Tulsequah Chief Mine

Air Cushion Barge Transportation System: Operations Plan

Prepared by

Redfern Resources

November 2008

Mr. Tom Crafford, Mining Coordinator
Department of Natural Resources
Office of Project Management and Permitting
550 W. 7th Avenue, Suite 900
Anchorage Alaska 99501

November 19 2008

Dear Mr. Crafford:

Re: Tulsequah Chief Mine Air Cushion Barge Transportation System Operations Plan - November Update

As requested, please find attached the updated Operations Plan for the Air Cushion Barge Transportation System. This document describes in detail the transportation system as it is currently proposed, and includes information that has been requested during the completeness review by State agencies. This document, together with the Barge Route Atlas (November 2008), comprises the project description for the purposes of this review.

Regards,

Tim Davies
Manager, Environmental and Regulatory Affairs

Suite 800, 1281 West Georgia Street, Vancouver, B.C., Canada V6E 3J7
Tel: 604 669 4775 Fax: 604 669 5330 Toll Free: 1-888-669-4775

Executive Summary

The State of Alaska agencies have determined that Redfern Resources Ltd.'s (Redfern) proposed Air Cushion Barge(ACB) Transportation System for the Tulsequah Chief Mine will require the following: (1) A Title 16 Fish Habitat Permit; (2) A Miscellaneous Land Use Permit; (3) and a Coastal Zone Consistency Review.

This Operations Plan is provided to clearly delineate and describe the proposed transportation system operations and activities that will occur within the permitable portion of the Taku River. The ACB transportation system is desired for use in the winter of 2008/09 to support mobilization of mine construction, as well as for operational transport of mine ore concentrate and supplies once mine construction is complete.

The transportation route between the US/Canada border and the tidal flats at the mouth of the Taku River covers a distance of approximately 28 miles. Of this distance, approximately 16 miles can be characterized as the lower Taku River, encompassing that section of the river and tidal flats downstream of Taku Lodge. This entire reach of the river is influenced by tides, with the uppermost limit of tidal influence close to Taku Lodge. Upstream of Taku Lodge to the US/Canada border, a distance of 12 miles, the river follows a more defined channel and is upstream of any tidal influence.

The barging operation consists of two operational components: a marine component that will handle transportation between Juneau and the Taku Inlet, and a river component that will operate on the Taku River up to the barge landing site in Canada. The Operations Plan describes only that portion of barging operations for the river component that will occur on the Taku River in Alaska – from the US/Canada border to the lower extent of the tidal flats at the mouth of the river. The reason for this is that this is the only section for which permits or authorizations are required.

The fleet of equipment proposed for the barging system consists of a combination of vessels that are designed specifically for operations in the marine environment, or in a riverine environment, or both. The primary fleet includes two air cushion barges, one marine tug, two shallow draft tugs, and four ATs; two that are tracked and two with soft flotation tires. Secondary vessels that will accompany the fleet include a small power boat or jet boat that will operate during the open-water (aquatic) season on the river, and snow machines or snow grooming equipment that will be employed during the winter (non-aquatic) season. A secondary tracked AT, a Hagglunds BV206 will also be used as a support vehicle to non-aquatic operations. These ancillary vessels will assist in navigation, crew changes, snow grooming, and to provide support in the event of emergencies. In addition to these vessels, an additional barge and shallow draft tug will be available to provide extra transport capacity at times when additional trips are required to make up for delays due to bad weather, maintenance, etc.

Aquatic Season Operations

During open water season, typically from late May to October, a conventional shallow draft tug will be used to shuttle the ACB up and down the river. The shallow draft tug will rendezvous with the marine tug to deliver the outbound ACB to the marine tug for transport to Juneau, and pick up the inbound ACB for transport to the mine. The rendezvous will take place in the open and deep waters of Taku Inlet. A small powerboat will accompany the shallow draft tug and act as a pilot vessel to scout the river and advise other river traffic of the barge's progress. The ACB will be manoeuvred around the east side of Canyon Island, crossing over the gravel bar at low water levels. The shallow draft tug will push the ACB up to the gravel bar along the east shore of the island. From here, the ACB will be pulled or winched by the ATs across the sandbar to the opposite end of the island. The shallow draft tug will proceed through the deeper channel around the west side of the island (the narrows), re-connecting with the ACB at the opposite end of the island, and continuing travel up (or down) river. The pilot boat will precede the shallow draft tug and ACB to notify fishermen and other traffic of the barge's arrival at the island, as required.

Non-Aquatic Season (Winter) Operations

During the winter when the river is frozen, four ATs will be used to tow/push the ACB over the ice and snow along the river. Four ATs are needed to provide the necessary propulsion, increase travel speed, provide greater manoeuvrability, and provide mutual aid if needed. The ATs will operate using low ground pressure tires or tracks travelling on the snow and ice.

The outbound ACB will be pushed and/or towed by the ATs along the frozen river floodplain. Similar to the summer operations, they will rendezvous with the tug in Taku Inlet, the outbound ACB will be transfer to the marine tug, and the inbound ACB will be picked up for the return trip up river. In winter, the rendezvous point will be closer to shore near Taku Point and Grizzly Bar. Here the ice frequently makes contact with the shore, and the inbound ACB will winched itself the shelf ice to the anchored ATs. During the winter, the route will typically follow the west channel around Canyon Island to avoid the open water areas in the east channel.

Transition Season

Operations in the aquatic season will continue as long as possible into the fall, nominally to mid October, based on a minimum river flow threshold of 8800 ft^3/s to provide the water depth required for the shallow draft tugs to operate. Operations will then be suspended until the river is frozen sufficiently to commence with non-aquatic operations using the ATs on ice and snow.

Similarly, non-aquatic operations will be continued into the spring until the leads become too numerous or too wide for regular transit by the ATs. At this time operations will be suspended until the river ice has melted through and the flow has reached sufficient levels for shallow draft tug operations to commence. A threshold flow of 8,800 ft^3/s will be used once the river is clear of ice.

Environmental Considerations

The ACB engines will be muffled and enclosed to minimize noise. The noise generated by the ACB and the ATs will not exceed 70 dB at 100 ft, roughly equivalent to a tug passing by.

The ACB will generate very little underwater noise. Tests performed on a similar ACB in January 2008 showed that on hover, the noise level measured 8dB immediately below the water surface and 5dB ten feet below the water surface.

The size of the wake is a function of the draft of the vessel (deeper draft generates more wake), and the speed of the vessel (faster speed generates more wake). Accordingly, that the ACB, which is large and shallow, towed by a shallow draft tug will generate minimal wake.

Operating procedures have been identified that will avoid or minimize potential adverse effects associated with the ACB operations on the river. The effectiveness of these procedures will be refined during the first couple of years of operations, and operations will be adapted, to the extent practical, to meet the stated operational objective. Annual follow-up with property owners, commercial tourism operators, commercial fishers and other users of the river will be carried out to ensure that concerns regarding barging operations can be addressed in a timely manner.

Redfern will develop a comprehensive spill prevention and contingency plan, prior to commencement of operation of the transportation system, which will be used by Redfern and any transportation system contractors.

A environmental effects monitoring program will be implemented that will include both a Aquatic Monitoring Plan and a Wildlife Management Plan. Monitoring programs will include:

- Aquatic Monitoring Plan:
    - Adaptive Management Plan framework
    - Wake-Induced Juvenile Stranding Monitoring Plan
    - Wake-Induced Turbidity of Clear Water Fish Habitat Monitoring Plan
    - Wake-Induced Bank Erosion Monitoring Plan
    - Canyon Island Salmon Monitoring Plan
    - Winter Open Lead Crossing Monitoring Plan

- Wildlife Management Plan:
    - Wildlife Mitigation Polices and Procedures
    - Wildlife Incidents and Observations Monitoring Plan
    - Project Effects to Moose Monitoring Plan
    - Grizzly Bear Habitat Use Monitoring Plan
    - Harbour Seal Habitat Use Monitoring Plan

Table of Contents

Letter of Transmittal
Executive Summary

Page

1. Introduction 1
1.1 Title 16 Fish Habitat Permit 1
1.2 Title 38 Land Use Permit 1
1.3 Coastal Zone Consistency Review 1
1.4 Scope and Purpose of the Operations Plan 2
1.5 Timing 2

2. The Transportation Route 4
2.1 Overview of the Route 4
2.2 Taku Inlet to Taku Lodge 4
2.2.1 River Depth and Tidal Influence 4
2.3 Taku Lodge to US/Canada Border 10
2.3.1 Canyon Island 11

3. River Operations 14
3.1 Aquatic Operations - Late May to Mid-October 14
3.1.1 Canyon Island Aquatic Season Operating Plan 15
3.1.1.1 Geomorphologic Setting 15
*3.1.1.2 Hydrologic Setting ..... **Error! Bookmark not defined.***
3.1.1.3 Aquatic Operations Plan at Canyon Island 18
3.1.1.4 Aquatic Operations Plan at Canyon Island: Intermediate Flow 19
3.1.1.5 Aquatic Operations Plan at Canyon Island: Shallow Overflow 20
3.1.1.6 Aquatic Operations Plan at Canyon Island: High Water Flow 22
3.1.1.7 Aquatic Operations at Canyon Island – Frequency of Operating Methods 22
3.2 Non-Aquatic Winter Operations – Late November to Early April 23
3.2.1 Canyon Island in Winter 24
3.2.2 ACB Exchange during Non-Aquatic (Winter) Operations 25
3.3 Transition Season (Spring Thaw and Freeze-up) 29

4. Equipment 30
4.1 General Equipment Description 30
4.2 Air Cushion Barge 30
4.2.1 Barge Components 31
4.2.2 Noise 36
4.2.3 Wake 37
4.2.4 On-board Fuel Containment 38
4.2.5 ACB Controls 38
4.3 Shallow Draft Tug – River Operations in Aquatic Season 39
4.4 Amphibious Tractors ATs – Non-aquatic Operations 41
4.4.1 TAV – Rubber Tracked AT 41

4.4.2 Morgan Skidder - Soft Flotation Tire AT 42
4.4.3 Hagglunds BV206 – Rubber Tracked AT Support Vehicle 44
4.4.4 Comparison of AT Specifications 45
4.4.5 Non-aquatic Support Vehicles 45
4.4.6 Controls 46
4.5 Communications 47
4.6 Manpower 47
4.6.1 Roles 47
4.6.2 Crew Requirements: Aquatic Operations 48
4.6.3 Crew Requirements: Non-aquatic Operations 48
4.7 Fuelling 48
4.8 Operating Constraints 48
4.9 Production Capability 50
4.9.1 2008/2009 Haulage Requirements 50
4.9.2 Fleet Requirement for the 2008/2009 Non-Aquatic Season 50
4.9.3 Trip Time 50
4.9.4 Maximum Capacity 51
4.10 2009/2010 Haulage Requirements 52
4.10.1 Trip Time 52
4.10.2 Maximum Capacity 53
4.10.3 Equipment Changes for Operations in 2009/2010 54

5. Commissioning 55

5.1.1 Above Water Noise 55
5.1.2 Underwater Noise 55
5.1.3 Footprint 56
5.1.4 Wake 56
5.1.5 Sedimentation 58

6. Operating Procedures and Objectives 59

6.1 Aquatic Operations 59
6.2 Winter Season 61
6.3 General Procedures 65

7. Environmental Management and Monitoring 67

7.1 Aquatic Monitoring Plan 67
7.2 Wildlife Management Plan 67

8. Spill Contingency Planning; Emergency Preparedness 68

8.1 Spills of Hazardous Materials 68
8.1.1 Spills on Water 69
8.1.1.1 Diesel Spills 70
8.1.1.2 Reagent Spills 70
8.1.1.3 Concentrate Losses 70
8.1.2 Mechanical Failure of ACB 70
8.1.3 Mechanical Failure of Shallow Draft Tug 70
8.1.4 Grounding 71

8.1.5 Capsize of ACB 71
8.1.6 Glacial Outburst Floods 71
8.1.7 River Collisions 71

List of Figures

Figure 1. Approximate Barge Route – Taku River Alaska 3
Figure 2. Route Through the Tidal Flats on the Lower Taku River 5
Figure 3. Bathymetry of Lower Taku River 6
Figure 4. Taku River Hydrograph at Canyon Island 7
Figure 5. Lower Taku River Showing Approximate Routes, Depending on Water Depth 8
Figure 6. Average, Low and High Flows on the Taku River (1986 – 2007) 9
Figure 7. View of Routes around Canyon Island, Looking Downstream 10
Figure 8. Canyon Island Showing Approximate Summer and Winter Routes 12
Figure 9. Canyon Island Development Plan 13
Figure 10. General Arrangement of Canyon Island 16
Figure 11. ACB Circumnavigation of Canyon Island during Aquatic Operations – Low Flow 18
Figure 12. Aquatic Operations at Canyon Island – Intermediate Flows 19
Figure 13. Aquatic Operations at Canyon Island - Partial Shallow Overflow 20
Figure 14. Aquatic Operations at Canyon Island - Extensive Shallow Overflow 21
Figure 15. Marine to Non-Aquatic Exchange Zone 27
Figure 16. Marine to Non-Aquatic Travel Transition 28
Figure 17. Air Cushion Barge Components 33
Figure 18. Air Cushion Barge Operating Heights 34
Figure 19. Modified Morgan Skidder 43
Figure 20. 2008/2009 Round Trip Time 51
Figure 21. 2009/2010 Round Trip Time 53
Figure 22. ACB Bridge Open Lead Crossing 63
Figure 23. Open Lead Crossing Method 64

List of Tables

Table 1. Average Calendar Days by Flow Level (1986 to 2007) 9
Table 2. Hydrologic Conditions of East Channel, Canyon Island 17
Table 3. Frequency of Operating Method at East Channel, based on Historic Flow Records 22
Table 4. Comparison of ACB and Hovercraft 31
Table 5. Noise Comparison 36
Table 6. Equipment Specifications 45
Table 7. Operating Constraint Guidelines 49
Table 8. 2008/2009 ACB Transportation Capacity 51
Table 9. 2009/2010 ACB Transportation Capacity 53
Table 10. *Siberian*: Above Water Noise Level Measurement 55
Table 11. *Siberian*: Underwater Noise Level Measurement 56
Table 12. Vehicle Specifications 56
Table 13. Typical Barge Load to Tulsequah Chief Project 69
Table 14. Process Consumables Transported via ACB Transportation System 69

1. Introduction

The State of Alaska agencies have determined that Redfern Resources Ltd.'s (Redfern) proposed Air Cushion Barge (ACB) Transportation System for the Tulsequah Chief Mine will require the following:

- a Title 16 Fish Habitat Permit;
- a Miscellaneous Land Use Permit; and
- Coastal Zone Consistency Review.

1.1 Title 16 Fish Habitat Permit

A *Title 16 Fish Habitat Permit* (formerly Title 41) will be required for that portion of the transportation system between Swede Point and the US/Canada border. This portion of the Taku River is "designated" under AS 16.05.841 (fish passage) and 16.05.871 (fish habitat). The project will undergo a review for consistency with ACMP standards; specifically those portions of *Habitats Standard at 11 AAC112.300*, and the *Transportation Routes and Facilities Standard at 11 AAC112.280.*

1.2 Title 38 Land Use Permit

A Land Use Permit will be required to authorize the portion of the transportation system extending from the tidal flats at the mouth of the Taku River to the US/Canada border. All submerged lands (shorelands) are owned and managed by the State of Alaska, and activities and operations that take place on or over shorelands on the Taku River are subject to the permitting process. Similarly, State-owned uplands on Canyon Island that will be utilized by the ACB route will be included within the scope of the Land Use Permit.

1.3 Coastal Zone Consistency Review

The Alaskan Coastal Management Program (ACMP) will determine the scope of the consistency review. The scope of this review is limited to those activities that are the subject of the State agency authorizations, and specifically to the footprints of the geographical area of the two State permits required for the operation. The Title 16 Fish Habitat permit is required for those activities within the Taku River described under 1.1 above. The Title 38 Land Use Permit will cover the shorelands and upland areas of the Taku River utilized by the barging operations (the tidal flats, Canyon Island, and open lead crossings). The consistency review coordinated by ACMP would occur concurrently with the Fish Habitat Permit and Land Use Permit reviews.

1.4 Scope and Purpose of the Operations Plan

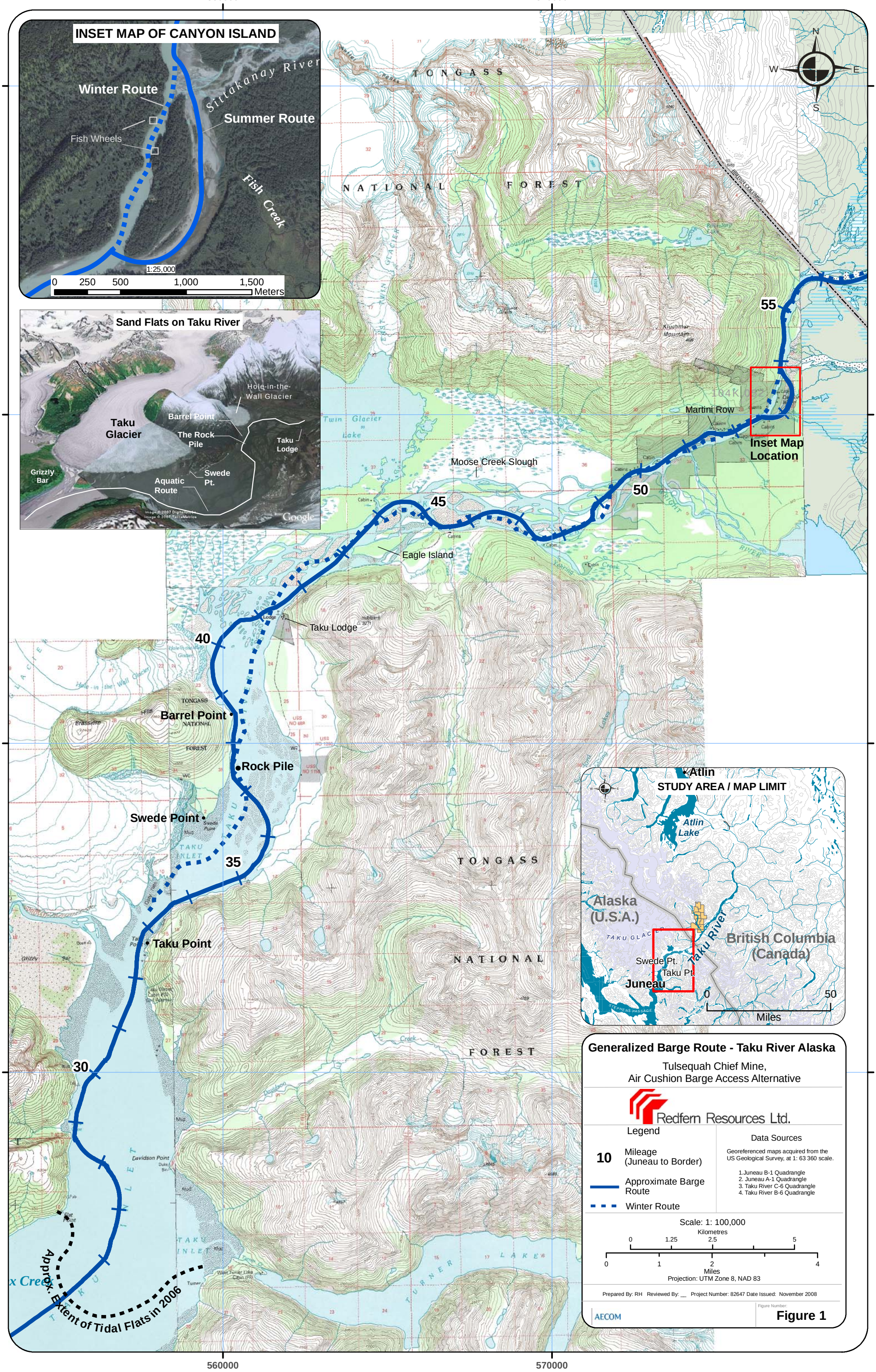
The scope of the Operations Plan pertains to that portion of the Taku River that is subject to State agency authorizations, as described above. This area can broadly be defined as that portion of the Taku River flowing between the US/Canada border and the downstream end of the tidal flats, at the mouth of the river. Figure 1 illustrates the area encompassed within the scope of these permit applications.
Taku Inlet to Taku Lodge

The Operations Plan is provided to clearly delineate and describe the proposed transportation system operations and activities (the project) that will occur within the permitable portion of the Taku River. This Plan will support the applications for a Title 16 and Title 38 Land Use Permit.

The Operations Plan is designed to accommodate the highly dynamic and variable nature of river and weather conditions that will be encountered on the Taku River. The transportation system, as is typical of most transportation systems in northern regions, must be sufficiently adaptive and flexible in order to respond to changing environmental conditions throughout the year. This allows the system operators to optimize operations on a daily basis to avoid and minimize potential impacts, avoid or minimize interference with other vessels and craft that navigate the river, and ensure the safety of the vessel and crew at all times. This Plan has been developed within this context.

1.5 Timing

Mine construction began in the fourth quarter of 2007. This effort has been supported by conventional barging on the Taku River in the summer of 2007 and 2008. The ACB barging system is desired for use in the winter of 2008/09 to facilitate continued support and mobilization of mine construction equipment and supplies.


INSET MAP OF CANYON ISLAND
Winter Route
Summer Route
Fish Wheels
Sittakanay River
Fish Creek
1:25,000
0 250 500 1,000 1,500 Meters
Sand Flats on Taku River
Hole-in-the-Wall Glacier
Barrel Point
Taku Glacier
The Rock Pile
Taku Lodge
Grizzly Bar
Aquatic Route
Swede Pt.
Google
TONGASS
NATIONAL FOREST
Martini Row
Inset Map Location
Moose Creek Slough
Eagle Island
Taku Lodge
Barrel Point
Rock Pile
Swede Point
Taku Point
Approx. Extent of Tidal Flats in 2006
55
50
45
40
35
30
Atlin
STUDY AREA / MAP LIMIT
Atlin Lake
Alaska (U.S.A.)
British Columbia (Canada)
Taku River
Swede Pt.
Taku Pt.
Juneau
0 50 Miles
Generalized Barge Route - Taku River Alaska
Tulsequah Chief Mine,
Air Cushion Barge Access Alternative
Redfern Resources Ltd.
Legend
10 Mileage (Juneau to Border)
Approximate Barge Route
Winter Route
Data Sources
Georeferenced maps acquired from the US Geological Survey, at 1: 63 360 scale.
1.Juneau B-1 Quadrangle
2. Juneau A-1 Quadrangle
3. Taku River C-6 Quadrangle
4. Taku River B-6 Quadrangle
Scale: 1: 100,000
Kilometres
0 1.25 2.5 5
0 1 2 4
Miles
Projection: UTM Zone 8, NAD 83
Prepared By: RH Reviewed By: __ Project Number: 82647 Date Issued: November 2008
AECOM
Figure Number:
Figure 1
560000
570000
6500000
6490000
6480000
6470000

2. The Transportation Route

2.1 Overview of the Route

The transportation route between the US/Canada border and the tidal flats at the mouth of the Taku Inlet covers a distance of approximately 28 miles. Of this distance, approximately 16 miles can be characterized as the lower Taku River, encompassing that section of the river and tidal flats downstream of Taku Lodge. This entire reach of the river is influenced by tides, with the uppermost limit of tidal influence close to Taku Lodge. Upstream of Taku Lodge to the US/Canada border, a distance of 12 miles, the river follows a more defined channel and is upstream of any tidal influence.

