Draft for Discussion

Tulsequah Chief Mine
Air Cushion Barge Transportation System

2008 – 09 Aquatic Monitoring Plan for Alaska

Prepared for
Redfern Resources Ltd.

Submitted by
Gartner Lee Limited

September 2008

Gartner Lee

Draft for Discussion

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Reference: **GLL 82-647**

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September 29, 2008

Mr. Tim Davies
Manager, Environmental and Regulatory Affairs
Redfern Resources Ltd.
710-1281 West Georgia Street
Vancouver, BC V6E 3J7

draft for discussion

Dear Mr. Davies:

Re: GLL 82-647 – Air Cushion Barge Aquatic Monitoring Plan for Alaska

Please find enclosed a draft copy of the 2008 – 09 Aquatic Monitoring Plan for Alaska. This document outlines the proposed monitoring plan that will be implemented to ensure that the aquatic risks associated with the ACB Transportation System are appropriately managed. The primary objective of the Monitoring Plan will be to monitoring the actual effects of the ACB Transportation System on aquatic resources and habitats, and to provide a structure for Adaptive Management to identify and implement appropriate additional mitigation measures, if any should be necessary.

Yours truly,

GARTNER LEE LIMITED

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BSF:gc

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Table of Contents

draft for discussion

Letter of Transmittal

Page

1. Introduction 1

2. Issue Identification 1

3. Management Plan 2

4. Wake induced Juvenile Stranding 3

4.1 Introduction 3
4.2 Purpose and Objectives 4
4.3 Methodology 4
4.3.1 Baseline Study 4
4.3.2 Operational Monitoring 6
4.4 Reporting 7

5. Wake Induced Turbidity of Clear Water Fish Habitat 7

5.1 Introduction 7
5.2 Purpose and Objectives 8
5.3 Methodology 9
5.3.1 Selection of Monitoring Sites 9
5.3.2 Data Collection 9
5.3.3 Reporting 10

6. Wake-Induced Bank Erosion 10

6.1 Introduction 10
6.2 Purpose and Objectives 11
6.3 Methodology 12
6.3.1 Selection of Monitoring Sites 12
6.3.2 Data Collection 12
6.3.3 Reporting 13

7. Canyon Island Salmon Monitoring Plan 13

7.1 Introduction 13
7.2 Purpose and Objectives 14
7.3 Methodology 14
7.3.1 Selection of Monitoring Sites 14
7.3.2 Data Collection 15
7.4 Reporting 15

8. Winter Open Lead Crossings 16

8.1 Introduction 16

8.2 Purpose and Objectives 17
8.3 Methodology 17
8.3.1 Initial Monitoring 17
8.3.2 Focused Monitoring 18
8.3.3 Open Lead Monitoring Parameters 18
8.4 Reporting 19

9. Thickening of Thalweg Ice from Snow Packing 20

9.1 Introduction 20
9.2 Purpose and Objectives 21
9.3 Methodology 22
9.3.1 Selection of Monitoring Sites and Data Collection 22
9.3.2 Reporting 22

10. Summary 22

11. References 23

List of Tables

Table 1 ACB Aquatic Effects Monitoring & Mitigation Plan - 2009 Monitoring Schedule

Appendices

A Aquatic Effects Monitoring and Mitigation Plan Monitoring Sites. Taku River Barging: Route Atlas

1. Introduction

Redfern Resources Ltd. (Redfern) has proposed using an Air Cushioned Barge (ACB) transportation system to haul mining equipment and mine ore along the Taku River, from the Tulsequah Chief Mine site in British Columbia, Canada to Juneau, Alaska. If successful, this plan would negate the need for Redfern to build a road from Atlin, B.C. to the mine site. In order to initiate barge operations Redfern Resources is seeking an amendment to its Environmental Assessment Certificate issued under the *BC Environmental Assessment Act* to include barging in its operational plan in Canada. In order for the barge to operate in Alaskan waters it must also receive a Title 16 Fish Habitat Permit, a Miscellaneous Land Use Permit and must undergo a Coastal Zone Consistency Review.

Redfern has been advised that an environmental management plan will be required as part of the approval process to carryout barging on the Taku River to support the operation of the mine. Redfern proposed to implement an adaptive approach to managing the barging operations. This will include an initial assessment of the issues, incorporating the results of the assessment into the operational plan, monitoring the activities during regular operations, conducting an analysis of the monitoring data, and modifying operations if necessary. It is envisioned that a committee would oversee the management process.

This document is being prepared for consideration during the environmental review of the barging operation. At this time, some of the baseline studies required to fully develop the aquatic monitoring plan are not complete. We anticipate that this document will evolve with input from the BC Environmental Assessment Office's (EAO) Working Group that includes representatives from the State of Alaska's Department of Natural Resources and the US Department of the Interior and was established to review the proposed barging operation. Aquatic studies are being conducted through the summer and fall of 2008 to develop a better understanding of the identified issues. A separate document for monitoring wildlife is available.

2. Issue Identification

Through the course of the review of the proposed ACB transportation system, several potential effects of the barging have been identified. These effects were evaluated by the EAO fisheries working group through the development of "*Fish and Fish Habitat Risk Assessment/Mitigation Matrix".* The Risk Matrix identified the uncertainties with the various issues which identified the need for a monitoring program to further study the issue once the barge operation begins. The monitoring programs have been developed to confirm that the operational plan is appropriately avoiding or minimizing affects to fish and fish habitat. Monitoring plans have been developed to address the issues identified in the risk matrix, including:

- wake induced stranding of juvenile salmonids;
- wake induced sedimentation of clear-water habitat;
- wake induced bank erosion;
- open lead crossing during winter operations;
- thickening of thalweg ice from snow packing; and
- effects of operations on salmon spawning habitat at Canyon Island.

3. Management Plan

The current barge operation plan (Redfern, 2008) has been developed to minimize environmental impact and achieve an efficient transit time up and down the Taku River. The Risk Matrix identifies a number of areas of uncertainty around the level of environmental protection offered by the proposed operational plan. The proposed adaptive management plan has been designed to provide a process for evaluating operations and identify areas where improvements are needed. The proposed adaptive management plan for the barging operation would achieve this through the following steps:

- Issue identification – Risk matrix;
- Develop monitoring plans to asses the issues;
- Conduct monitoring;
- Evaluate the data collected; and
- Adjust operating plans and monitoring plans as necessary.

The process is intended to collect the appropriate information so that an adaptive management planning committee can make informed decision about the effectiveness of the barging operations for protecting the environment based on the principle of continual improvement.

