used to determine the potential for sedimentation in specific substrate types,

The potential disturbance caused to the water column as the ACB and amphitrac moves from the water onto land, and the associated potential effect on juvenile rearing and spawning habitat will be carried out before and during the first year of operations on the Taku River. This purpose of this monitoring is to assess any sedimentation effects that may increase turbidity within juvenile salmonid habitat and/or deposit silt/sand on spawning habitat areas near the thalweg during low-flow transitional seasons (fall and early spring). The methods will include monitoring at approximately 17 juvenile rearing sites and potential spawning habitat areas (upwelling zones) near the thalweg. These sites will be visited three times: firstly to determine the presence of juvenile salmonids and potential spawning habitat prior to operating the ACB (early spring assessment); and twice during the fall to observe any sedimentation effects as the ACB system passes these sites (fall operational monitoring). Turbidity will be recorded before, during and after the ACB passes by, using a turbidity meter. In addition, observations will be recorded with photographs, and the information transferred onto maps showing the sites where observations were made.

It is understood that if the ACB and tow vehicles meet the specification standards as stated by the manufacturers, then the impacts to resources can be minimized or avoided. The manufacturer's specifications for the modified equipment, to be used during winter (non-aquatic operations) have been described in the *System Update June 2008*. The specifications for the ACB were provided in previous documents (*Volume 1: Project Description*). Redfern will ensure that a third-party will confirm the manufacturers' specifications are met prior to commencing operations on the Taku River. These performance tests will be carried out either at the Columbia River shipyard, or on gravel bars off Sheep Creek south of Juneau, or alternatively, north of Juneau at Eagle River

beach. Results of these tests will be summarized and provided to Alaskan regulatory authorities.

3. *Please provide the missing Appendix B referenced in Volume 2.*

The Appendix B referenced on page 4-28 and page 5-33 of Volume 2 refers to the *Wildlife Management Plan*. This Plan was provided to you on February 12, 2008. An updated version of the WMP has recently been provided *(Wildlife Management Plan: Mitigation Policies and Procedures May 2008)*

4. *The Taku mainstem channel profile was included as Attachment 2. Although this additional information is valuable, it does not clearly address the wetted width of the thalweg above the sand flats area during low flow periods or transition seasons. ….Interpretation of this data indicates that during low flow periods, there will be additional ground contact above the sand flats area as far upriver as Yehring Creek.*

The data that was obtained along the mainstem in summer 2007 has been further reduced to low flow. The results of this analysis are summarized in Attachment 2 (*Updated Taku River Mainstem Channel Profile April 2008)*. The results of this analysis confirms the presence of a continuous channel upstream of the tidal flats with depth adequate for the operation of shallow draft tug and ACB during the aquatic season at flows greater than 17, 660 cfs. As flows approach 8830 cfs, there appear to be two areas upstream of the tidal flats where there may be additional constraints to navigation, due to the shallowness of the channel. These areas will be surveyed in detail in spring 2008 to confirm the depth and width of the channel. The evidence presented by the successful river barging completed in summer 2007 at flows as low as 9160 cfs supports this conclusion.

5. *Response is adequate.*

6. *Please include wildlife habitat on this map based on the information exchanged with the State to this point, the additional information you will be submitted with the wildlife management plan and the additional information you are providing in the supplemental wildlife surveys. For information regarding marine mammals, please consult…. Erika Phillips, or Aleria Jensen.*

The *Detailed Wildlife Effects Assessment Report* has been provided. This report includes 35 maps showing wildlife habitat for various species. Additional wildlife information that is gathered during the wildlife monitoring programs will be included on updated maps as the monitoring results are compiled and reported on.

Gartner Lee has contacted E. Phillips at NOAA to obtain spatial information on marine mammals in the vicinity of the project. Additional marine mammals investigations were

carried out in April 2008, by GLL wildlife biologists and Ms. L. Flores. The results of both field observations will be compiled into a field report to be provided to regulators.

7. *Response is adequate at this time. Redfern will need to provide the species specific protocol the Environmental Monitor will follow when mapping fish and wildlife resources and habitats to OHMP before the Fish Habitat Permit is issued.*

   Noted.

8. *Response is adequate at this time. It is our understanding that the third-party contractor will evaluate potential impacts to rearing fish, specifically stranding and entrainment. Redfern will need to provide the specific protocol the Environmental Monitor will follow when monitoring fish and wildlife resources and habitats to OHMP before the Fish Habitat Permit is issued.*

   As mentioned in the response to the original RFAI, a biologist will identify potential areas of stranding and observe these specific areas during the first operating season. Specifically, the purpose of this monitoring is to assess and monitor any wake effects during the aquatic season that may strand juvenile salmonids along habitat areas near the thalweg during low-flow transitional seasons (spring and fall). The assessment will also monitor juvenile salmon entrainment that may occur when the ACB transitions from water to land (at Canyon Island). During the 2008 conventional barging of construction equipment and supplies to the project site, an assessment of potential stranding sites and stranding rates will be carried out. Approximately 17 sites will be identified that are potential juvenile rearing habitats near the thalweg, as described under Question #2 above. These sites will be visited three times – to determine the presence of juvenile salmonids prior to the start of conventional barging (spring), and twice during the fall transition season to observe and record any stranding and/or entrainment as the barge and river tug passes these sites. A report outlining the results of this work will be prepared prior to end of year 2008. The results of this study will be used to develop any specific operational procedures required to reduce effects, should this be necessary.

9. *Response is adequate at this time.*

10. *Response is adequate at this time. Please be advised that ground contact in areas of salmon or eulachon spawning will be considered an incident. Reporting requirements for fish and wildlife incidents may be included as a condition of the Fish Habitat Permit.*

    It is Redfern's intention to ensure that the crew maintain a daily log of every trip on the river. This log will include incidents such as grounding (including the specific location, discharge (as recorded on gauge at Canyon Island), speed/direction of travel, time of incident and

other relevant factors). Incident reporting forms for wildlife have been included in the Wildlife Management Plan.

11. *Response is adequate.*

12. *Please provide the Wildlife Right-of-Way Policy.*
This policy is included in the Wildlife Management Plan.

13. *Require the Wildlife Management Plan before response is considered to be complete.*
The Wildlife Management Plan was provided to you on February 12, 2008. An updated version of the WMP has recently been provided *(Wildlife Management Plan: Mitigation Policies and Procedures May 2008)*

14. *Require the Wildlife Management Plan*
See above regarding this Plan.

15. *Response is adequate*.

16. *How would Redfern avoid aggregations of marine mammals? Our expectation is that Redfern will provide a thorough and detailed explanation of what the potential conflicts are with each species of concern and how they propose to avoid, minimize, or mitigate these impacts in the Wildlife Management Plan.*

On March 28, 2008 NOAA provided Redfern with additional information on marine mammals that would likely be present along the barge route. Much of the information was from sources not readily available including personal communication from staff with NMFS in Alaska. Redfern is also in the process of collecting and analyzing data on marine mammals, including spring surveys of harbour seals and marine mammal activity around the time of eulachon spawning.

Species of concern include: Steller sea lions, and Humpback whales, both ESA Listed species and reported in Gastineau Channel, Stephens Passage and Taku inlet. MMPA protected species include harbour seals, harbour seals, Dall's porpoise and Killer whales. Fin whales have been reported in Gastineau Channel but are uncommon in this area. The following measures where provided by in the letter from NOAA for minimizing the potential for a take:

- Remain at least 100 yards from marine mammals in the water
- Use extra caution when approaching seals and sea lions that are on land or ice, as harassment may occur at distances greater than 100 yards;
- Wherever possible, limit ACB operation to middle of the river/inlet channel to minimize disturbance of resting animals along the river's edge;

- Whet the river is ice-free, avoid operation of the ACB in close proximity to gravel bar habitats near documented marine mammal haulout;
- When several vessels are in the area, communication between vessel operators may reduce the potential for disturbance and marine mammal collision;
- Employ adaptive management techniques to minimize the likelihood of disturbance and promote long-term prevention of takes. This might include: visual surveys to identify common haulout locations and foraging areas; long-term monitoring (over multiple years) or established haulouts to ensure that the number of animals using a site doesn't decline dramatically over time; and modification of the established ACB route as needed to minimize disturbance and prevent take.

Redfern has initiated the collection of additional marine mammal data around eulachon spawning time, a time when marine mammal activity in the area might be at a peak and the navigation route most constrained by low water levels at the mouth of the Taku River. The results of this work will be used in the context of the proposed adaptive management program to define the least risk route for the ACB.

As noted earlier, Gartner Lee has been in contact with NOAA staff to obtain spatial information on marine mammals in the area of operations. Unfortunately, no spatial information has yet been provided. Redfern completed a spring survey (late March) to identify harbour seal aggregation areas at the mouth of the Taku River. Additional surveys have been carried out during the eulachon migration (April) to identify the location(s) of congregations of seals and/or any sea lions in Taku Inlet and at the mouth of the river. Information collected during these surveys will be mapped, and integrated into appropriate operating procedures for avoiding, or minimizing disturbance of aggregations of marine mammals during these times. The Wildlife Right-of-Way Policy outlined in the Wildlife Management Plan is to maintain a minimum of 100 m (~ 130 yards) from seal haul-outs, rafting seals and sea lions and any aggregations of whales or other marine mammals.

17. *Response is adequate. OHMP may require Redfern to monitor ice stability as a condition of the Fish Habitat Permit.*
Noted.

18. *Please provide the methods the Environmental Monitor will use to monitor channelization, siltation and sedimentation, wake height and bank erosion attributable to the amphitrac and ACB in the Taku River. Specifically, provide a suggested protocol for measuring potential impacts to spawning habitats on the east side of Canyon Island.*

In response #2, the specific methods proposed to monitor and measure potential sedimentation and associated potential impacts to salmonid spawning and rearing habitats are described. The east channel at Canyon Island would be included as one of the sites that would be monitored.

A detailed site investigation of spawning habitat and spawning activity at Canyon Island was completed in early spring, 2008. The results of the spring investigation are illustrated on Figure 1 that show a ACB route along the east channel of Canyon Island that avoids all known spawning habitat. Further investigations in the late fall 2008 will be carried out to identify fall spawning activity around Canyon Island. The results of both surveys will be compiled and made available at that time. During initial operations, monitoring sedimentation at this site as well as behaviour of adult salmon as the ACB passes through this area will be carried out.

The wake height and potential bank erosion attributable to the ACB/tug system will be monitored by establishing pins along shore during low flows, at sensitive locations where the ACB route is close to shore and bank erosion has been previously identified (e.g. Martini Row). The condition and location of the bank would be documented prior to and after spring freshet, and on several occasions immediately after the ACB passes the shore during the remainder of the aquatic barging season. These observations will identify if, and the extent to which, wake during operations has any measurable effect on bank erosion. It should be noted that during the aquatic season, the ACB would be towed by a conventional shallow draft tug. An amphibious tractor will be used to shuttle the ACB over land at Canyon Island.

19. *Response is adequate. Fish Habitat Permit may specify reporting requirements for the removal of large woody debris that poses a risk to life or property.*
Noted.

20. *Response is adequate. The State will meet with Redfern quarterly the first year, and yearly thereafter. The State will approve changes to the Operations Plan.*
Noted.

21. *Response is adequate.*

22. *Please elaborate on your conclusion that glacial outburst floods will not affect the operation of the barging system in any significant way.*

Glacial outburst floods are short-term events, of varying magnitude. These occurrences have been recorded since 1932, with the majority occurring between late July and September. Typically, the flow as measured at the gauge at Canyon Island doubles or triples for a 2-3 day period. As the operations during this time would be aquatic involving the use of conventional shallow-draft tug and the ACB, the increased velocity for a short duration as the flood passes through the system may impose a temporary suspension of operations. These floods would also result in more debris swept into the river at that time. Temporary delays in operations are factored into the annual barging schedule, and as such, suspension of operations, should it be necessary during such events, is not expected to

Date Revised: November 22, 2006 Revision: 0
Date Plotted: November 22, 2006 File Location: E:\GIS\GIS_admin\templates\06kNov10_Bby_CorporateStandard\Bby-24x36_portrait.mxd

Gartner Lee Limited

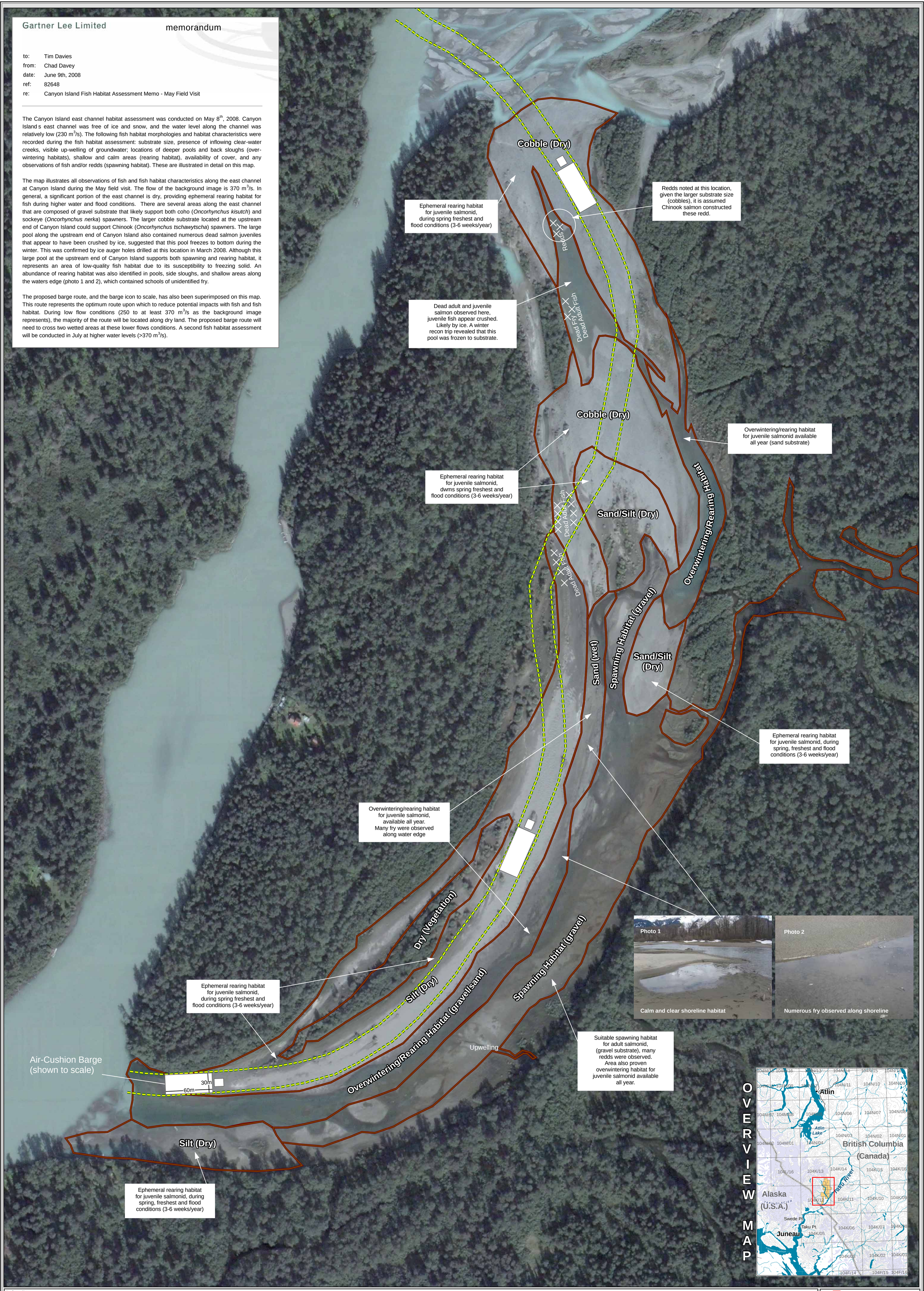
memorandum

to: Tim Davies
from: Chad Davey
date: June 9th, 2008
ref: 82648
re: Canyon Island Fish Habitat Assessment Memo - May Field Visit

The Canyon Island east channel habitat assessment was conducted on May 8th, 2008. Canyon Island s east channel was free of ice and snow, and the water level along the channel was relatively low (230 m^3/s). The following fish habitat morphologies and habitat characteristics were recorded during the fish habitat assessment: substrate size, presence of inflowing clear-water creeks, visible up-welling of groundwater; locations of deeper pools and back sloughs (over-wintering habitats), shallow and calm areas (rearing habitat), availability of cover, and any observations of fish and/or redds (spawning habitat). These are illustrated in detail on this map.

The map illustrates all observations of fish and fish habitat characteristics along the east channel at Canyon Island during the May field visit. The flow of the background image is 370 m^3/s. In general, a significant portion of the east channel is dry, providing ephemeral rearing habitat for fish during higher water and flood conditions. There are several areas along the east channel that are composed of gravel substrate that likely support both coho (*Oncorhynchus kisutch*) and sockeye (*Oncorhynchus nerka*) spawners. The larger cobble substrate located at the upstream end of Canyon Island could support Chinook (*Oncorhynchus tschawytscha*) spawners. The large pool along the upstream end of Canyon Island also contained numerous dead salmon juveniles that appear to have been crushed by ice, suggested that this pool freezes to bottom during the winter. This was confirmed by ice auger holes drilled at this location in March 2008. Although this large pool at the upstream end of Canyon Island supports both spawning and rearing habitat, it represents an area of low-quality fish habitat due to its susceptibility to freezing solid. An abundance of rearing habitat was also identified in pools, side sloughs, and shallow areas along the waters edge (photo 1 and 2), which contained schools of unidentified fry.

The proposed barge route, and the barge icon to scale, has also been superimposed on this map. This route represents the optimum route upon which to reduce potential impacts with fish and fish habitat. During low flow conditions (250 to at least 370 m^3/s as the background image represents), the majority of the route will be located along dry land. The proposed barge route will need to cross two wetted areas at these lower flows conditions. A second fish habitat assessment will be conducted in July at higher water levels (>370 m^3/s).



Map Sources/Notes:

1:2,000
UTM Zone 12N, NAD 83

File Name: 82648_CanyonIsland_rh_v1_12May2008
Reviewed By: Prepared By: RH
Date Issued: May 2008 Project Number: 82648

CANYON ISLAND
Fish Habitat Assessment

Legend
Proposed ACB Route

Flow of image is 370 m^3/s
Flow during assessment is 230 m^3/s

Redfern Resources Ltd.

Canyon Island
Fish Habitat Assessment

Gartner Lee

affect the annual barge operations to any significant extent. Given that the mine site itself is located along the Tulsequah River, the first sign of such events would be at the upstream end of barge operations, and this would provide a certain amount of time to adjust operations (delay barging).

23. *Please provide a detailed breakdown of potential costs considering the effects of these conditions of the potential expense of a theoretical salvage effort, along with a revised proposed bond amount based on this analysis.*

Counterspil Research Ltd of North Vancouver (Counterspil) was contracted to conduct an analysis of costs (USD) associated with a spill response and review legal implications of salvage. It appears from the memorandum that a salvage cost of $600 per gross ton of a vessel or $500,000, whichever is greater, is the maximum amount. In the case here the ACB vessel has an approximate gross weight of 495 tons. Therefore the associated bond amount required according to the Oil Pollution Act of 1990 (OPA-90) would be $300,000 when calculated, but defaults to the greater amount of $500,000 USD.

Further, the Counterspil report considered costs for a spill response. The maximum cost calculated was $417,008 USD. This indicates that a maximum bond of $500,000 would be sufficient for either salvage or spill response, and a full salvage combined with a partial spill.

The Counterspil report is located in Attachment 3.

Memorandum
25 June 2008

Attachment 1

Air Cushion Barge Transportation System Update

June 2008

Air Cushion Barge Transportation System Update June 2008

Tulsequah Chief Mine Project

Redfern Resources Ltd.
Suite 800 – 1281 W. Georgia Street
Vancouver, BC V6E 3J7

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Appendices

Appendix A - Taku River Barging: Route Atlas

Appendix B – Canyon Island: Aquatic and Non-Aquatic Season Routes

Introduction

1.1 Purpose

To follow development of process and operations along the Taku River, the need for an update and explanation of the Air Cushion Barge (ACB) Transport System- Operations Plan has been identified.

This document is issued to clarify and update the operations and activities described previously in the release of the document "Tulsequah Chief Mine, Air Cushion Barge Transportation System: Operations Plan" in November of 2007. It focuses on the operating plan for the coming non-aquatic 2008/2009 season (fall 2008 to spring 2009), with a preliminary discussion of anticipated changes to the haulage systems for full production beginning in the fall of 2009.

1.2 Defining the Change

In September of 2007, Redfern commissioned Hovertrans Air Cushion Systems to design and construct an amphibious tow vehicle called the "Amphitrac" to tow or push an Air Cushion Barge (ACB) between the barge landing site and Juneau, AK. It was a concept vehicle that was being custom designed and built specifically for this application.

It soon became apparent that the Amphitrac would not perform as well as conventional marine and river tugs for aquatic season operations; this was due in large part to a predictable lack of towing capability, or bollard pull provided by the Amphitrac's Archimedes screws when traveling in water. For this reason, the decision was made to adopt conventional towing vessels –marine tugs to tow the ACB from Taku Inlet to Juneau; and shallow-draft river tugs to tow the ACB along the Taku River during the aquatic season.

The use of the Amphitrac, therefore, was limited to largely non-aquatic amphibious operations during the winter and the shoulder seasons (fall and spring) when there would be insufficient flow for shallow-draft tugs to operate in the river.

As a result of this reduced role, Redfern began a thorough investigation and evaluation of what existing units could be used in place of the Amphitrac, yet maintain the same or better operating criteria as had been previously set forth. This exercise led to the discovery of numerous options that were considered more suited to the task. Accordingly, Redfern has suspended work on the Amphitrac and is proposing to utilize currently available, proven Amphibious Tractors (ATs) for the ACB transportation system. These tractors would essentially operate overland, and snow and ice during the winter season. The aquatic capability of these vehicles would be limited to crossing open leads during the winter, and crossing the main river channel between gravel bars during the shoulder season.

This document defines the vehicles that are being proposed as replacements to the Amphitrac and discusses how they would be operated on the river during the coming 2008/2009 non-aquatic season.

Four operational seasons (based on streamflow, or winter conditions) are defined as follows:

1. Transitional Period in Spring; aquatic operations at flows between approximately 250 – 500 m^3/s
2. Summer; aquatic operations at flows > 500 m^3/s; flows above this level will not require tidal assist to navigate the shallowest sections of the tidal flats in Alaska
3. Transitional Period in Fall; aquatic operations at flows between 500 – 250 m^3/s
4. Winter tractor operations travelling largely over frozen surfaces, primarily over snow/ice covered gravel bars. The operational objective is to identify a route that avoids crossing open water, as much as possible. For the purposes of this Operations Plan, winter has been defined by all of the following conditions on the river being met:
   - In Canada, no more than 9 open water crossings, generally perpendicular to the channel
   - In Alaska, no more than 16 open water crossings, generally perpendicular to the channel
   - Where there are long sections where gravel bars are few and far between and the route must follow the thalweg, there must be sufficient ice thickness along the edge of the channel to support operations. If not, operations would be suspended.

1.3 Operating Criteria

The vehicles selected for this application have been chosen to keep within the originally proposed low impact design and operation of the Amphitrac. Accordingly, all vehicles will conform to project requirements as follows:

- Produce “low ground-pressure”, less than 5psi
- Emit noise no higher than 75dB A at 100 feet
- Be amphibious – float in open water with limited self-propulsion
- Produce maximum towing force
- Be highly mobile
- Come equipped for self-recovery

As these vehicles are existing and real, and have documented performance specifications.

2. Equipment

Redfern's updated operating plan is based on two different AT vehicles, one with rubber tracks and one with low ground pressure soft rubber tires.

1. The tracked vehicle selected is the Tracked Articulated Vehicle (TAV), manufactured by ST Kinetics.

2. There are numerous manufacturers of similar low ground pressure soft flotation tire vehicles that are suitable for our application, such as Rolligon, ARDCO, Formost, or Marcep. These vehicles are referred to in this Plan as "Rolligons".

The updated transportation system proposes to use two TAVs forward of the ACB to tow, and two Rolligons behind for steering and braking control. We will rotate the vehicles' positions to determine the ideal towing configuration. A fifth vehicle, a Hagglunds BV206 will be used to scout the route ahead of the barge and for crew changes.

2.1 TAV – rubber tracked AT

Two TAVs will be used in front of the ACB to tow it and steer the bow as shown in Figure 1.

The TAV is a rubber tracked amphibious vehicle that is manufactured by ST Kinetics, a Singapore-based company with a branch office in Aldergrove, BC. It is a two-pod vehicle that is connected by a joint and articulates in both vertical and horizontal planes. The TAV is a rugged unit that will operate in nearly all terrain including ice and snow. As both pods are water-tight, it will float in open water with a draft of approximately 1.5m (5 ft). Its propulsion in water is limited, coming only from the tracks. There are no modifications anticipated to the tracks to increase traction.

A single operator is required, but the unit has room for an additional five passengers, all located in the front unit. The rear unit's typical use is for modularized cargo placement. Both front and rear pods float.

The vehicle specifications are as follows:

- Drive: Four Moulded Rubber Track
- Ground Pressure: 19kPa (2.75psi)
- Vehicle Weight: 14.6 tonnes (32187 lbs)
- Power: 223kW CAT diesel (300hp)
- Draw Bar Pull: 7.3 tonnes (16094 lbs)
- Length: 8.6m (28.2ft)
- Width: 2.3m (7.5ft)
- Height: 2.5m (8.2ft)
- Maximum Speed: 60km/h (38mph)
- In-Land Water Speed: 4km/h (2.5mph)
- Average Cross-Country Speed: 30km/h (18mph)
- Range: 500km (310miles); 4.6 round trips
- Steering Type: Hydrostatic, Articulated
- Turning Radius: 8m (26.25ft)
- Gradient: 60% (30°)
- Side Slope: 30% (17°)
- Vertical Obstacle: 1m (3.3ft)
- Trench Crossing: 2m (6.6ft)
- Front winch: 5 t

Figure 1: TAV tracked vehicle

2.2 Rolligon - Soft Flotation Tire AT

Two Rolligons will be used behind the ACB to push it, provide braking force to stop it, and to steer the stern. A typical 4x4 Rolligon type vehicle is shown in Figure 2.