2.2 Taku Inlet to Taku Lodge

Sandy sediment deposited by the Taku River and Taku Glacier is deposited at the mouth of the Taku River, causing the formation of extensive sand bars across the width of the river channel. The river is a series of braided, shallow channels interspersed with sandbars extending upstream of Annex Creek to the Taku Lodge (Figure 2). This represents approximately a 16-mile reach of the river. With the high sediment load carried by the river, the mouth of the river will migrate downstream indefinitely.

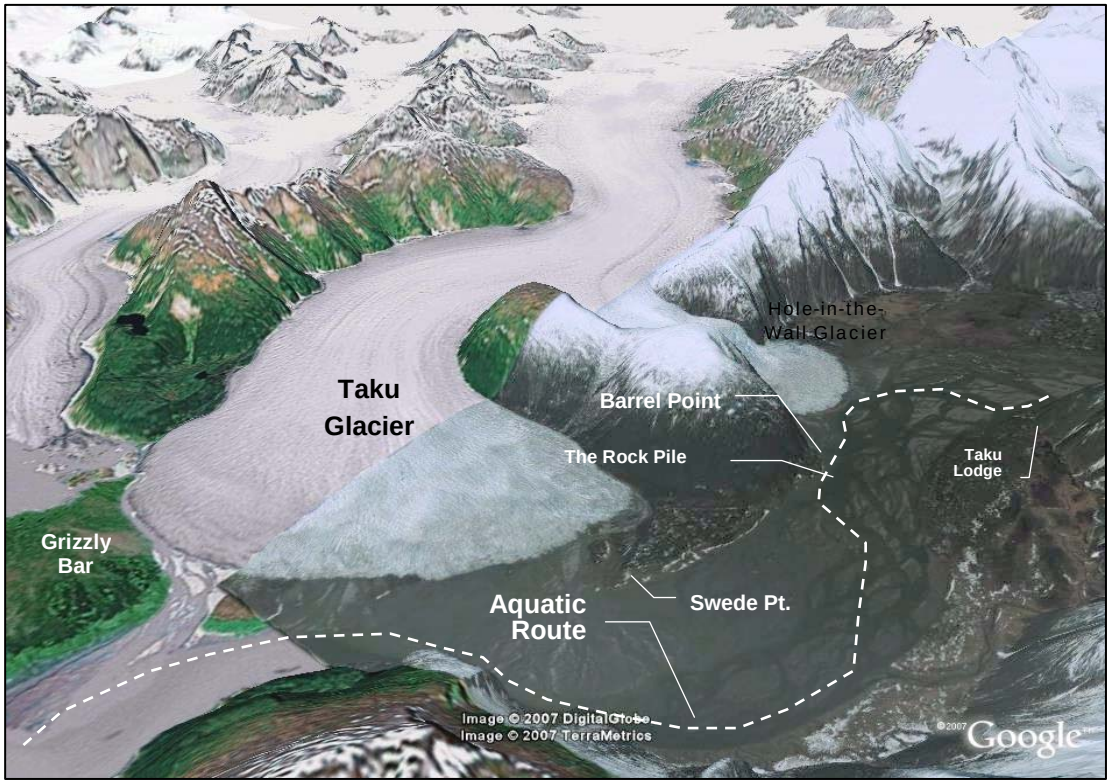
2.2.1 River Depth and Tidal Influence

Through this section, the river channel depths vary between <3 ft to 14 ft depending on the river discharge and tidal influence. Moving upstream from Taku Inlet, the influence of the tide on the depth of water in the river decreases, reaching the upstream limit of tidal influence near Taku Lodge. Here, the tide contributes only four inches of additional depth at low flows (discharge of 8,800 ft^3/s(250 m^3/sec) . At higher river discharge, the tide provides a similar contribution, but the river depth is greater as a result of the higher river discharge combined with tidal assist. Figure 3 illustrates the bathymetry of the river channel during low flows (spring and fall), and at mean low water (low tide).

During the period from about early May until early October, the historical mean monthly river discharge varies between 8,800 ft^3/s in spring and fall, to over 35,300 ft^3/s during June (Figure 4).

Between late May and mid August, the river discharge, combined with medium to higher tides, provides sufficient depth of water for a shallow draft tug to operate successfully through this section of the river. The tug would follow the main channel through this part of the river, as approximated on Figure 5. This channel has been identified through the knowledge and experience of local river users, as well as through bathymetric analysis completed both in 1997 and again in 2007 in this section of the river. Though the channel does migrate somewhat over time, it is interesting to note that the main channel has not shifted significantly during the ten years since the 1997 bathymetric analysis was undertaken.

Figure 2. Route Through the Tidal Flats on the Lower Taku River



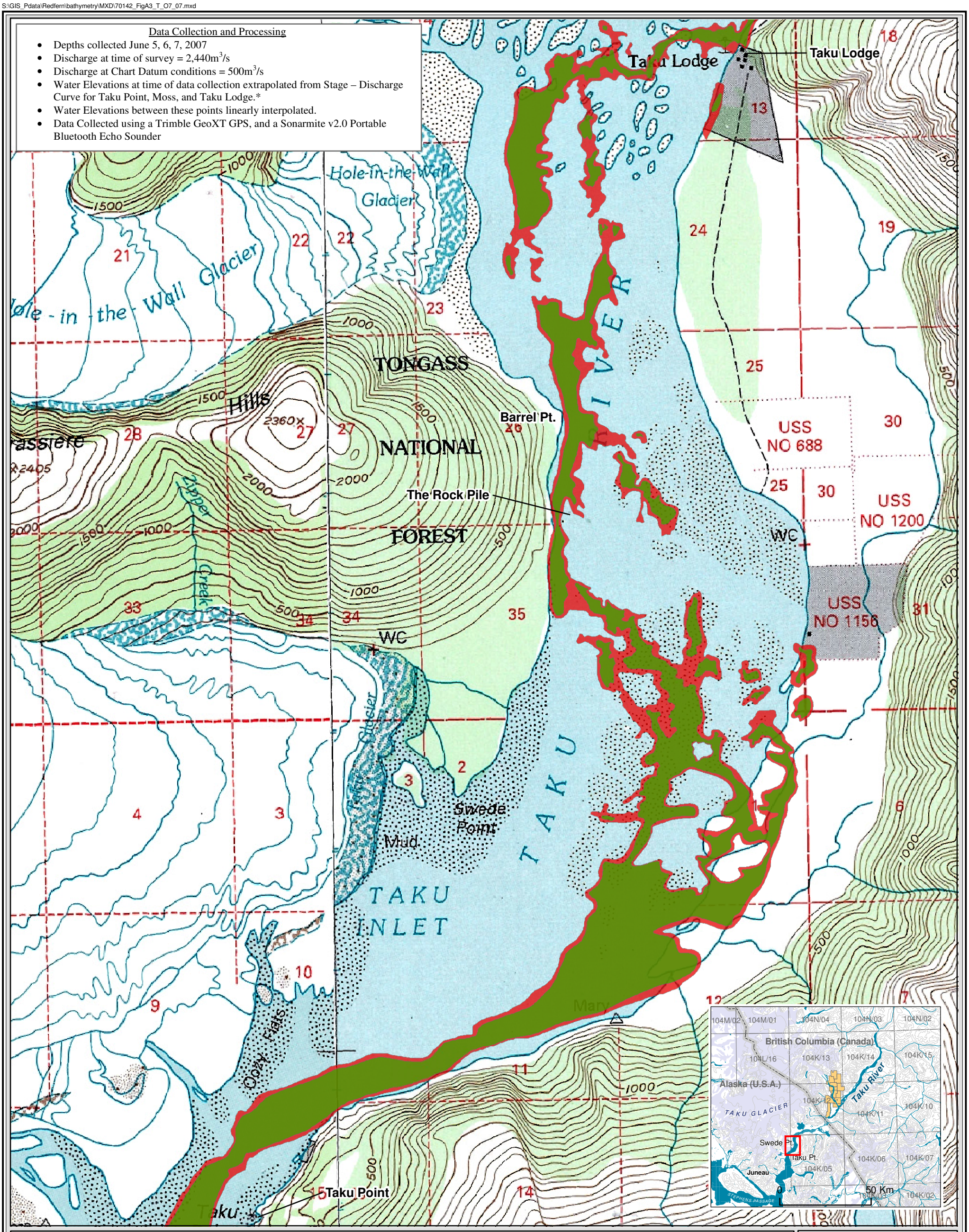
During the summer of 2008, the conventional river barging operations experienced several temporary groundings in the tidal flats area downstream of Taku Lodge. No groundings occurred upstream of Taku Lodge in Alaska. Additional depth soundings in the area that these groundings occurred was undertaken to augment bathymetric information through this section of the river. It is recognized that there is not a direct correlation between the USGS gauge at Canyon Island and the depth of water in the tidal flats, primarily due to the influence of the tide that extends as far upstream as Taku Lodge. The bathymetric analysis that has been performed to date (see *Channel Depth Analysis of the Lower Taku River, Gartner Lee Limited 2007*) explains the relationship of channel depth to both river discharge and tidal effect.

The Taku River experiences considerable variation in flow during the year, varying from as little as 1,800 ft^3/s to as high as 53,000 ft^3/s, as shown on Figure 6. The high and low flow ranges shown on Figure 6 shows the number of calendar days that various flow levels are maintained. As can be seen, the river provides a flow level of 8,800 ft^3/s (250 m^3/s) between 143 and 183 days of the year, defining the duration of the aquatic season.

Figure 6 represent flows during a typical wet and dry year respectively[1]. Mean monthly high and low are illustrated on Figure 4.

[1] *For detailed hydrographic range and record for Taku River, refer to the USGS Water Resource web site for site 15041200 TAKU R NR JUNEAU AK http://waterdata.usgs.gov/nwis/uv?cb_00060=on&format=gif_stats&period=31&site_no=15041200*

S:\GIS_Pdata\Redfern\bathymetry\MXD\70142_FigA3_T_O7_07.mxd



Map Sources/Notes:
Water Depth Measurements Collected on June 5-7/2007 by Gartner Lee Ltd. field staff.
*"Figure 5.1 Stage - Discharge Relationship for Lower Taku River' (Larson, M., Byres, R., 1995)
Topographic Images derived from Digital Raster Graphic (DRG) Images produced by the USGS.

N W E S

Kilometres
0 0.25 0.5 1
0 0.25 0.5 1
Miles

1:30,000
UTM Zone 8N, NAD 83

File Name: 70142_FigA3_T_O7_07.mxd
Reviewed By: FP
Date Issued: July 2007
Prepared By: JW
Project Number: 70142

Legend

- Areas with > 3 ft of water
- Areas with between 2 and 3 ft of water
- Areas with < 2 ft of water

Redfern Resources Ltd.

Bathymetry of Lower Taku River:

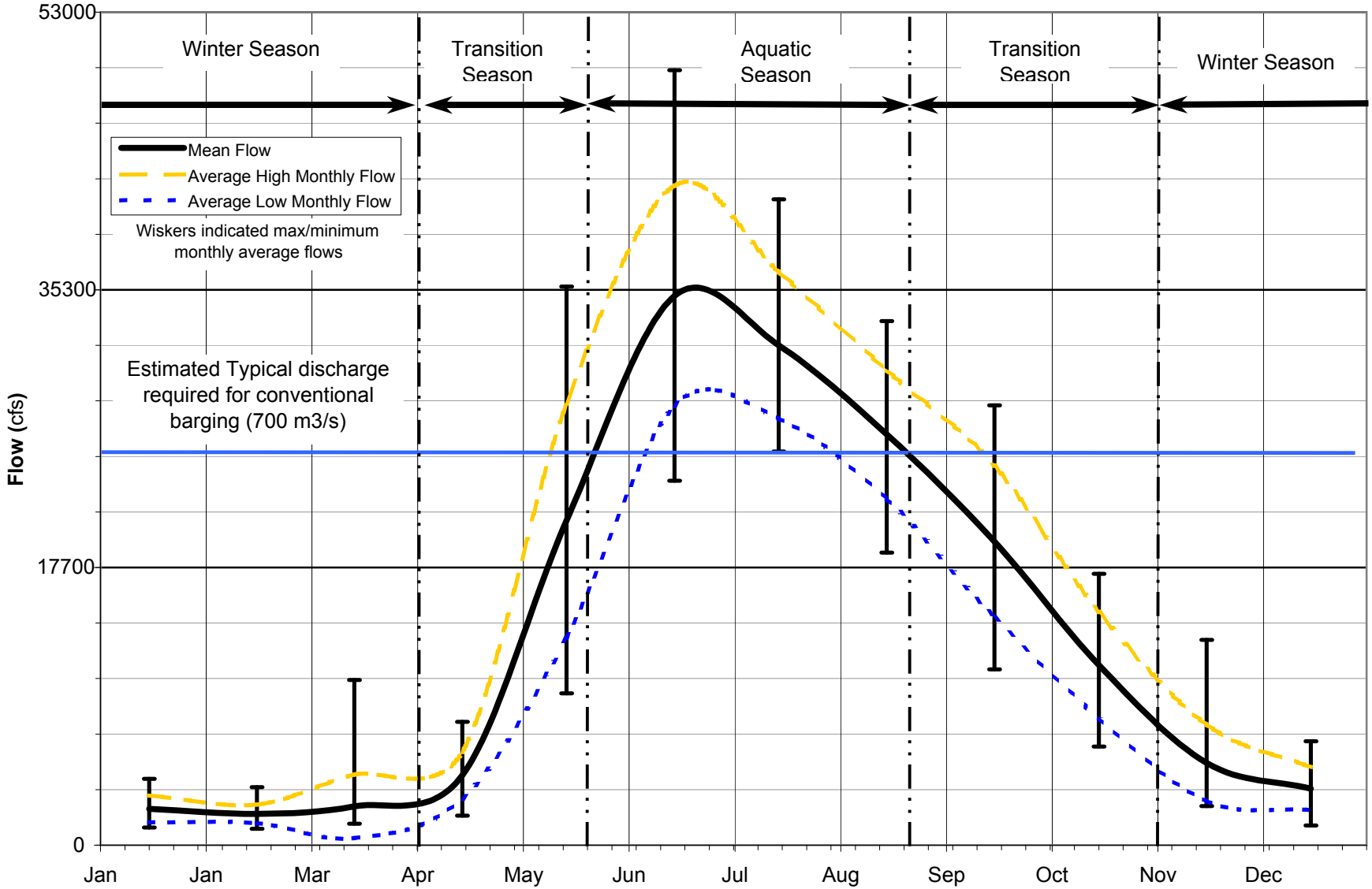
River Discharge
17,657 cfs and
Mean Low Low "0 ft" Tide
(MLLW)

Gartner Lee

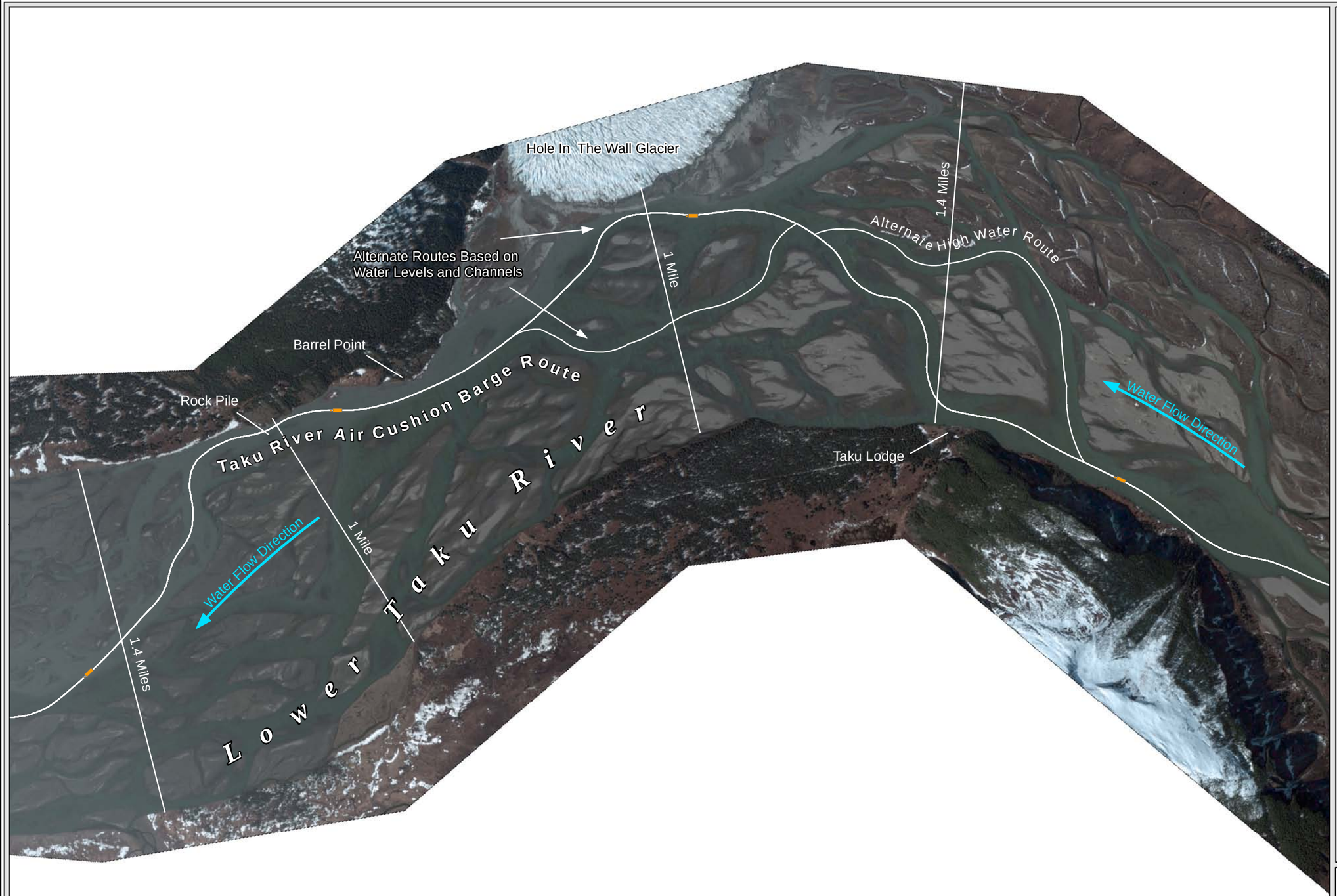
Figure 3
Version 1

Figure 4. Taku River Hydograph at Canyon Island

1986 - 2006

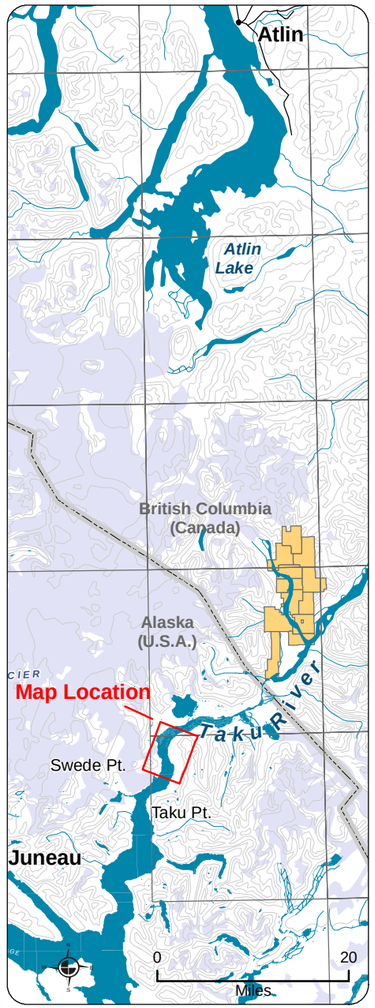


Taku_hydrograph.xls



Air Cushion Barge
(Shown to Scale)

Image Date: May 15 / 06



Map Sources/Notes:
Quickbird Imagery (Image Date May 15, 06),
Copyright 2007 Digital Globe Incorporated
All other data, Gartner Lee Limited

0.25 0.125 0 0.25 0.5 0.75 1 Km

1:25,000
UTM Zone 12N, NAD 83

File Name:	70142_Taku_River_Widths_Oct_2.mxd		
Reviewed By:	KW	Prepared By:	JW
Date Issued:	October 2007	Project Number:	72623

Redfern Resources Ltd.