Generally, the adaptive process would be carried out on a seasonal basis. The barging operations have two distinct seasons. The first is the fully aquatic summer season that will generally run from mid May through to September when the barge is pushed and/or towed by shallow draft tugs along the river and a winter season from November through March when amphibious tractors are used to navigate the barge up to the barge landing site on Big Bull Slough. The adaptive management program will have two cycles per year that coincide with the distinctly different operations on the river.

The EAO fisheries working group has been instrumental in the initial identification of issues and development of the risk matrix which has provided the direction regarding what would have to be monitored on the river once the barging begins. The following sections of this report provide draft monitoring plans for each of the identified issues. These monitoring plans provide a background to the issue and the goals and objectives of the monitoring. A methodology section describes how data will be collected and reported. The reports will include recommendations to the management

committee for consideration of any additional mitigation measures that may be required to reduce negative effects observed during the barging operations. The reports will also provide suggestions for modifying the monitoring programs so that they are more effective.

Where appropriate the monitoring plan includes a description of the field work that has been conducted in 2008 to collect baseline data that is intended to provide additional information to further modify the following, proposed monitoring plans. The 2008 work included collecting data on stranding, turbidity, habitat conditions at the anticipated open lead crossings, fish use around Canyon Island and additional bathymetric data. These studies were carried out while conventional barging took place on the Taku River and the knowledge gained will be used to finalize the monitoring plans and provide mitigation options.

The EAO Working Group anticipated that an adaptive management committee would be formed to review the recommendation from the monitoring reports and provide direction for the modification of subsequent barging operations on the Taku River. The committee would consist of representatives from the various regulatory agencies in Canada and the United States along with representation from the Taku River Tlingit First Nation. The intent is to establish one committee to oversee the monitoring along the length of the ACB transportation route. This would ensure consistency in the way the monitoring reports are evaluated and in the development of modifications to the operational plan if required. The management committee would work with Redfern in developing modification to the operating and monitoring plans.

4. Wake induced Juvenile Stranding

4.1 Introduction

The possibility of the ACB transportation system producing a strong enough wake to strand or entrain juvenile fish (salmonids in particular) along the Taku River is an issue of significant concern. As a result, Redfern has committed to implementing baseline studies and an operational monitoring plan to contribute to the adaptive management plan to protect the Taku River fish resources from potential wake related stranding or entrainment that may be associated with the barge operations.

The first step in developing a juvenile fish stranding monitoring program is to collect baseline data on the fish and fish habitat that may be susceptible to stranding. The initial baseline study is being conducted during the summer and fall of 2008. The study will also collect data on the size of barge wakes based on observations of the conventional barging being conducted by Redfern in 2008. The wake produced by the conventional tug/barge system has been assumed to provide a reasonable surrogate of the wake expected from the ACB transportation system.

4.2 Purpose and Objectives

Many studies have been carried out on juvenile fish movement in the lower Taku River by such authors as J.F. Thedinga *et al.* (1988), Murphy *et al.* (1989), Heifetz *et al.* (1987) and Lorenz *et al.* (1991) through the 1980's and early 1990s. These studies report on the timing of outmigration, size of fish and type of habitats used. Of particular interest to this study is the finding that mainstem edge habitat is used by outmigrating juveniles, particularly chinook and sockeye, and they can be found in this type of habitat during the open water season when the tug and barge will operate. This suggests that they are potentially susceptible to stranding along shoreline areas under particular conditions of beach gradient combined with certain wave heights.

Environmental Dynamics Inc. (EDI) completed two years of studies on the Yukon River assessing the stranding rates and conditions leading to stranding on the Yukon River during the operations of the tour boat, the Yukon Queen II (Schonewille and Tobler, 2007a, 2007b). These studies built on the work started in 2001 by other researchers looking at the effects of the operation of the Yukon Queen II. The results of EDI's work indicated that the highest rates of stranding were associated with the various habitat types found around creek mouths. This was attributed to two important factors: a) juvenile fish tended to be found in higher concentrations around creek mouths, and b) the deposition of bed material around creek mouths often provided low gradient shorelines that were more conducive to stranding fish. Low gradient gravel/cobble beaches not associated with creek mouths were areas of next highest stranding rates. The more vertical soft and hard shorelines showed little to no stranding. The EDI also reported that on average, observers were able to find 68% of stranded fish during stranding surveys.

4.3 Methodology

4.3.1 Baseline Study

Based on a review of previous studies on fish stranding, and particularly the EDI report, the study on the Taku River will focus on those shoreline conditions most susceptible to stranding. Site selection was a two step process, with the first step reviewing aerial images of the Taku River followed by on river observations to confirm the suitability of sites and to determine if sites should be dropped and/or other sites added. The selection of sample sites was based on a combination of the following factors:

- importance as juvenile rearing habitat along the mainstem of the Taku River, including; clear-water hyporheic zones along sediment bars, calm and shallow shoreline areas along sediment bars, and tributary confluences;
- proximity of the site to the proposed ACB route along the Taku River;
- low gradient shoreline areas with gravel/cobble substrate; and
- locations with historical fisheries information.

The sample site locations chosen, with all or some of the characteristics listed above, represent the most important juvenile rearing habitat that is present along the mainstem of the Taku River and are the most susceptible areas to a wake being produced by barging activities that may result in the stranding of juvenile fish. The initial selection of sample sites was completed with the guidance of a fish biologist from the Taku River Tlingit First Nations (Mark Connor) and are identified on the Route Atlas in Appendix A.

Each field visit will include a habitat assessment to confirm the conditions of each of the study sites in order to capture the specific conditions at each site at the different flow levels. The habitat assessment will document the type of beach and substrate, length and gradient of beaches or gravel bars, distance to the barging route, etc. Since conventional barging will be used during the summer and fall of 2008 to move construction equipment and supplies to the mine site, wakes and wake effects will be measured along with the fish sampling as an initial indication of what could be expected with the ACB system. Staff gauges will be installed at beach sites and used to measure the wave height created by the tug and barge and the distance of wave run-out up the beach will also be measured. The speed, direction and load on the barge will be recorded for each passage related to a stranding study. Fish sampling will be carried out at each selected site using a 10 m long juvenile seine net. While beach seining will be the preferred sampling method, some areas with large substrate (i.e., boulders) or the presence of woody debris may not allow for efficient beach seining. In this case minnow traps will be used. Various combinations of fish sampling will take place including:

- sampling prior to or after the tug and barge pass a study site;
- observation of the beach areas at the study sites after a barge and tug passes to look for and collect any fish stranded on the beach;
- fish sampling will involve standardized methods, i.e., the length of time minnow traps are left to fish and length or number of beach seine sets. Once a sampling method is established for a site it will be used for subsequent fish sampling efforts so that comparisons of fish presence can be made between sampling trips; and
- fish collected during each sampling event will be identified and counted and a representative sample will be weighed and measured.