A Rolligon is a multi-wheel drive vehicle with large soft tires that exert very low ground pressure. This makes it an ideal vehicle for operating in environmentally sensitive areas. Four and eight wheeled units float, with the buoyancy provided primarily by the tires. Its propulsion in water is limited, coming only from the tires. A single operator is required, with room for one additional passenger.

Specifications for a typical four wheel drive unit are as follows:

Drive: Four Rubber High Floatation Tires
Ground Pressure: 21.8kPa (3.16psi)
Vehicle Weight: 12.7tonnes (27999 lbs)
Power: 183kW Cummins diesel (250hp)
Draw Bar Pull: 6.4 tonnes (14110 lbs)
Length: 7.6m (25ft)
Width: 4.9m (16ft)
Height: 3m (10ft)
Maximum Speed: 40km/h (25mph)
In-Land Water Speed: 4.8km/h (3mph)
Average Cross-Country Speed: 18km/h (11mph)
Range: 720 litres of fuel for 24 hours operation
Steering Type: Hydrostatic, Articulated
Turning Radius: 6.1m (20ft)
Gradient: 50% (27°)
Side Slope: 45% (24°)
Front winch: 5 t

Figure 2: Rolligon type 4x4

2.3 Hagglunds BV206 – Rubber Tracked AT Support Vehicle

One Hagglunds BV206 will be used in a support role for the haulage system. It will be driven by a route master, who will monitor the safety of the operation, direct the activities of the towing crew, and scout ahead of the ACB to assess the condition of the route. The BV206 will also be used for crew changes. A BV206 can carry up to 17 passengers, 6 in the front unit and 11 in the rear unit. A spare unit will be carried on the deck of the ACB for emergency purposes. Images of a BV206 are shown in Figure 3.

The BV206 is widely used in Tracked and military applications. It is a standard rubber tracked NATO troop carrier and several are operated in the State of Alaska by the US Military. Its design is similar to the TAV; a two-pod articulated vehicle with flotation provided by both watertight pods. Its propulsion on land and in water is provided by two sets of rubber tracks on the front and rear units. There are no modifications anticipated to the tracks to increase traction.

Figure 3: Hagglunds BV-206

The Hagglunds vehicle's specifications are as follows:

Drive: Four Moulded Rubber Track
Ground Pressure: 13.6kPa (1.97psi)
Vehicle Weight: 6.5 tonnes (14330 lbs)
Power: 101kW Mercedes Diesel (136hp)
Draw Bar Pull: 3.3 tonnes (7275 lbs)
Length: 6.9m (22.6ft)
Width: 1.9m (6.25ft)
Height: 2.3m (7.5ft)
Maximum Speed: 55km/h (34mph)
In-Land Water Speed: 3km/h (2mph)
Average Cross-Country Speed: 30km/h (18mph)
Range: 300km (186miles); 2.7 round trips
Steering Type: Hydrostatic, Articulated
Turning Radius: 8m (26.25ft)
Gradient: 100% (45°)
Side Slope: 30% (17°)
Front winch: 3 t

2.4 Support Vehicles: Snow Grooming Machines and Snowmobiles

The operation will also employ snow grooming machines and snowmobiles.

Snow grooming will be done as needed to pack fresh snow along the route. Grooming will also be done to maintain safe snow cover over exposed ground during operations in the shoulder seasons. Snow grooming machines typically exert a ground pressure of between 0.86psi and 1.36psi.

Snow grooming machines like that shown in Figure 4 are not amphibious. In applications where the ice integrity is in question, a BV206 fitted with a dozer blade will be used for snow grooming.

Snow grooming equipment will accompany or precede the ACB Transportation System as required.

Snowmobiles will be used as backup evacuation or crew change vehicles in situations where speed is more important than comfort. Snowmobiles have very low ground pressure, typically less than 0.5 psi.

Figure 4: Typical Snow Grooming Equipment

2.5 Fleet Requirement for the 2008/2009 Non-Aquatic Season

There will only be one ACB available for the 2008/2009 non-aquatic season. The haulage fleet will be:

- Two TAVs
- Two 4 x 4 Rolligons
- Three Hagglunds BV206s

Augmenting the haulage fleet will be up to two snow grooming machines and snowmobiles as required.

Spare and support units will be kept aboard the ACB. The ACB will be equipped with a secondary ramp for the loading and unloading of all haulage and support vehicles. This ramp will also be used to winch broken units aboard the ACB for transport to the maintenance facility at the barge landing site.

2.6 Equipment Changes for Operations in 2009/2010

Three ACBs will be required for long term operations. In general, two will be on the river at any given time. One will be in transit to or from the inlet and the other will be at the barge landing site, being unloaded and reloaded. The river towing crew will therefore not be held up while the ACB is unloaded or loaded.

At present, Redfern owns two shallow draft tugboats for aquatic operations: the RDV-Gator and the RDV-Kid Commando. The RDV-Gator has just completed a re-powering from 700 BHP to 1430 BHP. The RDV-Kid Commando will undergo a similar re-powering, including lengthening and widening the vessel, in the 2009/2010 non-aquatic season.

With the higher demand of operations, more power will be required in the towing fleet, primarily to achieve a faster towing speed and reduced transit time. For this purpose, the Rolligon 4x4 vehicles will likely be replaced by Rollgion 8x8s in the non-aquatic phase of operations. These will have the same low ground pressure and flotation characteristics of the 4x4s discussed in Section 2.2 with increased power.

2.7 Equipment Comparison

Please refer to table 1 for a comparison of the new equipment to the amphitrac

Table 1: Equipment Comparison

Specification	Amphitrac	TAV	Rolligon	Hagglunds BV 206
Drive	Low Pressure tundra tires, and retractable Archimedes screws	4 Moulded Rubber Track	4 Rubber High Floatation Tires	Four Moulded Rubber Track
Ground Pressure	~3psi	2.75psi	3.16psi	1.97psi
Power	1,200hp	300hp	250hp	136hp
Draw Bar Pull	Not specified	7.3 tonnes (16,094lbs)	6.4 tonnes (14110lbs)	3.3 tonnes (7275 lbs)
Vehicle Weight	62 tonnes	14.6 tonnes 32,187 lbs	12.7tonnes 27,999 lbs	6.5tonnes 14,330 lbs
Length	18m (59ft)	8.6m (28.3ft)	7.6m (25 ft)	6.9m (22.6 ft)
Width	8.5m (28ft)	2.3m (7.5ft)	4.9m (16 ft)	1.9m (6.25 ft)
Height	Not specified	2.5m (8.2ft)	3m (10 ft)	2.3m(7.5 ft)
Average Cross-Country Speed (fully loaded)	14 kmh (9 mph)	6 kmh (3.7 mph) assumes no open lead crossings	6 kmh (3.7 mph)	n/a
Inland Water Speed Calm water	12.8km/h (8mph) propulsion from Archimedes screws	4km/h (2.4mph) propulsion only from tracks	4.8km/h (3mph) propulsion only from tires	3km/h (2mph)
Range	9000 litres fuel allowing at least 26 hours operating	500 km 310miles	720 litres fuel for 24 hour operations	300km 186 miles
Steering Type	Not specified	Hydrostatic, Articulated	Hydrostatic, Articulated	Hydrostatic, Articulated
Turning Radius	Not specified	8m 26 ft	6.1m 20ft	8m (26 ft)
Gradient	Not specified	60% (30°)	50% (27°)	100% (45°)
Draft	30 cm (1ft) wheels fully retracted	5ft	Not specified	Not specified

3. Operations

3.1 General Overview

In both aquatic and non-aquatic seasons, operations will be divided into two distinct sets of activities: those on the river and those on open water. Approximately 60 km of the 95 km one-way distance from the minesite to Juneau is on the river, the remaining 33 km on the open water of Taku Inlet and Gastineau Channel. This document focuses on river operations, not open water towing.

Regardless of season, there will only be one towing crew towing one ACB on the river at any given time. This crew will be met at the inlet by a seagoing tugboat. During this rendezvous, the seagoing tugboat and the river towing vessels will exchange ACBs. The concentrate-laden ACB will then be towed to Juneau by the seagoing tugboat and the supplies-laden ACB will be towed to the minesite by the river towing crew.

The aquatic and non-aquatic barging route is shown in Appendix A – *Taku River Barging Route Atlas – June 2008.*

3.2 Means of Propulsion

The ACB is an unmanned vessel with no means of self-propulsion. Its fans and winches will be operated remotely from the tow vehicles and vessels. During the aquatic season, the ACB will be towed using shallow draft tugboats. In the non-aquatic seasons, it will be towed using the equipment defined in Section 2.

In general, there will be two means of propelling the ACB during non-aquatic operations: towing and winching.

3.2.1 Towing

Towing will be done on ice and snow and will be the normal operating situation in the non-aquatic season. As the same route will be followed for the most part, the snow surface will become packed, reducing the friction.

Two TAVs will be used to tow the ACB from the front. They will drag the ACB using a cable drawn from the forward bow winches of the ACB.

Two Rolligons will be used to push the ACB from behind. They will be attached to the rear winches of the ACB and be equipped with push knees. A typical configuration is shown in Figure 5.

Based on measurement performed on a similar ACB, the *Siberian*, it is estimated that the ACB will require 12tonnes towing force to get it moving on flat ground and 3.5tonnes to keep it moving. Ice surfaces, with

lower friction, will require much less. The effects of unpacked snow are it is likely it will slow the operations, and regular snow grooming may be required.

Dependant on surface traction, the TAV will provide between 2 and 6 tonnes towing force each, and the Rolligons will provide between 2 and 8 tonnes of pushing force each. Thus, in normal conditions any two units should be able to get the ACB moving and any one unit should be able to keep it moving.

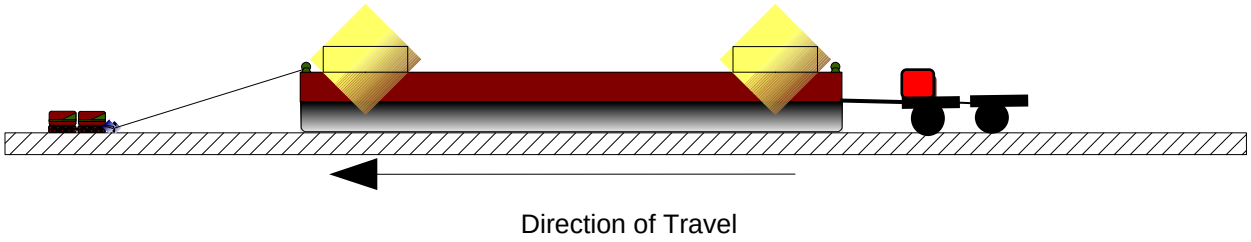


Figure 5: Typical ACB and AT Configuration

Steering of the ACB will be accomplished by the position of the towing TAV units and the articulation of the Rolligons that are attached to the rear of the ACB.

Braking will be accomplished using a plough-like anchor on the two rear Rolligons. This anchor will be similar for all towing vehicles.

3.2.2 Winching

Winching, being a much slower operation, will be done as required when towing is not possible. Winching will also be the standard procedure for crossing open leads.

During winching operations, the TAVs will drag cables forward from the ACBs 30 t bow winches. Each winch will have approximately 300m (1000 ft) of cable. The winches will roll free to spool out cable, so that the TAV is not towing the weight of the ACB. Anchor trailers will be mounted at the rear of TAVs. The anchor itself will be a plough shaped spade that digs itself into the ice or snow to provide a fixed point for winching. (see figure 6).

The winch will be located on the ACB, but operated remotely from the tow vehicle. See figure 8 for a depiction of the winching procedure.

Smaller winches, rated at approximately 5 tonnes, will be installed on all ATs for self-recovery and to assist other ATs.

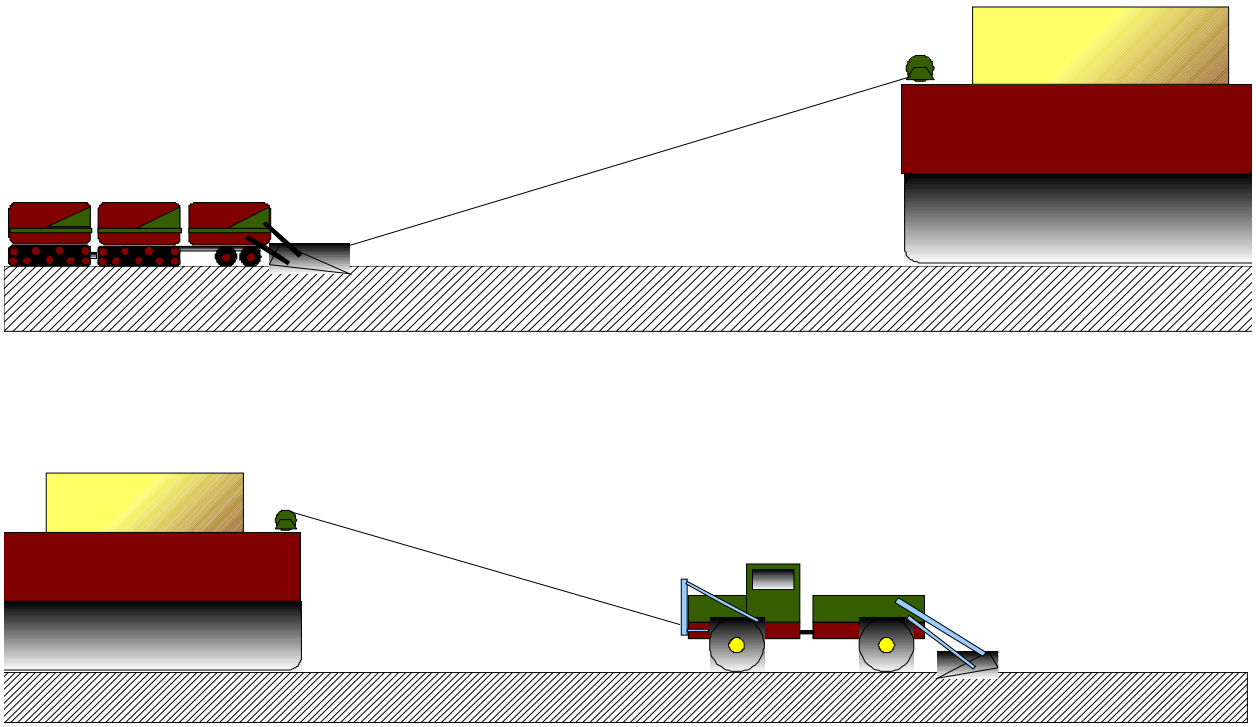


Figure 6: Winching Detail - Forward and Rear Anchoring

3.2.3 Special Situations

3.2.3.1 Crossing Open Leads

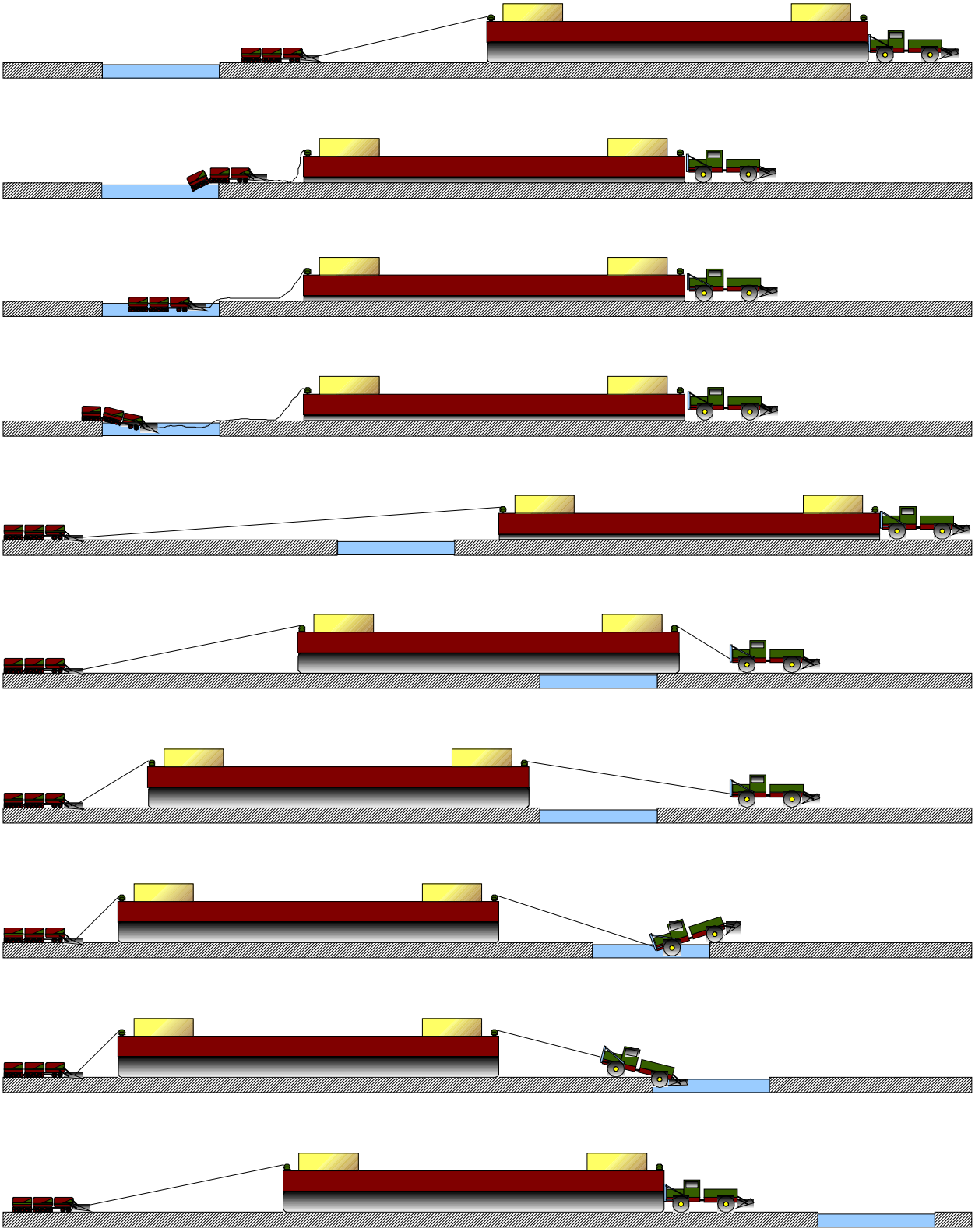
During the coldest portion of a normal winter,routine open lead crossings are unlikely to be required. In warmer winters and during the shoulder seasons, there will be a need to cross open leads with the ACB and the towing vehicles.

The objective for crossing open leads will be as follows:

- The occurrences of crossing the open leads will be minimized, both for efficiency and to minimize impact on the river.
- The number of crossing sites will be minimized and controlled by the route master, working in conjunction with an environmental monitor.
- Crossings will always be done at the same sites to allow effective impact monitoring for the river and ice cover conditions, and minimize spatial extent of potential disturbance.
- Wherever possible, the tow vehicle will travel around the open lead to avoid crossing it.
- All crossings will be done perpendicular to the open lead (and current) to minimize time and distance in the open channel.

A typical lead crossing is depicted in Figure 7. The TAVs will enter the open lead with free spooling cable in tow (not towing the weight of the ACB). They will cross the lead then climb out of the ice on the far side. The TAVs will then anchor themselves and winch the ACB across the open lead. The Rolligons will then pull themselves across the open lead using the ACB's stern winches.

Figure 7: Open Lead Crossing Series



3.2.3.2 Canyon Island Transit

The transit around Canyon Island will be through the narrows in the non-aquatic season and through the east channel in the aquatic season. This can be viewed in both Appendix A and in more detail in Appendix B.

Fish Creek, which feeds into the east channel of Canyon Island, is a warm creek that seldom freezes. This creates a large open lead that starts a few hundred meters downstream of the narrows and extends for a mile or more to the Martini Row area. It will be possible in the non-aquatic season to remain on the northwest side of this lead, travelling through the frozen narrows. As the narrows is the first location on the river to freeze in the fall and the last area to thaw in the spring, this route will be maintained for the duration of the non-aquatic season.

During the aquatic season, the preferred travel route will be through the east channel. At high water, this channel can be fully aquatic with minimum depth greater than 3 ft, allowing shallow draft tugs to travel directly through the east channel.

More typically, there is a large cobble bar at the north end of the east channel, denying flow from the Taku and barring any river traffic. During these conditions, the ACB will be towed overland on the dry gravel bar on the east side of the island as shown on Appendix B. The same equipment used in the non-aquatic season to tow and winch the ACB will be employed to transport the ACB across the east shore. The AT's will be stored on Canyon Island.

The procedure for crossing the dry land along the east shore of Canyon Island is as follows:

One of the shallow draft tugs will push the ACB in position up the east channel and hold it there while the second shallow draft tug travels through the west channel. Deck hands and first mates will disembark from the shallow draft tugs and board the ATs, located on the beach. The Rolligons will attach themselves to the ACB's stern winch cables and the TAVs will attach themselves to the ACB's bow winch cables, as per the usual practice for non-aquatic operations. The four ATs will tow the ACB across the dry land on the east shore to the other side of the channel. The towing shallow draft tug will be reconnected to the ACB and tow the ACB into the water, where it will be joined by the pushing shallow draft tug.

3.2.3.3 Transferring the ACB at the Inlet

In both the aquatic and non-aquatic seasons, the ACB will be towed back and forth between the mouth of the Taku inlet and Juneau using a standard ocean tug. .

A hand-off between river equipment and an ocean tug will therefore be required for each leg of the ACB's journey. In the aquatic season, this will be accomplished by having the shallow draft tugs pull alongside the ocean tug, and exchange the outbound ACB with the inbound ACB.

In the non-aquatic season there will be numerous ways that this transfer will be accomplished, including:

- Heave a line between tug and tow vehicle; pull in the line, which drags the tow cable
- Fire a line canon between tug and tow vehicle; pull in the line, which drags the tow cable
- Have the TAV, which is fully aquatic, drive to the ocean tug and retrieve the tow cable manually, then drive back to shore dragging it.
- Use a zodiac to carry the tow cable between tug and tow vehicle

Which of the above methods will be used on any given trip will depend on the conditions of wind, wave and the ice shelf (if any).

All of the above methods will result in transferring a cable from the ACB between tow vehicles across the transition zone. The ACB would then be winched or towed across the transition zone from the vehicle.

3.2.3.4 Equipment and Operational Malfunctions

Occasionally operations will be hindered by mechanical malfunction. Broken down vehicles will be repaired in the field if possible. If that is not possible, or would create extensive delay on operations, the broken vehicles will be towed back to the barge landing site for repair. This will be done either by winching it aboard the ACB (there is a secondary ramp on the ACB for this purpose) or by towing it independently behind a support vehicle (likely a BV206).

As all ATs are amphibious, there is no danger of the vehicles sinking; however there is the possibility of equipment getting stuck, particularly while crossing open leads. In such a situation, the remedy will be to winch the vehicle back to the ACB using the onboard winches. In the case of the forward TAVs, they will be attached by cable to the ACB during towing operations, so this will simply be done by the operator controlling his own winch, pulling the TAV back toward the ACB.

It may be required in extreme situations to use some of the ATs and support vehicles to recover a severely stuck vehicle. In general, winching will always be the recovery method, using either those of the ACB or the smaller winches mounted on the ATs.

3.3 Controls

Each tow vehicle will have a single operator, who will control his own vehicle. Operators will also control the winch on the ACB to which they are attached by cable. Each AT will also have an emergency stop button to shut down the hover fans on the ACB and drop bow and stern anchors remotely. Each AT operator will also control his own winching anchor.

The Route Marshall will control the ACB engines; both for shut down and start up and RPM setting. He will also have an emergency shutdown, identical to the AT operators.

All ATs will be equipped with video monitors to display multiple views including:

- a view of the ACB onboard gauges
- a forward view for the Rolligon Operators, as their view will be blocked by the ACB
- a rear view for the TAV, as rearward visibility is limited
- a view of the winch it controls.

All vehicles will be equipped with radios for constant communication with the Route Master and each other, including those operating independent of the towing crew for snow grooming or crew changes. The Route Master will also have communication with the barge landing site.

There will be manual controls located on a control tower onboard the ACB. These controls will be used in an emergency situation only and for controls during regular maintenance. The barge is an unmanned vessel.

3.4 Manpower

All manpower will be based at the camp located at the barge landing site, where they will start and end each shift.

3.4.1 Roles

The crew will be comprised of a route marshall, operators, junior operators, mechanics, and environmental monitors. Each role is described below.

The Route Marshall will be responsible for the safety and efficiency of overall operations. Being free to travel independently of the ACB, he will position his BV206 to best assess and direct all activities. During winching or towing operations, the Route Marshall will be the main hub of communications and provide direction to each operator. He will decide the route of travel and determine when to change the route slightly to allow for refreezing of particular river sections should cracking occur, or if an area of snow-covered river bank begins to show bare patches. Working in conjunction with the environmental monitor, the Route Marshall will determine if there is enough snow and/or ice cover for travel. He will also assess

the weather conditions, including wind, visibility, and temperature and determine if operations should be suspended until conditions improve.

The Environmental Monitor will assess how operations impact the river environment, with close attention to spawning grounds and fish habitat. Working closely with the Route Marshall, he will determine when environmental conditions do not match operational requirements and recommend suspension of operations until conditions improve. He will issue a monthly report that summarizes environmental concerns and actions taken to avoid, or mitigate those concerns.

Operators will each control one AT. Operators will also control the ACB winch to which they are attached by cable. TAV operators will tow the ACB and Rolligon operators will push against the rear of the ACB using push knees. TAV operators will also cross open leads to position their vehicles as forward anchor points for winching.

Junior Operators will be used to operate support vehicles for snow grooming and crew changes.

Mechanics will be used to keep all equipment in operating condition. During commissioning, the mechanic will accompany the towing crew, but will eventually be based at the minesite for regular maintenance and repair of the ATs and ACBs.

3.4.2 Crew Requirements: Non-aquatic Operations

At start up and commissioning, there will be six workers on each towing crew: one operator in each of the four ATs, the Route Marshall, and a mechanic. The Route Marshall will be located in a BV206, which will be driven by the mechanic.