Lower Taku River
Showing Approximate Routes,
Depending on Water Depth

18 October 2007

Gartner Lee

Figure 5
Version 1

File Name with or without path and/or client distribution date

Figure 6. Average, Low and High Flows on the Taku River (1986 – 2007)

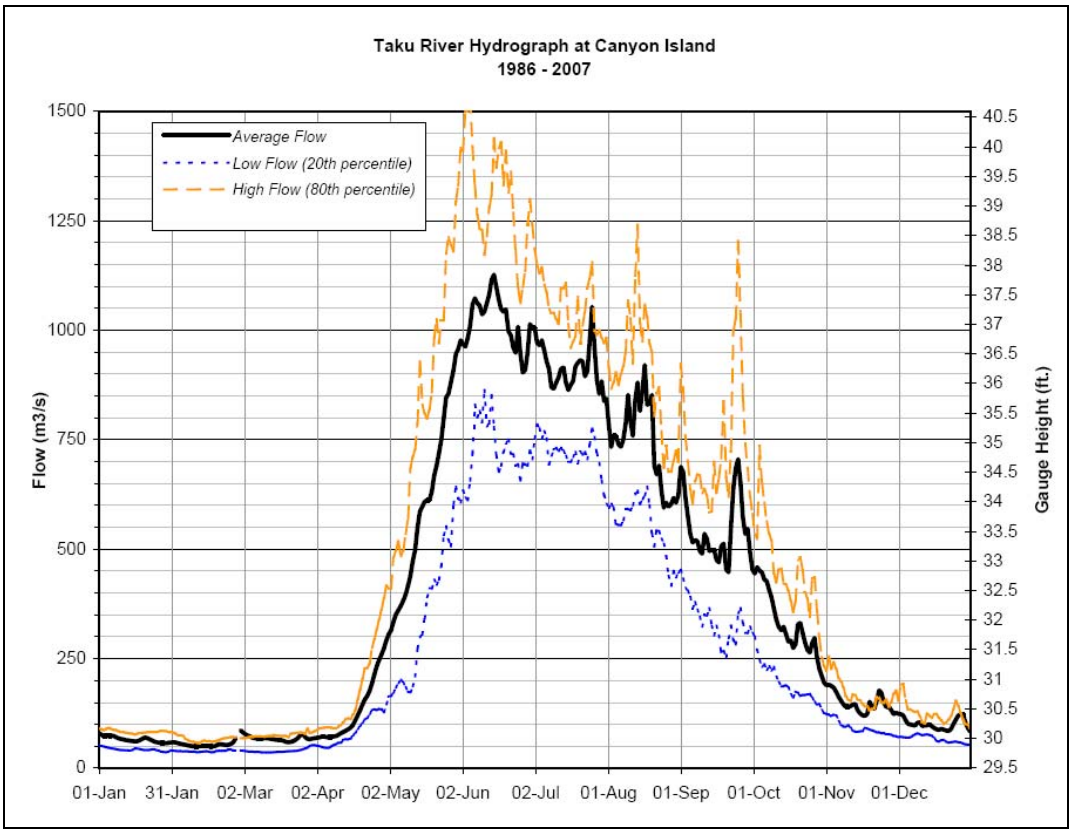


Table 1. Average Calendar Days by Flow Level (1986 to 2007)

Month	Days with flow Greater Than: (m3/s)									
	>100		>250		>350		>500		>700	
Flow Condition	Ave.	Low	Ave.	Low	Ave.	Low	Ave.	Low	Ave.	Low
January	0	0	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0	0	0	0
April	13	10	2	0	0	0	0	0	0	0
May	31	31	31	18	27	14	18	7	9	0
June	30	30	30	30	30	30	30	30	30	16
July	31	31	31	31	31	31	31	31	31	25
August	31	31	31	31	31	31	31	25	20	0
September	30	30	30	30	30	19	21	0	0	0
October	31	31	28	3	10	0	0	0	0	0
November	30	6	0	0	0	0	0	0	0	0
December	15	0	0	0	0	0	0	0	0	0
Total	242	200	183	143	159	125	131	93	90	41

Notes: *indicates continuous winter operation over ice*
Ave. *Indicates average flow year*
Low *Low flow year (20th percentile)*

Conventional barging in 2007 was successful at a river flow of down to 8,800 ft^3/s, which defines the minimal flow for aquatic operations. As shown on the Figure 6, use of this flow as a threshold indicates a typical aquatic season extending from about mid-May to mid-October.

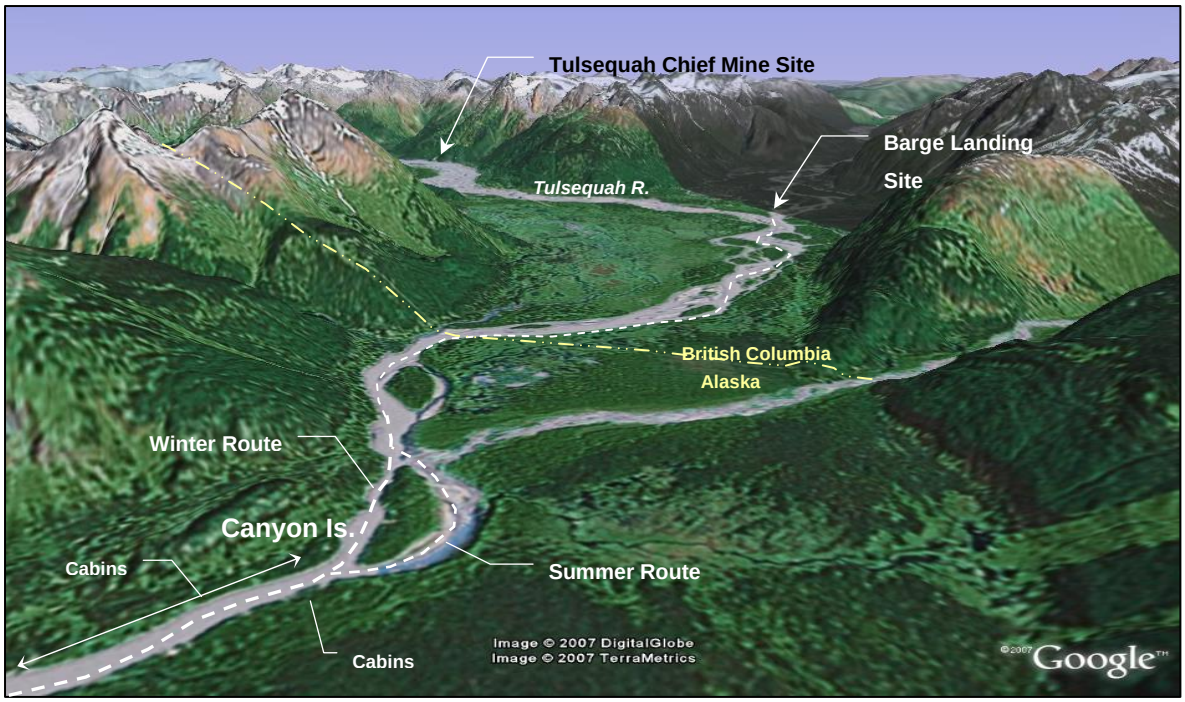
Table 1 shows the number of calendar days that various flow levels are maintained. As can be seen, the river provides a flow level of 8,800 ft^3/s (250 m^3/s) between 143 and 183 days of the year, defining the duration of the aquatic season.

During the winter period, from early November until early to mid-April, the river is frozen and will support the use of ATs using soft tires to provide the best means of transporting the ACB along the river corridor. The criteria for non-aquatic (winter) operations are discussed further in Section 3.2. Once the river ice is sufficiently thick and/or land fast, the barge operation would be over ice and snow-covered sand or gravel bars, or river ice and would follow the non-aquatic route illustrated on the Route Atlas.

2.3 Taku Lodge to US/Canada Border

The aquatic route from Canyon Island to the US/Canada border is illustrated on Figure 7. The section of the river upstream of Taku Lodge is characterized by a defined channel with sufficient depth and width to accommodate the shallow draft tug throughout the aquatic season. Private land holdings along this section include the Taku Lodge, located across from the Hole-in-the-Wall Glacier, and about 70 recreational cabins located further upstream along a 3 mile long reach of the Taku River immediately downstream of Canyon Island.

Figure 7. View of Routes around Canyon Island, Looking Downstream



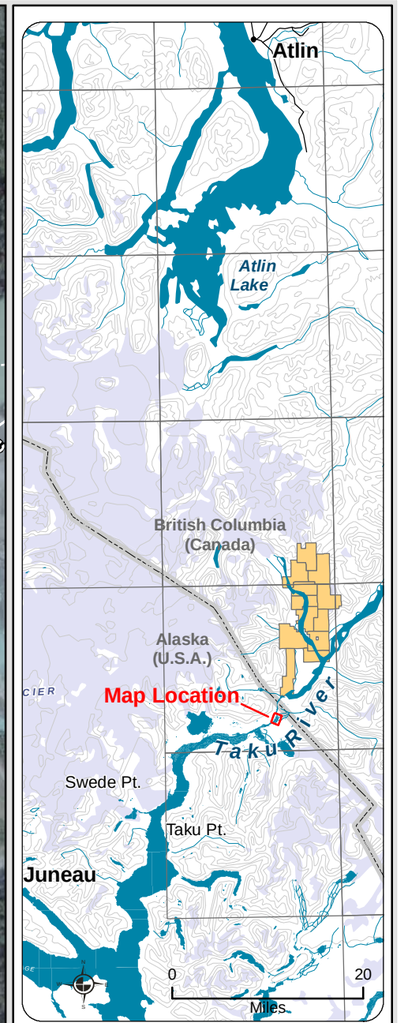
2.3.1 Canyon Island

Figure 8 shows the approximate aquatic and non-aquatic (winter) routes at Canyon Island. On the west side of the island, there is a single, narrow channel . At the narrowest point, this channel is approximately 130 ft wide at low water levels, and will not safely accommodate the width of the ACB (88ft wide x 208 ft. long). During the summer season, there is considerable boat traffic through the narrows, and two seasonal fish counters are located immediately upstream of the narrows. There is also a Personal Use fishery in July that contributes to increased river traffic at this location. For these reasons, the use of the west channel during aquatic operations presents greater navigational challenges than the use of the east side of the island.

During the aquatic season, the ACB would be towed across the gravel bars along the east side of the island by the amphibious tractors (ATs). The shallow draft tug would navigate through the narrows, meeting the ACB at the upstream or downstream end of the island (depending on direction of travel), reconnect to the ACB and continue to its destination.

Figure 9, Development Plan for Canyon Island, shows the proposed ACB operational corridor along the east channel of Canyon Island. The Plan identifies State shorelands below the Ordinary High Water Mark (OHWM) and State-owned uplands. The total area of the corridor is approximately 43 acres. The precise route taken by the ACB will vary depending on flows in the east channel, but will remain within the defined operational corridor. No private lands are crossed by the corridor.

During winter, after freeze up, the west channel would be used as the primary winter route as shown on Figure 8. The route would be entirely over ice and snow during this time using the low ground pressure tires of the ATs. Icebreaking is neither contemplated nor desirable. Local residents on the river report that the west channel at Canyon Island is one the first parts of the river to freeze over and one of the last portions to breakup. The west channel avoids the open water potion of the east channel that tends to remain open throughout the winter due to the inflow of warmer water from Fish Creek. The east channel will be utilized as an alternative route in the winter should conditions not allow the use of the west channel. The route in the winter season will follow a similar path to that designated in the application for the aquatic season when ATs are being used.



Map Sources/Notes:
Quickbird Imagery (Image Date 08/26/03),
Copyright 2007 Digital Globe Incorporated
All other data, Gartner Lee Limited

0.05 0.025 0 0.05 0.1 0.15 0.2 Km

1:5,000
UTM Zone 12N, NAD 83

File Name:	82647_Fig8_Taku_River_Widths_rh_v1_Nov08.mxd		
Reviewed By:		Prepared By:	RH
Date Issued:	November 2008	Project Number:	82647

Redfern Resources Ltd.

Canyon Island
Showing Approximate
Summer and Winter Routes

November 2008

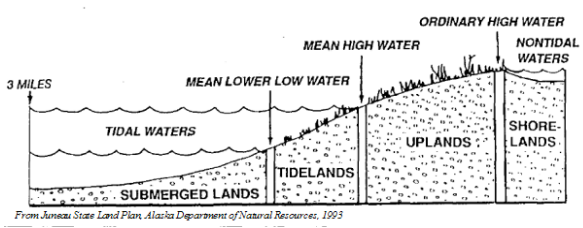
AECOM

Figure 8
Version 1

File Name with or without path and/or client distribution date

Ordinary High Water (OHW) Line

Ordinary High Water (OHW) is not a fixed boundary; the location of OHW changes based on the conditions of the river. The State defines OHW per 11 AAC 53.900, Ordinary high water means the mark along the bank or shore up to which the presence and action of the nontidal water are so common and usual, and so long continued in all ordinary years, as to leave a natural line impressed on the bank or shore and indicated by erosion, shelving, changes in soil characteristics, destruction of terrestrial vegetation, or other distinctive physical characteristics .



From Juneau State Land Plan, Alaska Department of Natural Resources, 1993

577000

6491000

Uplands

AT Storage Area

Shorelands

Canyon Island

West Channel

East Channel

BLOCK: 111 LOT: 0033

BLOCK: 111 LOT: 0340

BLOCK: 111 LOT: 0310

BLOCK: 111 LOT: 0320

BLOCK: 111 LOT: 0300

BLOCK: 111 LOT: 0321

BLOCK: 111 LOT: 0350

BLOCK: 111 LOT: 0290

BLOCK: 111 LOT: 0280

BLOCK: 115 LOT: 0080

BLOCK: 115 LOT: 0070

BLOCK: 115 LOT: 0060

BLOCK: 115 LOT: 0050

BLOCK: 115 LOT: 0040

BLOCK: 115 LOT: 0030

BLOCK: 115 LOT: 0020

BLOCK: 115 LOT: 0010

BLOCK: 115 LOT: 0090

208 ft. 88 ft.

Atlin

Atlin Lake

British Columbia (Canada)

Alaska (U.S.A)

Taku River

Swede Pt.

Taku Pt.

Juneau

6490000

577000

N W E S

m

0 30 60 120 180 240

1:5,000

UTM Zone 8N, NAD 83

© 2008 Gartner Lee Limited All Rights Reserved.
This document is protected by copyright law and may not be used, reproduced or modified in any manner or for any purposed except with the written permission of Gartner Lee Limited doing business as AECOM ("AECOM") or a party to which its copyright has been assigned. AECOM accepts no responsibility, and denies any liability whatsoever, to any party that uses, reproduces, modifies, or relies on this document without AECOM's express written consent.

Legend

- Air Cushion Barge (ACB)
- Typical Route (to be assessed and marked seasonally)
- Operational Corridor
- Requested Upland Use Area
- Ordinary High Water Mark
- Status Plat Boundary - approximate (Provided by County Bureau Juneau Alaska - Oct 23, 2008)

Redfern Resources Ltd.

Alaskan Operations Plan

ACB Transportation System Canyon Island Development Plan

November 2008
Project 82647

AECOM

Figure 9

Revision 1

Map Document: (S:\GIS_Pdata\TULSEQUAH_CHIEF\ACB_Access\82647 - Marine to Non-Aq Exch Zone\MXD\82648_DFIG_Fig 9 CanyonIs Dev Plan_08nov13_rg_v12.mxd)

3. River Operations

The barging operation consists of two operational components- a marine component that will handle transportation between Juneau and the Taku Inlet, and a river component that will operate on the Taku River up to the barge landing site in Canada. This system will use vessels and equipment best suited to the particular conditions expected to be encountered along the route, and will be coordinated to provide a transportation system that is flexible, reliable, safe, and efficient.

There will be two discrete bases of operations: an existing barge terminal in Juneau and the barge landing site at the confluence of the Tulsequah and Taku Rivers in Canada. It is proposed that two separate crews will operate the transportation system - a Juneau-based crew that is responsible for the marine portion of the system, and a crew based at the mine that will be responsible for the river portion of the system.

The criteria that have been developed to define the appropriate aquatic and non-aquatic operations reflect the capability of the equipment, consideration of the potential effects on fish and fish habitat, and ensure that the barge operations constitute a viable transportation system capable of supporting the Tulsequah Chief mine during its construction and operation phases. The operations have been described as aquatic and non-aquatic (winter) seasons, defined by minimum flows in the aquatic season, and a maximum number of lead crossings during the non-aquatic season.

The following sections describe only that portion of barging operations that will occur on the Taku River in Alaska – from the US/Canada border to the lower extent of the tidal flats at the mouth of the river.

3.1 Aquatic Operations - Late May to Mid-October

For approximately six months, from about mid to late May until mid October, average monthly flows in the river combined with tidal assist provide sufficient depth across the tidal flats to support fully aquatic operations using a shallow draft tug (draft $\leq$3 feet). The tidal flats extend downstream of Taku Lodge to approximately Annex Creek. The shallow draft tug is fully capable of navigating through this section of the river during medium to high tides, as the tide provides between 8 and 16 feet of additional depth in the channel, diminishing with distance upstream. The tidal influence near Taku Lodge is minimal, and river discharge controls the depth of water at this location. Without use of tidal assist, the shoals in the upper tidal flats are the "pinch point" along the river, and govern the navigability of the river when operating with the shallow draft tug. Without tidal assist, the shallow draft tug can operate at river discharge over 24,700 ft^3/s (700 m^3/s) as there would be sufficient depth of water through the shallowest sections of the route. When the river discharge is less than 24,700 ft^3/s and greater than 8,800 ft^3/s (between 700 and 250 m^3/s), tidal assist is needed to ensure sufficient depth through this section of the tidal flats. At discharge less than 8,800 ft^3/s , the shallow draft tug will not be able to routinely operate on this section of the river.

During this season, a conventional shallow draft tug will be used to shuttle the ACB up and down the river. The shallow draft tug will rendezvous with the marine tug to deliver the outbound ACB to the marine

tug for transport to Juneau, and pick up the inbound ACB for transport to the mine. The rendezvous will take place in the open and deep waters of Taku Inlet.

A small powerboat will act as a pilot vessel to scout the river and advise other river traffic of the barge's progress will accompany the shallow draft tug. All vessels will be equipped with marine radios to communicate with other river traffic.

3.1.1 Canyon Island Aquatic Season Operating Plan

A geomorphic and hydrologic description of the eastern channel of Canyon Island is provided in the following two sections. Implications for aquatic barging operations under a range of hydrologic conditions are described below.

3.1.1.1 Geomorphologic Setting

The majority of flow in the Taku River flows through the west channel at Canyon Island. The west channel is characterized by a narrow, incised bedrock channel consisting of two constrictions over a third of a mile (half a kilometre) distance with a channel depth exceeding 25 ft (7.5 m). Flow is maintained through the west channel year round.

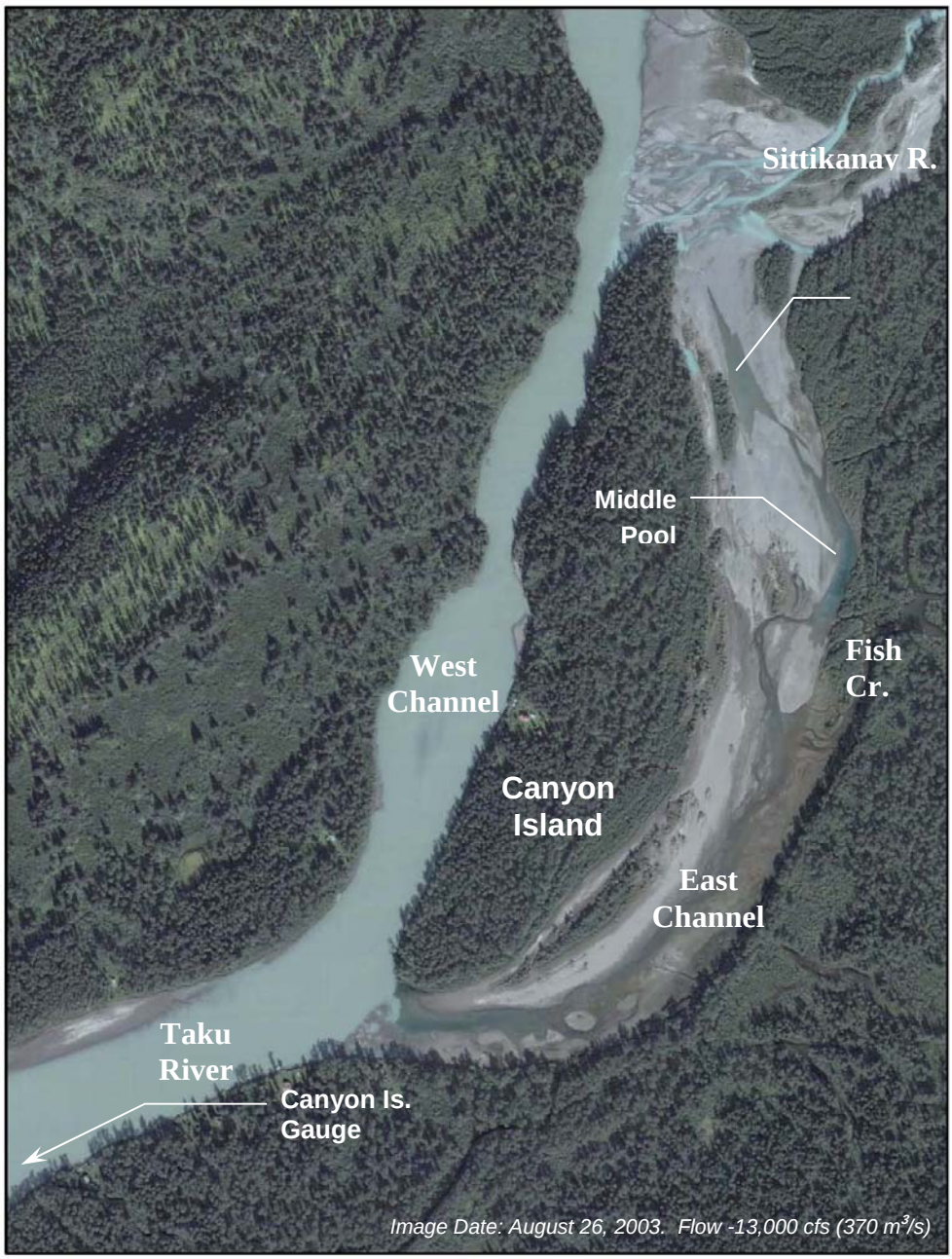
Taku River flows through the east channel are intermittent and only occur during high water events (e.g. spring freshet, jokulhlaups, or floods). The upper end of the east channel is blocked by an alluvial fan deposited from the Sittakanay River (Figure 10). These sediments are primarily sand and cobble gravel. The Sittakanay is a glacial fed, high energy river with significant sediment load and is reportedly subject to small jokulhlaups. Historical aerial photography shows that the growth of the Sittakanay River's alluvial fan has successively blocked off Taku River flow to the eastern channel. Historically, the east channel at Canyon Island used to convey a greater quantity of river flow (Taku and/or Sittakanay River). It is speculated that this depositional process has now reached a "steady-state" condition where the deposition rate of the Sittakanay River is matched by sediment removal by the Taku River during flood overflow events.

The east channel is characterized by unvegetated, exposed alluvial sand and gravel. The upper (northern) half of the channel is primarily exposed cobble gravel. The lower (southern) half of the channel is partially inundated by flow from Fish Creek and backwater from the Taku River. Sediment in the lower portion of the channel tends to be finer grained, consisting overbank deposits of sand. However, course granular sediments (cobble and boulders) are found in the substrate in the lower third of the inundated area. A detailed description of the aquatic habitats of the east channel is provided in the *Canyon Island Fish Habitat Assessment Memo, Gartner Lee Limited 2008*)

Fish Creek is a productive fish-bearing creek that drains a wetland (slough) complex east of Canyon Island. Fish Creek discharges into the lower half of the east channel at Canyon Island. Flow from Fish Creek, likely supplemented by hyporheic flow from the Taku River and Sittakanay River, keep the inundated lower portion of the east channel unfrozen year round. The mouth of Fish Creek represents the upper end of the year-round inundated portion of the eastern channel. Upstream of this point, a middle and an upper pool are typically found during the unfrozen seasons. The middle pool is adjacent to

Fish Creek and on the eastern margin of the channel. The upper pool is characterized by cobble gravel and is fed by hyporheic water from the Sittakanay River. The upper pool is accessible to fish, however is observed to freeze to bottom during winter. A relatively distinct elevation rise of 5 to 10 feet exists between the upper (northern) and lower (southern) portions of the eastern channel. The channel topography between the upper and lower portions of the channel is hummocky and has incised channels between 3 to 6 feet deep.