The relative fish abundance based on fish sampling, wake data and observations of stranding will be used to identify the types of sites were stranding is likely to occur. At sites where stranding is observed, an assessment of the number of stranding in relation to the relative abundance of fish in the area as reflected in the catch per unit of sampling effort will be made. Fish sampling before and/or after a barge passes will indicate the abundance of fish present to be stranded and will be correlated to the observed rates of stranding. The comparison of the relative abundance of fish present at stranding sites to the relative abundance of fish present at sites where stranding does not occur will be used to provide an indication of the risk to the population that barging will pose. This study will also help focus the degree to which measures for mitigating stranding have to be applied at various locations along the route.

Field crew members looking for stranded fish will under go a stranding accuracy test. Prior to conducting a test, a minimum of seven local threespine stickleback of varying sizes will be used as a surrogate for juvenile salmonids. The plan would be to collect any stickleback captured in minnow traps or seine pulls that will be done in the vicinity of the stranding sites. These fish will be kept alive in a holding container for use in the accuracy test. A test course will be set up with dimensions that are similar to a typical stranding survey completed in this study. The crew member not taking a test will randomly place 0 to 7 live threespine stickleback (number to be drawn from a hat) on the beach at random distances within the course. Without looking at the beach, fish will be dropped from a height of 0.5 to 1.0 m. The distance of each fish placed on the beach will be recorded. Regardless of the number of fish placed on the beach, the person will walk the entire length of the course. Once the crew member reaches the end of the course, the person taking the test will be told to proceed to the course and begin searching for the stranded fish. The start and finish time of the test will be recorded along with time that any fish are found. Upon completion of the test, all fish placed on the beach will be visited and notes/photos will be taken to determine why specific fish were found and/or missed during the test. It should be noted that the surveyor will not be told to stop the test despite finding all the artificially stranded fish as this would cause a bias in future stranding accuracy tests. Four different shoreline areas with varying characteristics (i.e., slope, substrate size and composition) will be used for the fish stranding accuracy tests.

The stranding survey should collect data that can be used to assess the stranding potential at different flow levels and should coincide with times of the year related to juvenile movement down the river. The study in 2008 will capture the summer and fall period and additional baseline data gathering will be carried out weekly in the spring and early summer of 2009 to collect additional data:

1. weekly in the early spring to coincide with the main out migration period for coho and chinook and once flow levels reach 300 to 400 m^3/s (10,000 to 14,000 ft^3/s) and when open water barging operations will likely begin. Current operating plans indicate that there will be a period of no barging as the ice breaks up and Taku River flows reach a level to support barging; and
2. weekly during high summer flow (late June, early July).

4.3.2 Operational Monitoring

During operation of the ACB there are two ways juvenile fish can be stranded. The first is through the barge wake carrying fish onto the beach as the barge passes off shore. The second is through the wave effects at the shoreline that are created as the ACB transitions from the water to land. This transition effect will occur where the barge passes around the east side of Canyon Island, and where it moves onto the barge landing site near the confluence of the Tulsequah River in BC. There may also be an effect during winter operations when the barge crosses open leads and moves on and off the ice on the shore. We will not be able to assess this transitional effect until the ACB is on the Taku River. However, the winter transitional effect is expected to be minimal as the barge will be winched very slowly across open leads.

The baseline study will be used to focus the operational monitoring for wake induced stranding. Currently the baseline study includes seventeen sites that appear to have the potential for stranding fish. Results of the baseline work will be used to determine which sites are appropriate for ongoing operational monitoring and if additional sites need to be added. The monitoring program is generally expected to follow the sampling program described above with beach seining at monitoring sites to determine the change in abundance of fish over the seasons, measurements of wave heights and run-out distances and observational surveys of the wave run-out areas looking for fish. Monitoring for stranding will be conducted weekly for the first year and divided up into three periods:

1. Early spring low flow monitoring once the open water barging season begins (May/June);
2. Summer monitoring at higher flows (July, August); and
3. Fall monitoring as flows drop but the barge is still in open water operation (September).

The periods for monitoring will be adjusted as appropriate after the baseline data is analyzed.

4.4 Reporting

The data from the 2008 field study will be collated and analyzed in a report that will be prepared after the late September trip. Findings from this work will be used to refine the 2009 stranding study if necessary and where appropriate findings will be extrapolated to provide an initial assessment of spring and summer stranding risk. Finally, the assessment will recommend on going monitoring for the proposed ACB barging operation as part of a management plan that will modified as necessary to respond to findings from the monitoring program to reduce effects like stranding if it does occur.

Once the monitoring phase begins, summary reports of fish stranding will be carried out for each of the three periods. Interim data and recommendations will be reported to the management committee. An annual monitoring report will be prepared that includes an in depth analysis of data collected throughout the year. The annual report will provide information on sites most prone to stranding along with recommendations made for operational changes to reduce or eliminate the stranding.

5. Wake Induced Turbidity of Clear Water Fish Habitat

5.1 Introduction

Barge operations on the Taku River may potentially affect clear-water fish habitats along the river. Specifically, the wake generated from barge operations may increase the turbidity of clear-water rearing habitats along the proposed barge route on the Taku River. In response, the following

Induced Turbidity of Clear-water Fish Habitat monitoring plan has been developed to monitor the potential disruption of clear-water fish habitat associated with barge related wake effects along the Taku River.

An extensive body of literature exists on the harmful impacts of increased turbidity on fish and fish habitat. Exposure to increases in turbidity has shown to reduce growth patterns (Sigler *et al.,* 1983) induce stress (Mcleay *et al.,* 1984), increase disease (Goldes *et al.,* 1988), and comprise physiological performance (Servizi and Martens, 1987) in both adult and juvenile fish. In response to observed impacts from increased exposure of turbidity to freshwater fish, a Canadian water quality guideline for the protection of aquatic life has been developed (CCME, 2007). The CCME (2007) guideline suggests that induced turbidity should not exceed 10% of background conditions, when background is greater than 80 NTU's.