This level of staffing may be reduced as experience is gained. Two or three ATs may be deemed adequate for operations, for instance, and the mechanic may be dropped from the crew after commissioning. The minimum towing crew is therefore three – two forward AT operators and the Route Marshall.

In addition to this operations crew, there will be additional manpower required for path grooming and operating the BV206 for crew changes. Environmental Monitoring is not anticipated to be a full time job and will be treated as an audit function.

3.4.3 Crew Requirements: Aquatic Operations

During aquatic operations there will be seven workers on each towing crew: one captain, mate, and deck hand on each tug and a route master. The Route Master will operate a smaller boat and act as guide and scout to survey the route ahead of the ACB. A support boat will also be used to change crews as required.

3.5 Fuelling

Vehicles will carry enough fuel for a minimum of one river transit (24 hrs), and will be refuelled at the barge-landing site. The ACB will be fuelled in Juneau and will carry enough fuel for a full round trip.

3.6 Route

The preferred non-aquatic route will be over solid ice and snow covering the main channel of the river and gravel or sandbars below the high water line. Open leads will be avoided as much as possible. See Appendix A (*Barge Route Atlas)* for a detailed depiction of the route selected for travel in the non-aquatic season.

3.7 Operating Condition Requirements

The conditions that will shut down towing operations on the river are shown in Table 2.

Table 2: Operating Condition Guidelines

Condition	Range	Operating Guideline
Snow accumulation over 48 hours	>3 feet	• Delay operations during heavy snowfall until route can be traversed and packed by snow grooming equipment (may take a few days)
	1-3 feet	• May require snow grooming equipment to immediately precede ACB to compact snow along route
	<1 foot	• No specific procedures needed.
Temperature[1]	< - 40° F (-40° C)	• Delay operations until temperatures predicted to remain above -40° F for at least 24 hours.
Sustained Wind Speed	>70 mph[2]	• Delay operations until wind speed remains below 70 mph for 24 hours;
	30 to 70 mph	• If wind speed is building, or strong winds continue to be forecast, delay departure until suitable conditions are forecast for 24 hour period. If operating, seek safe

[1] *The equipment is designed for operations in low temperatures. This constraint is more related to crew safety and comfort.*
[2] *72 mph winds are classified as hurricane force*

Condition	Range	Operating Guideline
		harbour. • If wind speed is subsiding, and forecast to continue to drop, operations would procede on schedule.
	<30 mph	• If wind speeds are less than 30 mph, operations would proceed as scheduled.
Ice Thickness and Extent of Ice Cover[3]	≤ 12 inches	• Maintain aquatic operations in mainstem channel if flows allow (>250 m³/s flow), avoid thin ice shelves forming/breaking up along sides of river channel, or near gravel bars)
	≥12 inches	• Select route that traverses floating or landfast shelf ice, avoiding open leads as much as possible to minimize ice breaking and maintain efficient operations
	jumble ice accumulation	• Avoid or groom
Visibility	<10 feet	• Delay departure until visibility improves
	10 to 100 feet	• Follow GPS route; reduce speed as determined by barge master; use flashing yellow beacon on ATs
	>100 feet	• No constraints identified

These operating constraints will require periodic temporary operational suspensions. More lengthy seasonal shutdowns are also anticipated, which are expected to be up to 6 weeks in the fall transition season, and up to 4 weeks in the spring transition season.

[3] *For purposes of this document, ice includes all floating ice extending from the shoreline or from landfast ice extending up to the mainstem (thalweg) river channel. Due to the braided nature of the river and lower water levels during the late fall and winter, formation of ice is quite extensive and tends to form first over gravel bars and shallow channels, whereas the thalweg remains ice free for a longer period, and tends to freeze last (river current is highest).*

3.8 Production Capability

This document is created primarily to define the operating equipment and procedures for the coming 2008/2009 non-aquatic season. It is expected that experience gained during the 2008/2009 non-aquatic season will help to effectively upgrade the fleet for operations in the 2009/2010 non-aquatic season, to service the operating mine, when demands on the system will be much higher.

3.8.1 2008/2009 Equipment

3.8.1.1 Haulage Requirements

During this period an average of 100 tonnes per day of inbound supplies will be required. This will be comprised of mobile and fixed equipment, diesel, cement, steel, electrical components, and various other supplies in support of the construction effort. Equipment and gear that is no longer required by the Project will also be demobilized from site during this period and transported back to Juneau.

3.8.1.2 Trip Time

During the non-aquatic season, trip time and system productivity will depend largely on the number of open leads that have to be crossed. From calculations based on the experience gained by towing a similar ACB, two vehicles of 300 hp each should be able to tow the ACB along at up to 6 km/hr on ice and snow. Winching the ACB will be much slower, with a winch speed of approaching 3 km per hour.

For the purpose of estimated trip time, the following delays are assumed:

Crossing an open lead	15 min
Exchange at Inlet	30 min
Exchange at Minesite	30 min
Crew Change	15 min every 12 hours

Figures 11 shows the estimated round trip time versus the number of open leads.

With the river completely frozen (no open leads), a round trip time of 18 hours is projected. With 10 open leads to cross, this increases the round trip time to 25 hours. At the extreme of 25 leads the round trip time increases to 32 hours.

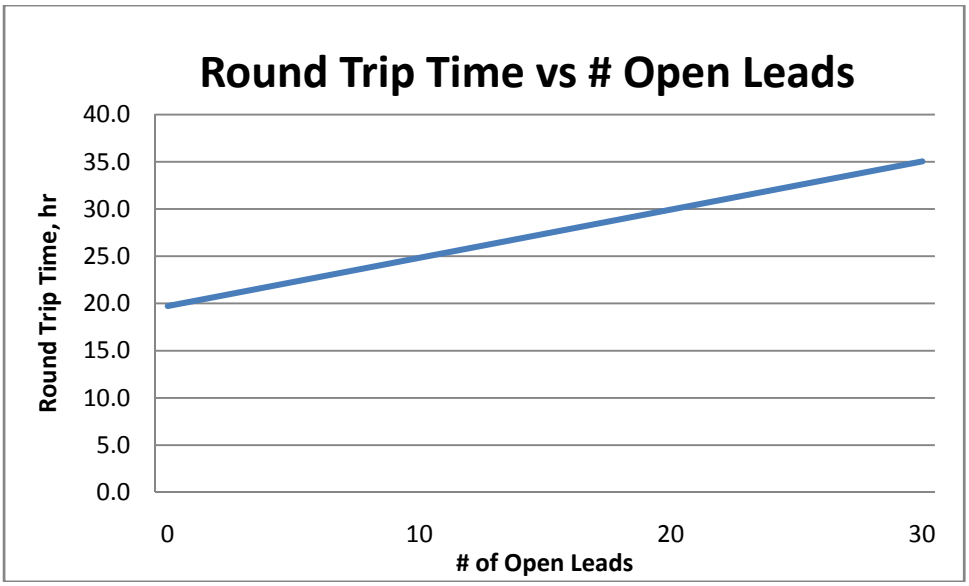


Figure 8: 2008/2009 Round Trip Time

3.8.1.3 Maximum Capacity

The maximum capacity of the 2008/2009 haulage system is shown in Table 3. This is based on the use of only one ACB.

Table 3: 2008/2009 ACB Transportation Capacity

Operating Month	Operating Days	# Open Leads	Round Trip Time, hrs			Number of Trips			Tonnes hauled
			River	Ocean	Total	#/DAY	Reliability	Factored	
October	28	0	17	15.5	32.5	0.7	80%	17	7,444
November	0	0	29.9	15.5	45.4	0.5	80%	0	-
December	16	10	24.8	15.5	40.3	0.6	80%	15	3,429
January	31	5	22.3	15.5	37.8	0.6	80%	16	7,094
February	28	5	22.3	15.5	37.8	0.6	80%	14	6,407
March	31	10	24.8	15.5	40.3	0.6	80%	15	6,644
April	2	20	29.9	15.5	45.4	0.5	80%	1	380
Total	157						-	75	31,399

Calculations indicate the system is capable of delivering sufficient quantity of supplies to meet the needs of the construction effort.

Note that an efficiency factor is applied to the system to allow for weather delays and mechanical reliability. In addition, operations are shown as suspended for six weeks in the fall to allow the river to freeze and four weeks in the spring to allow for the river to thaw and rise for aquatic operations.

3.8.2 2009/2010 Equipment

3.8.2.1 Haulage Requirements

During operations, an average of 342 tonnes per day (wet) of mineral concentrate will be produced, for a total of 113,560 tonnes per year. Allowing for the weight of the concentrate and supply containers, the total cargo requirement is 148,555 tonnes per year. Approximately 154 tonnes per day of supplies will be back-hauled to the mine.

3.8.2.2 Trip Time

It is assumed that replacing the two 4x4 Rolligons with two 8x8 Rolligons will allow an increase in the maximum towing speed to 10 km/hr over ice and snow. All other assumptions regarding delays and the time associated with crossing open leads remain the same.

Figures 12 shows the estimated round trip time versus the number of open leads for the fleet with the addition of two Rolligon 8x8s.

With the river completely frozen (no open leads), a round trip time of 12.3 hours is projected. With 10 open leads to cross, this increases the round trip time to 17.4 hours. At an extreme scenario of 25 open leads, the round trip time is estimated to be 25 hours.

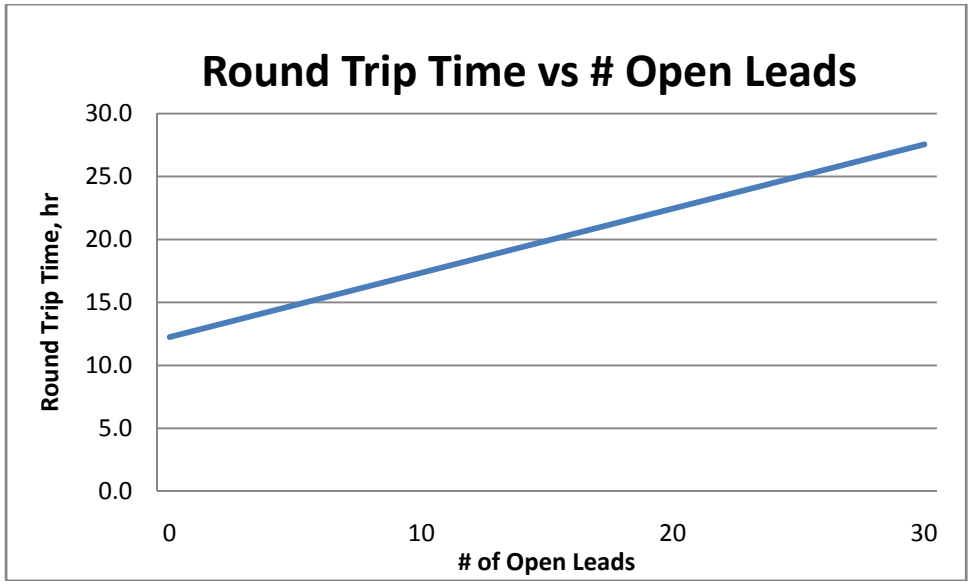


Figure 9: 2009/2010 Round Trip Time

3.8.2.3 Maximum Capacity

The maximum capacity of the 2009/2010 haulage system is shown in Table 4. This is based on a fleet of three ACBs. The load time has been reduced to three hours, but in reality could be reduced further. Both a reduced travel time and loading time are the result of using three ACB's as opposed to two or less. Again, shoulder season down time has been assumed at six weeks in the fall for freeze up and four weeks in the spring for thaw.

Table 4: 2009/2010 ACB Transportation Capacity

Month	Aquatic	Days	Op days	# Leads	Travel Time	Load Time	Total	#/day	Trips	Reliability	Est. Trips	Tonnage
November	No	30	0	0	15.3	3	18.3	1.6	0.0	80%	0	-
December	No	31	16	10	20.4	3	23.4	1.2	18.9	80%	15	6,792
January	No	31	31	5	17.8	3	20.8	1.3	41.8	80%	33	15,045
February	No	28	28	5	17.8	3	20.8	1.3	37.7	80%	30	13,589
March	No	31	31	10	20.4	3	23.4	1.2	36.6	80%	29	13,159
April	No	30	2	15	22.9	3	25.9	1.0	2.1	80%	2	754
May	Yes	31	31		15.2	3	18.2	1.6	48.1	90%	43	19,478
June	Yes	30	30		15.2	3	18.2	1.6	46.5	90%	42	18,850
July	Yes	31	31		15.2	3	18.2	1.6	48.1	90%	43	19,478
August	Yes	31	31		15.2	3	18.2	1.6	48.1	90%	43	19,478
September	Yes	30	30		15.2	3	18.2	1.6	46.5	90%	42	18,850
October	Yes	31	28		15.2	3	18.2	1.6	43.4	90%	39	17,593
Non-aqautic		181	108								110	49,340
Aquatic		184	153								214	96,133
Total		365	261								323	163,066

Calculations indicate the system is capable of delivering the necessary cargo required to support mine operations.

4. Schedule Update

4.1 ACB

ACB construction is underway in Portland, Oregon, with a test launch projected for early August 2008. A three week period is assumed for testwork and commissioning at the shipyard prior to shipment. An additional five weeks is allotted to shipping the ACB to Juneau and one week for field testing at sites near Juneau suggested by State of Alaska regulators, resulting in a handover date of September 30th.

4.2 Amphibious Vehicles

4.2.1 TAVs

SK Technologies has been commissioned to refurbish two TAVs in Singapore. They have committed to the same timeline as the ACB, with delivery to Juneau by the end of September.

4.2.2 Rolligon

Redfern is negotiating with SK Technologies to provide two Rolligon-type vehicles, also in September 2008.

4.2.3 Hagglunds BV 206

Redfern has purchased a BV206, which is being stored in Juneau at present. An additional two units will be secured from Hovertrans for operations this winter season. These units will be delivered in August 2008.

5. Testwork and Commissioning

5.1 General

Testing of the ACB will begin at the shipyard in Portland, Oregon. This will be followed by testwork performed near Juneau, Alaska, both on the ACB and the tow vehicles. This will be followed by a week of preliminary commissioning followed by ongoing season-specific commissioning that will last a full year.

5.2 Use of Existing Testwork

In January and February of 2008 a series of tests were performed on the ACB *Siberian* in Glasgow, Scotland. This above surface noise, ground pressure measurements, underwater noise level measurements, determination of wave attenuation performance, determination of wake generation, and a determination of drawbar pull requirements for the ACB that were used to project the performance of Redfern's ACB *Monty*.

The results of this testwork were as follows:

- Sound levels below water were minimal, measured at 8dBA
- Sound levels above the water were unacceptable (85 dBA at 30m)
- The bow wave was low, and a minimal wake was observed
- Air escapement from the Air Cushion skirt was minimal and should pose no threat to wildlife (A seal dove under the ACB while undertow and on hover. It popped up afterwards, looking very interested in the activities.)
- Air Cushion Pressure with the ACB unloaded was measured to be 0.65psi. Fully loaded ground pressure is estimated at a maximum of 1 psi.
- The ACB left no impression when towed across the sand banks at Holy Loch.
- An estimated 5 tonnes of force was required to tow the ACB from dead rest and 1 tonne of force to keep it moving.

The experience gained from this testwork that may be applied to our ACB, the *Monty* is as follows:

- Design work specific to surface noise dampening is required
- Noise level underwater is minimal, as expected, and this test need not be repeated[4]
- The expectations of low wake generation were confirmed
- The expectations of low ground pressure expectations were confirmed
- Towing force measurements were used to determine the drawbar pull requirements of the Amphitrac replacement vehicles discussed in Section 2. It is estimated that 12 tonnes of force will be required to tow the ACB from a dead rest and 3.5 tonnes will be required to keep it moving.

[4] *This finding is consistent with other work on hovercraft, such as this excerpt from a report prepared for a hovercraft operation at Prudhoe Bay: "The hovercraft was considerably quieter underwater than similar-sized conventional vessels and may be an attractive alternative when there is concern over underwater sounds." ©2005 Acoustical Society of America, Susanna Blackwell and Charles Greene Jr.*

5.3 Testwork at the Shipyard

The *Monty* will be tested on the Columbia River in Oregon prior to shipment to Juneau. The primary purpose of this testwork will be to establish the mechanical reliability of all systems and equipment on the ACB and assess its performance against design.

On the completion of the testwork at the shipyard, it will be transported to Juneau.

5.4 Testwork near Juneau

On arrival to Juneau in September 2008, there will be minor mechanical testing done to ensure that no systems were damaged during shipment and all are still operational.

There will then be a one-week program of commissioning, which will include tests similar to those performed on the *Siberian*, including:

- Noise level measurements (above the water only) vs. distance at idle, half hover and full hover engine speeds.
- Determination of wake vs. speed of towing
- Measurement of ground pressure beneath the ACB on hover
- Measurement of required bollard pull in water and drawbar pull on land.
- Documentation of the footprint left by the vessel on shallow water and exposed beach, at half hover and full hover. This will include measuring the impression of the vehicle made upon various substrates and the use of video footage.
- Photographic documentation of the spray generated by the vessel on land and on water and the effectiveness of the spray skirt.

This testing will be done in Gastineau Channel in open water and at other sites suggested by Alaskan regulatory agencies.

An open house will be arranged for the public to view the ACB and tow vehicles at this time. Commissioning of the system will then begin.

5.5 Commissioning

The initial commissioning period is anticipated to last one week, during which time the entire route will be traversed if feasible. Barging will begin with light loads, starting at 100 tonnes and increasing to the full cargo capacity of the ACB *Monty* (450 tonnes).

It should be noted that the barge will be an unmanned vessel. However, during commissioning a warming shack will also be kept on the deck of the barge for emergency use. The results of the testwork and initial commissioning will be compiled into a report prepared by an independent third party.

Season-specific commissioning will be performed as appropriate conditions are found on the river. This will be done as a component of ongoing operations over the first year of operations on the river, and will include the following determinations:

- Maximum speed of travel in open water
- Maximum speed of travel on ice
- Maneuverability in water and on ice
- Cable winching procedures
- Minimum ice thickness for travel
- Minimum thickness of ice that can be climbed onto without breaking it (ie- crossing open leads)
- Potential for damage to skirts by rubble ice or exposed snags
- Bollard pull requirement vs. speed on ice and snow
- Bollard pull vs. snow depth for fresh snow
- Effect of wind and waves on the vessels to confirm or adjust preliminary operating condition criteria
- Effectiveness of anchoring systems
- Reliability of communications system in all conditions
- Confirmation of effective safe havens along route

Thus the full commissioning plan will be span a full calendar year and will be done concurrently with operational use. It is anticipated that the company will have regular communications with a transboundary working group at least after each seasonal operation to report on and assess operations.