Figure 10. General Arrangement of Canyon Island



3.1.1.2 Hydrologic Setting

Flow through the west channel at Canyon Island is maintained year round by the Taku River. Surface water flow in the east channel is controlled by interactions between the Taku River, the Sittakanay River and Fish Creek. For most of the year, the upper portion of the east channel is exposed and does not experience contagious surface water flow. Much of the lower (southern) portion of the east channel is inundated by flow from Fish Creek and backwater from the Taku River year round. Water depths in the inundated lower portion of the east channel are typically 1 to 2 feet during the winter and low water periods

Overflow across the upper portion of the east channel only occurs during high flows in the Taku River, the Sittakanay River, or a combination thereof. Flow in the Taku River is monitored at a USGS gauging station located approximately half a mile downstream of Canyon Island. The specific time and extent of surface water overflow over the upper portion of the east channel will vary from year-to-year given the dynamic and complex nature of the glacially fed Taku and Sittakanay Rivers. Based on current conditions and a topographic survey conducted in November 2008, it appears that overflow from the Taku River into the east channel begins when the flow at the Taku River gauge is approximately 30,000 cfs (850 m^3/s or a gauge height 35.5 ft). However, this will be modified by discharge from the Sittakanay River. As flows rise in the Sittakanay River, this will cause water to spill into the east channel. The specific mix and quantity of water will vary depending on the relative stages of the Taku and Sittakanay Rivers

Based on east channel site data, water level data measured at the Canyon Island gauge, and contemporary site specific observations, flow conditions in the east channel can generally be categorized as shown on Table 2:

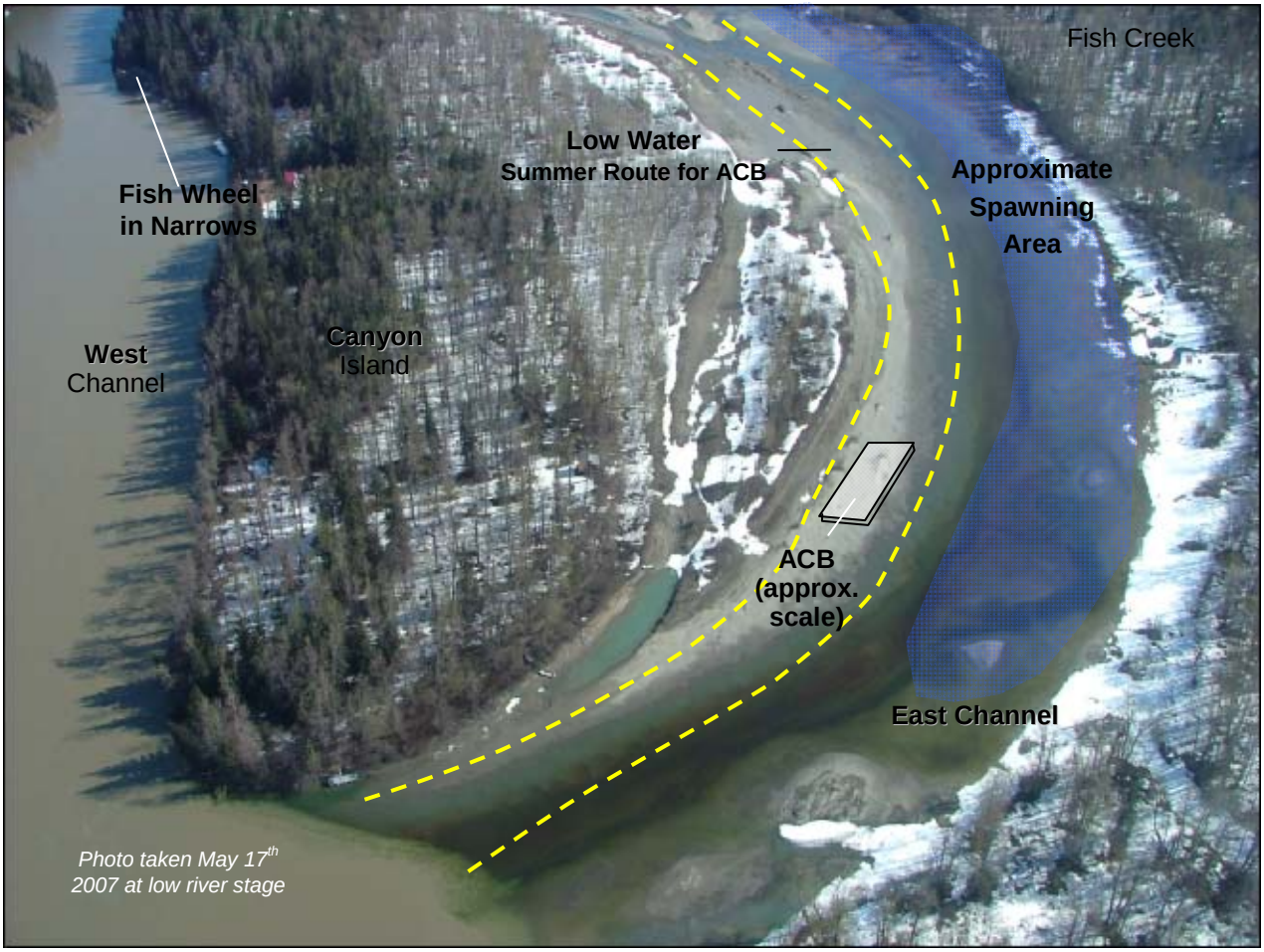
Table 2. Hydrologic Conditions of East Channel, Canyon Island

Flow		Gauge Height (ft)		Canyon Island East Channel
From	To	From	To	Flow Condition
-	< 23,800 cfs		<34.1	**Low Flow** - No overflow from Taku River- Upper portion of east channel exposed. Water depth in inundated portion (lower) of east channel is shallow (<3.5 ft deep)
23,800 cfs (650 m^3/s)	30,000 cfs (850 m^3/s)	34.1	35.5	**Intermediate Flow** - No overflow from Taku River. Upper portion of east channel exposed. Extensive inundation of lower portion of east channel (>3.5 ft water depth)
30,000 cfs (850 m^3/s)	56,000 cfs (1,600 m^3/s)	35.5	41	**Shallow Overflow** - Shallow/partial overflow from Taku River and/or Sittakanay River. Extensive inundation of lower portion of east channel (>3.5ft water depth)
>56,000 cfs (>1,600 m^3/s)	-	>41	-	**High Water Flow** - Flood Conditions. Significant flow in entire east channel (>3 ft water depth)

3.1.1.3 Aquatic Operations Plan at Canyon Island

When flows in the Taku River are less than 23,800 cfs (<650 m^3/s, gauge height 34.1), aquatic operations will traverse Canyon Island by towing the ACB overland along the east side of the island. The inbound shallow draft tug will advance the ACB to the bar at the southern tip of Canyon Island. The ACB will be met by the ATs, which will connect with the ACB and tow it overland as illustrated on Figure 9. Hydrologic conditions at this stage are well represented on Figure 11 and Figure 9 the Canyon Island Development Plan

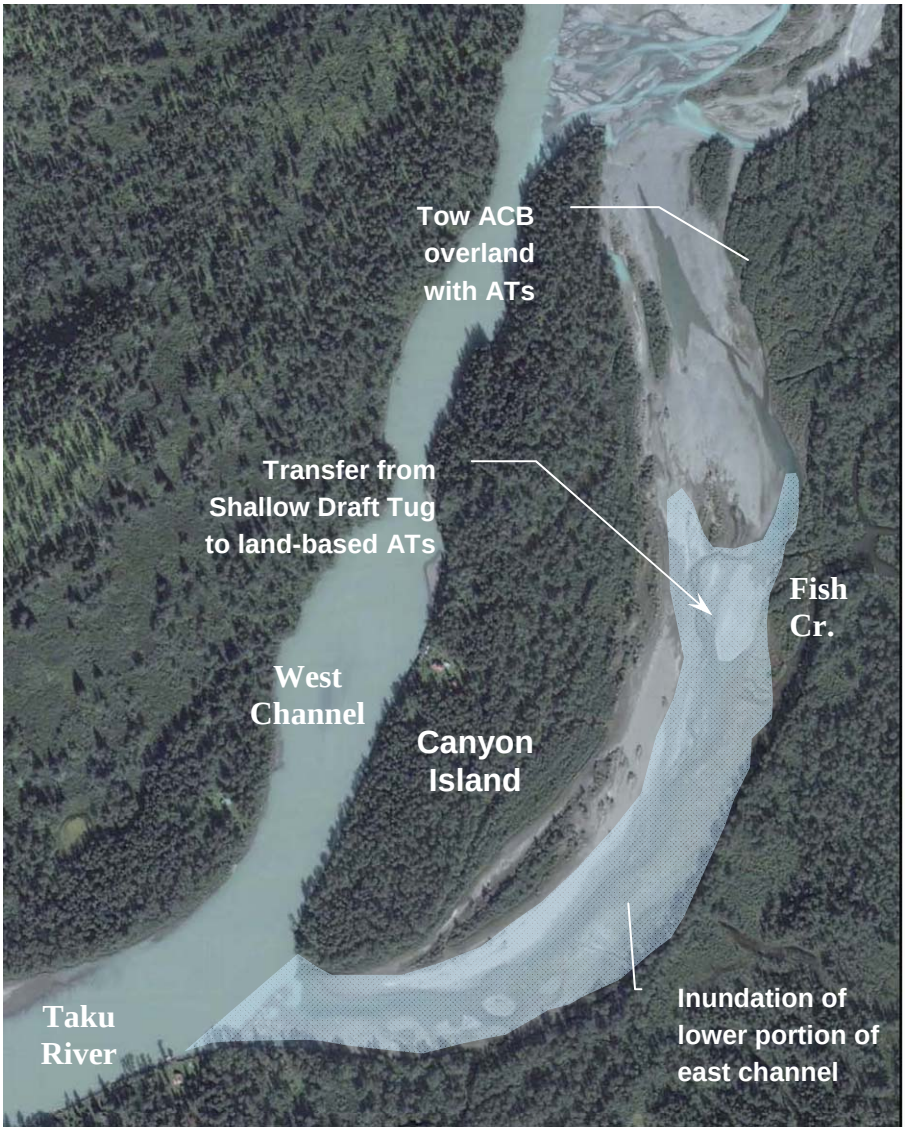
Figure 11. ACB Circumnavigation of Canyon Island during Aquatic Operations – Low Flow



3.1.1.4 Aquatic Operations Plan at Canyon Island: Intermediate Flow

At these flows in the Taku River (between 23,800-30,000 cfs (650-850 m^3/s)), water depth in excess of 3ft persist in the lower portions of the east channel. The shallow draft tug can advance the ACB though these inundated portions of the east channel. A tow line will then be extended to the ATs located on the exposed upper portions of the east channel. The ACB will winch itself over the exposed upper channel to the land based ATs.

Figure 12. Aquatic Operations at Canyon Island – Intermediate Flows

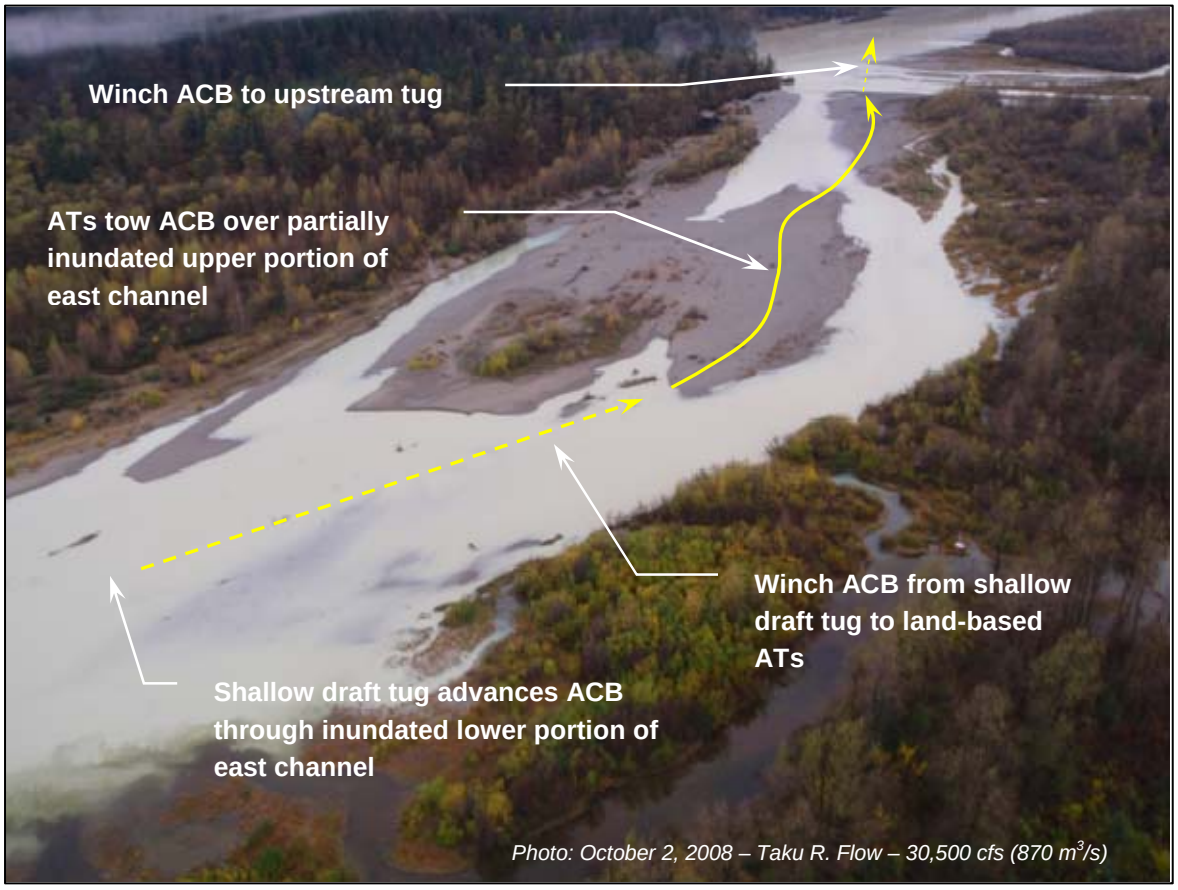


3.1.1.5 Aquatic Operations Plan at Canyon Island: Shallow Overflow

At flows in excess of 30,000 cfs (850 m^3/s), overflow can occur from the confluence of the Taku and Sittakanay Rivers into the east channel of Canyon Island. The extent of this overflow will depend on the specific stage of the two rivers. In general terms, overflow into the east channel will be greater as stage rises in the Sittakanay River (e.g. spring freshet) and not always correlated with Taku River stage as measured by the Canyon Island gauging station.

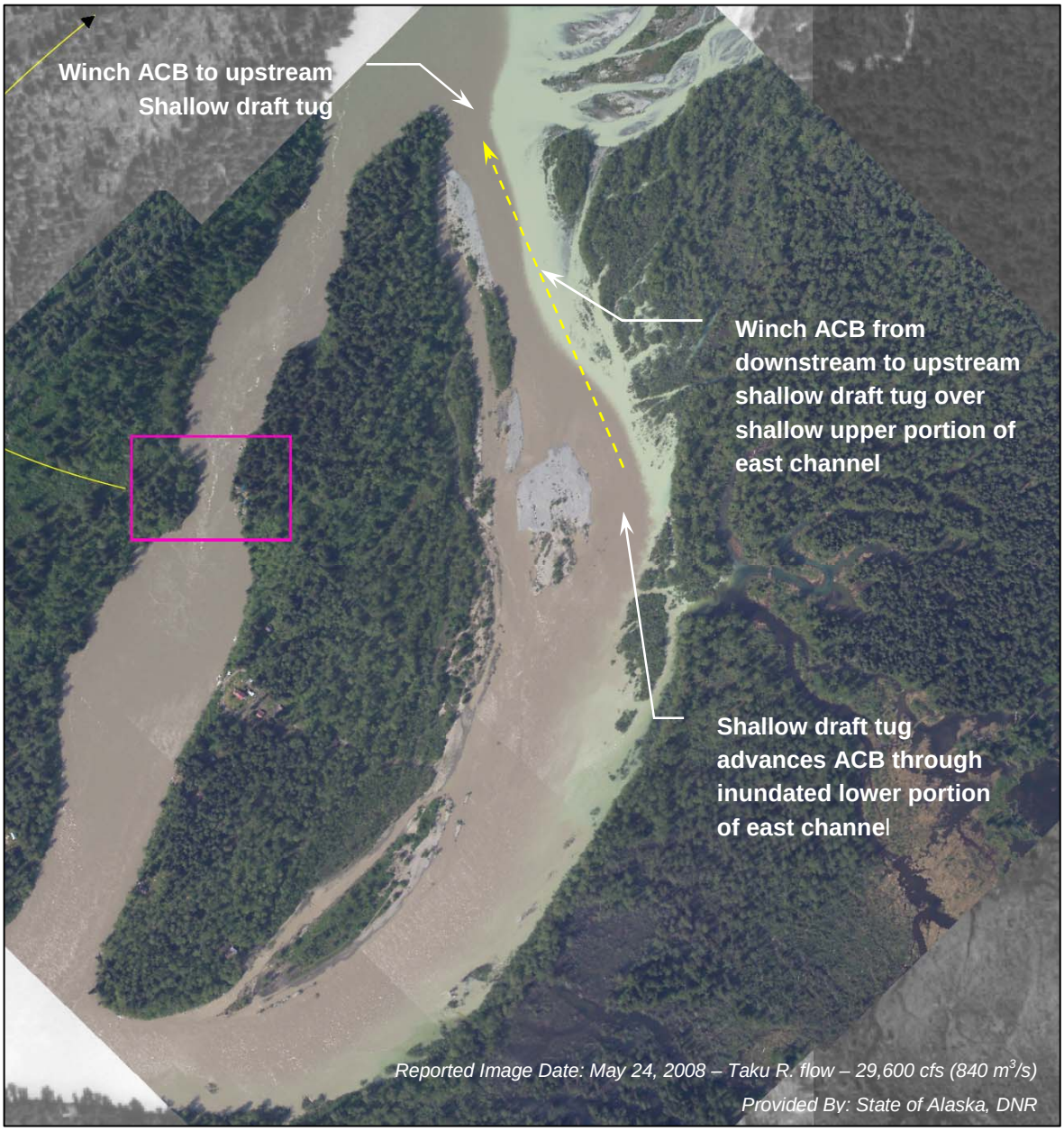
When partial shallow overflows occur, the shallow draft tug can advance the ACB thorough the inundated lower portion of the east channel to meet up with the land-based ATs (Figure 13) The ATs will then tow the ACB over the partially inundated upper portion of the east channel to meet up with the shallow draft tug upstream of Canyon Island, at which point the ACB will be winched to the upstream tug.

Figure 13. Aquatic Operations at Canyon Island - Partial Shallow Overflow



When extensive shallow overflows occur, the shallow draft tug can advance the ACB thorough the inundated lower portion of the east channel. A line can be extended using a small boat to an upstream shallow draft tug. The ACB can then which itself through the upper portion of the east channel to the upstream tug. This condition may occur when the Sittakanay River is in flood in combination with a moderately high flow in the Taku River.

Figure 14. Aquatic Operations at Canyon Island - Extensive Shallow Overflow



3.1.1.6 Aquatic Operations Plan at Canyon Island: High Water Flow

At flows in excess of 56,000 cfs (>1,600 m^3/s), significant flow through the east channel can be expected. At this discharge rate, water depths in excess of 3ft can be expected through the east channel. Discharges at this rate will only occur during flood events, such as spring freshet and jokulhlaups. On average, these flows do occur annually, but represent less than 1% of the average aquatic season. At these flow rates, the ACB can be navigated fully aquatically around the east channel of Canyon Island by the shallow draft tug(s).

3.1.1.7 Aquatic Operations at Canyon Island – Frequency of Operating Methods

Based on the hydrographic records of the USGS's Canyon Island gauge, the frequency of the various aquatic season operating methods around Canyon Island is provided in Table 3:

Table 3. Frequency of Operating Method at East Channel, based on Historic Flow Records

Flow		Gauge Height (ft)		Average # Days / Yr/	% of Aquatic Operating Season	Canyon Is. East Channel Flow Condition Operating Method
From	To	From	To			
-	< 8,800 cfs (<250 m^3/s)	-	<31.2	182	n/a	**Winter Flow** – Aquatic travel suspended.
8,800 cfs (250 m^3/s)	23,800 cfs (650 m^3/s)	31.2	34.1	83	45%	**Low Flow** - No overflow from Taku River- Upper portion of east channel exposed. Water depth in inundated portion (lower) of east channel is shallow (<3.5 ft deep)
23,800 cfs (650 m^3/s)	30,000 cfs (850 m^3/s)	34.1	35.5	30	16%	**Intermediate Flow** - No overflow from Taku River. Upper portion of east channel exposed. Extensive inundation of lower portion of east channel (>3.5 ft water depth)
30,000 cfs (850 m^3/s)	56,000 cfs (1,600 m^3/s)	35.5	41	70	38%	**Shallow Overflow** - Shallow/partial overflow from Taku River and/or Sittakanay River. Extensive inundation of lower portion of east channel (>3.5ft water depth)
>56,000 cfs (>1,600 m^3/s)	-	>41	-	0	<1%	**High Water Flow** - Flood Conditions. Significant flow in entire east channel (>3 ft water depth)

3.2 Non-Aquatic Winter Operations – Late November to Early April

The operational objective for winter is to identify a route that avoids crossing open water, as much as possible, following a route that traverses frozen surfaces, primarily over snow/ice covered gravel bars. Non-aquatic (winter) operations have been defined by all of the following conditions on the river being met:

- In Alaska, no more than 16 open water crossings, generally perpendicular to the channel; and
- in Canada, no more than nine open water crossings, generally perpendicular to the channel; and
- 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.

The number of open lead crossing defining the Non-Aquatic season is based on ice monitoring working conducted on the Taku River during winters of 2006/07 and 2007/08 supplemented by local knowledge of long-time river residents in both Alaska and Canada. This is also a functional threshold from an operational efficiency perspective. The number of open lead crossings during the coldest portion of the winter will vary from year to year, ranging anywhere from zero to four in Alaska.

Winter tractor operations would be travelling largely over frozen surfaces, primarily over snow/ice covered gravel bars and river ice. The operational objective is to identify a route that avoids crossing open water, as much as possible. During the winter, the amphibious tractors (ATs) towing the ACB will be employed. As illustrated on the Route Atlas, the non-aquatic winter route follows the snow/ice covered gravel bars along the edges of the river, only crossing the thalweg where necessary.