To avoid turbid water conditions and to seek refuge from swift flows, juvenile freshwater fish will typically (if possible) emigrate to still, clear-water environments. On the Taku River, with an average summer turbidity value of approximately 100 NTU (Gartner Lee, 2007), it has been found that the highest density of juvenile coho (*Oncorhynchus kisutch*) and sockeye (*Oncorhynchus nerka*) were positively correlated with calm, clear-water habitats (Thedinga *et al.,* 1988, Murphy *et al.,* 1989). Adult migrating sockeye salmon also tended to congregate in clear-water areas along the Taku River before moving up to their spawning grounds (Eiler *et al.,* 1992). Clear-water habitats along the Taku River typically occur in the form of; backwater channels, tributary confluences (Thedinga *et al.,.* 1988, Murphy *et al.* 1989), and hyporheic zones located at the downstream end of gravel bars (personal observation, Mark Connor, TRTFN personal communication).

5.2 Purpose and Objectives

Excluding the east channel of Canyon Island (Alaska), the proposed barge route along the Taku River follows the thalweg, and will not traverse directly cross non-thalweg clear-water areas inhabited by fish. However, the wake created by the barge operations may increase the turbidity within clear-water fish habitat in two ways: wash turbid Taku River water into clear-water habitats or create turbidity by entraining and suspending sediments within clear-water habitats in close proximity to the proposed route. Turbidity can be harmful to freshwater fish and clear-water areas tend to support higher densities of juvenile and adult salmonids along the Taku River. Thus, the Induced Turbidity in Clear-water Fish Habitat monitoring plan focuses turbidity monitoring on clear-water habitats in close proximity to the proposed route and the East Channel of Canyon Island during barge operations.

The primary objectives of the Induced Turbidity in Clear-water Fish Habitat monitoring plan are as follows:

- selection of suitable monitoring locations along the proposed barge route on the Taku River to monitor wake-related effects on the turbidity of clear-water fish habitats;

- to monitor turbidity within clear-water fish habitats at selected sites along the proposed barge route before, during and after the passage of barges;
- develop a Total Suspended Solids (mg/L)/turbidity (NTUs) relationship to determine the total amount of sediment (i.e., sedimentation) entering the clear-water habitats; and
- to provide field reports outlining the results of turbidity monitoring field visits. A final annual report will also be provided that will describe in detail all observations of induced turbidity from wake-related barging activity and identify further mitigation measures that can be implemented that would reduce barge-related increased turbidity within clear-water fish habitats.

5.3 Methodology

5.3.1 Selection of Monitoring Sites

A preliminary selection of monitoring sites located along both the Alaskan and BC portions of the Taku River was competed in February of 2008 in consultation from the TRTFN Fisheries Biologist (Mark Connor). These preliminary sites were selected based on the following criteria:

- presence of clear-water fish habitat along the mainstem of the Taku River, including:
    - clear-water hyporheic zones along sediment bars;
    - calm and shallow shoreline areas along sediment bars;
    - backwater areas; and
    - tributary confluences.
- proximity of the clear-water habitat to the proposed barge route along the Taku River; and
- a location with historical fisheries information (anecdotal or otherwise).

A total of 17 preliminary sites were selected based on the criteria listed above (including Canyon Island). These sites are identified on the Route Atlas provided in Appendix A. A field visit and preliminary monitoring of turbidity will be conducted at each of these sites in conjunction with conventional barging in late August 2008. Based on the results from the preliminary monitoring assessment, monitoring locations may be added, removed or relocated.

5.3.2 Data Collection

At each of the monitoring stations, the following data will be collected:

- background turbidity within the mainstem and clear-water areas will be recorded prior to the passage of a barge;
- turbidity will be monitored during the passage of the barge wake;
- if turbidity increases due to the passage of the barge wake, monitoring will continue until background conditions return including recording the time it takes for turbidity level to drop to background levels;

- if an increase in turbidity is observed, the amount of time background turbidity conditions return will be recorded;
- estimate of distance between passing barge and monitoring location;
- estimate of barge and river velocity as it passes monitoring location;
- visual observations of fish presence; and
- photo documentation at each site during turbidity monitoring will be conducted.

The barge wake may change in both magnitude and orientation, depending on which direction the barge is traveling. Consequently, the wake produced by both upstream and downstream barge travel will be monitored for induced turbidity at each site.

A turbidity versus TSS relationship will be produced from water quality data collected on the Taku River below the Tulsequah River confluence. Using this relationship it would be possible to quantify the degree of sedimentation that might be occurring in clear-water habitats where turbidity is observed to increase by the passage of the ACB.

Collection of turbidity at all monitoring sites will be conducted weekly for the first year during the open water period. Water samples will be collected for TSS analysis over a range of the turbidity levels observed in the river.

5.3.3 Reporting

Field reports will be provided following all field visit(s), containing maps, and photos of all sites during turbidity monitoring. A final report will be issued at the end of each year that will describe any instances where turbidity increased due to the passage of the barge wake, the amount of sedimentation that may have occurred from the increase turbidity within the clear-water areas and identify additional mitigation measures that may be employed to reduce barge related turbidity effects on clear-water habitats.

6. Wake-Induced Bank Erosion

6.1 Introduction

The environmental assessment indicated that accelerated bank erosion associated with the ACB transportation system was unlikely to be significant in the context of the existing natural environment. However, to confirm this assertion follow-up monitoring is proposed. Specifically, the concern exists that the wake generated from barge operations may cause an increase in bank erosion along the proposed barge route. Accordingly, the following Bank Erosion monitoring plan has been developed to assess wake-related bank erosion from the proposed barge operations along the Taku River.

Bank erosion is a natural process and integral to the health of fish habitats within a river environment. Elevated levels of bank erosion caused by human activities can increase turbidity (Garred and Hey, 1987), reduce riparian vegetation (Stern and Stern, 1980), and reduce channel depths (Smith and Patrick, 1979) along the lateral margins of a river. These effects can disrupt important rearing habitat for fish.

River boat traffic can have a significant influence on the rate and magnitude of bank erosion. Banks consisting of small-grained, uncohesive sediment that are exposed to boat induced wakes are particularly susceptible. It has been found that boat wakes can contribute to as much as 80% of the energy dissipated against stream banks during the year (Dorava and Moore, 1997, Limerinos and Smith, 1975). On smaller rivers, boat-generated waves significantly contribute to erosional processes along stream banks (Oswalt and Strauser, 1983). However, in larger rivers subjected to large flood flows, boat-generated waves were less important agents in stream bank erosion (Hagerty *et al.,* 1981, Hagerty *et al.,* 1983). Consequently, bank erosion studies from boat-generated waves in large rivers should focus on stream banks that that are not subjected to high velocity flood flows (Nansen *et al.,* 1994).