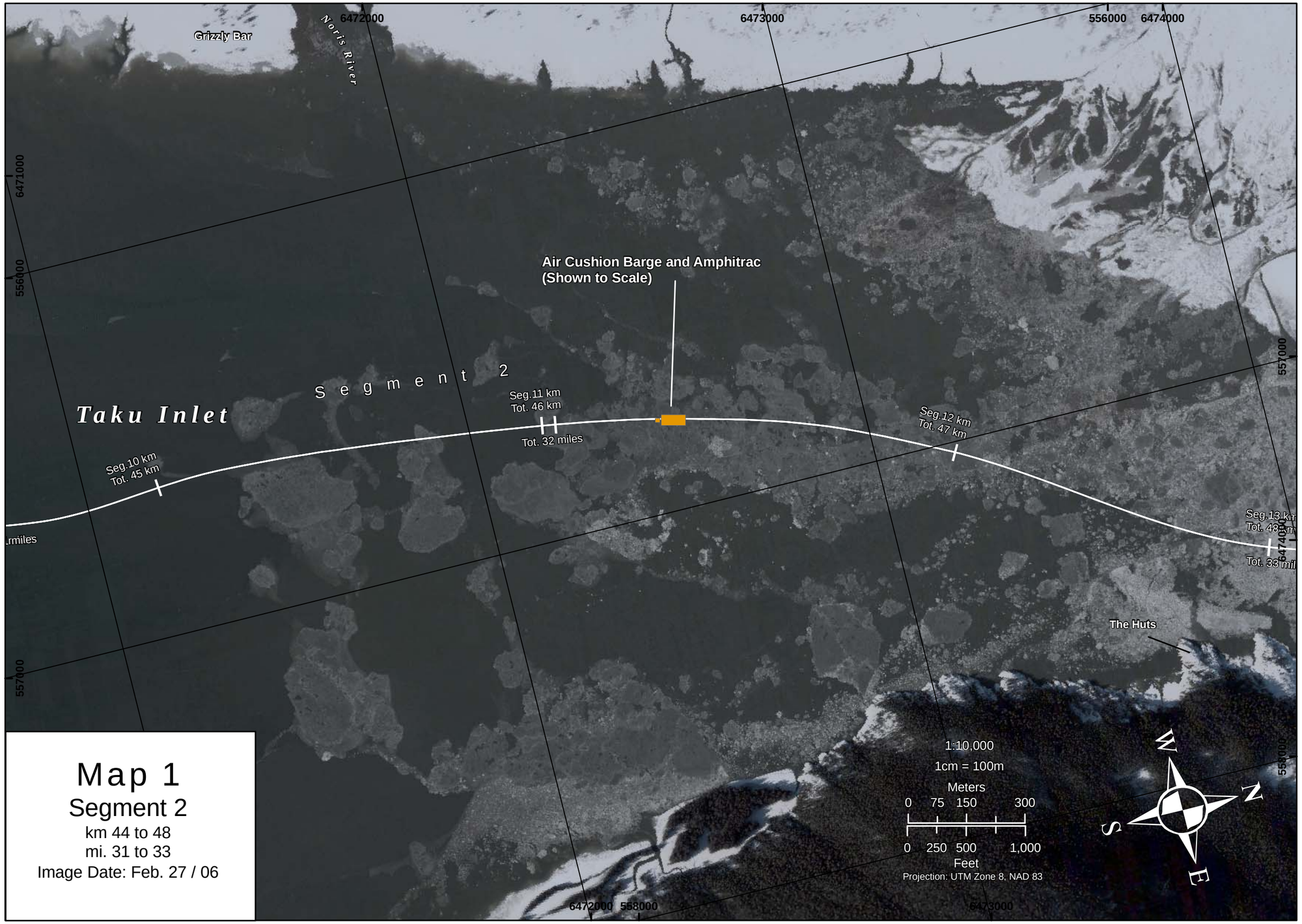
Appendix A

Taku River Barging: Route Atlas

Appendix A

Aquatic & Non Aquatic: Updated, June 2008

Taku River Barging: Route Atlas



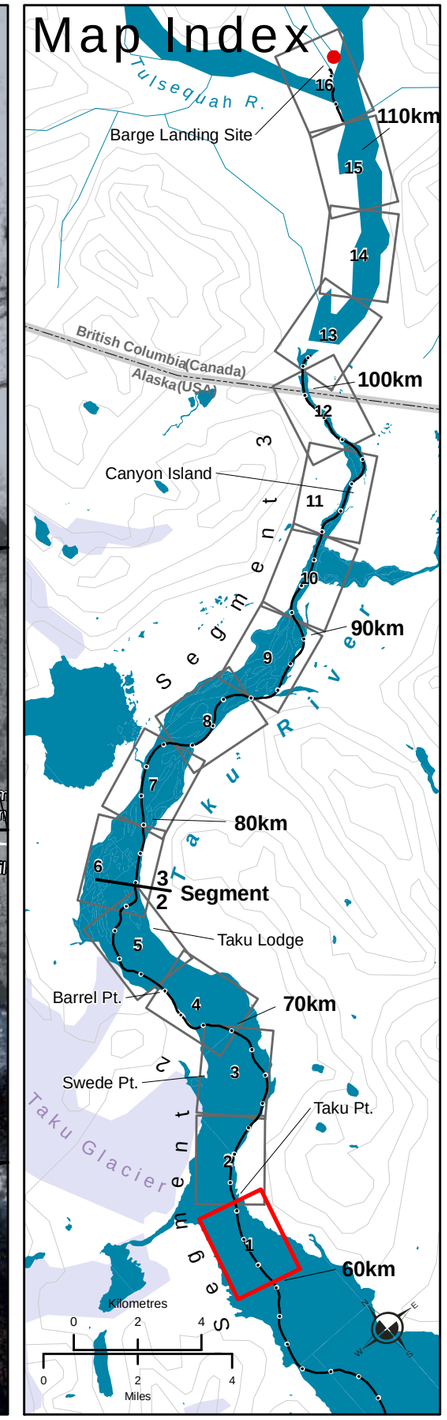
Map 1

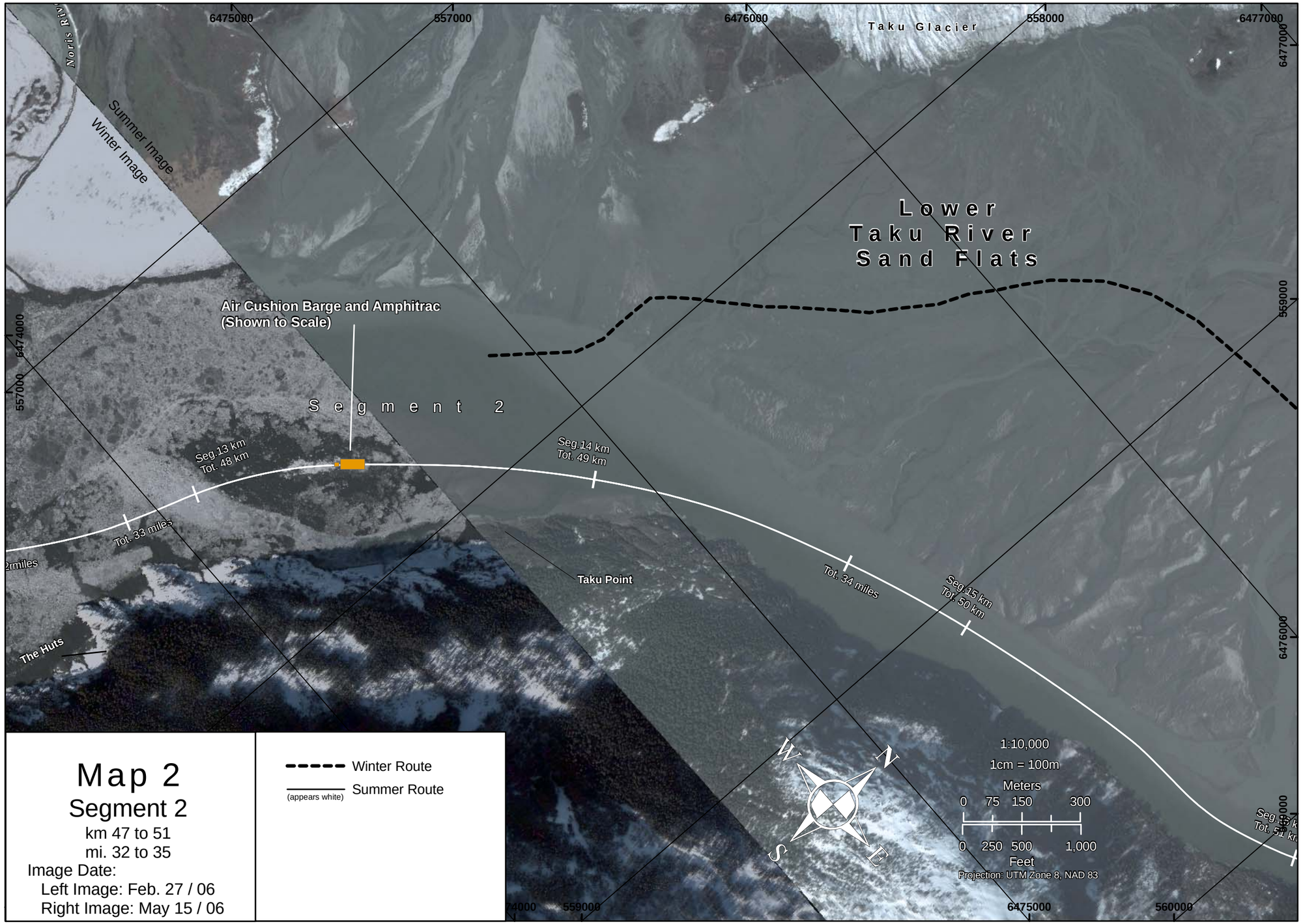
Segment 2

km 44 to 48

mi. 31 to 33

Image Date: Feb. 27 / 06





Map 2

Segment 2

km 47 to 51

mi. 32 to 35

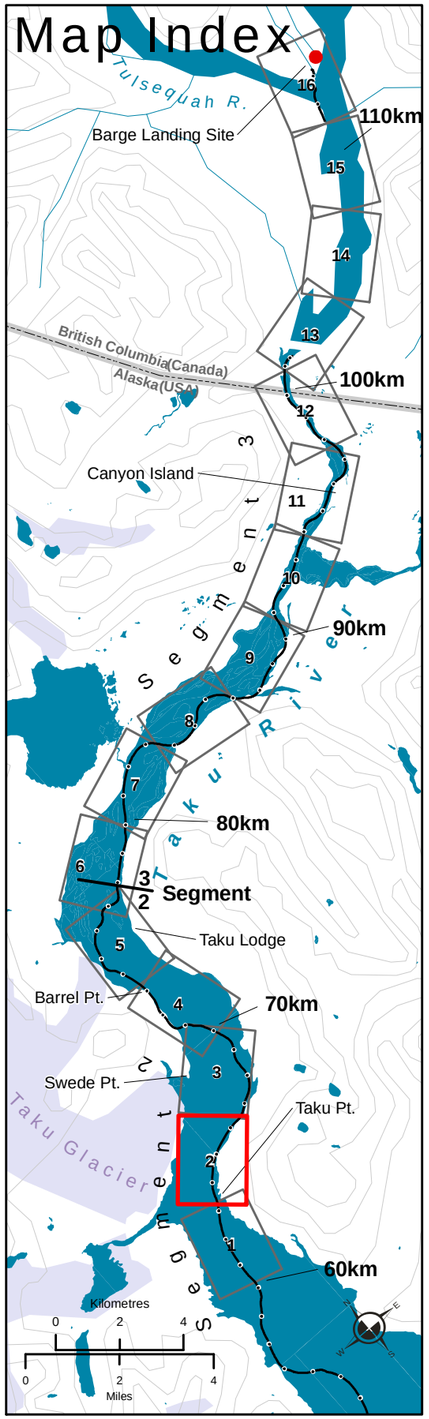
Image Date:

Left Image: Feb. 27 / 06

Right Image: May 15 / 06

Winter Route

Summer Route (appears white)

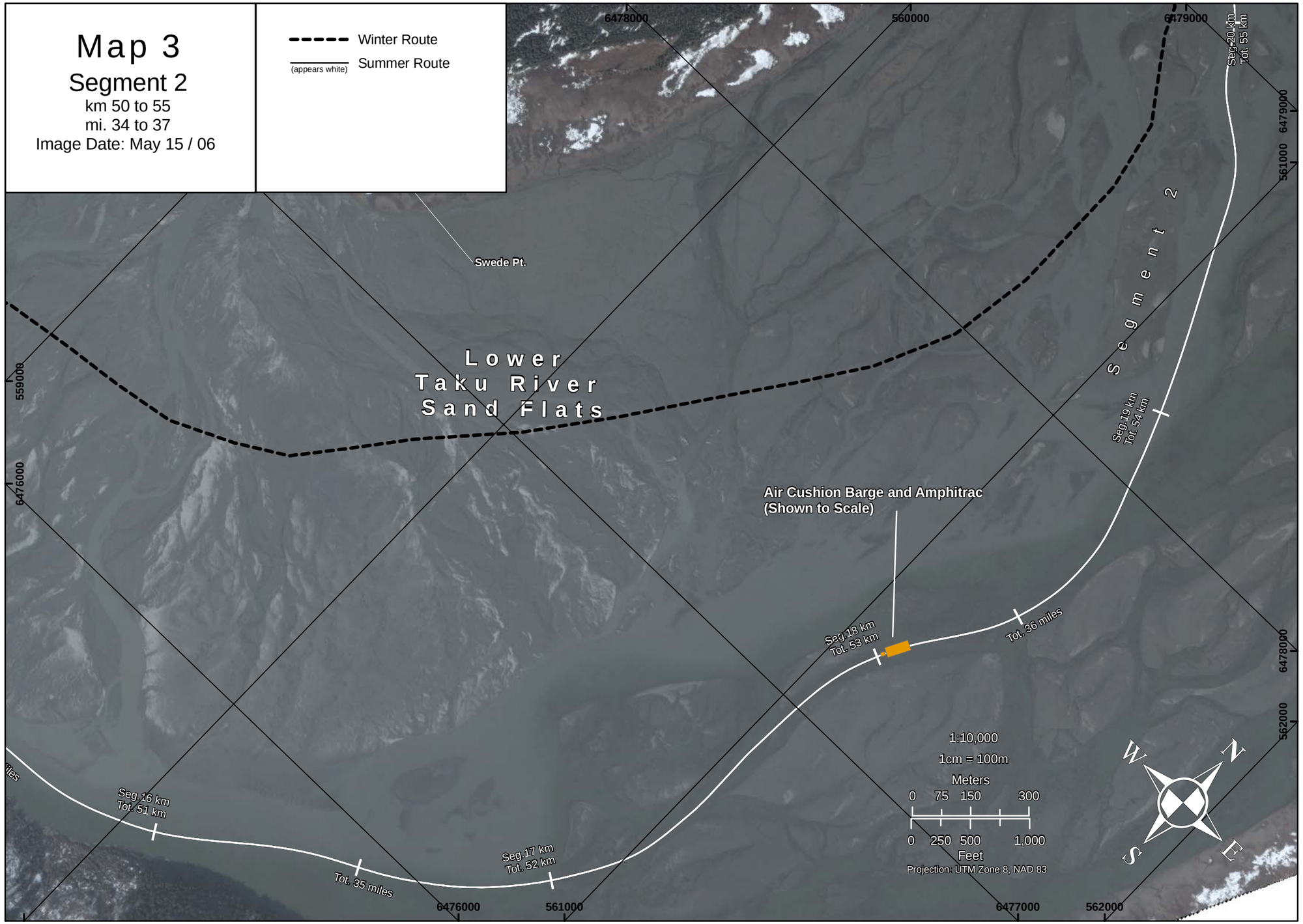


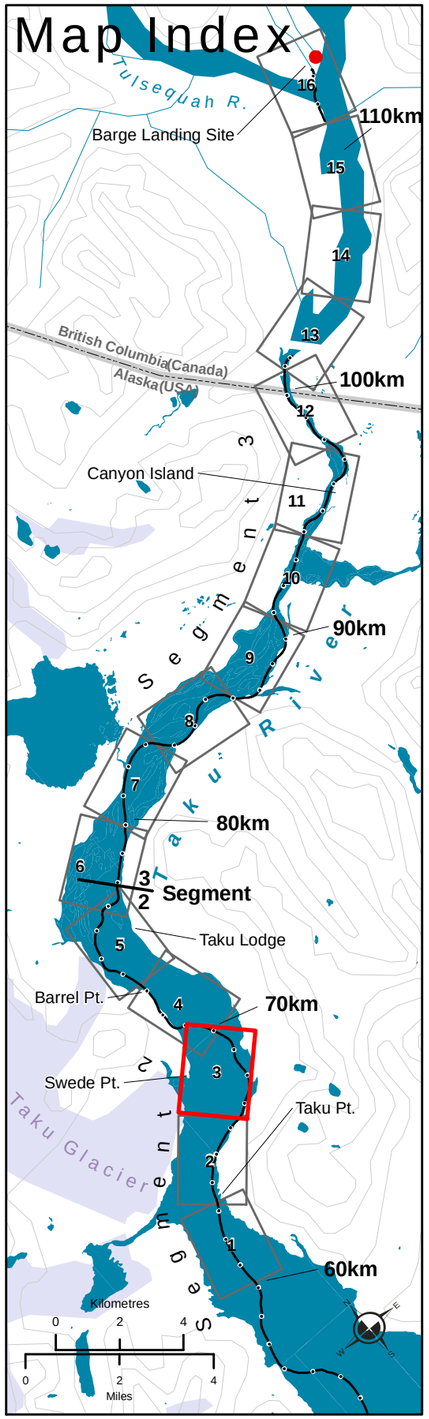
Map 3

Segment 2

km 50 to 55
mi. 34 to 37
Image Date: May 15 / 06

Winter Route
Summer Route (appears white)