The winter season typically spans the period from November until early or mid April, though there is considerable variation in the timing of freeze-up and break-up. During winter, once the river is frozen, the ATs will be used to tow the ACB up and down the Taku River, between the barge landing site at Big Bull Slough in Canada to the AT exchange zone near the foot of the Taku Glacier at the mouth of the Taku River. Four ATs are needed to provide the necessary propulsion, increase travel speed, provide greater manoeuvrability, and provide mutual aid if needed. The ATs will operate using low ground pressure tires or tracks travelling on the snow and ice.

Similar to the summer operations, they will rendezvous with the tug in Taku Inlet, the outbound ACB will be transfer to the marine tug, and the inbound ACB will be picked up for the return trip up river. In winter, the rendezvous point will be closer to shore near Taku Point and Grizzly Bar. Here the ice frequently makes contact with the shore, and the inbound ACB will winched itself the shelf ice to the anchored ATs.

Winter operations will likely include some route grooming to expedite travel, such as levelling limited areas of rubble ice or pressure ridges. Snow grooming equipment will be used for the majority of this work. This will help tamp down the snow along the route to reduce the amount of snow being blown around by the ACB, thereby improving operational visibility.

The ATs will be equipped with sophisticated navigational equipment so that they are able to navigate in whiteout conditions along the river. Weather reports will be monitored daily however the barge masters will be ultimately responsible for making decisions concerning the safety of the vessels and crew. During periods of extremely heavy snowfall, operations may be curtailed and snow can be packed down along the route before operations recommence.

3.2.1 Canyon Island in Winter

During the winter, the route will follow the west channel around Canyon Island to avoid the open leads in the east channel (see Photo 1). These leads tend to remain open throughout the winter as warmer water from Fish Creek flows into the Taku River at this location. The large open lead that starts a few hundred yards downstream of the narrows 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. The east channel will be utilized as an alternative route in the winter should conditions not allow the use of the west channel. The route in the winter season will follow a similar path to that designated in the application for the aquatic season when ATs are being used. There is sufficient frozen, area in the east channel during winter to allow transit of the ACB without traversing any open water areas in the east channel (see Photo 1)

Photo 1. View Looking Upstream of Open Leads in East Channel at Canyon Island

3.2.2 ACB Exchange during Non-Aquatic (Winter) Operations

During winter, once the river is frozen, the Amphibious Tractors (ATs) will be used to tow the ACB up and down the Taku River, between the barge landing site at Big Bull Slough in Canada to the AT exchange zone at the foot of the Taku Glacier at the mouth of the Taku River. The AT exchange zone is shown on Figure 15 and Photo 2, and has been selected as it is the downstream limit where the ATs can operate overland (over frozen gravel bars and ice). Downstream of Taku Point, there are few continuously exposed gravel bars and the ice is discontinuous/unstable throughout the Taku Inlet. The ATs would tow the outbound ACB to as close as possible to the edge of solid ice where the ACB would set down (low or off hover) on the ice.

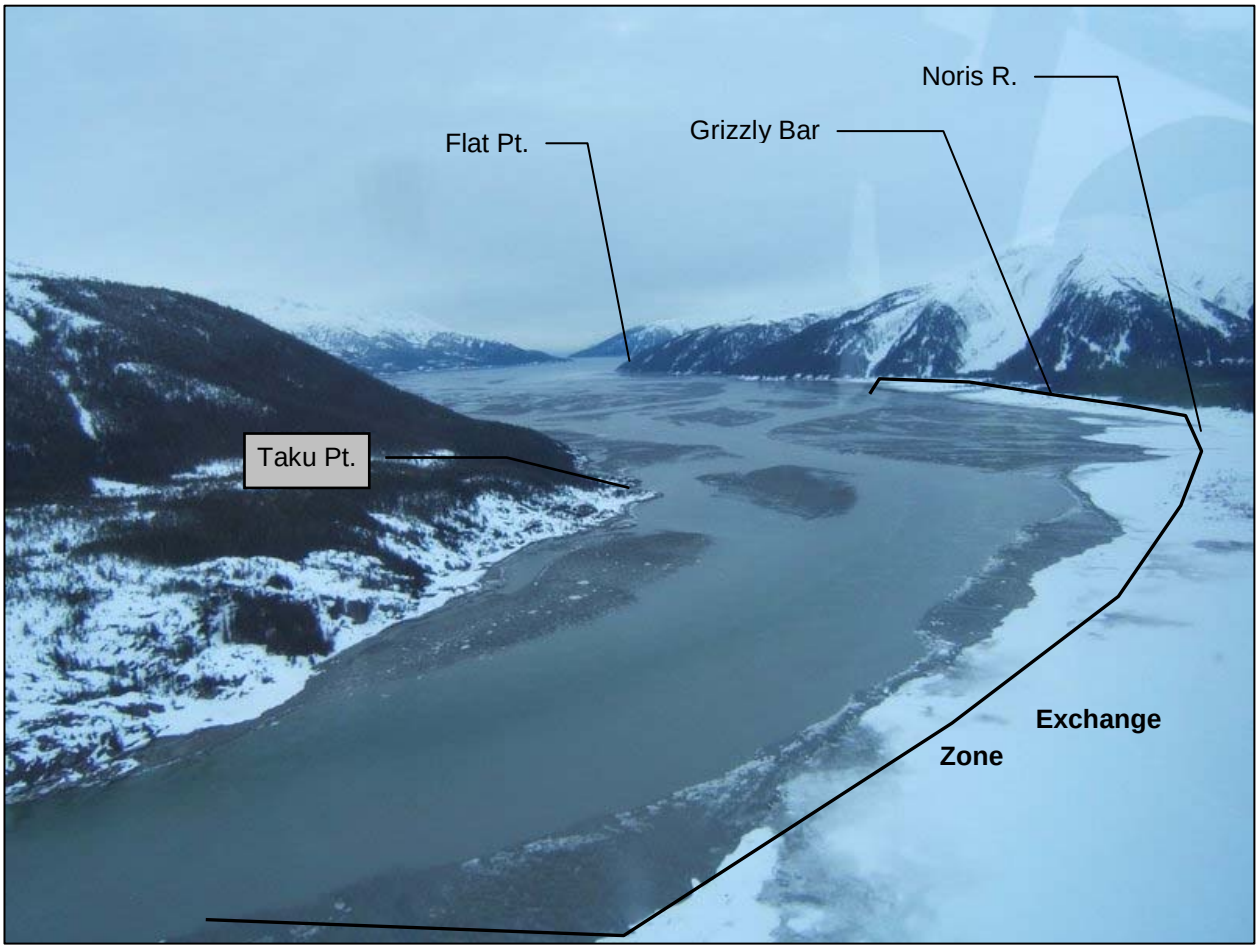


Photo 2. Marine to Non-Aquatic Exchange Zone opposite Taku Pt. Photo taken at low tide from Taku Glacier looking south to Taku Inlet. March 26, 2008.

Marine Exchange

A marine tug would travel from Juneau to Taku Inlet towing the inbound ACB. In most instances, the marine tug would rendezvous with the shallow draft tug in the deeper water of Taku Inlet, and transfer the inbound and outbound ACBs.

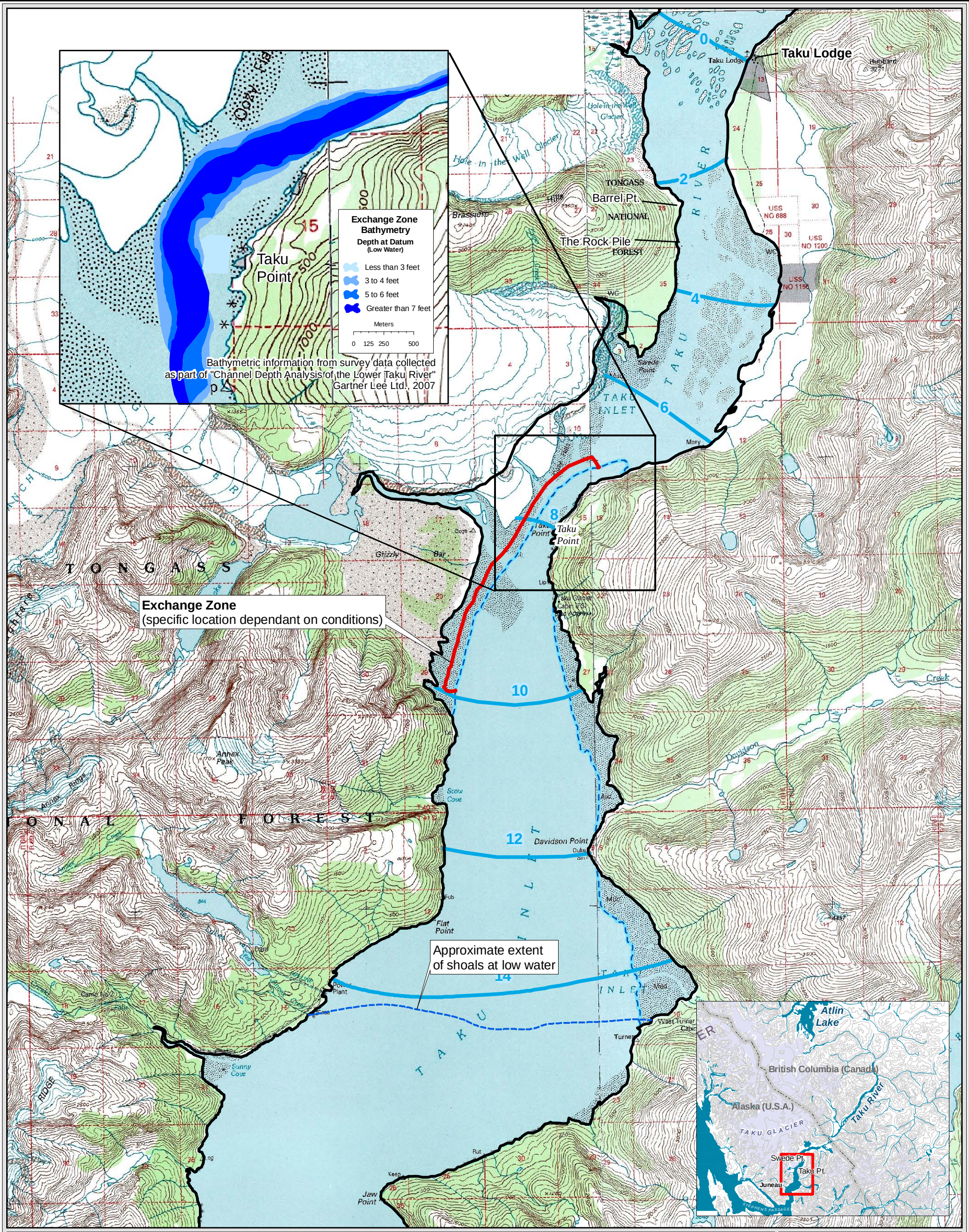
Alternatively, the marine tug may be able to navigate up to the AT exchange zone on a rising tide. The marine tug has a draft of approximately 7 feet and requires a continuous channel depth of at least 7 feet to avoid running aground in shallower waters. Figure 15 shows the tidal influence between Jaw Point (16 feet) and Taku Point (8 feet). The depth of water at the AT exchange zone is at least 8 feet at low water (chart datum), but can vary depending on the river discharge and channel morphology. Downstream of the AT exchange zone, the channel depth is dependant on the tide, and not influenced by river discharge.

Taku Point to Taku Inlet using a Shallow Draft Tug

Between approximately Flat Point and Taku Point, the north end of Taku Inlet is characterized by numerous shifting shoals, many of which are exposed at low tide. For this reason, it is proposed that a shallow draft tug be used to shuttle the ACBs through this section of the Inlet, exchanging ACBs with the ATs as described below, and exchanging ACBs with the marine tug in the deep water of Taku Inlet. The shallow draft tug(s) would be moored to a barge stationed in the leeward side of Jaw Point when not in operation. The barge would be temporarily anchored for a period not exceeding 14 days. The barge will be relocated to a new location at a distance of at least 2 miles from the previous location.

AT Exchange: Land-based Operations to Marine Tug

The suggested procedure for exchanging the inbound and outbound ACBs is illustrated on Figure 16. The ATs will position the outbound ACB on the frozen gravel bar opposite Taku Point, lowering it off hover if needed to provide additional stability in high wind conditions. At the same time, the tug will manoeuvre the inbound ACB into position offshore. A small boat will run a cable line from the inbound ACB to shore, and transfer this line to the ATs anchored on shore. The inbound ACB will winch itself to the ATs onshore using the winch cable connected to the line. During this procedure, the tug will provide any necessary assistance to secure the positioning of the ACB as it is winched onshore. Once the inbound ACB is positioned onshore, the ATs and tug will disengage from the inbound ACB. The outbound ACB will then be pushed into position near the edge of the sand bar by the ATs. The line attached to the winch cable will be transferred to the tug by the small boat, and once secured, the ACB will winch itself into towing position behind the tug. The tug will then proceed to downstream to rendezvous with the marine tug in Taku Inlet, and the ATs will proceed upstream to the mine site.



Basemapping from Ontario Ministry of Natural Resources
Orthophotography:

N
W E
S

m
0 500 1,000 2,000 3,000 4,000
1:75,000
UTM Zone 17N, NAD 83

' 2008 Gartner Lee Limited All Rights Reserved.
This document is protected by copyright law and may not be used, reproduced or modified in any manner or for any purposed except with the written permission of Gartner Lee Limited doing business as AECOM ("AECOM") or a party to which its copyright has been assigned. AECOM accepts no responsibility, and denies any liability whatsoever, to any party that uses, reproduces, modifies, or relies on this document without AECOM's express written consent.

Legend

- Mean High Water
- Typical Extent of Ice
- Mean Tidal Range (feet)
  (height of Mean High Water above datum)

Redfern Resources Ltd.

Tulsequah Chief Mine
ACB Transportation System

Marine to Non-Aquatic Exchange Zone

November 2008
Project 82647

AECOM

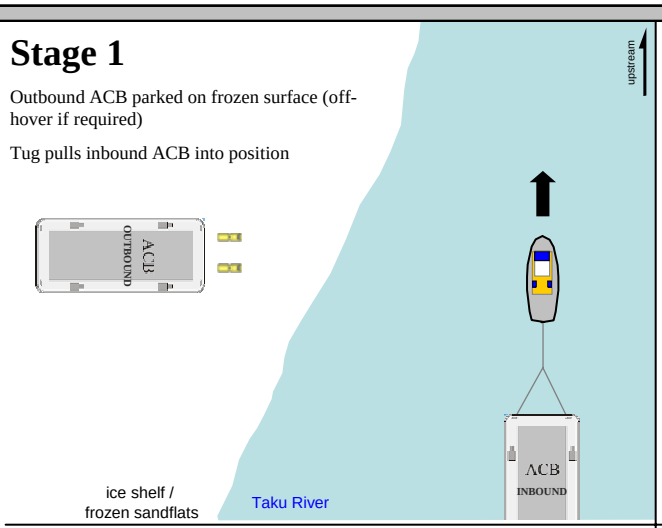
Figure 15

Map Document: (S:\GIS_Pdata\TULSEQUAH_CHIEF\ACB_Access\82647 - Marine to Non-Aq Exch Zone\MXD\82647_DFIG_Fig 15 Marine to NAq ExchZn_08nov14_rg_v3 .mxd)

Stage 1

Outbound ACB parked on frozen surface (off-hover if required)

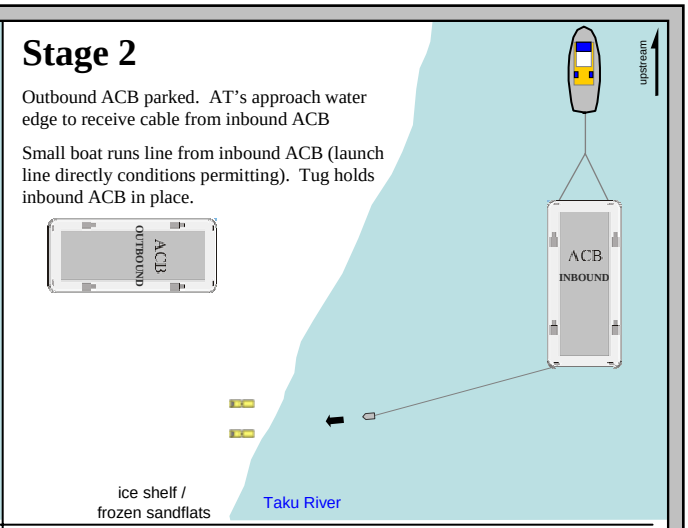
Tug pulls inbound ACB into position



Stage 2

Outbound ACB parked. AT's approach water edge to receive cable from inbound ACB

Small boat runs line from inbound ACB (launch line directly conditions permitting). Tug holds inbound ACB in place.

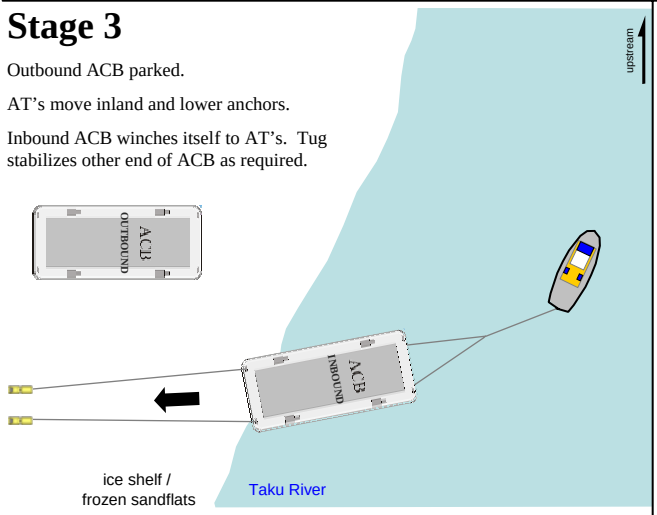


Stage 3

Outbound ACB parked.

AT's move inland and lower anchors.

Inbound ACB winches itself to AT's. Tug stabilizes other end of ACB as required.

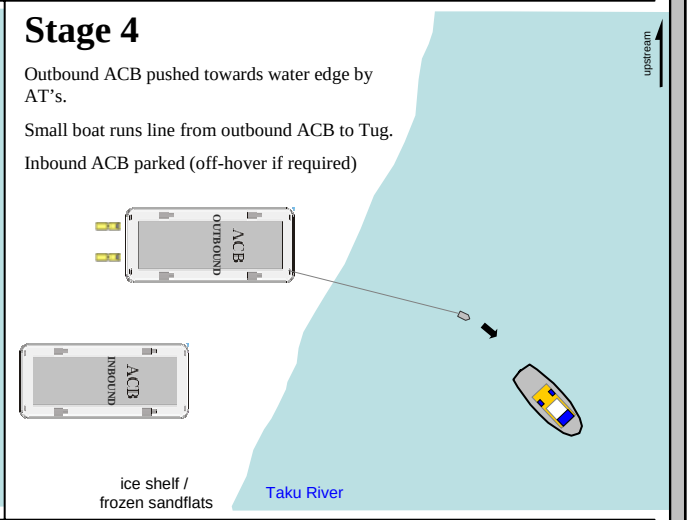


Stage 4

Outbound ACB pushed towards water edge by AT's.

Small boat runs line from outbound ACB to Tug.

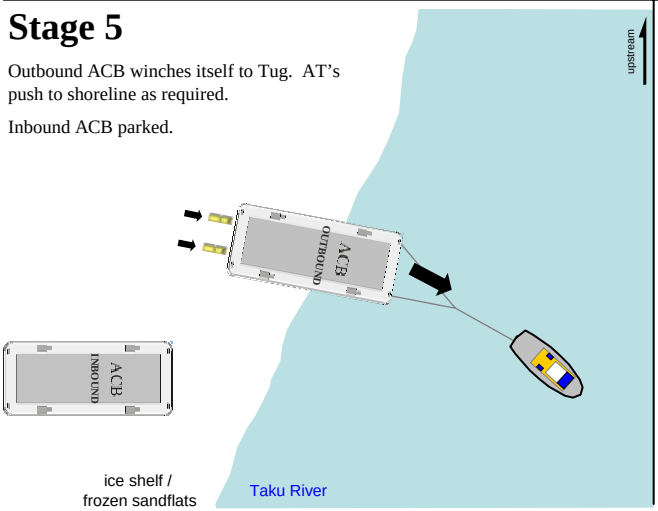
Inbound ACB parked (off-hover if required)



Stage 5

Outbound ACB winches itself to Tug. AT's push to shoreline as required.

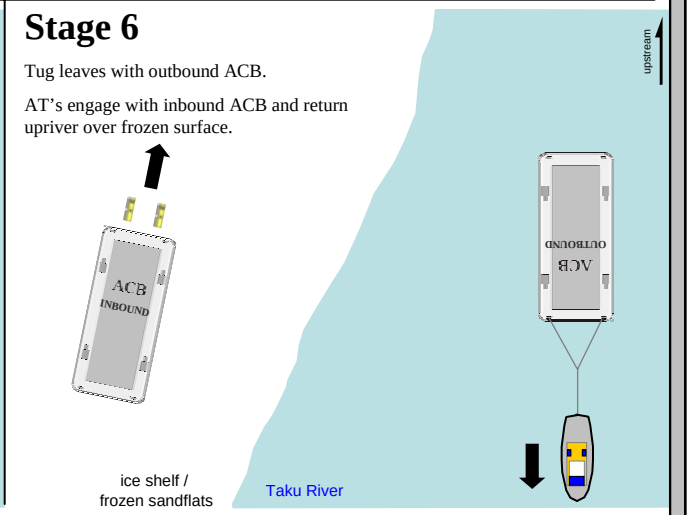
Inbound ACB parked.



Stage 6

Tug leaves with outbound ACB.

AT's engage with inbound ACB and return upriver over frozen surface.



Legend

AT – Articulated Tractor

ACB (Air Cushion Barge)

Tugboat

ACB, tug and AT's drawn to scale on diagram

Redfern Resources Ltd.

Tulsequah Chief Mine
ACB Transportation System

Marine to Non-Aquatic Travel Transition

AECOM

Figure 16

3.3 Transition Season (Spring Thaw and Freeze-up)

Given the above operational criteria, it is anticipated that on average, there would be a 6-week period in the fall, and a 4-week period in the spring when operations will have to be suspended for freeze-up and break up. As the specific dates at which these criteria are met will vary from year to year, it is not appropriate to define the operational seasons by the calendar dates. Temperature will clearly be an important contributor to the conditions on the river, but the actual flows or ice conditions will define the operations, not a temperature range per se. To our knowledge, there is no record of the historical pattern of freeze up or thaw on the river; any information that has been provided is based on local knowledge. However, Redfern started to systematically record this information in the winter of 2007/08, and will continue to do so throughout operations so that a better understanding of the relationship between weather (temperature, wind), flows, ice conditions and operations is developed.

Operations in the aquatic season will continue as long as possible into the fall, nominally to mid October, based on a minimum river flow requirement of 8,800 ft^3/s to provide the water depth required for the shallow draft tugs to operate in. Operations will then be suspended until the river is frozen sufficiently (e.g. the non-aquatic season operating criteria is met) to commence with non-aquatic operations using the ATs on ice and snow.