In general, accurately quantifying the rate and temporal distribution of bank erosion, from either natural or human related agents, can be very difficult and labour intensive. Typically, erosion pins, sediment traps, surveys, and aerial photography are used to estimate the net amount of bank erosion between field visits. In labour intensive field investigations of bank erosion, simple measurements of wave height and period provided a fairly significant correlation with bank erosion (Nansen *et al.,* 1994). To reduce field visits and aid in the quantification of various erosional agents, an erosion monitoring device called the PEEP (Photo-Electric Erosion Pin) has been developed and automatically measures the timing, magnitude and frequency of specific erosion events.

6.2 Purpose and Objectives

Concerns exist that the proposed barging operation on the Taku River has the potential to produce a wake that may enhance bank erosion along certain areas of the proposed barge route. The Taku River is a large river that currently exhibits naturally high rates of erosion along high-velocity banks during floods, other natural causes (wind), and human activities (small boat generated waves). The purpose of the Bank Erosion Monitoring plan is to determine the relative contribution of bank erosion (if any) from the wakes generated by barging operations along the Taku River. The bank erosion monitoring plan, to determine the potential contribution of bank erosion from barge related wakes, requires both conventional (net erosion) and contemporary (contribution of individual sources) measurement techniques. The objective of the Bank Erosion Monitoring plan is as follows:

- selection of suitable monitoring locations along the proposed barge route on the Taku River to asses the possible contribution of bank erosion from barge-generated wakes;

- to monitor bank erosion at selected sites along the proposed barge route while the barge is in operation; and
- to provide field reports outlining the results of bank erosion monitoring field visits. A final annual report will also be provided that will describe in detail all observations of bank erosion, the relative contributions of bank erosion from each source if possible, and identify potential mitigation measures that could be implemented that would reduce the bank erosion contribution from barge-generated wakes.

6.3 Methodology

6.3.1 Selection of Monitoring Sites

Monitoring sites for bank erosion will be located along river banks that do not experience high-velocities during flood flows and are in close proximity to the proposed barge route. It is proposed that eight bank erosion monitoring sites will be chosen - including a site along Martini Row and one control site. The selection of sites will be conducted by reviewing high resolution (60 cm) Quickbird satellite imagery and have been marked on the Route Atlas in Appendix A. Confirmation of the preliminary monitoring sites will be conducted during the first field visit.

6.3.2 Data Collection

Field visits are required to install the bank erosion measurement devices, measure the net bank erosion between field visits, and to calibrate the timing of specific wake measurements to the erosion recorded by the automated PEEP monitor. The following activities will be conducted at each monitoring location:

- confirmation of monitoring locations and installation of erosion pins and a PEEP monitor (first visit only);
- measurement of barge wake height and period during barge passage;
- measurement of wake height and period caused by other vessels or wind;
- recording the time of impact(s) of the barge wake on the bank;
- measurement of turbidity before, during and after passage of barge wake;
- estimation of the area of disturbance from a turbidity increase (if any) following the impact of the barge wake on the bank;
- recording the time turbidity conditions return to background conditions;
- recording the wind speed and direction;
- estimation of the distance between the passing barge and bank;
- observation of the current flow conditions and water levels at time of visit; and
- downloading of data from PEEP monitor.

A minimum of three field visits are suggested to adequately determine the relative effect of the barge wake on bank erosion; however weekly monitoring through the open water season is

proposed. In efforts to quantify the effects of natural processes on bank erosion, daily flow data from the USGS gauge on Canyon Island and, if possible, daily wind speed and direction data will be obtained. To determine the timing of barge wakes in between field visits, Redfern Resources Ltd. will provide a detailed daily barging schedule. In addition, the timing and location of the barge will be tracked continuously (five minute intervals) by a GPS unit installed on board the barge.

6.3.3 Reporting

Field reports will be provided following all field visit(s), containing maps, and photos of all sites during bank erosion monitoring. A final report will be issued at the end of each year that will outline:

- the calibration techniques employed to distinguish between natural and anthropogenic sources;
- outline the results of monitoring program with respect to the significance of the barge wake contributions to the overall erosion observed during the year;
- if the results of the monitoring program show that the barge wake is significantly contributing to bank erosion, mitigation measures that may be employed to reduce bank erosion will be identified; and
- It is anticipated that data from at least one aquatic barging season will be required to determine if barging is causing increased erosion,

7. Canyon Island Salmon Monitoring Plan

7.1 Introduction

The Tulsequah Chief Mine Air Cushion Barge (ACB) transportation system is intended to operate almost year-round along the mainstem of the Taku River. However, during the aquatic season, the west channel is too narrow at Canyon Island for the tugs to safely navigate the ACB through the narrows. Therefore, the ACB will be towed along the east channel of Canyon Island by team of amphibious, low-ground pressure tractors (Redfern Resources, 2008a). The east channel of Canyon Island contains important spawning and rearing habitat for salmonids. Concerns have been raised that ACB operations within this area may cause increased turbidity in clear-water habitats, stranding of juveniles, and visual disturbance to adult fish. The background information on wake effects causing stranding and turbidity in the previous monitoring plans. The following literature review focuses on visual disturbance to fish.

To date, no literature on the visual disturbance of adult freshwater fish in regards to changes in reproductive success and fecundity has been identified. It has been observed that freshwater adult fish are easily frightened by a visual disturbance (i.e., sudden movement or presence), but quickly resume to natural holding and/or spawning behaviour once the visual disturbance has ended. In absence of literature regarding visual disturbance effects, research on noise effects has been used as a proxy. There is a body of research with respect to noise effects on fish. For the purposes of

this monitoring plan, we are assuming that physiological responses to visual disturbance should be very similar (i.e., increase in cardiac output) to physiological responses to noise disturbance.

In general, freshwater fish mainly respond to low frequency noise (i.e., primarily substrate movement) but much of their hearing is likely masked by ambient noise in a turbulent river (Hawkins and Johnstone, 1978). In addition, noise originating in the air went largely undetected by Atlantic salmon (*Salmo salar*) in the River Dee, Scotland (Hawkins and Johnstone, 1978). A similar study conducted on Pacific salmon eggs showed no increase in mortality when exposed to sonic booms (Rucker, 1973). Rainbow trout (*Oncorhynchus mykiss*) yearlings exposed to sonic booms exhibited no change in physiological performance and little to no behavioural reaction. Graham and Cooke (2008) measured the physiological disturbance to adult largemouth bass (*Micropterus salmoides*) from underwater noise sources created by canoe paddles, a small trolling motor, and outboard motor and found that all fish experienced sub-lethal increases to cardiac output to all noise sources. The strongest cardiac response, and subsequently the longest cardiac recovery time (~40 minutes) on the adult fish, was initiated by the outboard motor (Graham and Cooke, 2008).