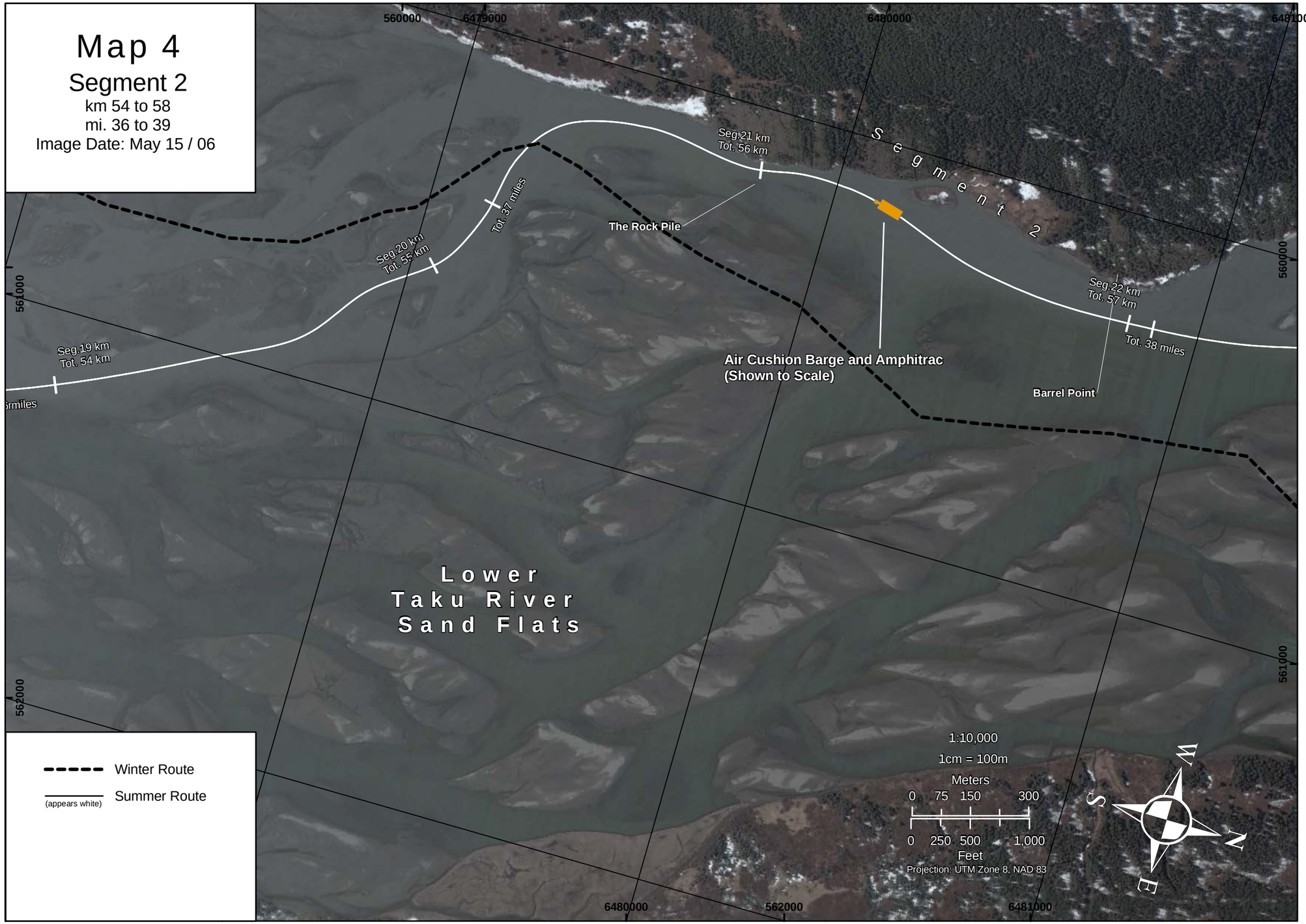


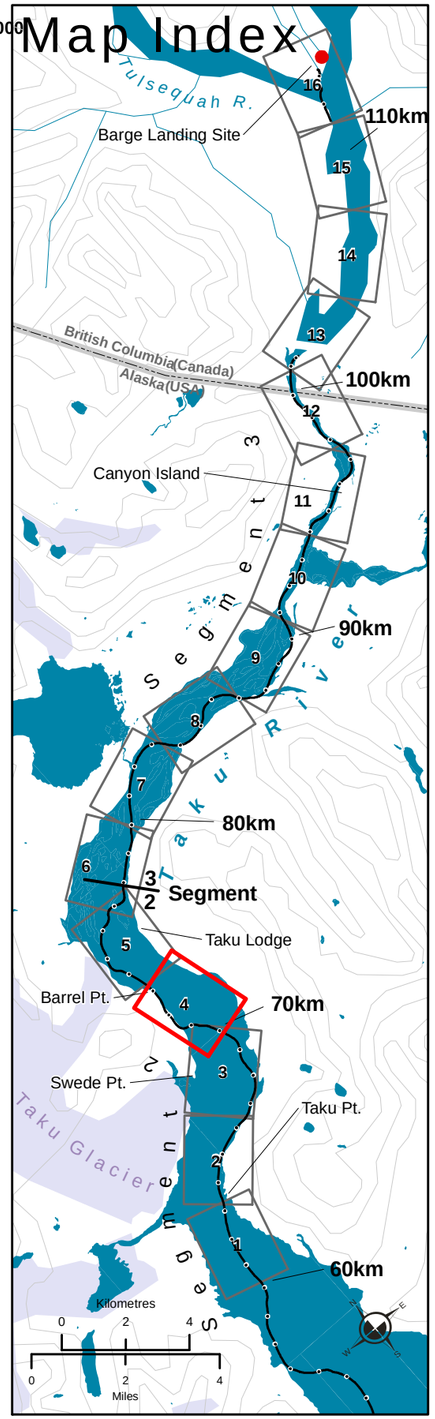


Map 4

Segment 2

km 54 to 58
mi. 36 to 39
Image Date: May 15 / 06

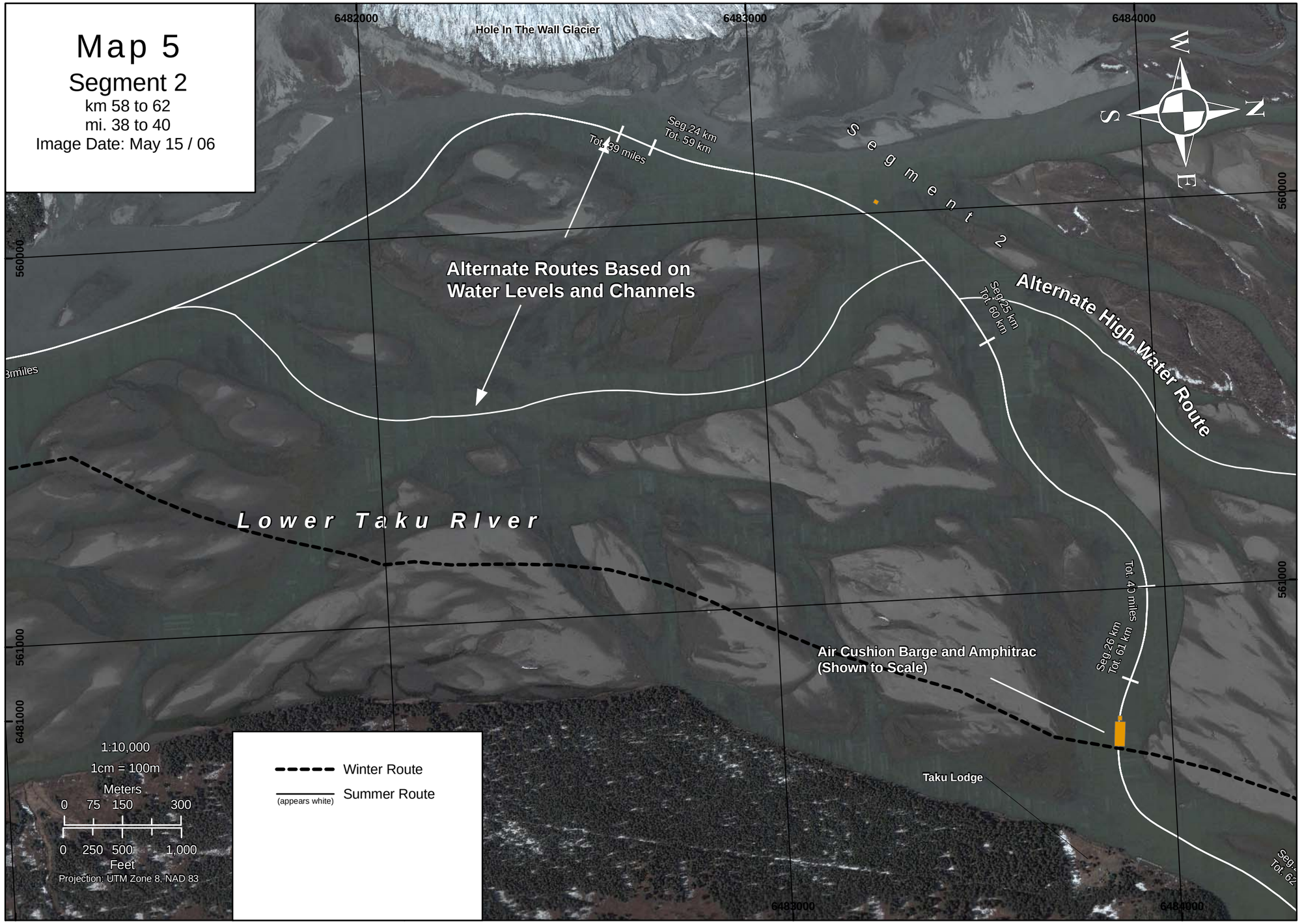


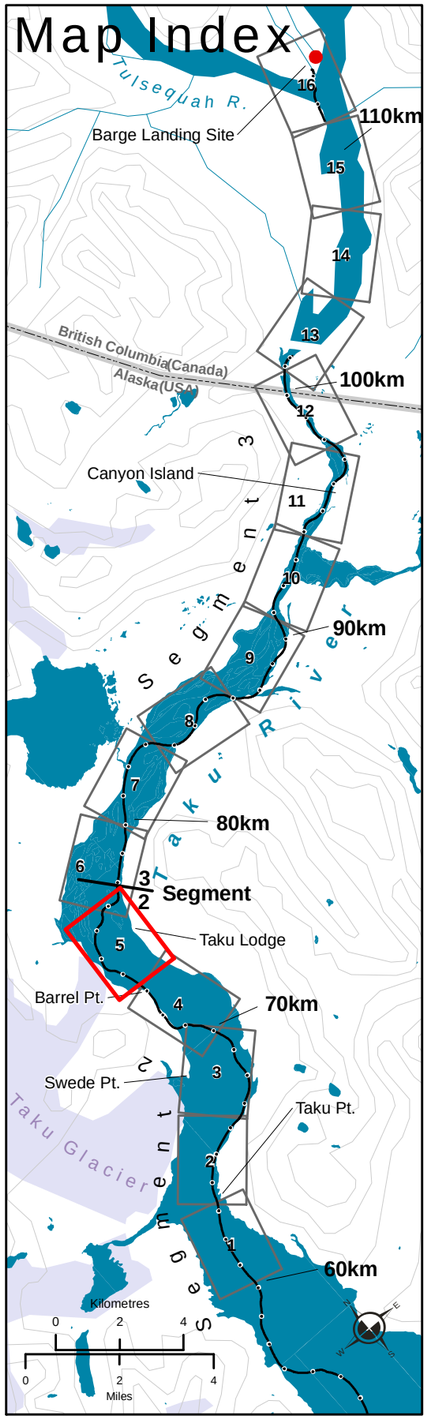


Map 5

Segment 2

km 58 to 62
mi. 38 to 40
Image Date: May 15 / 06



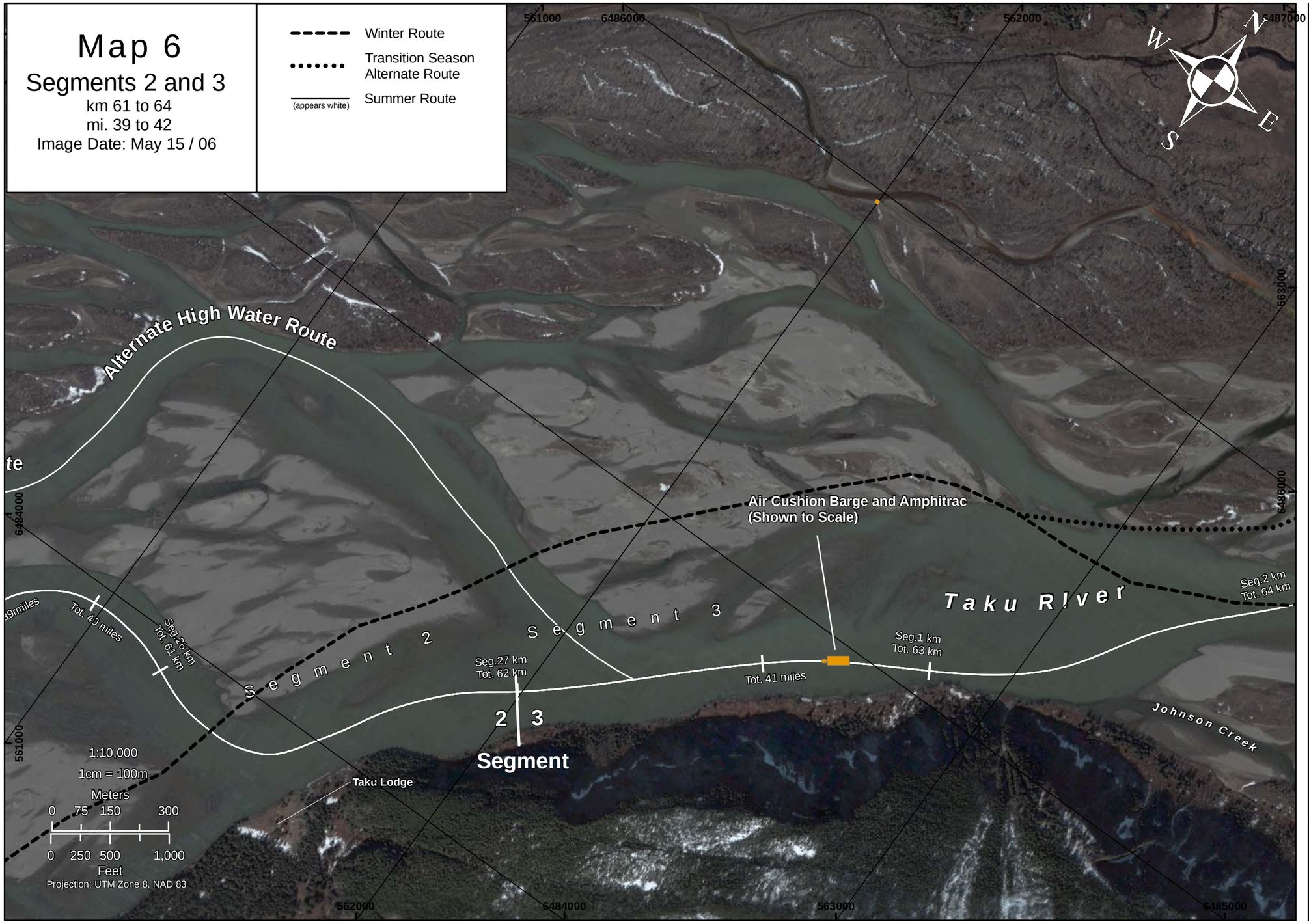


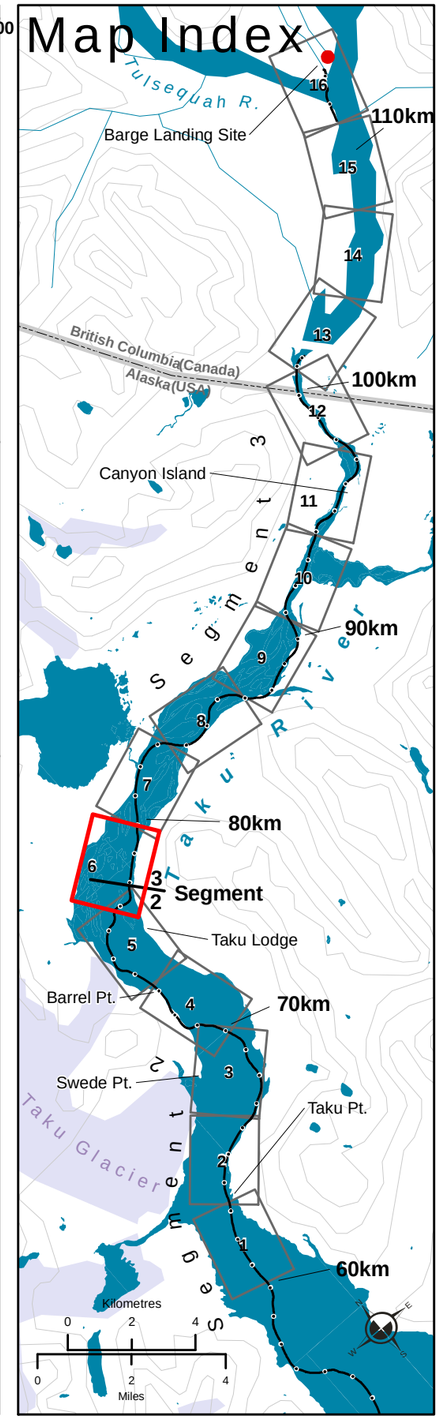
Map 6

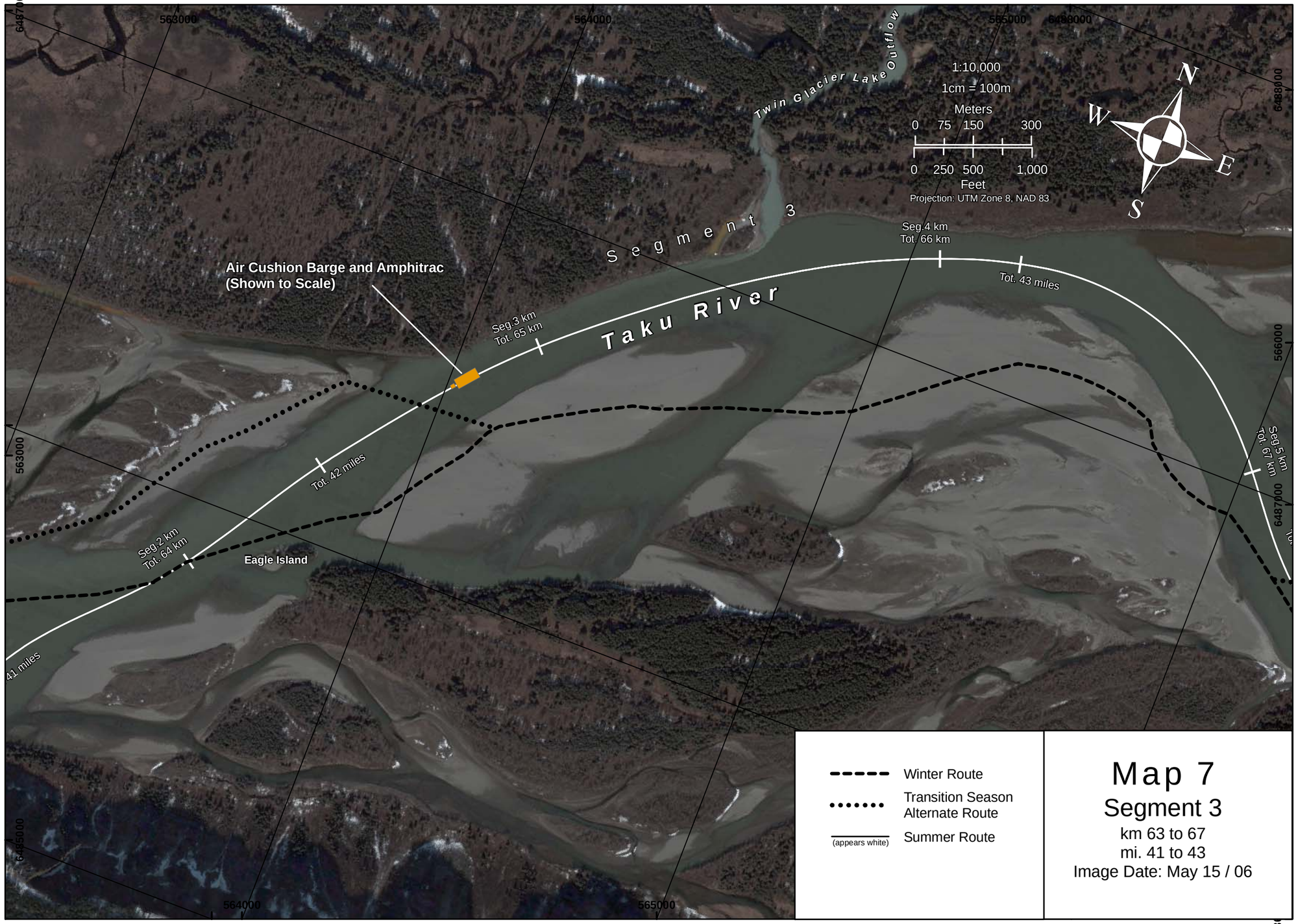
Segments 2 and 3

km 61 to 64
mi. 39 to 42
Image Date: May 15 / 06

- Winter Route
- Transition Season Alternate Route
- Summer Route (appears white)







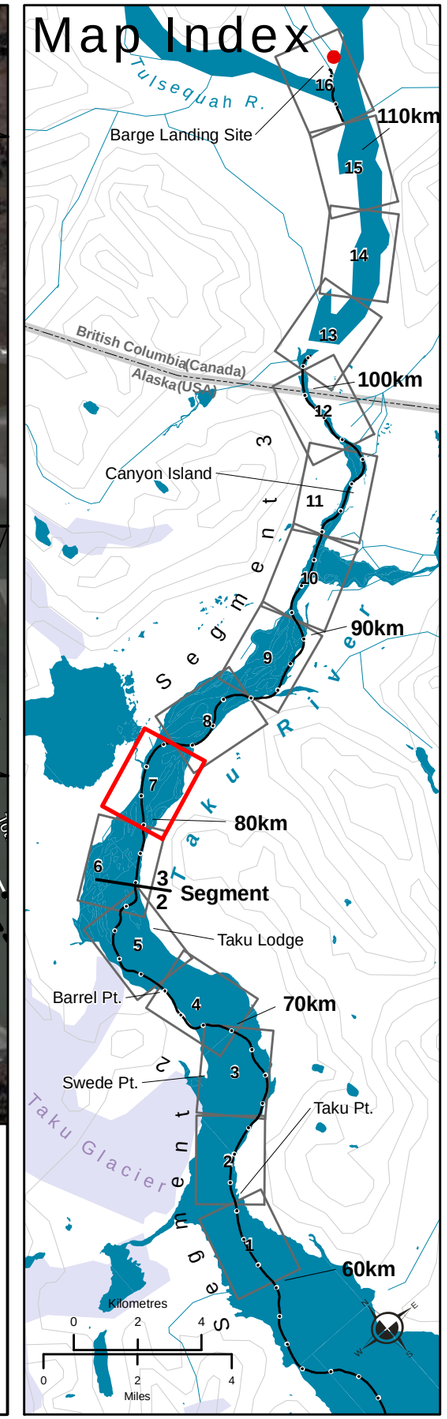
Map 7

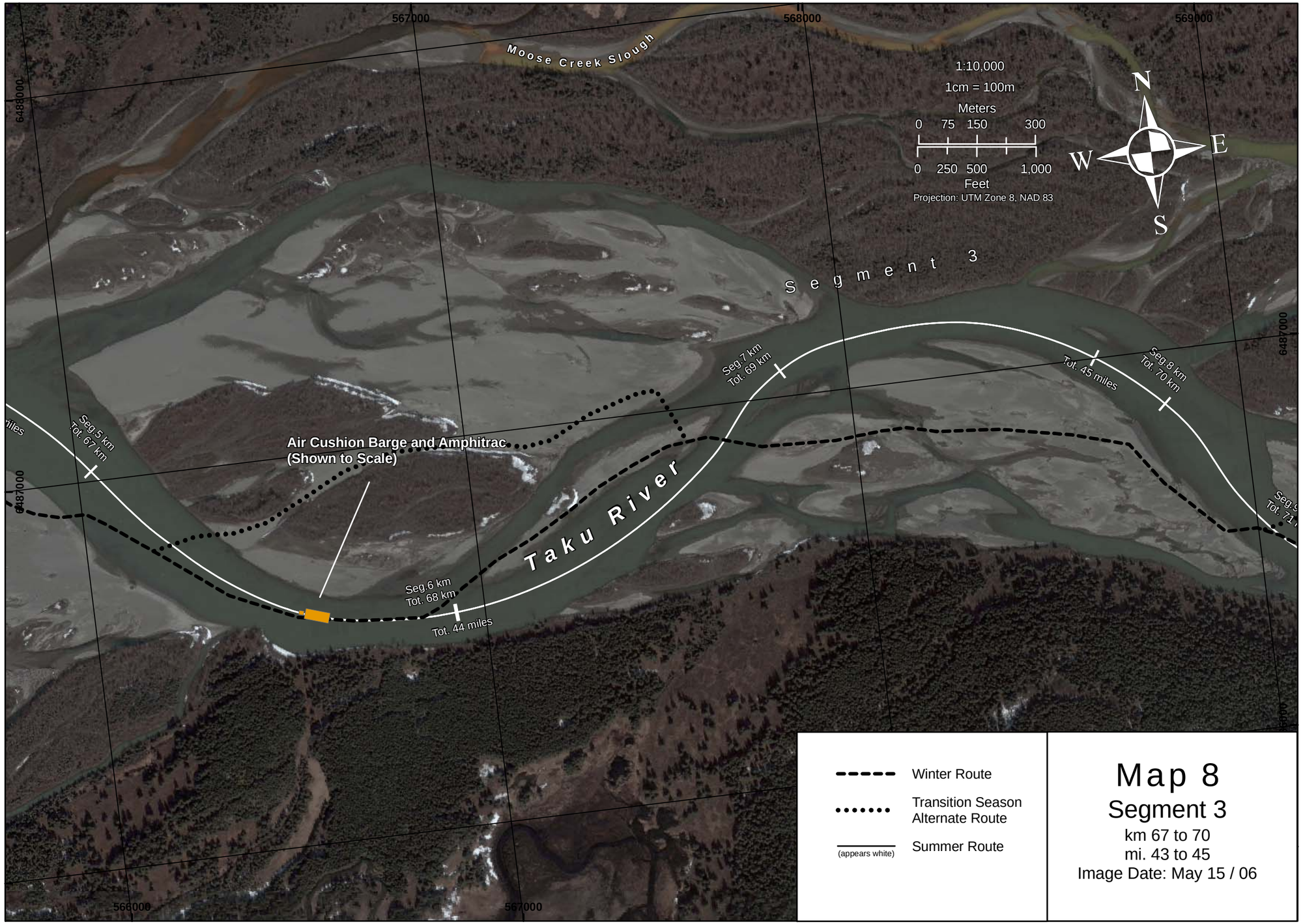
Segment 3

km 63 to 67

mi. 41 to 43

Image Date: May 15 / 06





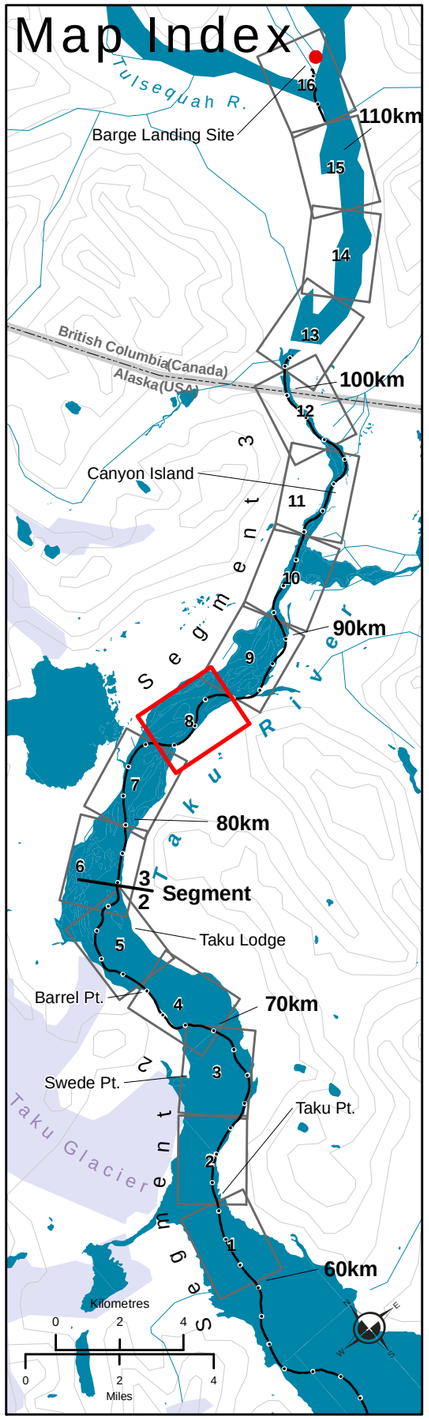
Map 8

Segment 3

km 67 to 70

mi. 43 to 45

Image Date: May 15 / 06



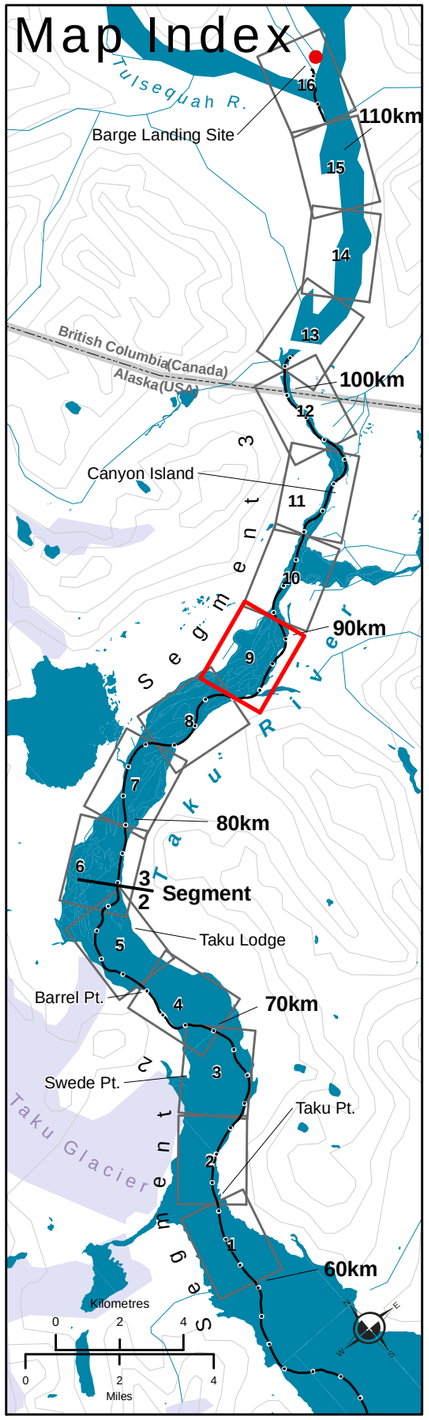
Gartner Lee Limited

Redfern Resources Ltd.

Map 9

Segment 3

km 70 to 74
mi. 45 to 47
Image Date: May 15 / 06



Quickbird Satelite Imagery, 2006. Provided by LANDINFO Worldwide Mapping, LLC

Printed: April 29, 2008

70142_App_C_Taku_River_Barging_Route_Atlas_Map9_RH_ver2.mxd

Map 10

Segment 3

km 74 to 77

mi. 47 to 49

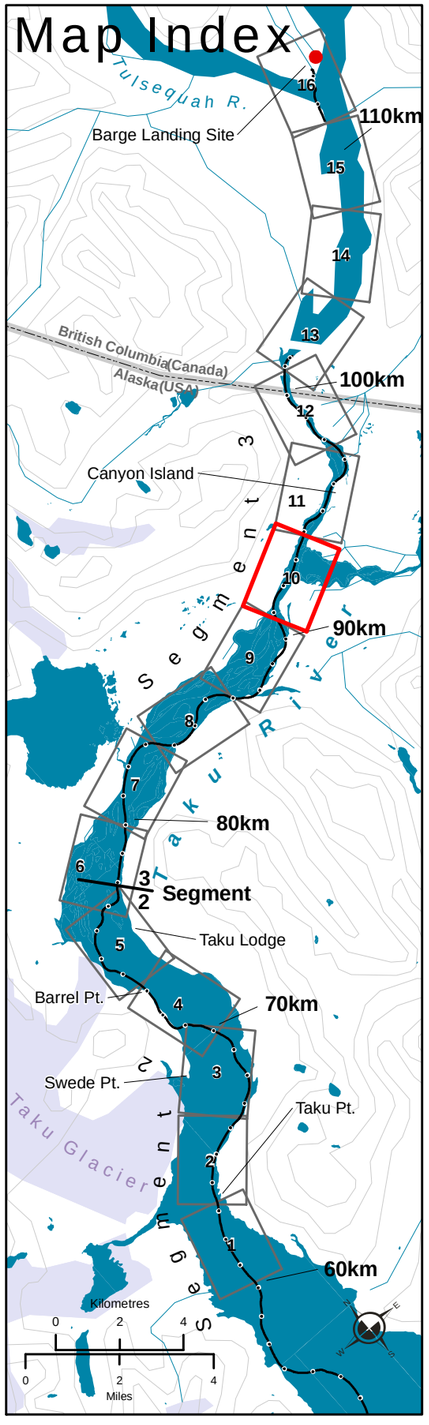
Image Date:

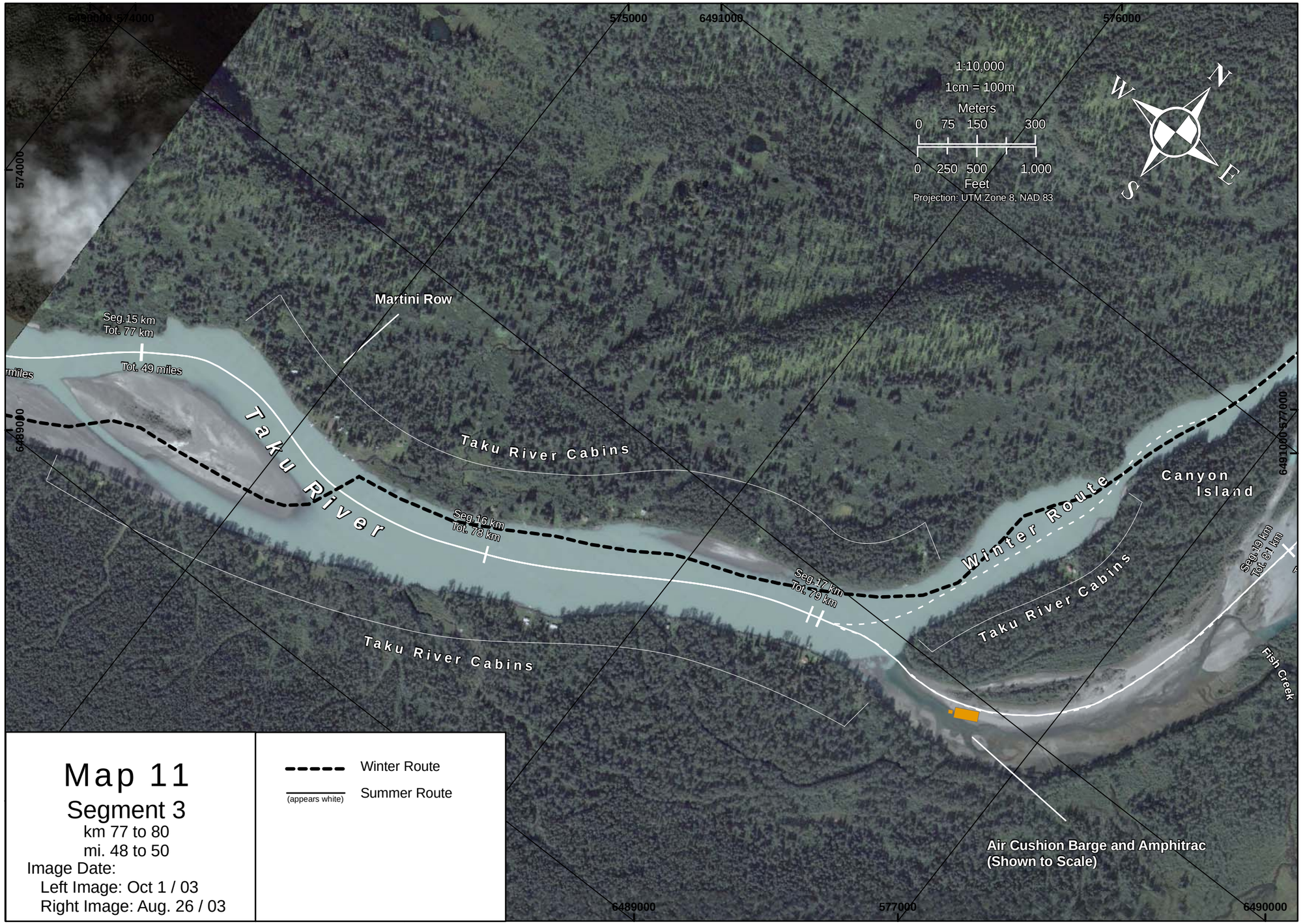
Left Image: May 15 / 06

Centre Image: Oct 1 / 03

Right Image: Aug. 26 / 03

- Winter Route
- Transition Season Alternate Route
- Summer Route (appears white)





Map 11

Segment 3

km 77 to 80

mi. 48 to 50

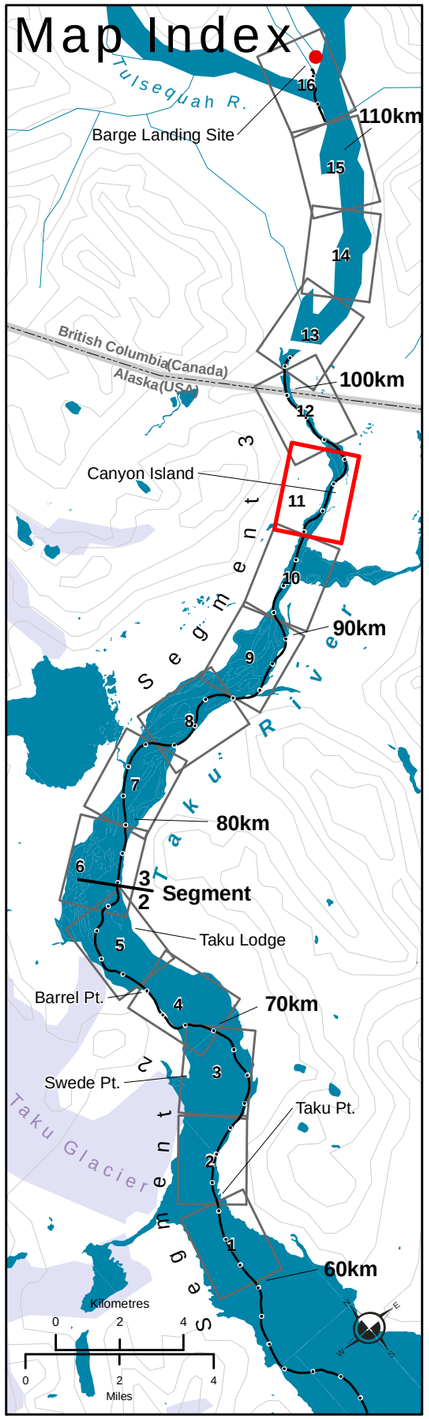
Image Date:

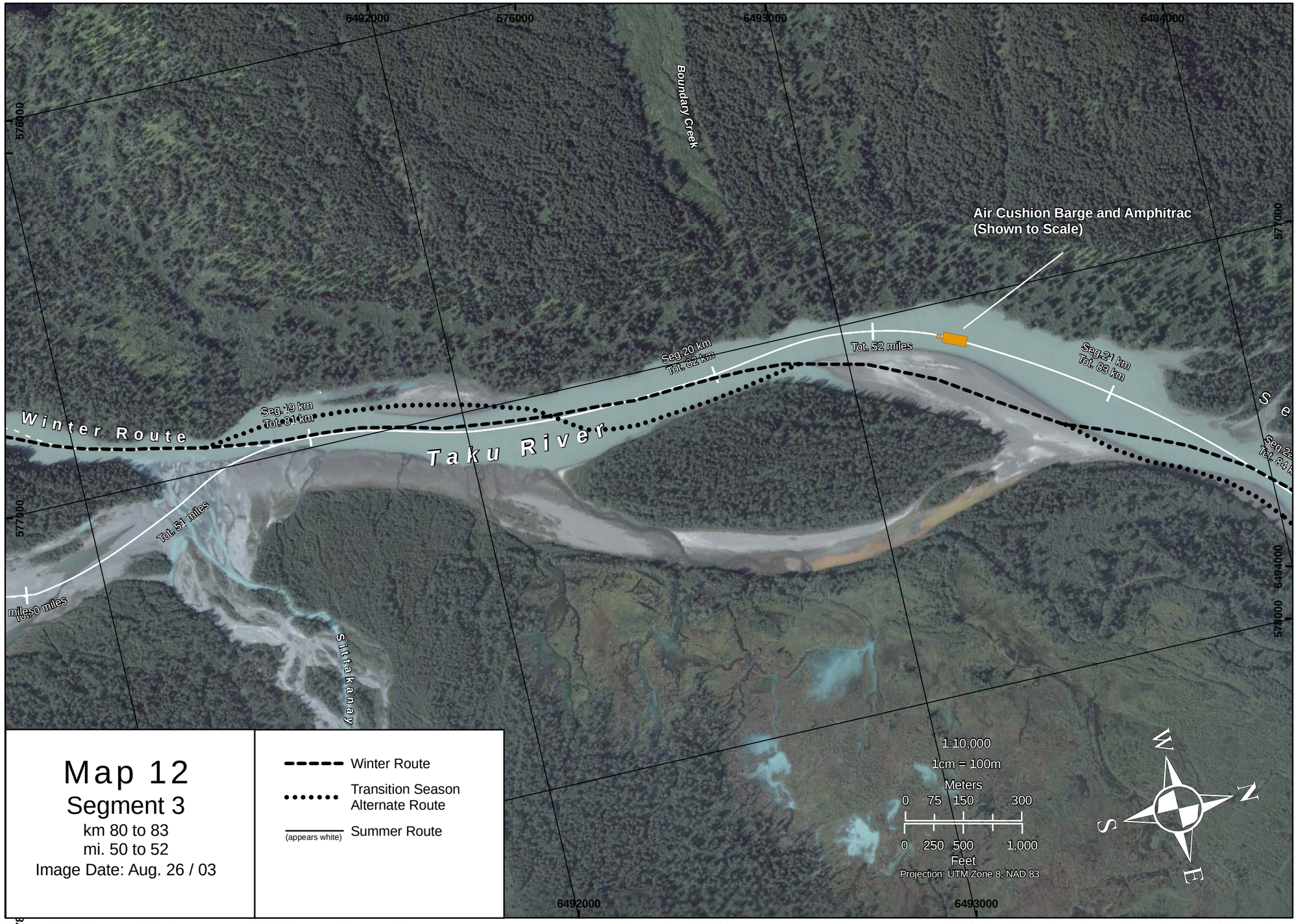
Left Image: Oct 1 / 03

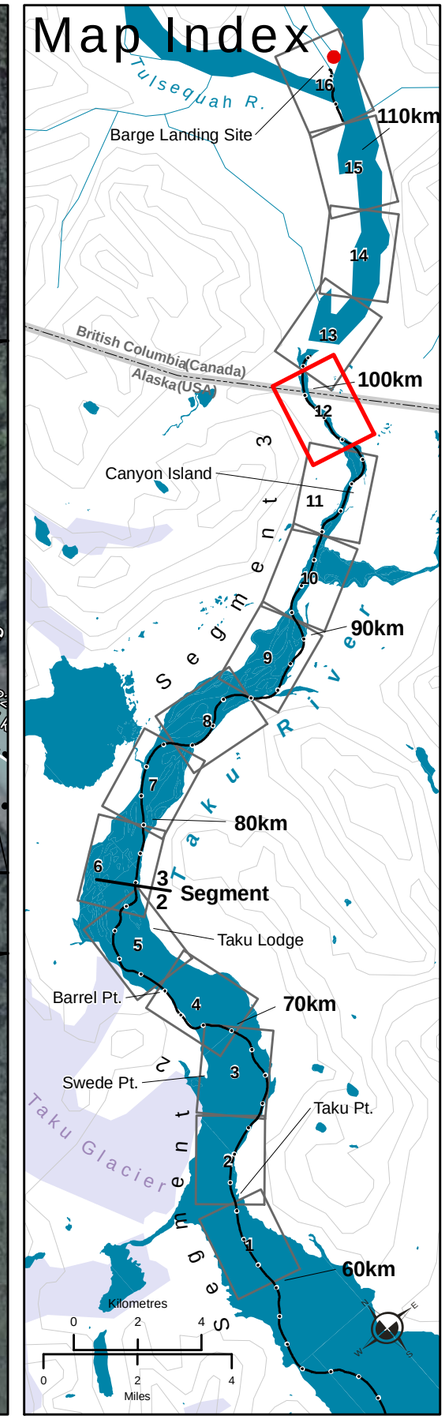
Right Image: Aug. 26 / 03

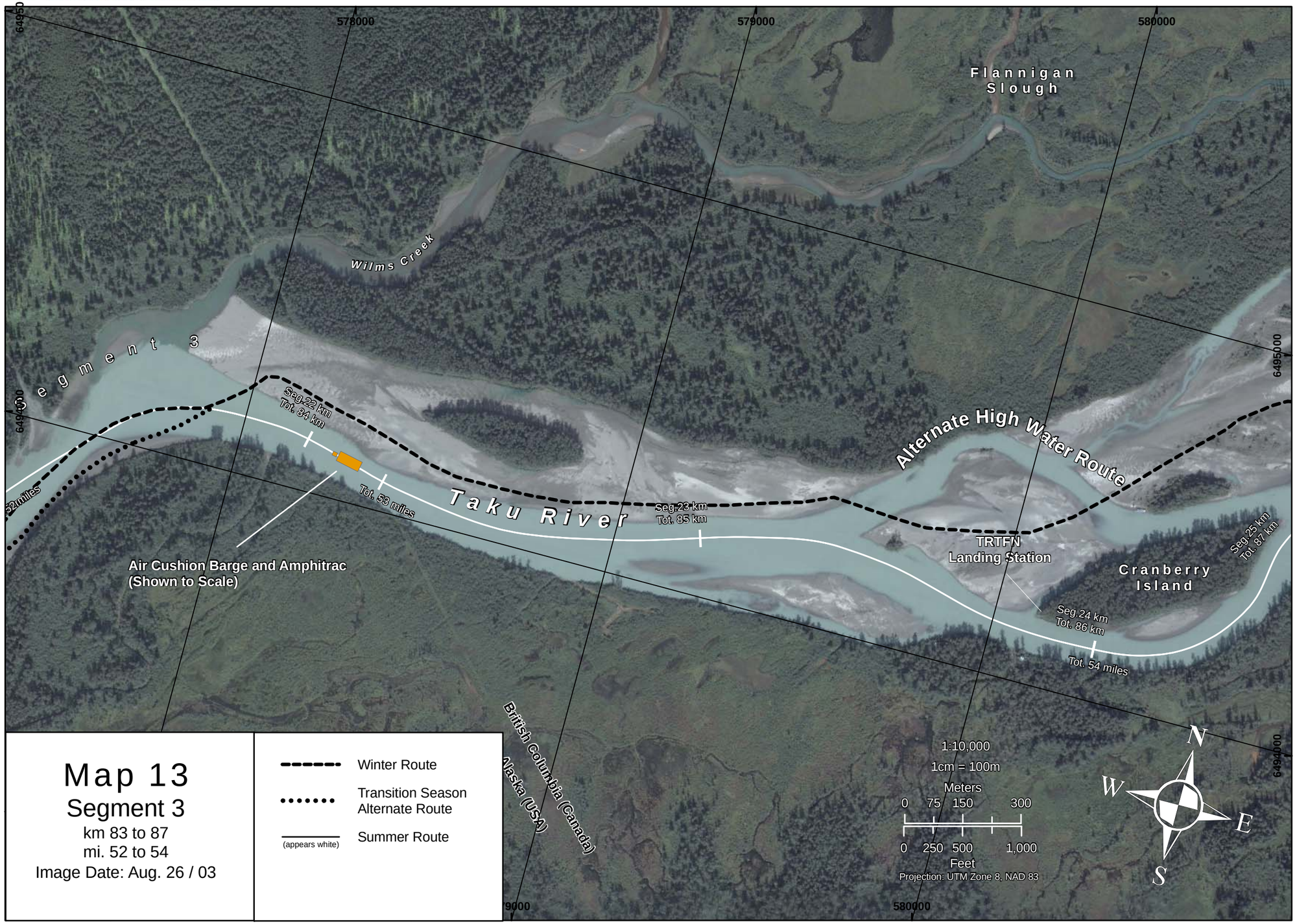
Winter Route

Summer Route (appears white)




6492000
576000
6493000
6494000
578000
577000
Boundary Creek
Air Cushion Barge and Amphitrac
(Shown to Scale)
Seg.20 km
Tot. 52 km
Tot. 52 miles
Seg.21 km
Tot. 83 km
Seg.19 km
Tot. 81 km
Winter Route
Taku River
Tot. 51 miles
miles 50 miles
Sittakanay
Map 12
Segment 3
km 80 to 83
mi. 50 to 52
Image Date: Aug. 26 / 03
Winter Route
Transition Season
Alternate Route
Summer Route
(appears white)
1:10,000
1cm = 100m
Meters
0 75 150 300
0 250 500 1,000
Feet
Projection: UTM Zone 8, NAD 83
W
N
S
E


Map Index
Tulsequah R.
Barge Landing Site
110km
British Columbia(Canada)
Alaska(USA)
100km
Canyon Island
Segment 3
90km
Taku River
80km
3/2 Segment
Taku Lodge
Barrel Pt.
70km
Swede Pt.
Taku Pt.
Taku Glacier
Segment 2
60km
Kilometres
0 2 4
0 2 4
Miles



Map 13

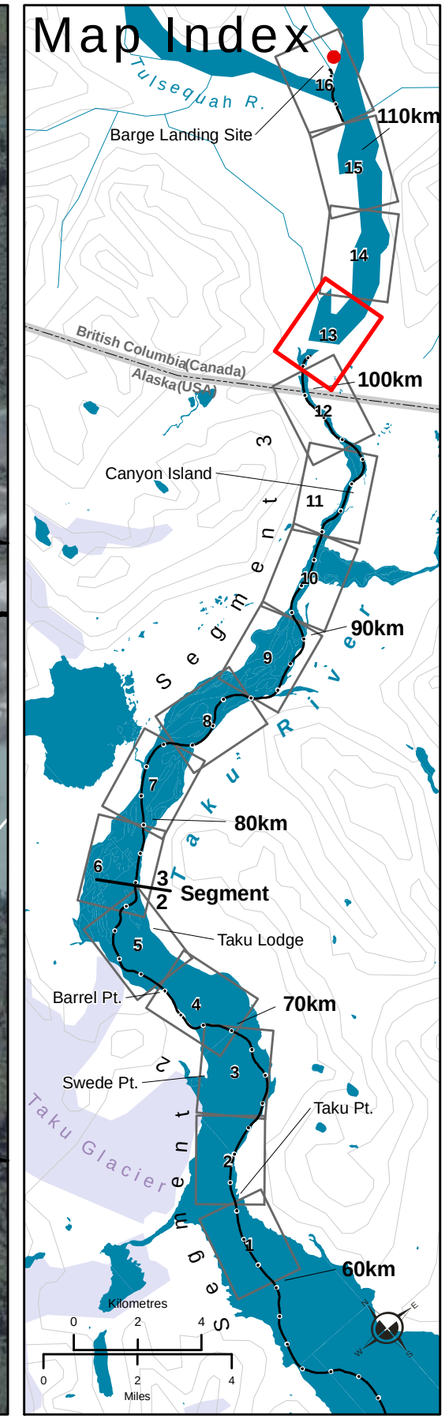
Segment 3

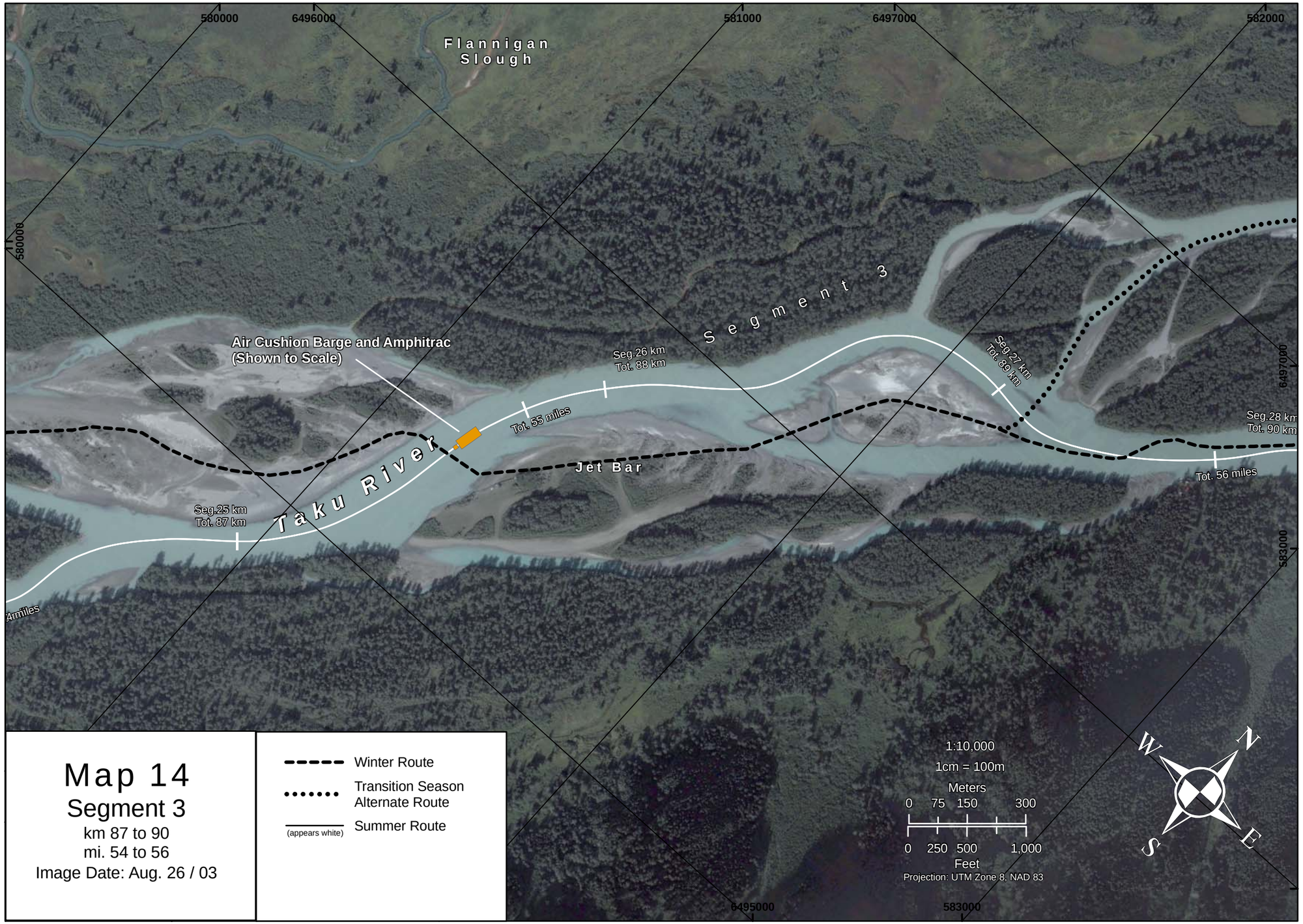
km 83 to 87

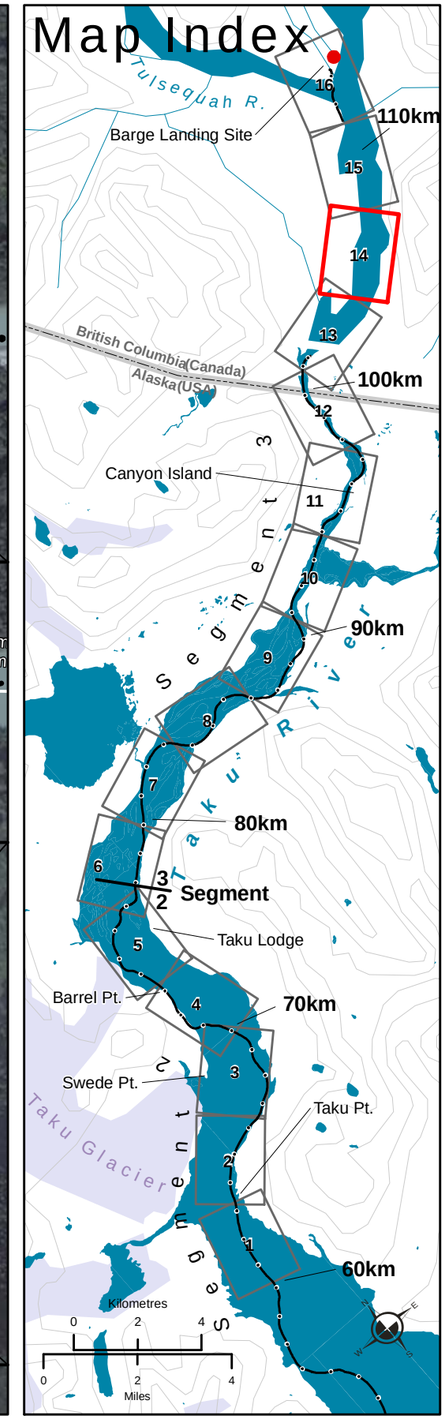
mi. 52 to 54

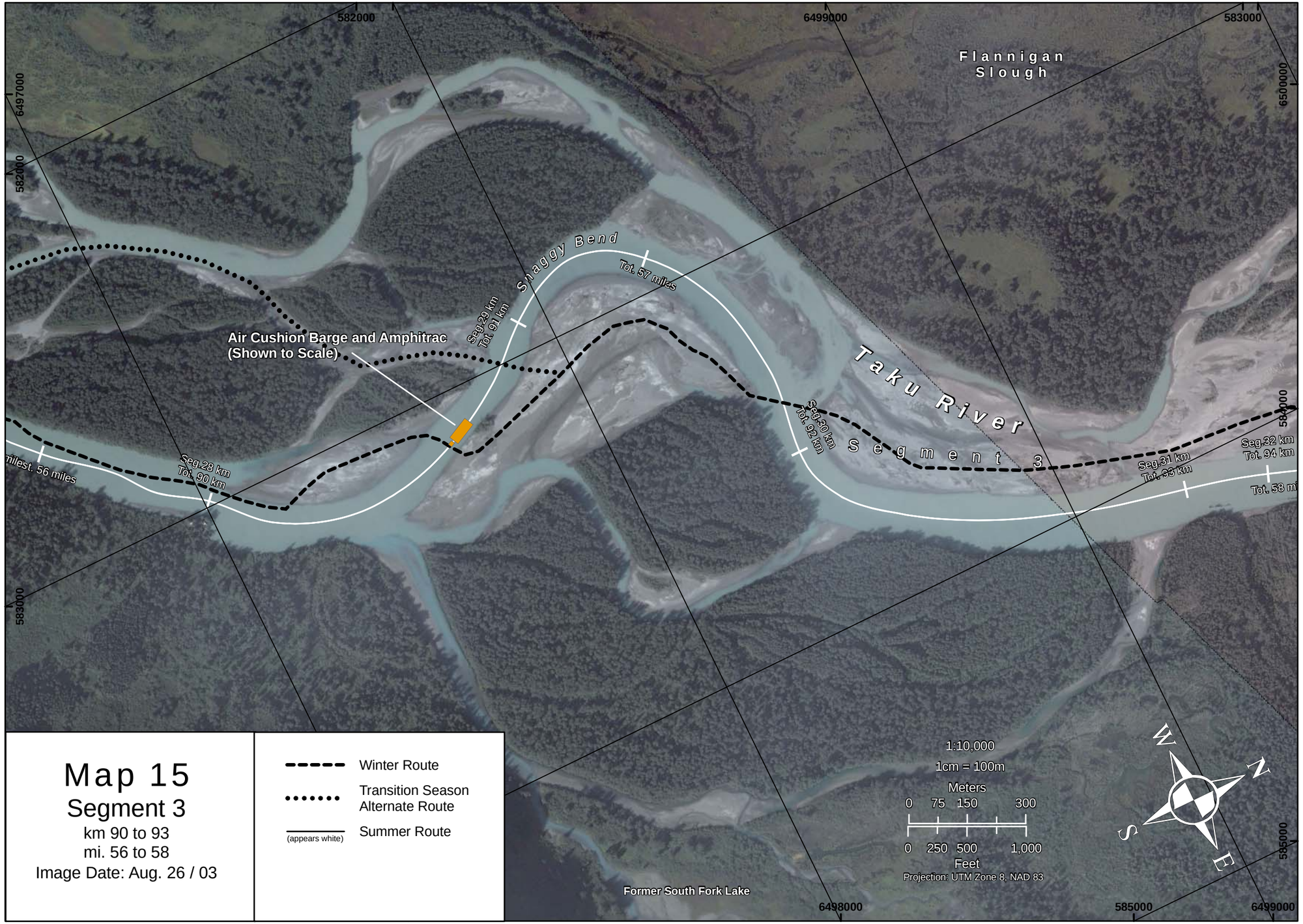
Image Date: Aug. 26 / 03

- Winter Route
- Transition Season Alternate Route
- Summer Route (appears white)




580000
6496000
581000
6497000
582000
580000
6497000
583000
6495000
583000
Flannigan Slough
Segment 3
Air Cushion Barge and Amphitrac (Shown to Scale)
Seg.26 km
Tot. 88 km
Seg.27 km
Tot. 89 km
Tot. 55 miles
Jet Bar
Taku River
Seg.28 km
Tot. 90 km
Tot. 56 miles
Seg.25 km
Tot. 87 km
4miles
Map 14
Segment 3
km 87 to 90
mi. 54 to 56
Image Date: Aug. 26 / 03
Winter Route
Transition Season Alternate Route
Summer Route
(appears white)
1:10,000
1cm = 100m
Meters
0 75 150 300
0 250 500 1,000
Feet
Projection: UTM Zone 8, NAD 83
N
E
S
W


Map Index
Tulsequah R.
Barge Landing Site
110km
British Columbia(Canada)
Alaska(USA)
100km
Canyon Island
Segment 3
90km
Taku River
80km
3/2 Segment
Taku Lodge
Barrel Pt.
70km
Swede Pt.
Taku Pt.
Taku Glacier
60km
Kilometres
0 2 4
0 2 4
Miles



Map 15

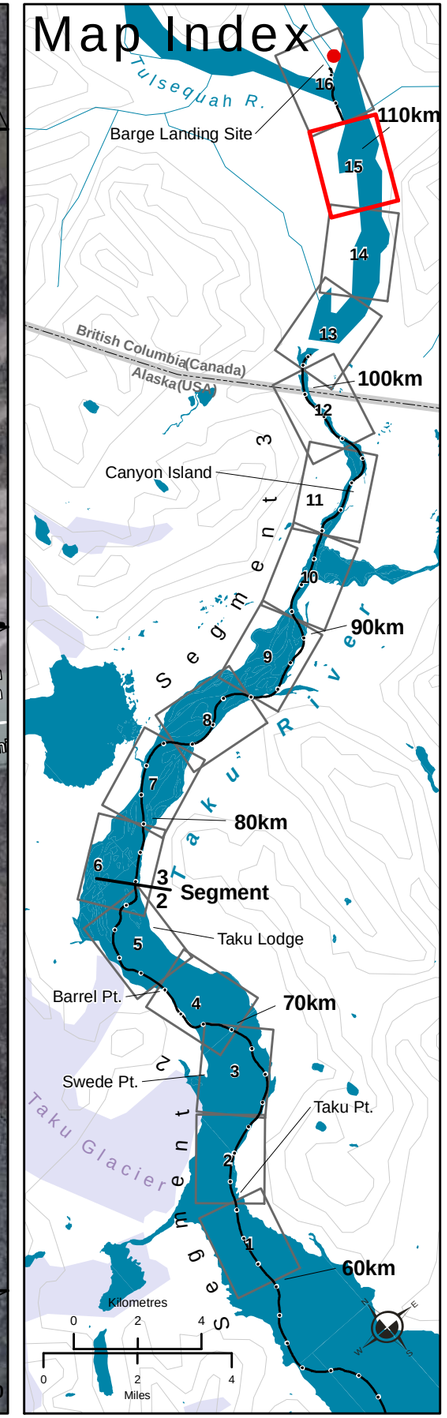
Segment 3

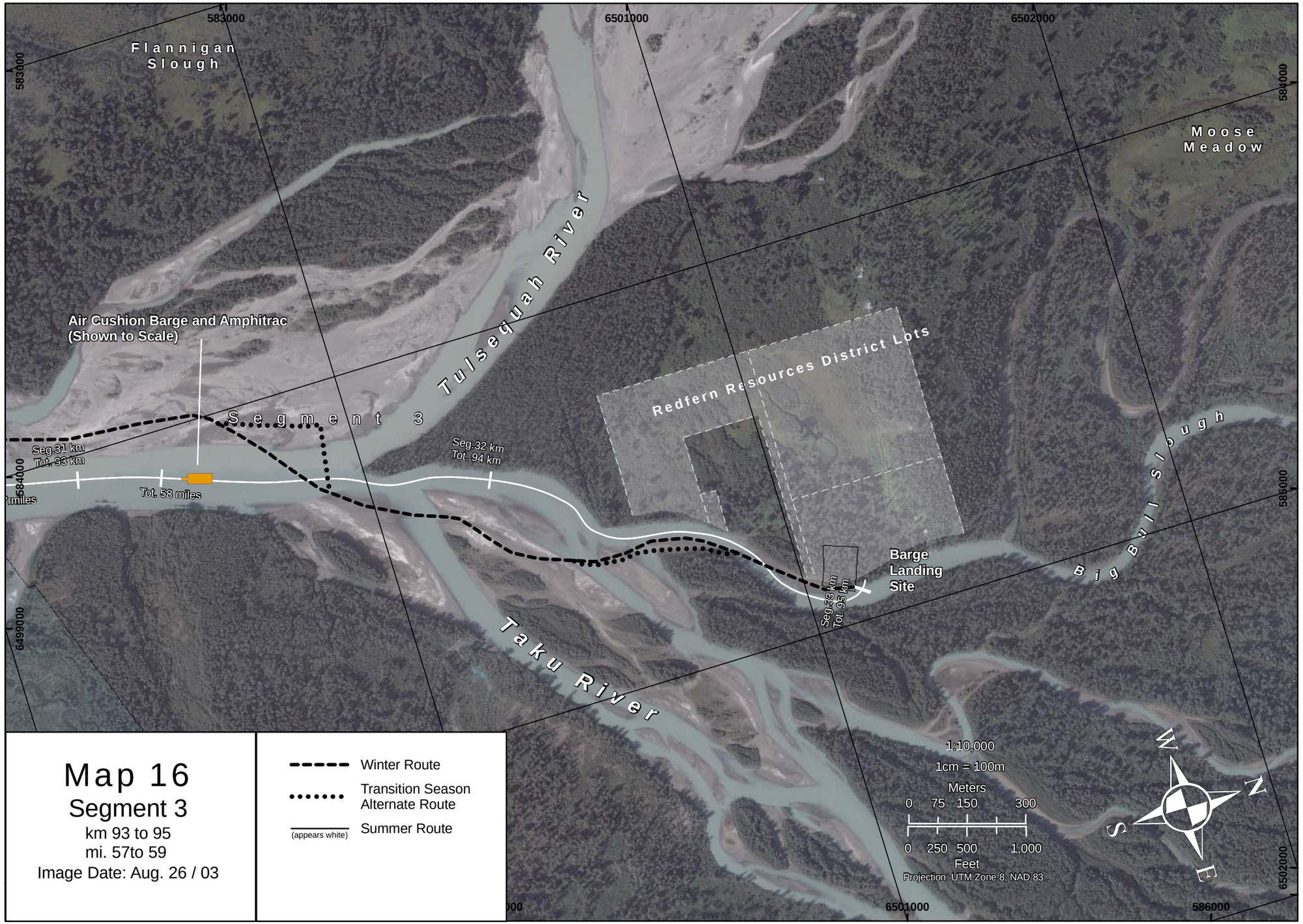
km 90 to 93

mi. 56 to 58

Image Date: Aug. 26 / 03

- Winter Route
- Transition Season Alternate Route
- Summer Route (appears white)