Similarly, non-aquatic operations will be continued into the spring until the leads crossings become too numerous (in excess of the non-aquatic operating criteria) or too wide (in excess of winch cable length installed on the ACB) for regular transit, at which time operations will be suspended until the river ice has melted through and the flow has reached sufficient levels for shallow draft tug operations.

4. Equipment

4.1 General Equipment Description

The fleet of equipment proposed for the barging system consists of a combination of vessels that are designed specifically for operations in the marine environment, or in a riverine environment, or both. Conventional vessels such as the marine and shallow-draft tugs are a familiar and accepted means of transportation for the purposes for which they are designed. ACBs have operated in a variety of challenging and sensitive environments around the world and offer a year-round transportation solution in the range of conditions that will be encountered on the Taku River and in the Gastineau Channel. ATs will be able to operate during the winter over the frozen river ice on soft flotation tires or low pressure tracks.

The primary fleet includes two air cushion barges, one marine tug, two shallow draft tugs, and four ATs; two that are tracked and two with soft flotation tires. Secondary vessels that will accompany the fleet include a small power boat or jet boat that will operate during the open-water season on the river, and snow machines or snow grooming equipment that will be employed during the winter season. A secondary tracked AT, a Hagglunds BV206 will also be used as a support vehicle to non-aquatic operations. These ancillary vessels will assist in navigation, crew changes, snow grooming, and to provide support in the event of emergencies. In addition to these vessels, an additional barge and shallow draft tug will be available to provide extra transport capacity at times when additional trips are required to make up for delays due to bad weather, maintenance, etc. The following sections describe the key features and capabilities of the fleet.

4.2 Air Cushion Barge

Air cushion barges are slow moving (5 to 10 knots), shallow-draft barges that can be towed by aquatic vessels such as tugs, or winched along a fixed cable attached to shore or another anchor point. They are built to meet marine specifications to accommodate the specific sea conditions on or off hover. The air cushion makes the barge amphibious, able to operate in open water or on land, and through extreme weather conditions. The barge travels at low speed with the bottom of the flexible skirt in the water. Air cushion barges have several distinct and important advantages over conventional barges:

- ACBs can travel over shoals, sand, gravel, ice, and not ground out;
- ACBs exert approximately 1 psi on hover – less than human footprint on land;
- The very low ground pressure allows these craft to operate in sensitive environments; and
- ACBs are very stable in rough water as skirts dampen the effect of waves.

Numerous ACBs have been operated around the world over the past 30 years. The most widely known Alaskan experience was the ACBs that were used year-round to cross the Yukon River during the construction of the Trans-Alaska pipeline in 1976, and during this period there were no known environmental issues identified. (see Photo 4).

As the ACB has been confused with a hovercraft, it is useful to summarize the key differences between these two vessels, as shown in Table 4:

Table 4. Comparison of ACB and Hovercraft

Feature	ACB	Hovercraft
Speed of travel	5-10 knots- sits in water at depth of about 0.7 m (2 ft)	35-60 knots – skims the water
Cargo Capacity	Depending on size, but has large capacity (hundreds of tons).	Limited cargo capacity as compared to ACB.
Skirt construction	Individual segments. If one tears, the adjacent segments fill in and seal the cushion.	Loop skirt segments (see comment below on reliability.
Noise	Diesel engines to fill skirt; ATs and ACB engines similar noise level as a tug.	Loud - hovercraft is self-propelled with turbine engines and travels at higher speed.
Wake	Low speed generates minimal wake.	Higher speed generates more wake.
Ability to travel in adverse conditions	Can operate safely in rough sea conditions; less prone to wave impacts than hovercraft.	More prone to effects of wave impact, cushion wash out, wind and wave action causing vibration.
Reliability	Very reliable in wide range of weather and sea conditions.	Reliable within the range of conditions for which it is designed.

4.2.1 Barge Components

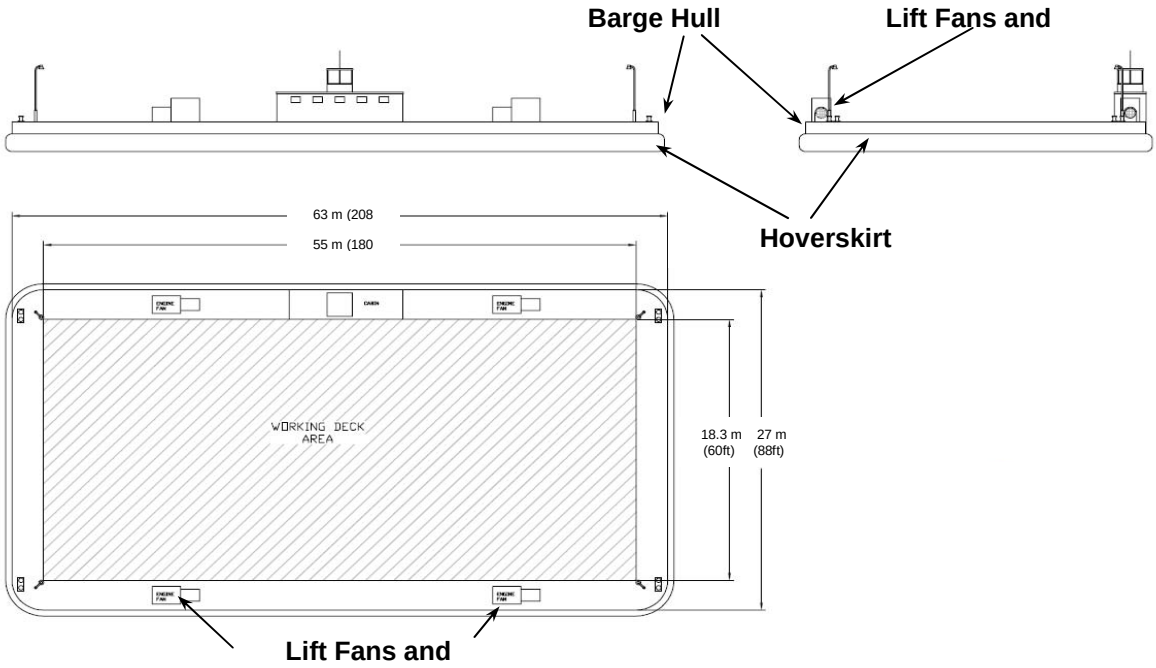
The main components of the barge are shown on Figure 17 and include the marine steel hull, the skirts, and the fans and engines that provide the lift when on hover. The overall dimension of the barge will be approximately 208 ft x 88 ft. Unloaded, its weight will be 550 tons. Fully loaded, the gross weight will be 1,050 tons, and will exert lpsi of pressure on the surface when on hover. Off hover, the ACB will exert 1.37 psi on the ground surface.

The dimension of the pontoon is 60 x 180 ft, representing the usable deck area. The pontoon is 5 ft thick. Over water, the barge will hover at a height of approximately 6 ft over the water's surface. When fully loaded, the draught will be approximately 2.4 ft on hover, and the deck of the barge will be approximately 3.6 feet above the surface of the water. When not hovering, the barge will float with the pontoon in the water and the deck about 1.7 ft above water. Figure 18 illustrates the hoverbarge operating heights on and off water.

The ACB is classified by American Bureau of Shipping (ABS) as an over-strength barge, and as such is equipped with normal marine systems, such as anchoring systems. Marine anchors are mounted at either end of the ACB and can be deployed remotely from the tug. The barge is not powered and is controlled (steered) by the vessel(s) conveying the barge.

Photo 4. ACBs Operating Year-round Crossing the Yukon River during the Construction of Trans-Alaska Pipeline (1976)

Figure 17. Air Cushion Barge Components

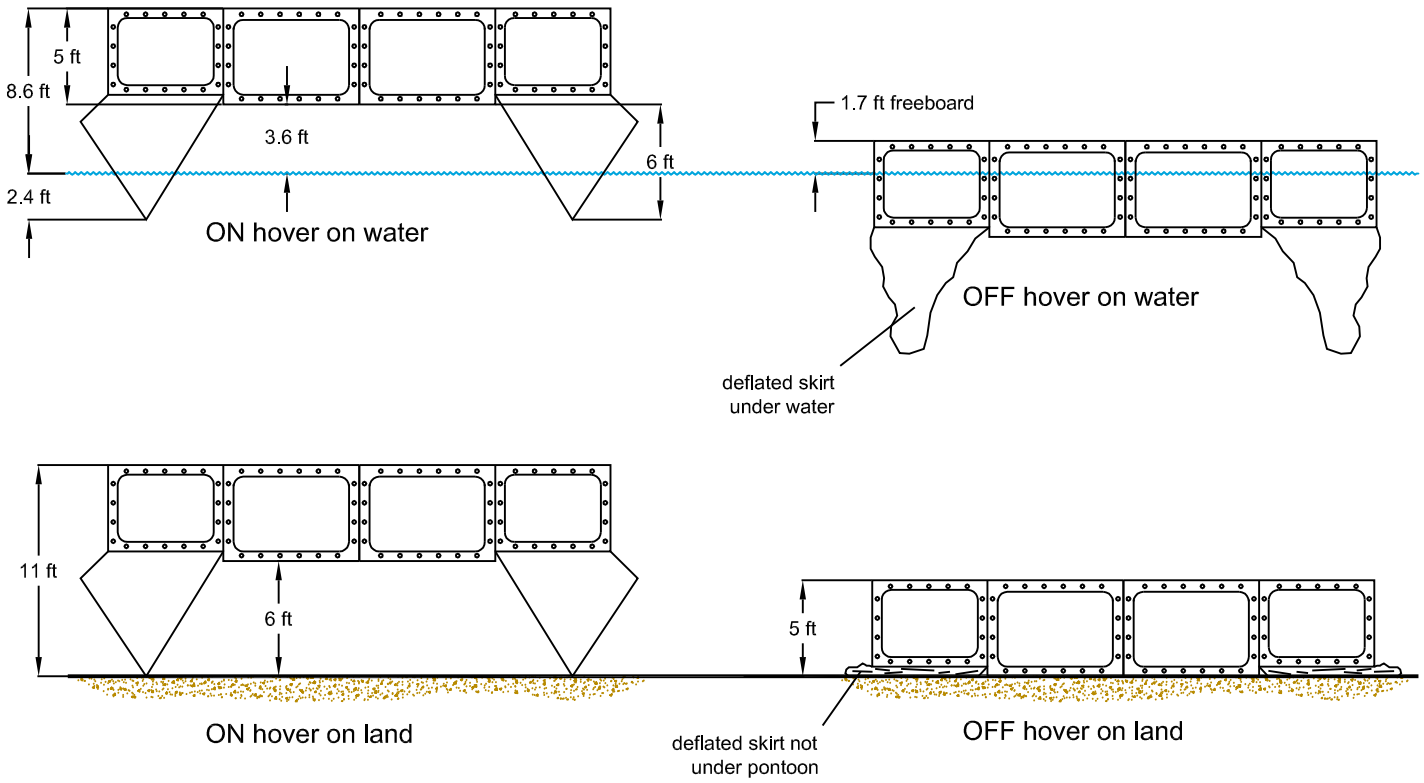


Date Revised: month dd, yyyy Revision: 0

Date Plotted: November 14, 2008 File Location: S:\GIS_Pdata\TULSEQUAH_CHIEF\ACB_Access\82647 - Marine to Non-Aq Exch Zone\CAD\82647_Fig18_ACBOperatingHeights_rh_Nov08.dwg

Air Cushion Barge Section

showing critical dimensions; barge width NTS



Vertical Scale: 1" = 10'

File: 82647_Fig18_ACBOperatingHeights_rh_Nov08.dwg
Reviewed by: FP
Date Issued: November 2008
Prepared by: RH
Project Number: 82647

Redfern Resources Ltd

Project: Tulsequah Chief Mine, Air Cushion Barge Access Alternative
Project Description
Location: Northwest British Columbia

Air Cushion Barge Operating Heights

AECOM

Figure 18
Version 1

On land, the barge will be able to move across obstacles less than the hover height (Photo 4). When not on hover, the barge will gently settle on the ground surface. The skirts fold under themselves when the barge comes off hover and do not become trapped beneath the pontoon.

Photo 5. ACB Outer Spray Skirt – Operating in Suriname

The skirt, comprised of many individual segments, surrounds the perimeter of the ACB. When inflated with air, the skirt creates a flexible seal with the water/ground surface. On uneven ground, the skirt segments will conform to the uneven surface, and at sea, this dampens the wave action as the barge travels through the water. When fully loaded and operating on water, about 2.4 ft of the skirt will drag through the surface of the water. As the skirt system is comprised of many individual segments, damage to one or several adjacent segments does not affect its performance. Adjacent skirt segments simply over inflate and fill the gap created by the damaged segments, thereby reducing loss of air and maintaining hover pressure. The barge can tolerate considerable damage to adjacent segments before there is any noticeable loss of air pressure.

Pressurized air escapes from beneath the skirt, or between the skirt segments. A spray skirt lining the perimeter of the barge will contain spray and reduce ice formation on the skirts in winter.

Four 500 HP diesel engines will drive the fans pressurizing the skirts and provide power for lighting, heat, and cable winching. There is adequate resilience in the lift system for complete failure of one engine with no affect on performance. The fans are positioned on each corner of the barge deck. The pressurized air will be forced through the skirt segments into the space underneath the pontoon, and it is this air pressure that lifts the barge. The average pressure exerted on the ground surface is 1 psi (pounds per square inch). By comparison, a human foot exerts 5 to 10 psi of ground pressure.

4.2.2 Noise

The ACB engines will be muffled and enclosed to minimize noise. The noise generated by the ACB and the ATs will be approximately 70 dB at 100 ft, roughly equivalent to a tug passing by. Table 5 shows the noise rating for the ACB and ATs, as compared to various other vessels and craft. It should be noted that the dB rating is a logarithmic scale: a ten point change in the scale indicates double the noise.

Table 5. Noise Comparison

Sound Source	dB
Pain threshold	140
Ship siren at 100 ft distance	130
Jet boat at 30 mph	88
Sport hovercraft at 85 ft	87
Float plane on take off	85
Jet ski at 20 ft.	80
Jet boat idling	70
AT at 100 ft	70
ACB at 100 ft	70

The ACB will be operated such that when it is in open water, the engines will be throttled back, as the skirt need not be fully inflated. When it is operating along the Taku River during the summer, for example, the noise generated will be less than when it operates over land.

The ACB will generate very little underwater noise. Noise, which is a vibration, will not be transmitted directly from the steel pontoon to the water as there is no contact between the pontoon and the water when on hover. The only contact between the ACB and the water would be the skirts that do not transmit sound well. All other sound will be muffled by the 6 ft air gap between the pontoon and the water's surface. Noise transmitted to the water will also be muffled by the 5 ft internal air gap between the upper and lower planes of the pontoon.

Two studies monitored noise effects of hovercraft, and concluded that underwater noise impacts from hovercraft were considerably less than from similar sized conventional vessels, and had little effect on fish and wildlife resources in the area of operation.

One of these studies was completed for the US Postal Service, and was carried out by Volpe National Transportation Systems Center. The conclusion of a three-year monitoring project was "*the winter underwater noise monitoring and visual observations showed that the hovercraft had little impact on blackfish subsistence gathering by local Eskimos. It also showed that, after careful observation and repeated testing performed by Volpe staff over the past three years, the hovercraft had little impact on waterfowl.*"

A second study was conducted by Susanna B. Blackwell and Charles R. Greene, Jr. of Greeneridge Sciences Inc. of Goleta CA in Prudhoe Bay to assess the underwater and in-air sounds created by a Griffon 2000TD hovercraft driven at full power. This work was published in the 1 Dec. 2005 Journal of the Acoustical Society of America. Their conclusion was "The hovercraft was considerably quieter underwater than similar-sized conventional vessels and may be an attractive alternative when there is concern over underwater sounds."

As hovercraft are in the order of four times louder than ACBs, it is reasonable to conclude that underwater noise from the ACBs would have even less effect on fish an wildlife operating under similar conditions.

These findings were confirmed by testing performed on Hovertrans' most recent ACB, the *Siberian* in January 2008. Offshore Research Ltd. took underwater noise level measurements while towing the ACB from the Ferguson Shipbuilders yard to the test location at Holy Loch in Scotland. The noise level was measured at an average of 17.5 dB while towing at 4.2 Kts. The majority of this noise was the microphone dragging through the water. On hover and stationary, the noise level was measured as 8 dB immediately below the surface, and 5 dB ten feet below the surface. By comparison, a soft whisper is approximately 30 dB.

4.2.3 Wake

The size of the wake is a function of the draft of the vessel (deeper draft generates more wake), and the speed of the vessel (faster speed generates more wake). The ACB, which is large and shallow, towed by a shallow draft tug will generate minimal wake.

This is supported by Photo 3, showing the Yukon Princess being ferried across the Yukon River at 5 mph. This photo was taken when the Yukon River was flowing at ten knots. This is further supported by Photo 5, showing the wake generated by the *Siberian* while being towed on the River Clyde.

Photo 5. Wake Generated by the Towed ACB *Siberian* (Jan 2008)

The main contributor to wake, therefore, will be the shallow draft tug pushing the ACB. The tug will produce less wake than a marine tug due to the shallower draft.

Wake is of concern primarily in areas of development along the river banks, where increased bank erosion and potential damage to docks and/or moored craft is a concern. In areas such as Martini Row where cabins are concentrated over a very short stretch of the river, speed will be reduced through this area to minimize wake. The operation of the barge system will contribute insignificantly to ongoing bank erosion that results from the annual floods that modifies the river morphology annually, such as occurred in June 2007. No wake issues have been identified during conventional barging in the summer of 2007 or the ongoing barging in the summer of 2008.

4.2.4 On-board Fuel Containment

Approximately 8000 gallons of diesel fuel will accompany the barge to provide sufficient fuel to the engines during a round trip as well as emergency fuel supply. The fuel will be contained in four 2000 gallon double-walled tanks with surrounding containment. Refuelling of the ACB will be done in Juneau at the existing marine fuelling facilities.

4.2.5 ACB Controls

The ACB will not be manned, but will be operated remotely from the towing vessels (tug or AT). All maintenance on the ACBs will be done in Juneau. As the lift is provided by standard diesel engines, no specialized maintenance personnel or facilities are required.

4.3 Shallow Draft Tug – River Operations in Aquatic Season

Shallow draft tugs will be used to propel the ACB during the aquatic season on the Taku River. The shallow draft tug will operate on the mainstem of the Taku River, between the barge landing site and the Taku Inlet where the barge(s) will be transferred between the shallow draft tug and marine tug.

Shallow draft tugs are commonly used on large, shallow rivers such as the Tanana in Alaska, the McKenzie River in Northwest Territories, and the Mississippi and Ohio Rivers in the United States. Numerous designs have been developed over the years that are appropriate for this purpose. The closest parallel to Redfern's requirements is found on the McKenzie River, where powerful boats with shallow drafts are used. As a result, numerous vessel designs have been developed over the years that are appropriate to the application of towing an ACB on the Taku River. Some of the best designs for shallow draft tugs are produced in British Columbia by Robert Allen Ltd. and A.G. McIlwain Ltd. Redfern has purchased two A.G.McIlwain designed tugs, the RDV - Gator and RDV – Kid Commando, shown in Photos 5 and 6.

A unique feature of these vessels is the embedding of the propellers inside tunnels, allowing large propellers to be used while maintaining a shallow draft.

Photo 6. RDV – Gator Shallow Draft Tug

The specifications of the shallow draft tug RDV - Gator are as follows:

■ Length	48 ft 8 ins
■ Beam	18 ft 0 ins
■ Depth	4 ft 0 ins
■ Maximum Full Load Draft	2 ft 6 ins
■ 2 Main Engines	1,430 BHP
■ Fuel Oil Capacity	1,700 USG
■ Steel Hull, Aluminium House Work	

Photo 7. RDV – Kid Commando Shallow Draft Tug

The specifications of the shallow draft tug RDV – Kid Commando are as follows:

■ Length	44 ft 0 ins
■ Beam	12 ft 0 ins
■ Depth	4 ft 0 ins
■ Maximum Full Load Draft	2 ft 9 ins
■ 2 Main Engines	700 BHP
■ Fuel Oil Capacity	400 USG
■ Steel Hull, Aluminium House Work	

The shallow draft tugs will be refuelled at the barge landing site in Canada. Refuelling will be carried out in a designated area only, and spill contingency equipment will be in place at all times at the barge landing site.

4.4 Amphibious Tractors ATs – Non-aquatic Operations

Redfern's operating plan for non-aquatic operations 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 of Singapore.

2. The wheeled vehicle selected will be a Morgan skidder fitted with soft flotation tires, designed and manufactured by the Kinetic Drive Solutions of Aldergrove, BC, a Subsidiary of ST Kinetics.

Support for both vehicles will be provided by the Aldergrove office.

The non-aquatic ACB transportation system proposes to use two TAVs forward of the ACB to tow, and two Morgans behind to push and for steering and braking control. The vehicle positions will be rotated 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.

The vehicles selected for this application have been chosen conform to project requirements as follows:

- produce "low ground-pressure", less than 5 psi;
- emit noise no higher than 70 dB at 100 feet;
- be amphibious – float in open water with self-propulsion;
- produce maximum towing force;
- be highly mobile; and
- come equipped for self-recovery.

4.4.1 TAV – Rubber Tracked AT

Two TAVs will be used in front of the ACB to tow it and steer the bow. (Photo 8)

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 (Kinetic Drive Solutions). 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 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.

Photo 7. TAV tracked Vehicle

4.4.2 Morgan Skidder - Soft Flotation Tire AT

Two Morgans (see Photo 8) will be used behind the ACB to push it, provide braking force to stop it, and to steer the stern.

The adapted Morgan (Figure 19) will be a four-wheel drive vehicle with six large soft tires that exert very low ground pressure. This makes it an ideal vehicle for operating in environmentally sensitive areas. Buoyancy provided primarily by the tires and styrofoam-filled frame. Its propulsion in water is limited, coming only from the tires. A single operator is required, with room for one additional passenger.