7.2 Purpose and Objectives

Concerns have been raised that ACB operations along the east channel of Canyon Island will disrupt juvenile fish and adult fish i.e., during rearing or during spawning activity. The purpose of the Canyon Island Monitoring Plan is to have a plan focused on the issues related to barge passage around Canyon island including potential impacts to juvenile fish (i.e., stranding) and fish habitat (i.e., increased turbidity), and to adult salmonids (i.e., visual disturbance). The details of the turbidity and stranding study are provided in pervious sections. The objectives of the monitoring plan for assessing disruption to salmonid movement includes recording response to presence of the barge and tow vehicles along the proposed route, recording the time it takes fish behaviour to return to pre-passage conditions. Field reports outlining the results of Canyon Island monitoring field visits and a final annual report will be provided that will describe all observations.

7.3 Methodology

7.3.1 Selection of Monitoring Sites

Additional monitoring sites will be chosen for assessing the turbidity and juvenile stranding issue along the east channel of Canyon Island. These sites will be located along clear-water areas in close proximity to ACB operations that enter and exit the water. These sites have not yet been plotted on the ACB Route atlas.

Three monitoring zones will be located within the proposed ACB route along the east channel of Canyon Island to monitor for visual disturbance. These monitoring zones will be of sufficient size to encompass both adult salmonid holding habitat and spawning habitat. The exact location of these

zones may change in relation to the actual location of holding/spawning adult fish within the east channel.

7.3.2 Data Collection

The nature of the turbidity and stranding of juvenile monitoring have been described in previous sections

The following activities will be conducted at each visual disturbance monitoring zone:

- confirmation of the presence of holding and/or spawning adult salmonids;
- observe the behaviour of the adult salmonids before, during and after the passage of the ACB transportation vehicles;
- record behavioural changes (i.e., agitation – sudden movements, relocation to another area, etc.), if any, to the holding/spawning adult salmonids within the monitoring zones during ACB operations within the east channel;
- if behavioural changes are observed, record the time for the holding/spawning salmon to return to normal behaviour/activities; and
- if adult salmon are frightened from the immediate area, note where the salmon relocated and if/when it returns to its original location.

During the first season of ACB operations, weekly monitoring through the open water season is proposed.

7.4 Reporting

Field reports will be provided following all field visit(s), containing photos and documentation of observations of all sites during the Canyon Island monitoring. A final report will be issued at the end of each year that will outline:

- the results of the turbidity monitoring of clear-water habitats during ACB operations within the east channel of Canyon Island;
- the results of the juvenile stranding monitoring during ACB operations within the east channel of Canyon Island;
- the results of the visual disturbance monitoring during ACB operations within the east channel of Canyon Island; and
- the Canyon Island monitoring program will also outline the success of mitigation measures used to reduce the observed effects, if any, of ACB operations within the east channel of Canyon Island.

8. Winter Open Lead Crossings

8.1 Introduction

The Tulsequah Chief Mine Air Cushion Barge (ACB) transportation system is intended to operate almost year-round. During the non-aquatic season, the ACB will be towed over the frozen Taku River by team of amphibious, low-ground pressure tractors. Open leads occur on the Taku River, with increasing extent during the shoulder seasons (freeze-up and break-up). Generally, an ice thickness of 0.3 m has been identified by the equipment manufacturer as being required for over-ice travel by the ACB transportation system without causing extensive ice breaking. In the proximity of open leads, the thickness of ice will decrease approaching the open water. Crossing of the leads by the ACB transportation system is undesirable from both an operational logistics and environmental perspective. However, due to the nature of the Taku River and the nearly year-round operation of the ACB transportation system, it is inevitable that some open lead crossings will be required during the non-aquatic season. Based on monitoring of ice conditions on the river in early 2008, areas where the barge may have to cross open leads were identified and have been located on the Route Atlas in Appendix A.

Generally, the operational procedure for crossing open leads will be as follows:

1. Assess open leads and determine if stable ice/frozen route exists to allow both the amphibious tractors and the air cushion barge to circumnavigate the lead. If a route exists, then adjust route to avoid lead crossing entirely;
2. If the open lead cannot be circumnavigated entirely, determine if amphibious tractor (which is significantly smaller and more mobile than the ACB) can circumnavigate the open lead. If tractor can circumnavigate the lead, then assess open lead to determine optimum crossing location for ACB (typically shortest/narrowest portion of lead). Amphibious tractor then circumnavigates open lead extending winch cable(s) from ACB. Once established on the far side of the crossing location, anchor the amphibious tractor and winch the ACB across the open lead. Support vehicles and/or additional amphibious tractors should either be stowed on the deck of the ACB for the lead crossing, if possible, or circumnavigate the open lead under their own power; and
3. If the open lead cannot be circumnavigated by any of the equipment, then a full crossing of the open lead is required. This is described in section 2.2.2 of the August 2008 Air Cushion Barge Transportation System: Operations Plan (prepared by Redfern Resources Ltd.)

The aquatic risk assessment completed as part of this project's environmental assessment indicates that the mitigated aquatic environmental effects associated with this activity are likely to be moderate to low. Given the unique nature of this project, there are uncertainties associated with this activity. Moderate residual effects are largely related to uncertainty associated with sedimentation effects associated with the open lead crossings. As such, the following monitoring plan, as part of the ACB transportation system's adaptive management plan, will monitor the environmental effects of the open lead crossings and the effectiveness of the mitigation measures.

8.2 Purpose and Objectives

The purpose of the Open Lead monitoring plan is to assess the environmental effects of the open lead crossings, the effectiveness of the mitigation measures and identify opportunities to modify operations to further mitigate and reduce residual effects associated with open lead crossings of the Taku River.

Specific monitoring objectives are as follows:

1. Document the location, frequency, seasonality and spatial extent of open lead crossings required;
2. Document the nature of open lead crossings (full or partial lead crossing);
3. Document the environmental conditions of the open lead crossing (river morphology, water conditions, extent and nature of ice cover etc.);
4. Assess the effects of the lead crossings on both ice-extent at the lead crossing and downstream of the crossing (e.g., accumulations of ice);
5. Assess sedimentation effects of the open lead crossing locations;
6. Assess direct effects on fish at the open lead crossings; and
7. Assess impacts to the river substrate at the lead crossing locations.