Map 16

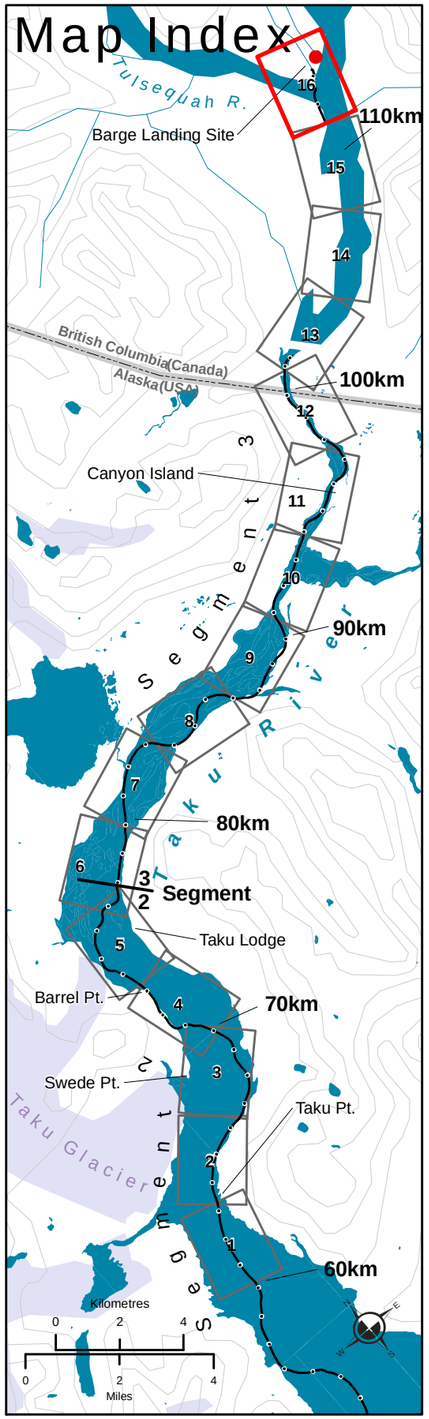
Segment 3

km 93 to 95

mi. 57to 59

Image Date: Aug. 26 / 03

- Winter Route
- Transition Season Alternate Route
- Summer Route (appears white)



Appendix B

Canyon Island: Aquatic and Non-Aquatic Season Routes

Aquatic Season Route

Non-Aquatic (winter) Season Route

Cobble (Dry)

Cobble (Dry)

Sand/Silt (Dry)

Overwintering/Rearing Habitat

Canyon Island

Spawning Habitat (Gravel)

Sand/Silt (Dry)

Sand (wet)

Fish Creek

West Channel

East Channel

Dry (Vegetation)

Silt (Dry)

Rearing Habitat (gravel/sand)

Spawning Habitat (gravel)

Upwelling

Air-Cushion Barge (shown to scale)

60m

30m

Overwintering/Rearing Habitat

Silt (Dry)

Photo 1

Calm and clear shoreline habitat

Photo 2

Numerous fry observed along shoreline

OVERVIEW MAP

Atlin

Atlin Lake

British Columbia (Canada)

Taku River

Alaska (U.S.A.)

TAKU GLACIER

Swede Pt.

Taku Pt.

Juneau

STEPHENS PASSAGE

1:5,033
UTM Zone 12N, NAD 83

File Name: 82648_CanyonIsland_rh_v3_13June2008
Reviewed By: Prepared By: RH
Date Issued: June 2008 Project Number: 82648

CANYON ISLAND

Aquatic and Non-Aquatic Season Routes

Legend

Proposed ACB Route

Appendix B

Flow of image is 370 m^3/s

Redfern Resources Ltd.

Canyon Island
Aquatic and Non-Aquatic
Season Routes

Gartner Lee

Memorandum
25 June 2008

Attachment 2

Updated Taku River Mainstem Channel Profile

April 2008

Updated Taku River Mainstem Channel Profile

Prepared for
Redfern Resources Limited

Submitted by
Gartner Lee Limited

April 2008

Gartner Lee

1. Introduction

Navigation on the Taku River is largely constrained by the tidally influenced sand flats at the mouth of the river between Taku Lodge and Taku Point. Navigation becomes increasingly challenging upstream of the US/Canada boarder where the river becomes more braided and less constrained to a single mainstem channel. Accordingly, a detailed bathymetric analysis has been completed of these two river sections to characterize constraints to navigation. Between the sand flats and the international border, the mainstem river channel is relatively well defined and presents fewer limitations to river navigation. To confirm this interpretation, a mainstem channel depth profile was measured in summer 2007 as part of the sand flats bathymetric survey. Further details on the sand flats survey and methods are presented in the "*Channel Depth Analysis of the Lower Taku River*", Gartner Lee Limited 2007.

In January 2008, a report on the bathymetry of the Taku River in Alaska was provided to the Department of Natural Resources to support Redfern's application for a Title 41 Fish Habitat Permit and a Title 38 Land Use Permit. That analysis focused on river flows at or above 26,000 cfs (740 m3/s) that represents average summer flows. The results of that analysis showed that at average summer flows, there was sufficient depth of water in the main river channel for conventional shallow draft tug use.

Since that time, State regulators have requested that Redfern provide an analysis of the channel depth at lower flows. This report includes the results of this additional analysis.

2. Methods

Continuous depth soundings were collected along the mainstem channel from Taku Point to the mouth of the Tulsequah River in British Columbia on July 6th, 2007. Measurements were collected using a Sonarmite v2.0 Portable Bluetooth Echo Sounder linked to a Trimble XT GPS and digital data recorded mounted on the transom of a locally charted river boat. The local river boat operator generally followed the mainstem channel, although given the relatively high river stage at the time of the survey, the route followed does not absolutely follow the deepest part of the river, or thalweg. However, the results of the profile do provide a general indication of typical minimum channel depth associated with the river mainstem.

River discharge at the time of the survey was relatively high due to high discharge and flooding in the summer of 2007. Accordingly, the channel depth data was reduced to represented normal summer river conditions and levels when normal open water barging would occur. Discharge at the time of the survey was 34,900 cfs (3,185 m3/s). Average summer discharge is 26,000 cfs (740 m3/s). Measured channel depth data was corrected using the stage-discharge relationship

for the USGS's hydrology station at Canyon Island for the upstream end of the survey. The stage-discharge relationship developed by Sandwell (1995) for Taku Lodge was used to reduce the downstream end of the channel profile survey.

3. Results and Discussion

3.1 Average Summer Discharge: 26,000 cfs (740 m^3/s)

Mainstem channel depth results are illustrated in Figure 1, attached. The profile shows the reduced depth data corresponding to average summer water levels. Water depth measurements less than 3 ft (1 m) are portrayed with a yellow dot, whereas water depths greater than 3ft (1m) are shown in green. Three feet is the typical depth required to operate a shallow draft river tug and barge.

The profile confirmed that the major constraint to navigation on the river is the sand flats area. The detailed bathymetric survey work conducted in summer of 2007 mapped the channels through the sand flats. Upstream of the mudflats, the mainstem channel depth is typically 10 feet (3 m) increasing to 18 feet (5.5 m) deep on average in the Canyon Island area. The water depth data shows occasional shallow measurements upstream of the sand flats. Given the sporadic nature of these measurements, these likely represent locations where the boat strayed from the thalweg and/or anomalous measurements.

The Canyon Island river level gauge records river levels throughout the year. River levels typically fluctuate between gauge heights 33 ft to 37 ft (a fluctuation range of 4 feet (1.2 m)) during the "open water season" as described in the Tulsequah Chief ACB Transportation System project description. The water level / gauge height corresponding to summer flow of 26,000 cfs is 34.7 ft. The water depth profile shown on Figure 1 corresponds to this gauge height. During the transition season (freeze-up and break-up), river levels range between 29 and 33 ft gauge height. Therefore, water levels measured on the gauge near Canyon Island during flows between 17,660 cfs and 8,830 cfs are approximately 33.8 ft. and 31.4ft. respectively. During barge operations, the gauge heights will be monitored daily to assist the barge master in assessing the navigability of the river as discharge approaches 8,830 cfs during the transition seasons.

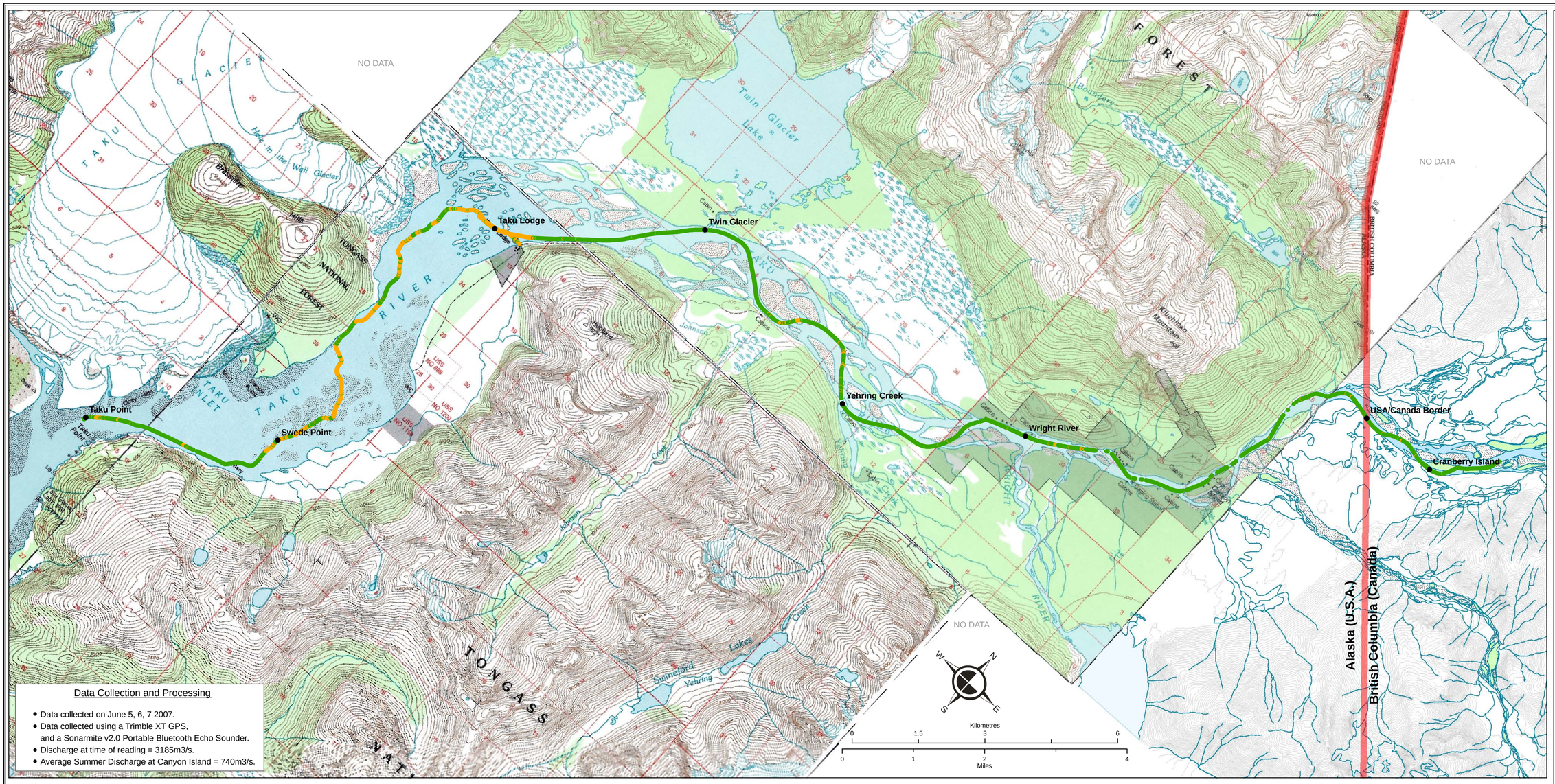
3.2 Low Flow Conditions: 17,660 cfs (500) and 8830 cfs; (250 m^3/s)

Figures 2 and 3 illustrate the channel depth at river discharges of 17,660 cfs and 8,830 cfs, respectively. As is shown on Figure 3, there is a continuous channel upstream of the tidal flats with depth greater than 3 feet. As river discharge approaches 8829 cfs, however, the data suggests that there are two locations between Yehring Creek and Twin Glacier that may pose navigational challenges. It should be noted, however, that the bathymetric data was obtained

during very high flows in 2007, and may not reflect the deepest portion of the thalweg (as it was difficult to identify precisely during the flood conditions). To confirm depths at these locations, additional cross-sectional bathymetric data will be collected during the spring of 2008. It should also be noted that multiple barging trips were successfully completed on the Taku River in late summer, 2007, at flows as low as 9160 cfs (260 m^3/s), demonstrating that a continuous channel of sufficient depth and width is present along the thalweg, upstream of the tidal flats area.

4. Conclusions

The Taku River mainstem channel profile data confirms the presence of a continuous channel upstream of the tidal flats with depth adequate for the operation of shallow draft tug and barge during the open water season at flows greater than 17,660 cfs. As flows approach 8830 cfs, there appear to be two areas upstream of the tidal flats where there may be additional constraints to navigation, due to the shallowness of the channel. These areas will be surveyed in detail in spring 2008 to confirm the depth and width of the channel. The evidence presented by the successful river barging completed in summer 2007 at flows as low as 9160 cfs complements this conclusion.



Data Collection and Processing

- Data collected on June 5, 6, 7 2007.
- Data collected using a Trimble XT GPS, and a Sonarmite v2.0 Portable Bluetooth Echo Sounder.
- Discharge at time of reading = 3185m3/s.
- Average Summer Discharge at Canyon Island = 740m3/s.

Key To Features

Survey Route

Depths Along Route (ft)

- >3
- <3

Land Cover

- Vegetated area
- Glacier
- Sandbar

Topography

- Index (100m)
- Intermediate (20m)

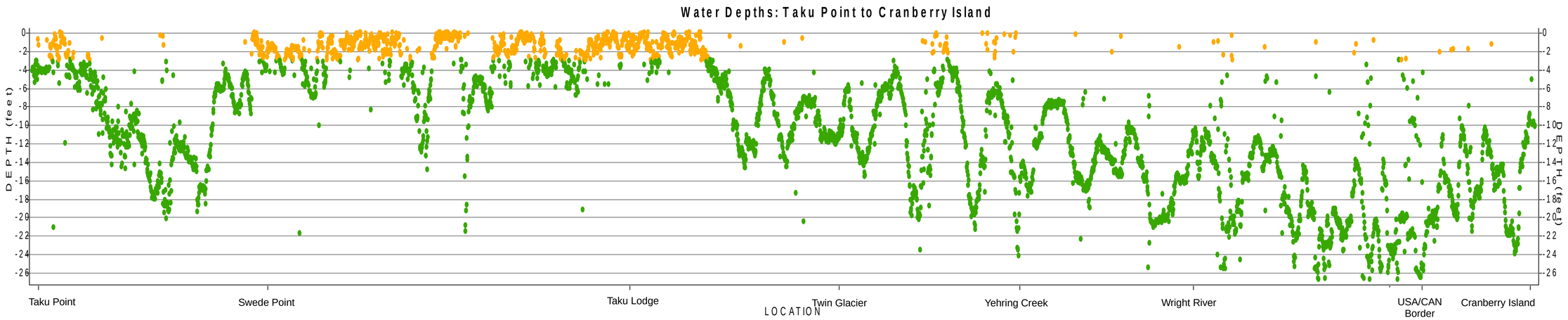
Water Features

- Streams
- Lakes / Rivers

Map Sources/Notes:
Water Depth Measurements Collected on June 7/2007 by Gartner Lee Ltd. field staff.

Topographic Images derived from Digital Raster Graphic (DRG) Images produced by the USGS. Terrain Resource Information Management (TRIM) base data compiled by the Ministry of Environment, Lands and Parks, Geographic Data BC, Province of British Columbia at a scale of 1:20,000

UTM Zone 8N, NAD 83



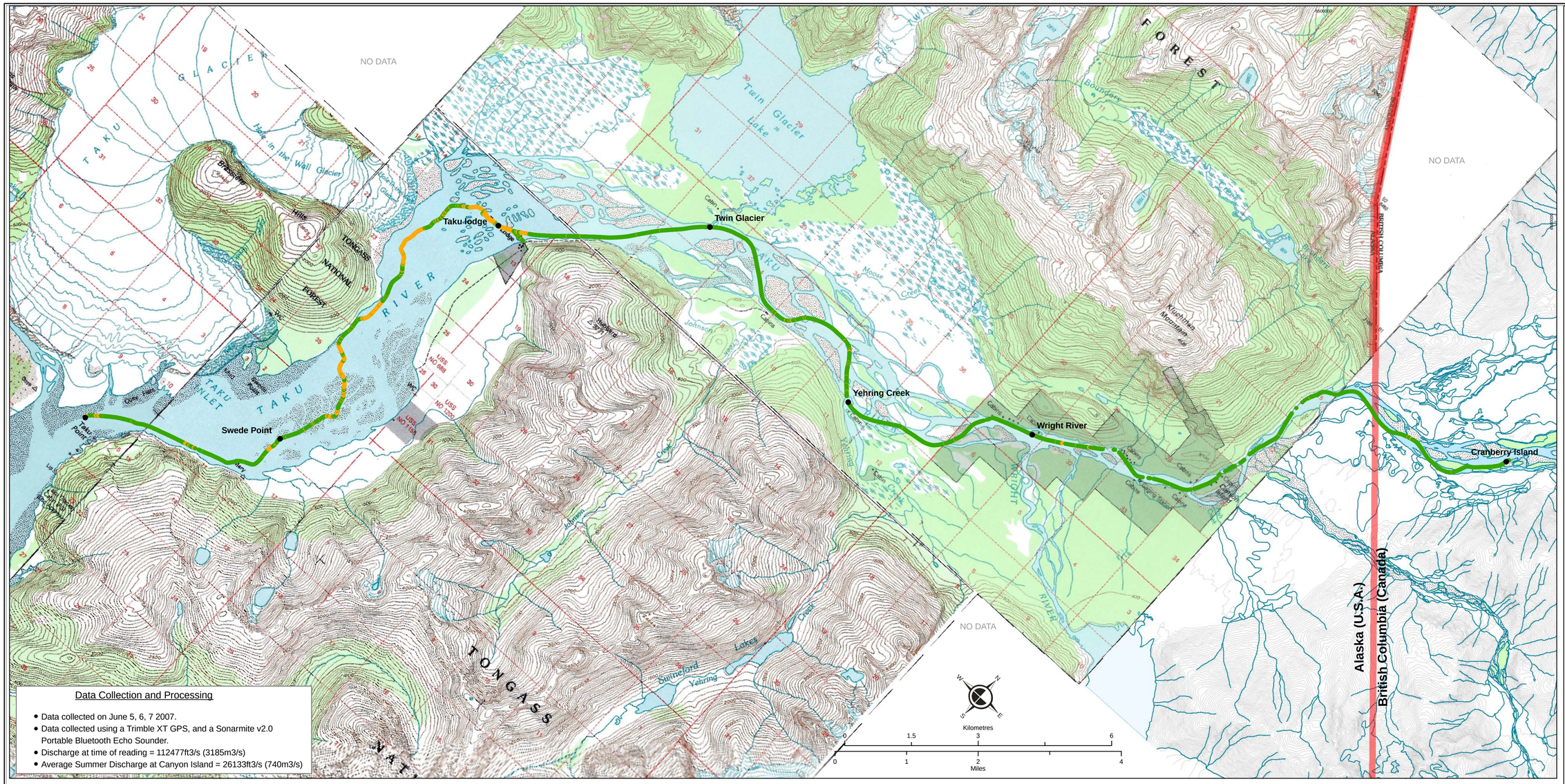
Redfern Resources Ltd.

Channel Depth During Taku River Flood Discharge = 740m3/s

Gartner Lee

Figure 1
Version 1

Date Revised: January 8, 2008
Date Plotted: January 8, 2008
Revision: 0
File Location: S:\GIS_Plots\Redfern\Bathymetry\2008_Johnny_Aquatics_Janaure_added.mxd



Data Collection and Processing

- Data collected on June 5, 6, 7 2007.
- Data collected using a Trimble XT GPS, and a Sonarmite v2.0 Portable Bluetooth Echo Sounder.
- Discharge at time of reading = 112477ft3/s (3185m3/s)
- Average Summer Discharge at Canyon Island = 26133ft3/s (740m3/s)

Key To Features

Survey Route

Depths Along Route (ft)

- >3
- <3

Land Cover

- Vegetated area
- Glacier
- Sandbar

Topography (U.S.A.)

- Index (500ft)
- Intermediate (100ft)

Topography (Canada)

- Index (100m)
- Intermediate (20m)

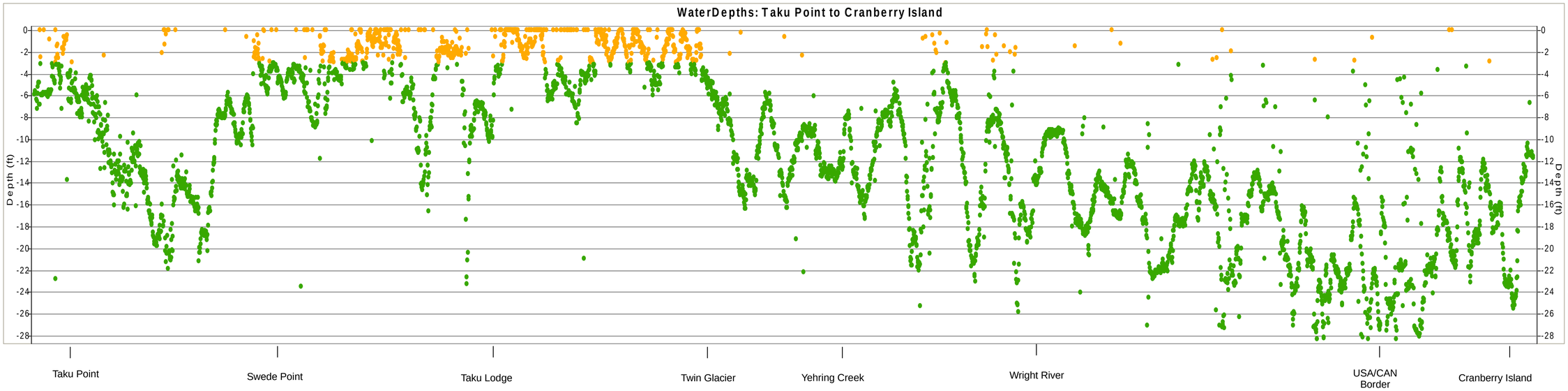
Water Features

- Streams
- Lakes / Rivers

Map Sources/Notes:
Water Depth Measurements Collected on June 7/2007 by Gartner Lee Ltd. field staff.

Topographic Images derived from Digital Raster Graphic (DRG) Images produced by the USGS. Terrain Resource Information Management (TRIM) base data compiled by the Ministry of Environment, Lands and Parks, Geographic Data BC, Province of British Columbia at a scale of 1:20,000

UTM Zone 8N, NAD 83



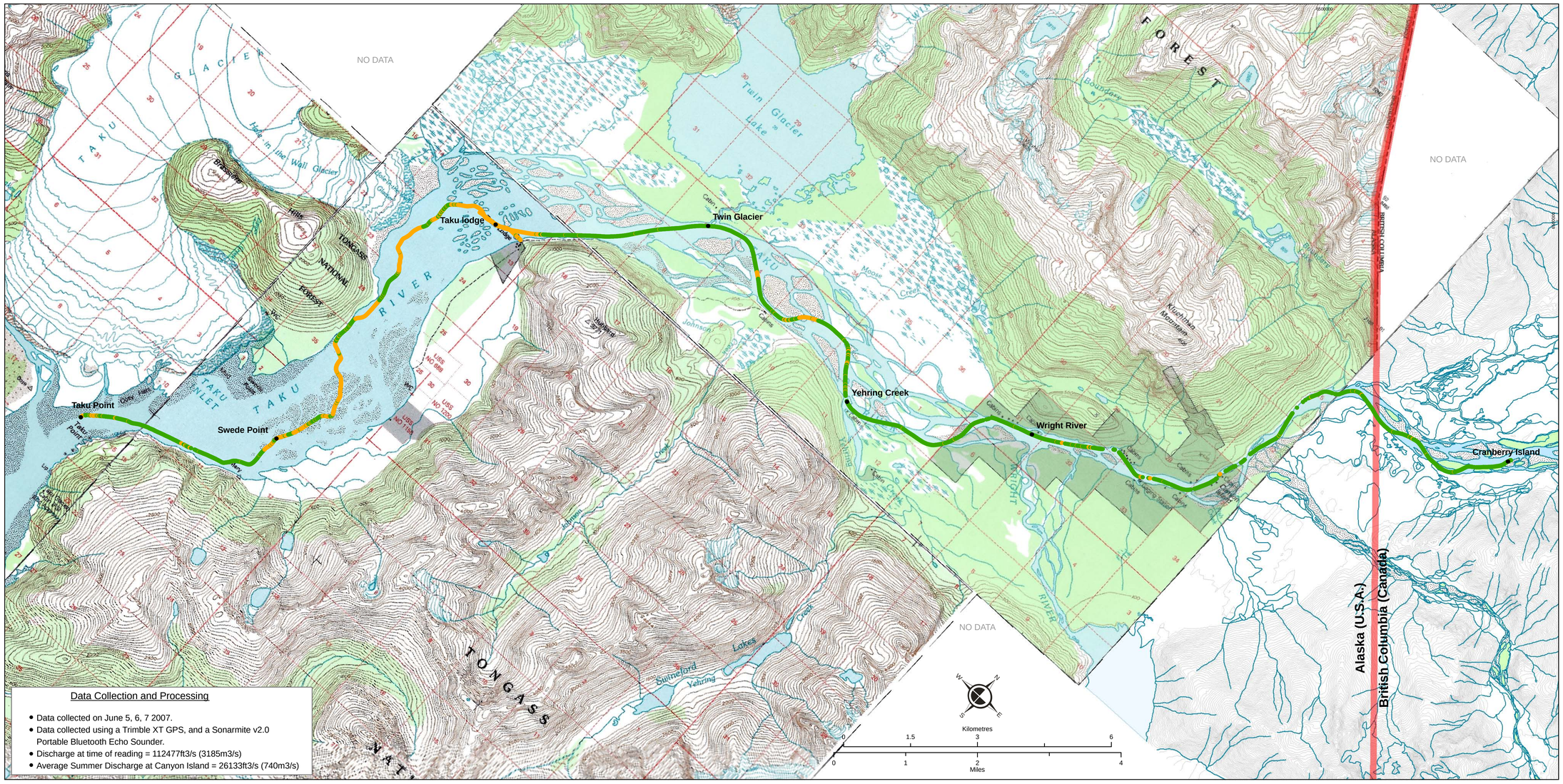
Redfern Resources Ltd.