Photo 8. Morgan Skidder with Soft Flotation Tires

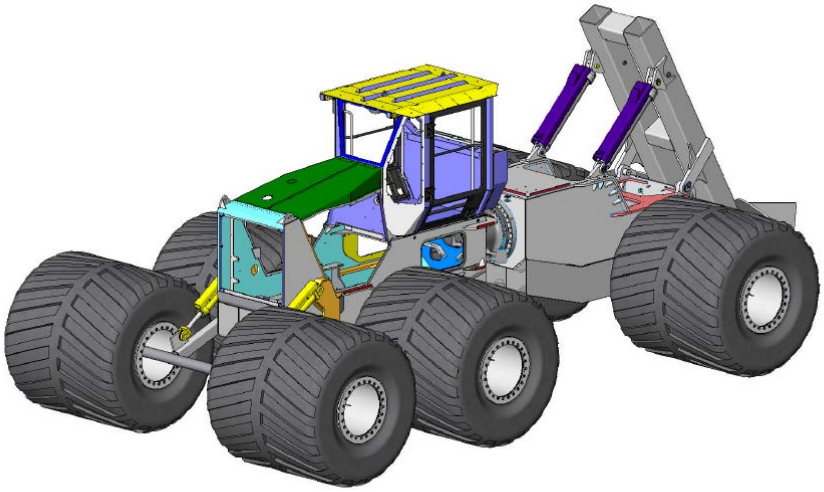


Figure 19. Modified Morgan Skidder

The modifications done to the standard skidder are as follows:

- the tires will be replaced by soft flotation tires to reduce the ground pressure and aid buoyancy;
- the grapple hook will be replaced with an ice anchor; and
- the grading blade will be replaced by a third set of flotation tires.

The AT snow/ice anchor is a bucket shaped device of approximate dimensions 10’ w x 5’ h x 3’ d, having frontal area of nearly 50sqft, and a volume of approximate 110ft^3. It is equipped with a flat cutting edge

blade, and excavator bucket teeth, similar to that of used on a snow groomer. When winching, the blade would be lowered to the snow down to a firm layer (or ice surface). Upon completion of winching, an imprint will be left where the blade was lowered. This imprint will be filled in with snow during the next snowfall.

4.4.3 Hagglunds BV206 – Rubber Tracked AT Support Vehicle

One Hagglunds BV206 (**Photo 9**) 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, six 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. A third BV206 will be retained during at site as a back-up and to support crew changes, as required.

Photo 9. Hagglunds BV-206

The BV206 is widely used in tracked and military applications. It is a standard rubber tracked NATO troop carrier and many are operated in 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.

4.4.4 Comparison of AT Specifications

Table 6 below compares the specifications of the three ATs selected for the non-aquatic haulage system.

Table 6. Equipment Specifications

Specification	TAV	Morgan	Hagglunds BV 206
Drive	4 Moulded Rubber Track	4 Rubber High Flotation Tires with 2 "tag axle" tires 72 x 68 x 28	Four Moulded Rubber Track
Ground Pressure	2.75psi	4 Tires Front 2.5 psi Rear 1.5 psi 6 Tires 1.5 psi ea*	1.97 psi
Power	300 hp	260 hp	136 hp
Draw Bar Pull	7.3 tonnes (16,094 lbs)	10 tonnes (20,000lbs) (Traction Limited) 15 tonnes - theoretical	3.3 tonnes (7,275 lbs)
Vehicle Weight	14.6 tonnes 32,187 lbs	20 tonnes 44,000 lbs	6.5 tonnes 14,330 lbs
Length	8.6 m (28.3ft)	10.6 m (35 ft)	6.9 m (22.6 ft)
Width	2.3 m (7.5ft)	5.25 m (17 ft)	1.9 m (6.25 ft)
Height	2.5 m (8.2ft)	4 m (13 ft)	2.3 m (7.5 ft)
Average Cross-Country Speed (fully loaded)	6 kmh (3.7 mph) assumes no open lead crossings	6 kmh (3.7 mph)	n/a
Inland Water Speed Calm water	4 km/h (2.4 mph) propulsion only from tracks	3.2 km/h (2mph) est. propulsion only from tires	3 km/h (2 mph)
Range	500 km 310 miles	720 litres fuel for 24 hour operations	300 km 186 miles
Steering Type	Hydrostatic, Articulated	Hydrostatic, Articulated	Hydrostatic, Articulated
Turning Radius	8 m 26 ft	6.1 m 20 ft	8 m (26 ft)
Gradient	60% (30°)	60% (30°)	100% (45°)
Draft	5 ft	not to be used in water >3ft depth.	5 ft

*Notes: * The Morgan can raise/lower the front set of tires (tires 5 & 6), thereby changing the ground pressure on the front pair of fixed tires.*

4.4.5 Non-aquatic Support Vehicles

The operation will also employ snow grooming machines (Photo 10) and snowmobiles.

Snow grooming will be done as needed to pack fresh snow along the route. Snow grooming machines typically exert a ground pressure of between 0.9 psi and 1.4 psi.

Snow grooming machines are not amphibious. In applications where the ice integrity is in question, a BV206 will be used for snow grooming.

Photo 10. Typical Snow Grooming Equipment

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.

4.4.6 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/she will also have an emergency shut down, 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 rear AT Operators, as their view will be blocked by the ACB;
- a rear view for the TAV, as rearward visibility is limited; and
- a view of the winch it controls.

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

There will be manual controls located 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 when operating in the aquatic environment.

4.5 Communications

Telecommunications are an essential component of marine transportation, and are particularly important in remote locations that do not have other available communication systems. A satellite phone between the barge landing site, the vessels, and Juneau will be used to provide reliable, constant communication for crews operating the system.

4.6 Manpower

4.6.1 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, the environmental monitor will determine when environmental conditions do not match operational requirements and recommend suspension of operations until conditions improve. He/she 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 rear AT 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 minor maintenance and emergency repair of the ATs and ACBs.

4.6.2 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.

4.6.3 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.

4.7 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.

4.8 Operating Constraints

The conditions that will shut down towing operations on the river are shown in Table 7.

Table 7. Operating Constraint Guidelines

Condition	Range	Operating Guideline
Snow accumulation over 48 hours	>3 feet 1-3 feet <1 foot	■ Delay operations during heavy snowfall until route can be traversed and packed by snow grooming equipment (may take a few days) ■ May require snow grooming equipment to immediately precede ACB to compact snow along route ■ No specific procedures needed.
Temperature[3]	< - 40° F (-40° C)	■ Delay operations until temperatures predicted to remain above -40° F for at least 24 hours.
Sustained Wind Speed	>70 mphF[4] 30 to 70 mph <30 mph	■ Delay operations until wind speed remains below 70 mph for 24 hours; ■ 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 harbour. ■ If wind speed is subsiding, and forecast to continue to drop, operations would proceed on schedule. ■ If wind speeds are less than 30 mph, operations would proceed as scheduled.
Ice Thickness and Extent of Ice Cover[5]	≤ 12 inches ≥12 inches jumble ice accumulation	■ 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) ■ Select route that traverses floating or landfast shelf ice, avoiding open leads as much as possible to minimize ice breaking and maintain efficient operations ■ Avoid or groom
Visibility	<10 feet 10 to 100 feet >100 feet	■ Delay departure until visibility improves ■ Follow GPS route; reduce speed as determined by barge master; use flashing yellow beacon on ATs ■ No constraints identified

[3] *The equipment is designed for operations in low temperatures. This constraint is more related to crew safety and comfort.*

[4] *72 mph winds are classified as hurricane force.*

[5] *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).*

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

4.9 Production Capability

The following discussion outlines the anticipated haulage requirements for the upcoming 2008/09 non-aquatic season. It is expected that experience gained during the 2008/2009 non-aquatic season will help to refine the fleet for operations in the 2009/2010 season, when demands on the system will be much higher to service the operating mine.

4.9.1 2008/2009 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.

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

The 2008/2009 haulage fleet will be:

- one 450-ton nominal capacity ACB;
- two TAVs;
- two Morgans; and
- 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.

4.9.3 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 4 mph on ice and snow. Winching the ACB will be much slower, with a winch speed of approaching 2 mph.

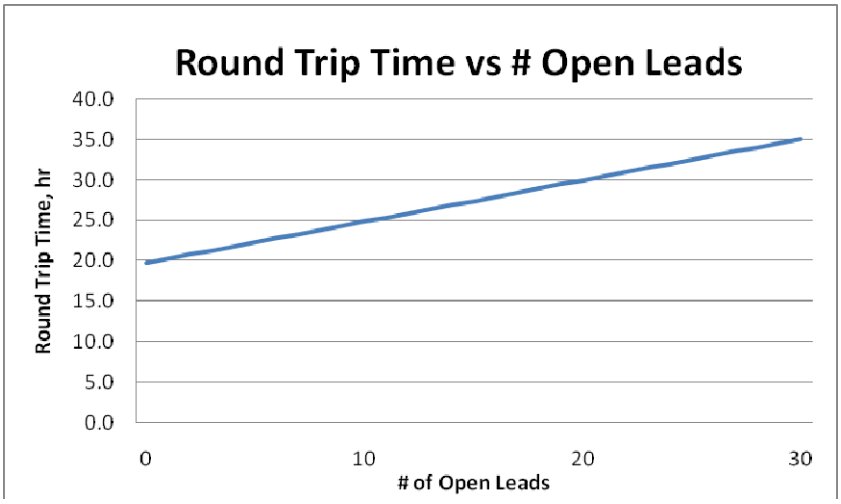
For the purpose of estimated trip time, the following delays are assumed:

Crossing an open lead	15 min
Exchange at Taku Inlet	30 min
Exchange at Barge Landing	30 min

Figure 20 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 ten 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 20. 2008/2009 Round Trip Time



4.9.4 Maximum Capacity

The maximum capacity of the 2008/2009 haulage system is shown in Table 8. This is based on the use of only one ACB.

Table 8. 2008/2009 ACB Transportation Capacity

Operating Month	Operating Days	# Open Leads	Round Trip Time, hrs			Number of Trips			Tonnes hauled
			River	Ocean	Total	Max	Reliability	Factored	
November	15	20	29.9	15.5	45.4	0.5	80%	6	2,854
December	31	10	24.8	15.5	40.3	0.6	80%	15	6,644
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	21	20	29.9	15.5	45.4	0.5	80%	9	3,995
Total	157						-	75	33,639

As can be seen, this system is capable of delivering sufficient quantity of supplies in the non-aquatic season to meet the needs of the construction effort.

Note that an efficiency factor is applied to the system capability 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.

4.10 2009/2010 Haulage Requirements

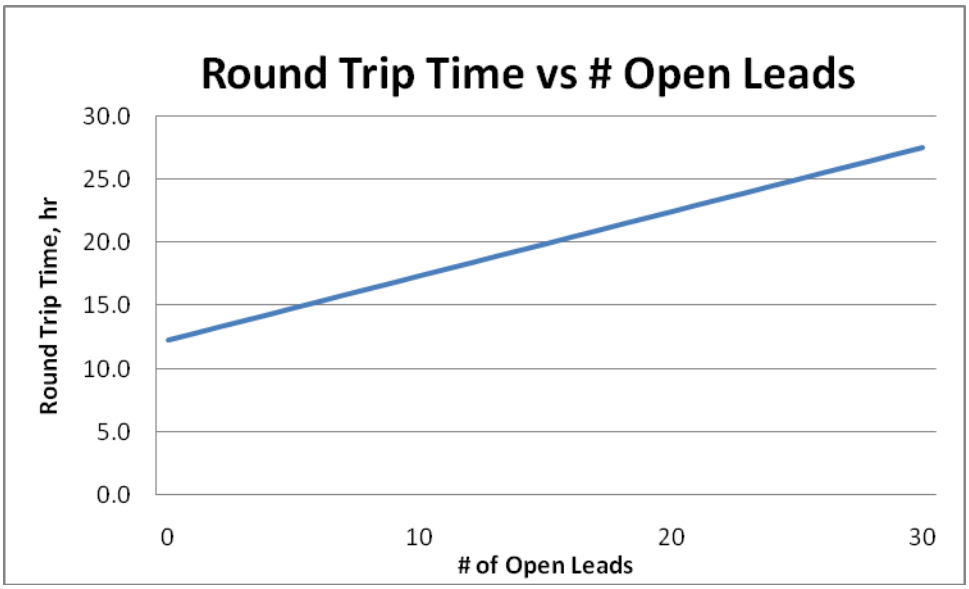
During mine operations, an average of 342 tonnes per day (wet) of mineral concentrate will be produced, for a total of 113,560 tonnes per year. Allowing for the weight of the concentrate and supply containers, the total cargo requirement is 148,555 tonnes per year. Approximately 154 tonnes per day of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

4.10.1 Trip Time

It is assumed that operational experience and efficiencies 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.

Figure 21 shows the estimated round trip time versus the number of open leads for the fleet for the 2009/2010 non-aquatic season. With the river completely frozen (no open leads), a round trip time of 12 hours is projected. With ten open leads to cross, this increases the round trip time to 17 hours. At an extreme scenario of 25 open leads, the round trip time is estimated to be 25 hours.

Figure 21. 2009/2010 Round Trip Time



4.10.2 Maximum Capacity

The maximum capacity of the 2009/2010 haulage system is shown in Table 9. 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. Shoulder season down time has been assumed at six weeks in the fall for freeze up and four weeks in the spring for thaw. This system is capable of delivering the necessary cargo required to support operations.

Table 9. 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	15	15	22.9	3	25.9	1.0	15.7	90%	14	6,365
December	No	31	31	10	20.4	3	23.4	1.2	36.6	90%	33	14,804
January	No	31	31	5	17.8	3	20.8	1.3	41.8	90%	38	16,926
February	No	28	28	5	17.8	3	20.8	1.3	37.7	90%	34	15,288
March	No	31	31	10	20.4	3	23.4	1.2	36.6	90%	33	14,804
April	No	30	15	15	22.9	3	25.9	1.0	15.7	90%	14	6,365
May	Yes	31	15		15.2	3	18.2	1.6	23.3	95%	22	9,948
June	Yes	30	30		15.2	3	18.2	1.6	46.5	95%	44	19,897
July	Yes	31	31		15.2	3	18.2	1.6	48.1	95%	46	20,560
August	Yes	31	31		15.2	3	18.2	1.6	48.1	95%	46	20,560
September	Yes	30	30		15.2	3	18.2	1.6	46.5	95%	44	19,897
October	Yes	31	0		15.2	3	18.2	1.6	0.0	95%	0	-
Non-aqautic		181	151								166	74,552
Aquatic		184	137								202	90,862
Total		365	288								368	165,414

4.10.3 Equipment Changes for Operations in 2009/2010

Three ACBs will ultimately 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 1,430 BHP. The RDV-Kid Commando will undergo a similar re-powering, including lengthening and widening the vessel, in the 2009/2010 non-aquatic season. Re-power of the tugs does not change their operational draft.

5. Commissioning

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 being constructed for Redfern. While the *Siberian* is smaller (200 tonne payload) than Redfern's the performance of the *Siberian* during its commissioning in Scotland provides equivalent data. Given the similar design features of the two ACBs, the performance of the *Siberian* demonstrates that the ACBs for the Tulsequah Chief mine will perform comparably under similar conditions. Poor weather conditions during commissioning confounded empirical measurement of wave and wake, although visual observations obtained during these trials indicated minimal wake generated while under tow.

5.1.1 Above Water Noise

The following tables provide measurements of sound obtained during the commissioning of the *Siberian*.

Table 10. *Siberian*: Above Water Noise Level Measurement

Distance (m)	Distance (feet)	Noise (dBA)
Ambient		68
0	0	110
1	3.3	98
5	16.4	98
10	32.8	97
20	65.6	95
30	98.4	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 Tulsequah Chief mine ACBs will have mufflers surrounding the lift fans, as well as housing around each engine to reduce sound levels. Redfern's ACB will be tested on the Columbia River to ensure that the 70dB specification is achieved as stated.

5.1.2 Underwater Noise

Underwater noise level measurement were collected 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 proposed as the results from the *Siberian* tests are considered to be indicative of underwater noise levels anticipated for the Tulsequah Chief mine's ACBs.

Table 11. *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

5.1.3 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 Tulsequah Chief mine ACBs 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*.

Commissioning work on the Columbia River or at another site near Juneau will be performed for to confirm the ACB's ground pressure. These tests will confirm the ACB ground pressure on full hover and off hover, and a photographic record of the impression left on substrate(s) will be made at that time.

The design objectives for the tow vehicles have been selected to achieve a low ground pressure of < 5psi. The manufacturers' specifications for the tow vehicles are as follows:

Table 12. Vehicle Specifications

Type of Vehicle	Ground Pressure Specification (manufacturer)
Tracked Articulated Vehicle	2.75 psi
Morgan – 6 tires	Front tires: 2.5 psi; Rear tires: 1.5psi
Ancillary Vehicles: Hagglunds BV-206	1.97 psi

5.1.4 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 in Photo 12 . 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 suitable 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.

Photo 12. ACB Siberian – View of Wake from Stern of ACB, January 2008

5.1.5 Sedimentation

The potential for sedimentation as the ACB transitions between water and land will be assessed during the commissioning. 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. These observations and measurements will be carried out for the ACB on hover. Results of the commissioning work will be summarized and provided to Alaskan regulators.

6. Operating Procedures and Objectives

Operating procedures have been identified that will avoid or minimize potential adverse effects associated with the ACB operations on the river. The effectiveness of these procedures will be tested during the first couple of years of operations, and operations will be adapted, to the extent practical, to meet the stated operational objective. Annual follow-up with property owners, commercial tourism operators, commercial fishers and other users of the river will be carried out to ensure that concerns regarding barging operations can be addressed in a timely manner.

6.1 Aquatic Operations

Several operating procedures have been identified for aquatic operations on the Taku River. These procedures include an appropriate route that would be followed; use of appropriate and suitable equipment for river operations; timing and scheduling considerations; as well as specific procedures or measures to minimize potential adverse effects of operations during this season.

Procedure: *Travel in the Thalweg (deepest part of river channel) during the Aquatic Season*

The ACB and associated river equipment will travel in the thalweg (deepest portion) of the Taku River for the majority of the route. The route along the mainstem of the river channel avoids many sensitive aquatic habitat areas, as well as nearshore or shallow water areas that are frequented by wildlife and birds. The use of the main, deepest channel as the preferred route along the Taku River during the open water season will achieve multiple objectives:

- avoid potential channelization effects;
- avoid potential disturbance to exposed tidal flats;
- avoid potential disturbance of substrates upstream of Taku Lodge;
- avoid potential re-suspension of sediments (as fine sediments will not generally accumulate in the thalweg to be re-suspended by the propeller wash from the tug);
- avoids eulachon spawning areas as identified on Juneau State Land Plan: Areas 14a44 and 14a55 by staying in mainstem channel;
- avoid salmon spawning in side channels and creek mouths;
- Minimize the wave energy produced by the passing tug/barge so that by the time it reaches the beach areas, the potential for stranding juveniles is minimal;
- avoid the high value moose foraging habitats identified in preliminary assessments (e.g., sloughs, side channels).
- ACB route avoids most of the high value grizzly and black bear habitats identified in preliminary assessments;
- avoids ADF&G research activities such as fish trapping that occur close to shore; and
- avoids direct interference with hunting activity along the Taku River. The areas typically used for moose hunting do not include the mainstem of the Taku River, and hunting of mountain goats occurs at higher elevations above the valley floor, and would be unaffected by the ACB operations. Bear

hunting is very limited, occurs mostly at lower elevations accessible from the river, and disturbance would be limited to the temporary noise generated by the ACB as it passes by on the river.

Procedure: *Use of Shallow Draft Tug and ACB during aquatic operating season.*

These vessels draw less than 3 feet of water, making them appropriate for use on shallow rivers such as the Taku. Use of shallow draft vessels will achieve the following objectives:

- avoid potential channelization effects;
- avoid disturbance of sand flats associated with deeper draft vessels (marine tugs and barges);
- avoid potential disturbance of substrates upstream of Taku Lodge (associated with deeper draft vessels (marine tugs and barges);
- use of the ACB and shallow draft tug will minimize wake and potential bank erosion. ACBs produce very little wake as compared to conventional barges;
- minimize re-suspension of sediment and potential bank erosion that can result from excessive wake associated with conventional barges.

Procedure: *Large Woody Debris will be removed from the river channel only if it poses a significant navigational risk. Any woody debris removed from the river channel will be placed on board the ACB and disposed of at a suitable location at the loading facilities in either Juneau or at the barge landing site in Canada.*

The removal of large woody debris is not anticipated given the relatively wider and deeper channel in Alaska. This will allow the tug to manoeuvre around obstacles embedded in the channel, and the ACB will either go around, or over such obstacles that may be encountered. If large woody debris becomes an unavoidable navigational hazard to either the safe operation of the ACB and/or a human health and safety risk then the large woody debris will be removed from the channel. Such incidents will be recorded and reported on during the regular incident reporting.

Procedure: *Avoid areas where marine mammals are observed to congregate.*

This will avoid disturbance of seals that tend to congregate in the spring at the edge of the ice, in anticipation of the eulachon spawning season. Refer to the *Tulsequah Chief Mine ACB Transportation System: Wildlife Management Plan - Wildlife Mitigation Policies, Procedures and Monitoring Program for Alaska* for details.

Procedure: *Approaching ACB to coordinate transit through the take-off and landing area at Taku Lodge by maintaining constant radio communication with approaching aircraft when approaching or within the immediate vicinity of the aircraft landing zone.*

This procedure will minimize any disruption to the aircraft traffic at Taku Lodge. This is primarily a summer/aquatic season issue related to increased aircraft traffic associated with the Juneau tourism industry. The ACB and shallow draft tug will all be equipped with radios and will monitor the aircraft

frequency in this area, allowing direct communications between the barge and Taku Lodge to give advance warning of the transit and in turn be advised of incoming flights.

6.2 Winter Season

The winter operations will involve the use of the ATs and ACB, traveling along the route as shown on the Route Atlas. The winter route will traverse frozen gravel bars along the floodplain, crossing the thalweg only where necessary. The route will vary somewhat within the floodplain depending on ice conditions, the presence of jumble ice and open leads, snow accumulations, and other weather related factors. The specific winter procedures that have been identified will include the following:

Procedure: *Use the West Channel around Canyon Island as the Primary Route during the winter season*

This procedure will avoid potential impacts to the high value fish spawning and over-wintering habitat associated with open water portion in the east channel and at the mouth of Fish Creek.

Procedure: *Avoid critical winter moose habitats and river crossing sites* where possible. No key crossing locations have been observed so far.

Procedure: *Use ice-covered sand flats and ice shelves during winter.*

- use of ACB and ATs during winter to travel across ice covered sand flats and ice shelves, avoiding the shallow reaches lower Taku River sand flats, thereby avoiding potential disturbance to sand flats and any adjacent fish habitat.

Procedure: *Avoid ice-breaking during winter freeze-up and spring thaw*

This procedure will accomplish the following objectives:

- avoids ice breaking and allows the river to freeze up and thaw naturally. A frozen river surface is the preferred operational condition for the Taku River ACB transportation system in winter. It is anticipated that there will be up to six weeks in the late fall and 4 weeks in the early spring (November and April respectively) when the transportation system will not operate.

Procedure: *Crossing Open Leads*

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

Redfern's policy on lead crossing 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; and
- all crossings will be done perpendicular to the open lead (and current) to minimize time and distance in the open channel.