8.3 Methodology

Prior to the start of ACB operations an assessment of the likely locations of open lead crossing will be carried out. Based on the monitoring of the river conditions in early 2008 these potential crossing locations have been identified and marked on the route atlas provided in Appendix A. The initial habitat assessment took place mid-September 2008 and data collected will be used to refine this operational monitoring plan. The operational open lead monitoring plan generally consists of three phases: 1) an initial comprehensive monitoring event; 2) an extended focused monitoring period; and 3) reporting.

8.3.1 Initial Monitoring

Initial comprehensive monitoring shall be conducted for initial non-aquatic return-transit of the Taku River by the ACB transportation system. During this initial monitoring, the environmental monitor shall observe every open lead crossing en route to determine the variability and scope of potential environmental effects associated with the specific lead crossing locations. Based on this initial comprehensive monitoring, a set of up to ten lead crossing locations along the length of the route shall be selected for an extended period of focused monitoring. These locations should be representative of the range of environmental conditions and potential environmental effects associated with the open lead crossings. If it is found that the open lead crossings have very similar environmental conditions and potential effects, then the number of sites used in the extended monitoring period can be reduced such that a meaningful, focused monitoring program is implemented. A brief letter report, accompanied by an annotated map and photos, shall be

produced following the initial monitoring event documenting the observations and the proposed sites for the focused monitoring period.

8.3.2 Focused Monitoring

Up to ten sites along the entire ACB route shall be selected for focused monitoring over the winter barging period. These sites should represent the range of environmental conditions and potential environmental effects associated with open lead crossing. These sites should be monitored:

- initially for each trip for the first week; and
- then weekly for the remainder of the non-aquatic season of the first year.

Monitoring frequency maybe increased during the break-up period or during other periods of substantive environmental change (e.g., unusual cold weather, premature breakup, etc.) at the discretion of the environmental monitor.

Following the first and every subsequent year's monitoring, the monitoring requirement and frequency shall be assessed for the future year.

8.3.3 Open Lead Monitoring Parameters

At each open lead crossing, the following items shall be monitored. A standardized field form will be developed for the recording the appropriate information at each of the monitoring sites.

Lead Crossing Description

- Date, time, and geographic location (description and GPS coordinates) of open lead crossing.
- Nature of lead crossing, including direction of travel (upriver or downriver), payload, fleet inventory (name of ACB, and tow equipment inventory), partial or full lead crossing (e.g., ACB only, or ACB and amphibious tractor(s).
- Time taken to complete lead crossing.
- Observation of percentage of lead crossing where amphibious tractor was "touching" river bottom versus floating.

Environmental Conditions

- Weather conditions at time of lead crossing (include air and water temperature, and brief summary of weather conditions during previous week).
- Dimensions of open lead (approximate width at crossing and lead length upstream and downstream of crossing), prior to crossing.
- Description of river morphology at lead crossing location (riffle, pool, etc.). Include description of type of lead (thalweg, side channel, groundwater bed, etc). Note proximity of groundwater discharge areas (hyporheic discharge zones)
- Description of river morphology and fish habitat downstream of lead crossing location.
- Description of river substrate, if visible.
- Estimate of water depth and velocity at open lead crossing location.

Ice Effects

- Changes in lead size (e.g., extent of ice breaking occurring, width and length) – quantify extent of ice breaking, if it occurs.
- Document ice conditions at downstream end of lead prior to crossing (e.g., presence of jumble ice and extent of existing jumble ice).
- Document downstream ice conditions after lead crossing (e.g., accumulation of significant new jumble ice, etc.).

Turbidity Effects

- Brief written description of water conditions before lead crossing.
- Field turbidity measurements before lead crossing, during (downstream of ACB) and after, safety permitting. Sampling frequency to be determined on-site by environmental monitor based on observed effects.
- Written description of observed turbidity conditions before, during and after lead crossing, including duration of residual turbidity and downstream extent of ACB related turbidity, if any.

Fish Effects and Other

- Written results of visual inspection of lead crossing location prior to crossing for presence of fish (adults or juveniles) and redds, safety permitting.
- Observation and description of effects (e.g., disturbance) on any fish observed prior to the crossing, if any. Observe and document after crossing is completed to assess temporal effect (e.g., how long until fish return to the crossing location if disturbed during the crossing procedure).
- Document any mishaps or operational challenges.
- Identify any recommendations for optimizing open lead crossings and opportunities for meaningful reduction in environmental effects, if any.

Photographs

- Open Lead before crossing, including upstream and downstream of lead crossing location.
- Amphibious tractor entering, crossing and existing lead.
- ACB entering, crossing and exiting lead.
- Photos of substrate, if possible.
- Ice conditions downstream (specifically downstream end of lead) before and after lead crossing).

8.4 Reporting

At the end of the non-aquatic operation season, a Winter Open Lead Crossing Monitoring and Assessment report shall be produced by a qualified environmental consultant. The written report

shall be produced with two months of the end of the non-aquatic season. The report shall be accompanied CD-ROM (or equivalent digital media) containing all field reports/observations, data and photographs generated during the monitoring period.
The report shall include:

1. A brief narrative summarizing of the extent of lead crossing operations over the non-aquatic season;
2. A map (or series of maps) illustrating the lead crossings, frequency and seasonality;
3. A photographic log providing a representative illustration of the range of lead crossing conditions and observed environmental effects, include seasonal changes;
4. A written summary of observed environmental effects related to the ACB transportation system, including:
    - changes to ice conditions at the lead crossing (including temporal extent);
    - observed changes to ice conditions downstream of the lead crossing location(s);
    - turbidity effects;
    - changes/effects on river substrate at the crossing location (include temporal duration – e.g., were the substrate effects still observable on return trips to that location); and
    - observations of direct effects on fish, if any.
5. A professional assessment of the significance of the observed environmental effects; and
6. Recommendations for operational modifications that could result in meaningful reductions to undesirable environmental effects.

9. Thickening of Thalweg Ice from Snow Packing

9.1 Introduction

Winter barge operations on the Taku River may have the potential to alter the ice break-up regime during the spring. Specifically, the packing of snow at thalweg crossings during winter barge operations may thicken the ice in these areas and possibly alter the nature and timing of ice break-up along the Taku River. In response, the following Thalweg Ice monitoring plan has been developed to monitor the ice thickness and timing/nature of the ice break-up during winter barge operations on the Taku River. Generally, an ice thickness of 0.3 m has been identified by the equipment manufacturer as being required for over-ice travel by the ACB transportation system without causing extensive ice breaking. In the proximity of open leads, the thickness of ice will decrease approaching the open water.