Channel Depth of Taku River Flood Discharge = 17657ft3/s (500m3/s)

Gartner Lee

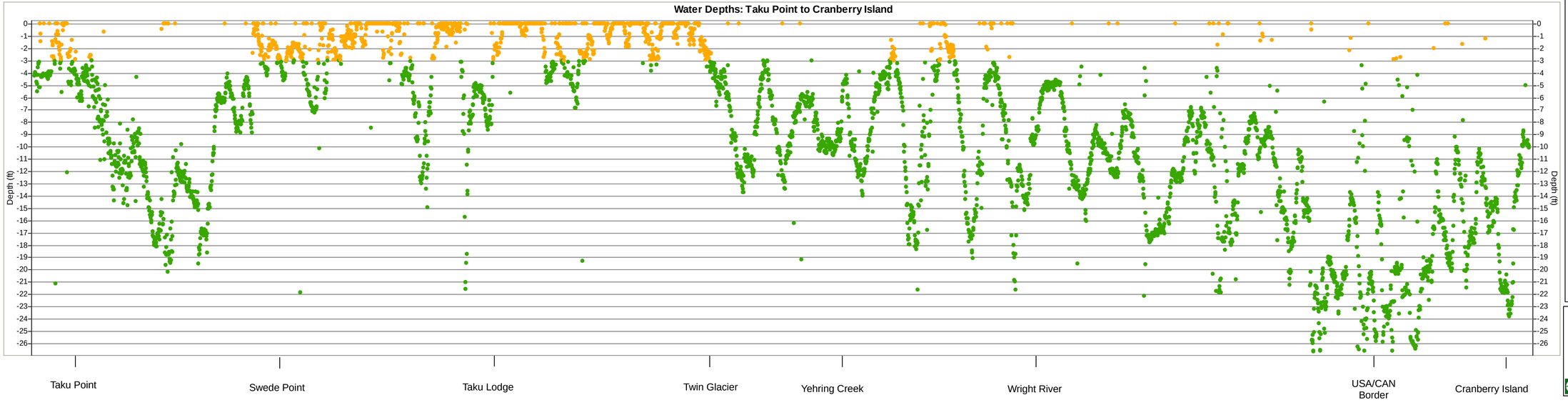
Figure 2
Version 1

Revision: 0
File Location: S:\GIS_Projects\Redfern\bathymetry\2008_Johnson_reduction_transects_added_500m.mxd
Date Revised: March, 2008
Date Plotted: March, 2008



Data Collection and Processing

- Data collected on June 5, 6, 7 2007.
- Data collected using a Trimble XT GPS, and a Sonarmite v2.0 Portable Bluetooth Echo Sounder.
- Discharge at time of reading = 112477ft3/s (3185m3/s)
- Average Summer Discharge at Canyon Island = 26133ft3/s (740m3/s)



Key To Features

Survey Route

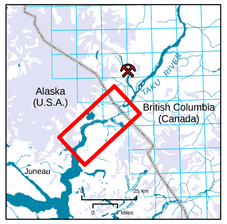
Depths Along Route (ft)
- >3
- <3

Land Cover
- Vegetated area
- Glacier
- Sandbar

Topography (U.S.A.)
- Index (500ft)
- Intermediate (100ft)

Topography (Canada)
- Index (100m)
- Intermediate (20m)

Water Features
- Streams
- Lakes / Rivers



Map Sources/Notes:
Water Depth Measurements Collected on June 7/2007 by Gartner Lee Ltd. field staff.

Topographic Images derived from Digital Raster Graphic (DRG) Images produced by the USGS. Terrain Resource Information Management (TRIM) base data compiled by the Ministry of Environment, Lands and Parks, Geographic Data BC, Province of British Columbia at a scale of 1:20,000

UTM Zone 8N, NAD 83

Redfern Resources Ltd.

Channel Depth of Taku River Flood Discharge = 8828ft3/s (250m3/s)

Gartner Lee

Figure 3
Version 1

Date Revised: March, 2008
Date Plotted: March, 2008
Revision: 0
File Location: S:\GIS_Projects\Redfern\Bathymetry\2008_Johnny_reduction_Janson_added_250m.mxd

Memorandum
25 June 2008

Attachment 3

Memo re: Posting DNR Bond

Counterspil Research Inc. February 2008

Counterspil Research Inc.

205 – 1075 West 1st Street
North Vancouver, British Columbia, Canada
V7P 3T4

Telephone (604) 990-6944 Fax (604) 990-6945 E-mail mail@counterspil.com

February 5, 2008

Attention: Tim Davies
Manager, Environmental & Regulatory Affairs
Redcorp Ventures Ltd/Redfern Resources Ltd.
Suite 800 - 1281 West Georgia Street
Vancouver, BC V6E 3J7

Bryan Lundale
Supervisor, OH&S

Subject: **Posting DNR bond**

This report, revised following our discussion, addresses the cleanup costs of a spill that originates from barging operations associated with the Tulsequah Chief Mine and that affects US waters. The work was conducted as input to determining the amount of a bond to be posted with DNR relating to abandoning equipment in place along the water route.

Generally, the literature focuses on the cost of cleaning up **oil** spills. Costs vary considerably and are not linearly related to the size of the release due to response methods, oil type, season, location, receiving body, etc. Damage claims have been excluded from these calculations versus the costs of direct response activities since impacts depend on many different factors. The US Natural Resource Damage Assessment (NRDA) Process, for example, also referred to as the Damage Assessment, Remediation, and Restoration Program (DARRP) can take years for the National Atmospheric and Oceanic Administration (NOAA) to implement in following its three steps of (1) preliminary assessment, (2) injury assessment/restoration planning and (3) restoration implementation.

Salvage costs were not included in these determinations, as discussed. Legal questions also require consideration by trained people with experience in such matters, e.g., regulatory rules, compensatory versus punitive damages, etc. The US Oil Pollution Act of 1990 (OPA-90) more exactly defines limits of liability and refers to $600 per gross ton of a vessel or $500,000, whichever is greater, as the maximum amount re: the total liability of a responsible party for the size of vessel in question. Nevertheless, I have summarized the main factors and noted relevant data that should shed light on the request for spill cost information.

Sincerely,

Laurence B. Solsberg, P.Eng.

.

Introduction

There is a risk of spills of various substances that will be shipped to the Tulsequah Chief Mine by air cushion barge (ACB) from Juneau to the barge landing site at the confluence of the Taku and Tulsequah rivers. The water route covers approximately 95 kilometres (59 miles) of which approximately 85 km (53 miles) is in US waters.

Diesel is transported in the greatest quantity and the cost to clean up a diesel spill was seen as a worst-case scenario. Spills of reagents were also briefly investigated but these are for the most part water-soluble and actual cleanup costs such as booming, skimming, recovery and disposal are likely to be limited and therefore much lower. This report summarizes possible cleanup costs for a "worst-case" spill scenario of 50,000 litres of diesel. It also points to the importance of preventative steps that will be taken such as contingency planning, training, and program management.

All reagents packaged in bags and "supersacs" will be transported in containers on the ACB. Lined drums, tanker trucks and other containers will be used in the transportation on the barge of other materials (see Background Information). This reduces the likelihood of a release along with any significant consequences including diesel, which will be carried in tank trucks. Segregation of the reagents will reduce the likelihood of chemical interactions, particularly with acids. The IMDG Code, which addresses these concerns, will be strictly followed. The principles of the International Cyanide Management Code will also be complied with in any operations involving sodium cyanide including transportation, handling and storage.

Diesel spills might in theory be cleaned up if only because diesel is an insoluble petroleum product that might leave some residue and, with due care and attention, a safe response can be mounted. Often, however, it quickly dissipates and its cleanup is also often limited in coastal and river environments. See also Spill Response below.

Spill Response

The factors that affect response and dissipate spills include (1) in river reaches, the water velocity, sediment load, water depth (1 to 4 1/4 m or 3 to 14 ft), and discharge (500 to 1000 m^3/s or 17,700 to 35,300 cfs) and, (2) in the marine corridor, water depth and flushing action of tides plus wind and wave energy. Salt water also has a buffering effect on many chemicals.

Effective containment and control of most of the reagents will often not be practical should a spill occur in open water conditions. Sediment load will mask the spill location in the river and dilution of the reagents, most of which are soluble, will occur as they are carried downstream.

Should an accident occur during winter, then it is very likely that concerns for environmental impacts reduce significantly. Should diesel be spilled, then in situ burning could be an option where an ice and snow cover exists and conditions, along with quick regulatory approval, allow this option to be implemented.

Spill prevention is the highest priority. During transfers, the ACB will be on shore, and it is unlikely that a mishap will occur that will result in a significant release to water. Historically, it is in the delivery (and especially during fuel transfer by pumping) that the majority of spill incidents occur involving vessels. Pre-booming at source may be difficult in river currents and can only likely address a release of diesel and not reagents. Response along the marine corridor will be similarly limited – which is where the DNR concern applies.

Cost of Spill Cleanup

Various sources were reviewed that address oil spill cleanup costs (see References). Costs to clean up chemical spills are not similarly reported. The work of Dagmar Schmidt Etkin of Environmental Research Consulting was used to estimate costs. Her research is used by the US Environmental Protection Agency in its Basic Oil Spill Cost Estimation Model (BOSCEM). The main factors are summarized below that are usually considered in estimating cleanup costs with additional comments added where appropriate.

Because many technical factors determine the actual costs of a spill incident, simple comparisons between different events based on a single parameter such as spill volume can be highly misleading. Note that an understanding of the relative importance of the various factors can also help focus the development of more practical spill contingency plans and, if ever needed, a cost-effective response. A short-coming of the costing methods is that they do not use estimates specific to the fate and behaviour of a spill but rather apply various modifiers to pre-determined base costs and therefore can err on the conservative side.

Method 1 (Etkin 2000)

Etkin integrated various cost factors into a single algorithm. This approach generates a conservative estimate for cleanup: manual methods were applied to a smaller (i.e., more expensive to clean up) release of diesel, based on highest (US) world-wide unit costs, affecting extensive, continuously sensitive shoreline in an area with high regional concerns.

$Cu_i = Cl_i\, t_i\, o_i\, m_i\, s_i$ *and* $Cl_i = r_i\, l_i\, Cn$ *and* $Ce_i = Cu_i\, A_i$ *where:*

Cu_i	=	response cost per unit for scenario, *i*
Cl_i	=	cost per unit spilled for scenario, *i*
Cn	=	general cost per unit spilled in US, *n*
Ce_i	=	estimated total response cost for scenario, *i*
t_i	=	oil type modifier factor for scenario, *i*
o_i	=	shoreline oiling modifier factor for scenario, *i*
m_i	=	cleanup methodology modifier factor for scenario, *i*
s_i	=	spill size modifier factor for scenario, *i*
r_i	=	regional location modifier factor for scenario, *i*
l_i	=	local location modifier for scenario, *i*
A_i	=	specified spill amount for scenario, *I*

Applying the Etkin formulae from her paper and values in 1999 US dollars:

Cn	=	$17.81/L (North America) $23.02 (US)
t_i	=	0.18 (diesel)
o_i	=	0.61 (20-90 km)
m_i	=	1.89 (manual)
s_i	=	0.65 (34-340 tonnes)
r_i	=	1.25 (regional concern)
l_i	=	1.48 (local concern)
A_i	=	50,000
Ce_i	=	estimated total response cost for scenario, *i*
Cu_i	=	response cost per unit for scenario, *i*

The total cleanup cost is estimated to be $287,227
(Corrected to 2008 $US by adding 25% @ an annual inflation rate of approximately 3%.)
Spill Response Cost ($2008) = $359,033

Method 2 (Etkin 2004)
EPA's Basic Oil Spill Cost Estimation Model (BOSCEM) developed by Etkin was also applied to estimate the cleanup costs of a diesel spill. A mechanical recovery efficiency of 50% was assumed to partially account for dissipation of the diesel. These costs include shoreline oil removal, mobilization, source control, mechanical removal, and protective booming and therefore actual costs of a spill might reduce significantly.

To calculate spill response cost, the base per-gallon response cost based on oil type/volume/response method and effectiveness (Table 1 in paper), was multiplied by the medium modifier (0.7 – moderate impact - in Table 4) and by the spill amount:

per-gallon response cost X *medium modifier* X *spill amount = total response cost*

The total cleanup cost for light fuels @ $41/gal x 0.7 x 13,209 = $379,098

NOTE: If in situ burning is used with 50% efficiency then this cost reduces to $166,433. Again, each of the above figures could be increased by 10% to account for inflation:

Spill Response Cost ($2008) = $417,008 $183,076 (burning option)

The response cost is somewhat higher than the calculations based on Etkin's 1999 data. It assumes more costly, intensive manual methods that are required in addition to mechanical operations and so a higher base number results. Still, the numbers are comparable.

Mitigating Factors
The two methods for estimating spill cleanup costs err on the conservative side. There are specific factors that might significantly reduce any costs that should be considered when determining a reasonable level at which the bond should be posted:

The costing models assume that diesel will strand on shoreline and require manual cleanup.

A spill of diesel or reagents that enters the Taku River or Inlet is likely to dissipate relatively quickly and there will be limited opportunities to apply manual or mechanical methods.

Cleanup costs for diesel will be far less than if the substance released were persistent, viscous and adhesive such as weathered crude oil or bunker. Residue that remains after oil strands may require a combination of natural and manual cleaning that might primarily involve removal especially by the former route, i.e., wave, current and tidal energy.

Should a spill occur during winter, containment and control of a spill might be more feasible. There is a possibility that diesel could be burned in situ.

A knowledgeable spill response management team that is quickly assembled to make decisions on appropriate actions to take could reduce costs significantly. A shoreline treatment specialist who can offer practical, expedient advice will further reduce costs.

Training in the proper storing, handling, and transfer of all substances and quick response to spills are key. These will be a part of contingency planning and the ongoing management of facilities and operations and will reduce the likelihood of a large release and cleanup.

These mitigating factors should reduce cleanup costs significantly. They are in no way meant to diminish the possible significance with which spills in the Taku River and area are viewed and the response that might be demanded by agencies and local communities.

Conclusions

Spill cleanup costs were computed in 2008 $US as input to estimating the amount of a bond to be posted for a release into US waters. If it is assumed 50,000 litres of diesel somehow escape from tanker trucks on a barge, then the direct cleanup costs were estimated to vary between **$359,033** and **$417,008**. Many factors point to the lower actual cost of a response including:

- Packaging and containerization result in a much smaller release than 50,000 litres
- Dissipation of a non-persistent oil such as diesel in the river or coastal waters
- Minimal on-water response operations
- Combination of natural cleaning action and reduced manual methods
- Overall reduced shoreline cleanup
- Possibility of release onto snow/ice and reduced impacts
- Possibility of using in-situ burning methods during winter

Further reductions to cleanup costs should also result from and point to the importance of:

- Comprehensive and practical contingency plans
- Proper packaging, securing and segregation of reagents on the ACB
- Practical training on accident prevention and spill response
- Ongoing management of facilities, operations and procedures
- Well trained spill management team familiar with Incident Command System
- Availability of knowledgeable shoreline advisor

This costing exercise points to an amount for the bond that should be considerably lower than that provided by the calculations for what is likely to transpire in the way of a spill and required cleanup. If 10,000 litres, for example, of diesel were released then costs would reduce by 1/5. A figure of $250,000 would therefore not be unreasonable to consider to address concerns for both cleanup and salvage costs.

Background Information

A discussion of the factors that affect spill cleanup costs follows that provides background information to the cost estimates. A brief review of reagents is also included.

Oil Type

Oil type is one of the most important factors governing cleanup costs. Generally, the more viscous and persistent the oil, the more difficult and costly the cleanup is. Spills of light refined products such as diesel often do not require extensive cleanup. In the Taku River and along the marine route, a diesel spill will likely largely dissipate. "Rapid evaporation" of "light end components" does NOT always occur along with total dispersion of diesel. Some very light residual oil could remain on shorelines and attempts to remove it, albeit limited, might have to be made as occurred during the sinking of BC Ferry's Queen of the North in March 2006. Still, this type of response is far less costly than one involving crude oil or Bunker C.

Amount Spilled, Spill Location, Rate of Spillage/Season

The amount of oil spilled is an important factor in determining overall response costs. A 1,000 tonne spill is likely to result in far wider contamination than a 1 tonne spill. However, spills that occur offshore and that do not contaminate coastline result in minimal cleanup. The cost of such responses would be limited to aerial monitoring of slick movement and dispersion. A spill in the Taku River would be closely monitored due to ecological and other sensitivities. This emphasizes the need to compare cleanup costs based on more than spill volume.

The rate of spillage can also be an important factor. For example, the cleanup operation required in response to a single large release of oil may be considerable but may be completed in a matter of weeks. However, the same quantity of oil lost over several months from a damaged vessel or container(s) close to the coast may require a prolonged cleanup.

The physical characteristics of the spill site (e.g., prevailing winds and weather, tidal range, currents, water depth, coastal topography) also have a bearing on response costs. The sensitivity of different shoreline types, the extent to which they self-clean, and the availability and cost of local labour and resources will influence the overall costs. A diesel spill in Taku Inlet is likely to dissipate> There will likely be limitations on containment and removal systems on open water due to winds, waves and currents..

The Taku River will be of high national/international importance for fishing, indigenous peoples, tourism, and conservation. Seasonal differences will also occur in the sensitivity of these resources to a spill. This in turn will determine the requirement for, and extent of, spill cleanup and its cost. The costs during winter and high wind/wave conditions could be lower.

Shoreline Cleanup

In many oil spills, the most expensive component of the response is the shoreline cleanup. This is generally the most labour-intensive and time-consuming part of the operation.

Shoreline response strategies are moving towards "natural cleansing" options in shoreline locations that are exposed to wave action. There is a greater awareness of the impacts of aggressive shoreline cleaning tactics such as hot-water washing and use of heavy machinery.

Shoreline cleanup operations that rely primarily on manual techniques are relatively expensive compared to the much lower costs of natural cleaning methods, which often require only careful monitoring. Often, local interests press for aggressive cleanup responses on oiled shorelines despite evidence that such operations can cause greater long-term damages.

Usually, a Shoreline Cleanup Assessment Technique is applied whereby shoreline is segmented, assessed for cleanup needs, and then treated. This is a possibility for reaches of the Taku River but it is unlikely that a lengthy cleanup will be involved for reagents or diesel.

Management of Response Operations

Inadequate planning often results in the mistakes of previous spills being repeated. The result is damage to the environment that could have been avoided and thus, excessive costs. The tendency to react to political, media and public perceptions and pressures, rather than basing decisions on technical realities, is a problem that can also escalate the cost of any incident beyond what would be considered "reasonable" under the international compensation conventions. Redcorp/Redfern requires a management team for spill response that is familiar with the Incident Command System and includes members who have sound local environmental, socio-economic and spill countermeasures knowledge to avoid this pitfall.

SeaPro

SEAPRO, an oil spill response co-operative in Juneau, responds to oil spills and not chemical releases (Dave Owings, 2008). Personnel costs exclusive of expenses would be approximately $10,000 per day with a management team and ten responders. It is difficult to estimate cleanup costs on this basis since it is very incident-specific.

Risk of Spills

The following substances will typically be shipped on the barge to the mine site:

Supplies	
Material	**Approximate Weight (tonnes)**
Diesel	47
Cement	34
Process Consumables	21
Misc. Equipment and Supplies	6
Food and Camp Supplies	5
Propane	2
Explosives	2
Process Plant Maintenance Supplies	1.5
Rock Bolts	0.5
Misc. Underground Supplies	0.2

Process Consumables	
Material	**Delivery Container**
Flocculant	25 kg bags
Copper Sulphate ($CuSO_4$)	1,000 kg supersacs
Zinc Sulphate ($ZnSO_4$)	1,000 kg supersacs
Sodium Sulphite ($Na2SO_3$)	1,000 kg supersacs
Methyl Isobutyl Carbinol	Tanker truck or 200 L drums
DF250 (frother)	Tanker truck
Potassium Amyl Xanthate	Pellets in 1,000 kg drum or 1-tonne tote bags
Sodium Cyanide (NaCN)	Briquettes in 100 kg drums or 1-tonne tote bags
Sodium Metabisulphite ($Na_2S_2O_5$)	Powder form in 1,000 kg fabric bags
Sodium Ethyl Xanthate	Pellet form in 1,000 kg drums
3418A	Liquid in drums
Sulphuric Acid (H_2SO_4)	Tanker truck
Dextrin	100 kg fabric bags or 25-kg bags
Ferric Sulphate ($Fe_2(SO_4)_3$)	Tanker truck
Lime	Unslaked powder form in 40-tonne trucks

Diesel
Clear, yellowish flammable liquid transported by tanker truck that floats on water, is insoluble, and has toxic effects on fish and vegetation. Booming, skimming, manual removal using sorbents and/or burning are sometimes possible but unlikely as on-water operations in the Taku River and nearby coastal environment. Shoreline, river bank cleanup may be needed.

Flocculant
Off-white, non-flammable powder that is soluble and forms a viscous solution in water. Packaged in bags. Toxic to fish and plants. Limited response.

Copper Sulphate ($CuSO_4$)
Bluish powder that is non-flammable and sinks and mixes incompletely in water. In supersacs. Toxic to fish and plants. Limited response.

Zinc Sulphate ($ZnSO_4$)
White crystalline pellets that sink and mix with water. Supersacs. Results in aquatic toxicity. Limited response.

Sodium Sulphite ($Na2SO_3$)
White, non-flammable powder that sinks in and partially mixes with water. Supersacs. Ecological effects not indicated but some impacts can be expected. Limited response.

Methyl Isobutyl Carbinol
Clear, colourless, flammable liquid with low water solubility (1.82 g/100 g at 20°C) that floats and has relatively low aquatic toxicity. Stored in tanker trucks and drums. Limited response since residue will be difficult to locate.

Dowfroth DF250 (frother)
Yellow-to-dark brown liquid (98% ether) that is flammable, floats and is partially soluble in water. Transported in tanker truck. It can cause impacts to aquatic and marine life. Limited response. Some shoreline removal using manual methods may be possible.

Potassium Amyl Xanthate
Combustible yellow pellets, somewhat soluble in water (16.9 g/100 g at 0°C), high pH, toxic to fish. Stored in drums or bags. Neutralization with sodium bicarbonate can be tried.

Sodium Cyanide (NaCN)
White crystalline briquettes that are non-flammable and sink and are soluble in water. Stored in drums or bags. Highly toxic to aquatic and marine life. Response hazardous, limited.

Sodium Metabisulphite ($Na_2S_2O_5$)
White to yellow-white crystalline granules that are non-flammable and are very soluble in water, forming an acidic solution and producing toxic sulphur dioxide gas. Stored in bags. Environmental toxicity is not reported but should be anticipated. Limited response.

Sodium Ethyl Xanthate
Pale yellow flammable pellets that sink in, mix and react with water to result in a low pH (acidic) mixture of various compounds that would have toxic impacts. Stored n drums. Limited response.

Aerophine 3418A
Yellowish, non-flammable liquid stored in drums that is slightly alkaline and sinks and mixes completely in water. It is not classified as dangerous to the environment. Limited response.

Sulphuric Acid (H_2SO_4)
Colourless-to-brown corrosive, non-flammable liquid that sinks, mixes, reacts with water. Highly toxic. Transported by tanker truck. Neutralization with sodium bicarbonate can be tried.
Dextrin

Non-flammable, stable white to off-white solid (starch or vegetable gum) stored in bags that sinks in water (is “soluble in hot water”) and presents minimal risk to the environment. Manual removal can be tried where this is feasible to consider.

Ferric Sulphate ($Fe_2(SO_4)_3$)
Greyish-white powder that sinks and is soluble in water and therefore likely has impacts to aquatic and marine life (no environmental toxicity data indicated). Transported by tanker truck. Limited response.

Lime
White-to-grey, non-flammable powder/granular corrosive solid transported by truck. Sinks and is soluble in water to form calcium hydroxide. High pH could result in significant impacts to aquatic, marine organisms. Neutralization with sodium bicarbonate can be tried.

A brief review of the substances that might be released serves to indicate relative concerns. Most of the reagents are water soluble, toxic, and will therefore present concerns and difficulties in cleanup if their packaging is compromised. However, any amount released is very likely to be minimal because of their packaging and placement in containers on the ACB. Sulphuric acid, DF250 frother and sodium cyanide warrant separate albeit brief review. Both the acid and frother are shipped in tanker truck and could cause impacts if a tank is somehow breached. Spill response might be limited unless there is a smaller, more continuous release and, in the case of the acid, a neutralizer can be added. Sodium cyanide is a high toxicity chemical that poses cleanup difficulties and high hazards to responders and the environment.

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Dave Owings 2008 General Manager SEAPRO, personal communication