In order of preference, the procedures for navigating around or across open leads that may be encountered enroute are as follows:

1. avoid the lead if possible
2. Use ACB as bridge to cross the lead
3. Cross leads at a shallow location with ATs contacting bottom (<1m depth)

The preferred procedure for crossing open leads would use the ACB itself as a temporary bridge to allow the ATs to cross over the lead (see Figure 22). This procedure can be followed under the following circumstances:

- the width of the lead does not exceed the width of the ACB (27m);
- the lead cannot be circumnavigated; and
- the depth of water at the crossing site exceeds 1 m.

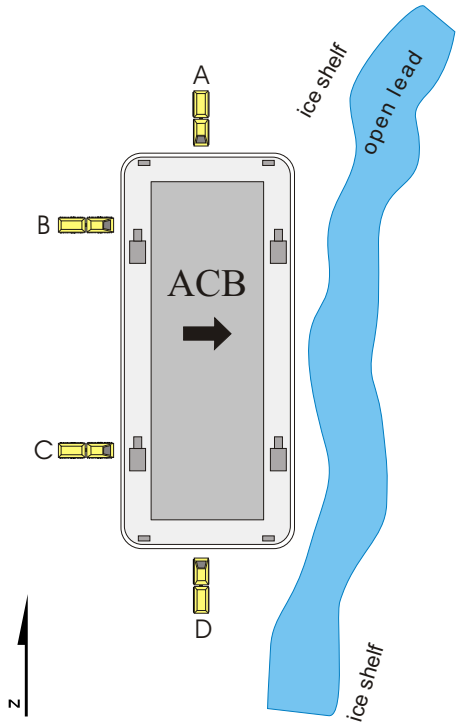
At depths greater than 1 m, the ATs are susceptible to being pushed downstream by the current as they would essentially be floating in the water. At shallower depths, the ATs are able to cross the channel as the soft tires would be in contact with the channel bottom.

An alternative crossing procedure is depicted in Figure 23. In this instance, the forward ATs 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 forward ATs will then anchor themselves and winch the ACB across the open lead. The rear ATs will then pull themselves across the open lead using the ACB's stern winches.

Height of the ice surface above river level is typically less than 1 ft. based on the Taku River ice monitoring program completed in 2008. Loose snow accumulations on top of the ice adjacent to open leads can add another 2 to 3 ft to the surface above the water level.

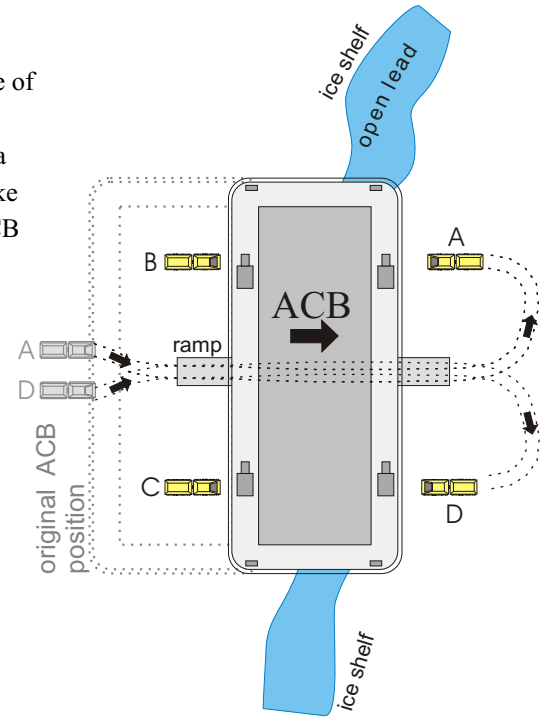
STAGE 1

AT's position ACB over open lead and two of the AT's hold ACB in position and/or ACB may be taken off hover to assist in holding position. Remaining AT's wait.



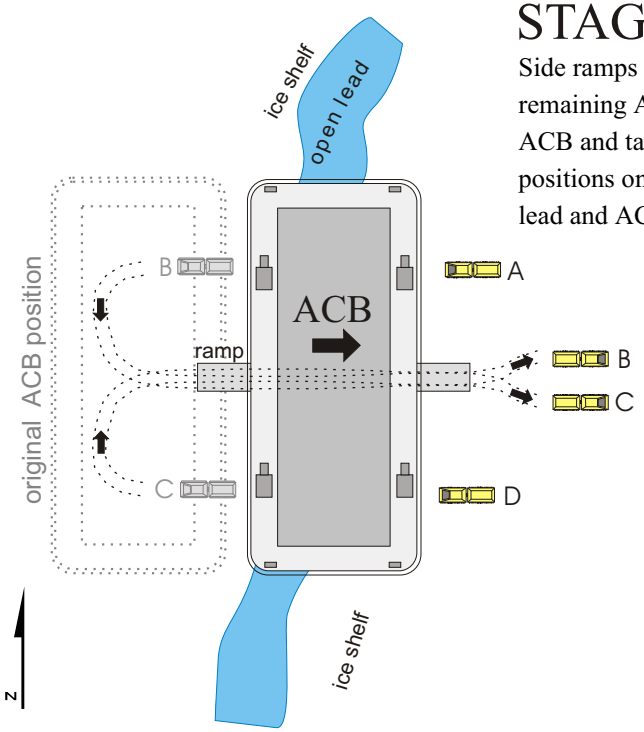
STAGE 2

AT's on the original side of the lead disconnect and cross lead over ACB via ramps as well. They take up position to move ACB off lead.



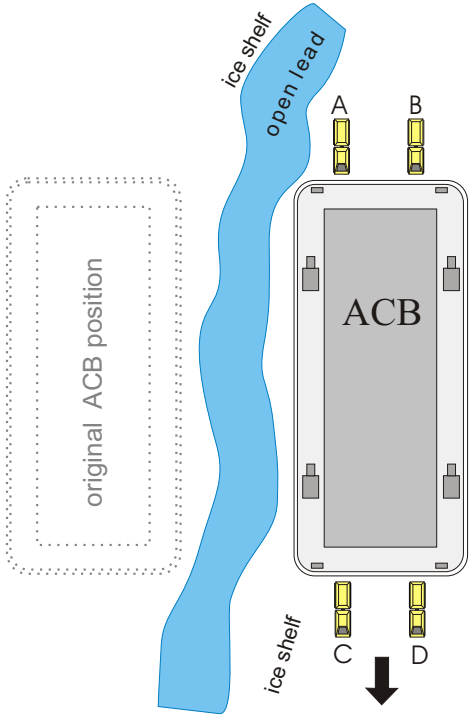
STAGE 3

Side ramps are lowered and remaining AT's cross over ACB and take up holding positions on opposite side of lead and ACB.



STAGE 4

Ramps are raised; then ACB is moved off lead; then AT's take up regular tow/push positions again and whole unit proceeds up or downstream.



Legend

TAV - rubber tracked AT

ACB (Air Cushion Barge)

Direction of travel

Barge and ACB drawn to scale in diagram.

Redfern Resources Ltd.

Tulsequah Chief Mine Project

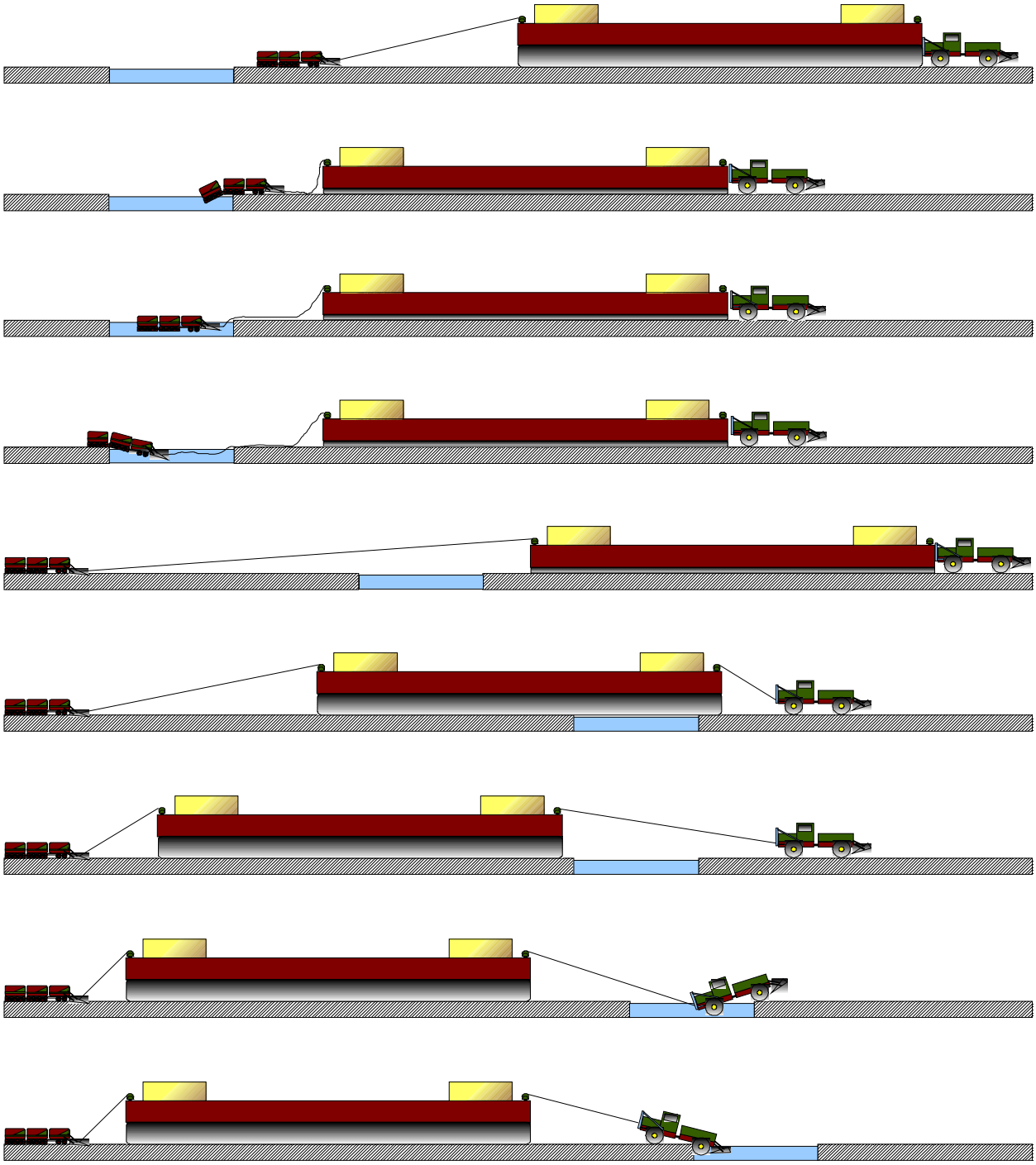
ACB Bridge Open Lead Crossing

November 2008
Project 82647

AECOM

Figure 22

Figure 23. Open Lead Crossing Method



6.3 General Procedures

Procedure: *Implement the Wildlife Management Plan*

This Plan will provide direction to minimize impacts to wildlife habitat and populations through best management practices and establishment of wildlife monitoring programs. The monitoring will include a Bear/Human Management Plan and outline general operating expectations and procedures for reporting wildlife sightings and incidents, etc. The Plan provides framework for modifying operations if warranted.

Procedure: *Implement a No Firearms Policy for all Redfern employees, including the ACB crews and personnel.*

Procedure*: Implement a Wildlife right-of-Way Policy for transportation system operations*.

This procedure will minimize potential for collision or disturbance of moose using the transportation route in winter. The slow travel speed of the ACB will allow animals to move away from the approaching ACB, also minimizing the potential for wildlife collisions. Refer to the *Tulsequah Chief Mine ACB Transportation System: Wildlife Management Plan - Wildlife Mitigation Policies, Procedures and Monitoring Program for Alaska* for details.

Procedure*: A minimum distance of 650 feet from active bald eagle nest sites will be maintained during ACB operations, where possible*.

Identify high value *bald eagle* sites and avoid during operations through distance or timing, to extent possible. This measure will minimize disturbance of active bald eagle nest sites during operations.

Procedure*: Avoid, to the extent possible, high value nearshore and freshwater foraging birds and waterfowl habitats during operations through distance and timing.*

The ACB route mostly follows the deeper channels thereby avoiding nearshore areas favoured by marine foraging birds and waterfowl.

Procedure*: Avoid high value shorebird habitats* during operations through distance and timing, where practical. The ACB route mostly follows the deeper channel of the river, thereby avoiding shorebird habitat and disturbance of foraging birds.

Procedure: *Develop a Transportation Communication Plan that will, at minimum, include the following*:

- a schedule of ACB transits throughout the open water season to be communicated to commercial fishermen and organizations, the Taku River Recreation Association and the general public in advance of the open water season, and any commercial fishing openings;
- advance notification of any changes to the schedule, to the extent practical;

- direct communication with commercial fishing organizations prior to the start of the commercial fishing season, and again at the close of the season to identify particular issues that may arise;
- radio communication on the tug operating on a common marine frequency;
- equipping the barge and tug with standard marine lighting to ensure visibility;
- direct communication with the Alaska Dept. of Fish and Game prior to the start of the Personal Use fishery, and again at the close of the season to identify particular issues that may arise and identify means to avoid or minimize conflicts with this fishery and navigation;
- seasonal discussions with the Taku River Recreation Association to review the Communications Plan and identify opportunities for improvement; reporting of incidents;
- communication with ADF&G to identify any interference to research activities;
- discussions with the Taku Lodge operators to co-ordinate schedules to minimize disruption to the incoming and outgoing aircraft activity. This may include routine or seasonal meetings to review the success of the co-ordination and communication.

Procedure: *The ACB and towing vessels will be maintained in good condition and repair, ensuring a tidy, clean and generally acceptable appearance of the vessels at all times.*
This will reduce visual impacts.

Procedure: *The ACB and towing vessels will be navigated by experienced crew who are familiar with the river and obstacles along the route.*

If warranted, travel speeds will be reduced along the section of the route near recreational properties (Martini Row, for example) to ensure that potential collisions with structures adjacent to the shore (docks; wharves) and small craft are avoided in congested areas.

Procedure: *In the event of a mishap that results in damage to structures such as docks, wharves or other property moored along the shoreline, the property owner would be compensated for any damages attributable to the ACB operations.*

Procedure: *During times of heavy boat traffic, a pilot vessel will notify any small craft of the pending approach of the ACB.*

7. Environmental Management and Monitoring

A environmental effects monitoring program will be implemented that will include both a Aquatic Monitoring Plan and a Wildlife Management Plan. These programs are being developed in conjunction with the BC Environmental Assessment Office and therefore address the transboundary nature of the project. The monitoring plans are provided under separate cover.

7.1 Aquatic Monitoring Plan

The *2008 – 09 Aquatic Monitoring Plan for Alask*a includes the following constituent plans:

- Adaptive Management Plan
- Wake-Induced Juvenile Stranding Monitoring Plan
- Wake-Induced Turbidity of Clear Water Fish Habitat Monitoring Plan
- Wake-Induced Bank Erosion Monitoring Plan
- Canyon Island Salmon Monitoring Plan
- Winter Open Lead Crossing Monitoring Plan

7.2 Wildlife Management Plan

The *Wildlife Management Plan - Wildlife Mitigation Policies, Procedures and Monitoring Program for Alaska* includes the following constituent elements:

- Wildlife Mitigation Polices and Procedures
- Wildlife Incidents and Observations Monitoring Plan
- Project Effects to Moose Monitoring Plan
- Harbour Seal Habitat Use Monitoring Plan

8. Spill Contingency Planning; Emergency Preparedness

The conceptualization of the air cushion barging (ACB) system has evolved in an iterative manner with engineering design, transportation logistics and environmental management all given due consideration. As a result, preventative and mitigative measures have been incorporated into the proposed air cushion barging system, and the potential for accidents and malfunctions has been discussed and considered at some length during this process. Protocols will be implemented that are designed to avoid or minimize environmental disturbances and hazards to people, aquatic systems and wildlife. Most importantly, all reagents or dangerous goods shipped upstream and all concentrate and dangerous goods shipped downstream will be transported in standard containers designed for marine and riverine use and approved by all the relevant regulatory agencies in both Canada and the United States. In addition, the proposed transportation system will be connected to the larger shipping route from Alaska to the contiguous United States and therefore all shipping containers will be required to meet all standard shipping regulations on that route. Redfern's parent company Redcorp Ventures Limited has prepared a *Draft Emergency Response Assistance Plan* (November 2008) to be finalized prior to commencement of operation of the transportation system. This Plan will be used by Redfern and any transportation system contractors.

The following sections outline examples of potential mishaps, including spills, and where appropriate, measures incorporated to prevent or minimize the associated risk.

8.1 Spills of Hazardous Materials

Potentially hazardous materials, such as diesel fuel, reagents, and ore concentrate, will be transported in significant quantities on the ACB system. On average, during operations there will be one to two round trips daily between the ACB landing site and Juneau. On a typical outbound ACB load, nine or ten containers of ore concentrate will be shipped, and on a typical inbound barge load, up to 14,000 gallons of diesel fuel and 37.5 tons of cement will be transported. Table 13 lists a typical ACB load traveling upstream and Table 14 lists the process consumables that will be transported by the ACB system and in what containers they will be shipped. Materials will be assembled into standard ISO containers before shipping to site.

Table 13. Typical Barge Load to Tulsequah Chief Project

Material	Approximate Weight (tons)
Diesel	51.8
Cement	37.5
Process Consumables	23.1
Misc. Equipment and Supplies	6.6
Food and Camp Supplies	5.5
Propane	2.2
Explosives	2.2
Process Plant Maintenance Supplies	1.7
Rock Bolts	0.6
Misc. Underground Supplies	0.2

Table 14. Process Consumables Transported via ACB Transportation System

Material	Delivery Container[1]
Flocculant	55 lb bags
Copper Sulphate ($CuSO_4$)	2,200 lb tote bags
Zinc Sulphate ($ZnSO_4$)	2,200 lb tote bags
Sodium Sulphite (Na_2SO_3)	2,200 lb tote bags
Methyl Isobutyl Carbinol	50 gal barrels
DF250 (frother)	50 gal barrels
Potassium Amyl Xanthate	Solid in 550 lb tote bags
Sodium Cyanide (NaCN)	2,200 lb tote bags inside UN approved Wooden Box
Sodium Metabisulphite ($Na_2S_2O_5$)	2,200 lb tote bags
Sodium Ethyl Xanthate	Solid in 550 lb tote bags
3418A	Liquid in drums
Sulphuric Acid (H_2SO_4)	3836 lb tote bag; or 20-tonne ISO container
Dextrin	55 lb bags
Ferric Sulphate (Fe_2SO_4)	2200 lb supersacs
Lime	Solid in 20-tonne bulk Pneumatic Container (DBPC)

1: All materials packaged in bags will be transported in containers on the ACB.

8.1.1 Spills on Water

All cargo will also be transported in marine-certified containers to prevent leakage or spills into water. Hazardous materials will be handled and transported in accordance with current regulations pertaining to transportation of hazardous goods. The containers will be secured to the deck of the barge to prevent shifting during transit. There will be no transfer of bulk materials from one barge to another during the transfer from river to marine operations; rather the river and marine tugs will exchange barges.

8.1.1.1 Diesel Spills

Fuel will be transported to site in either ISO tanks or standard fuel tanker truck approved for public transportation systems. These will be secured on the ACB by industry-standard methods. Redfern has committed to joining SEAPRO (Southeastern Alaska Petroleum Resource Organization) and possibly Burrard Clean Operations (equivalent Canada based response organization). SEAPRO has pre-positioned oil spill response teams and equipment maintained in a state of readiness in the event that any member organization has an incident. There is a SEAPRO team located in Juneau, AK. SEAPRO is also classified as an oil spill removal organization for rivers and canals.

8.1.1.2 Reagent Spills

All reagents or dangerous goods will be transported in keeping with the *Transportation of Dangerous Goods Act* in Canada, and all other relevant legislations. Redfern's Emergency Response Assistance Plan addresses potential spills of reagents and the appropriate spill response. In the event that a portion of the transportation system is contracted to an independent operator, Redfern will require that the operator meet all legislated requirements regarding the shipping of dangerous goods.

8.1.1.3 Concentrate Losses

The ore concentrate will be shipped in sealed containers. Given the weight of these containers and the stability of the barge, loss of a container overboard is considered to be very unlikely. The sealed containers would prevent or minimize spillage of concentrate into the environment, even in the unlikely event that a container became submerged. If the container were to become submerged negative impacts to the environment would be limited as oxidation of the concentrate would be prevented by submergence.

8.1.2 Mechanical Failure of ACB

It is possible that one or more of the four engines on the ACB could fail during operations. The ACB can maintain hover on only two engines, and the likelihood of all four engines failing simultaneously is very remote. The loss of hover on the ACB would mean that the barge would settle onto the surface and float or rest on the pontoon, depending if it is on water or land at the time. As more than one towing vessel (the shallow draft tugs or two ATs) will frequently operate together, crews would be able to provide mutual support to manoeuvre the barge into a secure position until the engine(s) could be repaired. No environmental impacts are anticipated.

8.1.3 Mechanical Failure of Shallow Draft Tug

While it is possible that the shallow draft tug could experience a mechanical failure during operations, contingency plans will be prepared to deal with this situation. Typically, another tug or suitable vessel will provide assistance to the crippled vessel, and tow it to Juneau where it can be repaired. In the case of the shallow draft tug operating on the river, a second tug would provide the needed assistance to tow it out to the Taku Inlet where it would then be towed or escorted to Juneau by a marine tug or other suitable vessel. The barge would be taken off hover, set down on shore until such time that another vessel could rendezvous with the barge and complete the trip.

8.1.4 Grounding

In the event that the shallow-draft tug ran aground, the standard procedures will be followed to re-float the tug. This may involve waiting for tidal assist, or towing by a second tug. While grounding is an inconvenience, it does not usually pose a serious threat to safety, some groundings may be reportable to appropriate authorities in Canada or United States. Given that the tugs are most likely to run aground on sand or gravel bars the risk associated with this kind of accident is minimal. In any event, running aground is a standard operational risk and there are minimal environmental impacts associated with this type of mishap.

8.1.5 Capsize of ACB

Capsize of the ACB is highly unlikely. The ACB is remotely controlled, and can be lowered off hover to provide additional stability on water or land if needed. The hull is comprised of 25 individual pontoons and multiple floodings would be required before vessel stability would be compromised. As such, it is very improbable that the ACB would capsize or sink.

8.1.6 Glacial Outburst Floods

Glacial outburst floods (jokulhaups) 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 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).

8.1.7 River Collisions

The Taku River is used for pleasure boating as well as fishing. In order to avoid any collisions with other craft, the ACB and tug boats will be equipped with lights and a fog-horn or noisemaker and will follow all navigational rules and regulations. Only qualified operators will be retained to run the ACB and tug boats. The communications protocol has also been put forward in this document as a means to avoid collisions. In the event that a portion of the transportation system is contracted out, Redfern will require the operator to follow all relevant regulations and legislation regarding emergency preparedness.