Ice break-up in rivers have a profound influence on the structure and function of lotic ecosystems. During break-up, river ice can scour bed sediments (Prowse, 1994), rapidly change the water temperature (Marsh and Prowse, 1987), and cause abrupt, intermittent flooding in localized areas

(Scrimgeour *et al.*, 1994). From an ecological perspective, variability in the magnitude and timing of ice break-up can: influence the amount of organic matter entering the river (Sedell *et al.*, 1989), affect algal productivity, and affect consumer productivity (as reviewed by Scrimgeour *et al.,* 1994). The magnitude of ice break-up on both abiotic and biotic systems is dependant on a variety of hydraulic and meteorological conditions. Typically, there are two types of ice break-up events on rivers: dynamic and thermal (Scrimgeour *et al.*, 1994).

Dynamic ice break-ups occur where local climate conditions produce melting and ice break-up in a downstream direction; heightening the risk if ice jams and severe flooding. In contrast, thermal ice break-ups occur when local climate conditions warm and reduce ice thickness in an upstream direction, prior to spring melt; reducing the risk of ice jamming and bed scour. Although both types of ice break-up regimes can have similar significant effects on aquatic ecosystems, thermal ice break-up events occur with much less intensity and have smaller scale impacts to river environments than dynamic break-ups (Scrimgeour *et al.,* 1994).

The ice break-up along the Taku River is typified by a thermal break-up; where ice cover reduces and ablates prior to spring melt. However, river ice within the Sand Flats area of the Taku River tends to melt last, due to the close proximity of the Taku and Hole in the Wall glaciers that provide a locally cooler climate, promoting thicker river ice conditions. Consequently, the Sand Flats area will support jumble ice formation, and the occasional ice jam, although not of magnitude that creates ice jam flooding as characterized by dynamic ice break-ups.

9.2 Purpose and Objectives

Concerns exist that the proposed barging operation on the Taku River has the potential to alter the timing and magnitude of the river ice break up within areas of the proposed barge route. Winter barge operations along the Taku River may pack snow on the ice along the proposed barge route. Packed snow on ice across the thalweg may increase ice thickness and potentially delay the thermal ice break-up along the Taku River. Given the wide range of potential impacts to the aquatic ecosystem from a delay in ice break-up, a Thalweg Ice Monitoring plan has been developed. Note that monitoring of affects to wildlife associated with snow packing is detailed in the Moose effects section of the Wildlife Monitoring Plan. The objective of the Thalweg Ice Monitoring plan is as follows:

- selection of suitable monitoring locations along the proposed winter barge route on the Taku River at thalweg crossing locations;
- monitoring of Taku River ice thickness and observing the progression of the spring thermal ice break-up; and
- to provide field reports outlining the results of ice thickness monitoring field visits. A final annual report will also be provided that will describe in detail all observations of ice break-up and analyses of the ice thickness assessment. The final report will also outline potential mitigation measures that could be implemented that would reduce the effect of snow packing (if any) from winter barge operations.

9.3 Methodology

9.3.1 Selection of Monitoring Sites and Data Collection

Monitoring sites will be chosen at thalweg crossings where barge operations are packing snow. A minimum of five monitoring sites will be visited on weekly during the winter to measure the effect of snow packing from barge operations on river ice thickness. The Route Atlas in Appendix A shows sites where winter monitoring may be required. The following data will be collected at each monitoring location:

- ice thickness will be measured within the snow packed barge track along the thalweg at each monitoring site;
- for control purposes, ice thickness will also be measured one barge width upstream and downstream outside the snow packed track along the thalweg; and
- snow depth measurements inside and outside the barge track will also be measured.

Field visits will also be conducted to monitor the progression of the thermal melt/ice break-up during the spring; during these visits the following will be recorded:

- photo-documentation showing the barge route and snow packing in relation to open leads;
- photo-documentation showing the melting/breaking-up progression at snow-packed thalweg crossings; and
- duration and timing of melt/break-up event.

9.3.2 Reporting

Field reports will be provided following all field visit(s), containing maps, and photos of all sites during ice thickness monitoring and melt/break-up river ice progression at thalweg crossings. A final report will be issued at the end of each year that will outline:

- the results of the ice thickness analyses;
- the progression of melt/break-up along the Taku River in relation to snow packed areas along the thalweg;
- general observations made during the river ice melt/break-up; and
- if the results of the monitoring program show that snow packed areas tended to delay ice break-up, mitigation measures that may be employed to reduce snow packing will be identified.

10. Summary

The ACB transportation system has been developed by Redfern Resources as a cost efficient and environmentally superior option to building the, currently approved, 100 mile resource road from

Atlin, BC to the mine site. Barging would be used to transport operational supplies to the mine site and ore concentrate to Juneau over the life of the mine. Barging would take place along 37 miles of the Taku River from the mouth to the confluence with the Tulsequah River. Once the mine is decommissioned barging would cease, leaving behind little evidence of the barging activities. The environmental monitoring and adaptive management plan proposed here will monitor the effects of barging on aquatic and terrestrial (provided in a separate report) resources on the river. If effects are greater than expected or if unanticipated effects are noted, the adaptive management committee will work with Redfern Resources to develop appropriate changes to the operational plan to keep barging effects at acceptable levels.

Six aquatic monitoring plans have been developed for the Alaskan portion of the barging route. The scope of these studies is focused on addressing specific issues identified through the environmental review and permitting process for the barging. These plans involve collecting data at important fish habitat sites along the barging route, including Canyon Island, creek mouths and clear water habitats connected to the Taku River. The coverage provided by the monitoring plans will be broad enough to also identify any unanticipated effects from barging.

Table 1 provides a proposed schedule for the monitoring programs and a tentative meeting schedule for the adaptive management committee. It is anticipated that this schedule and the monitoring plans will be modified prior to the start of ACB operations in January 2009. Through 2008 Gartner Lee collected fish and fish habitat data related to the proposed monitoring plans. The collected information is currently being collating and assessed in the context of the proposed monitoring plans and if appropriate recommendations will be made to adjust the operational monitoring plans. Therefore, it is anticipated that the adaptive management committee be established in time to review recommended changes to the monitoring plans and accept the recommendations as appropriate prior to the start of barging.

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Table

Table 1. ACB Aquatic Effects Monitoring & Mitigation Plan - 2009 Monitoring Schedule

Tulsequah Chief Project - ACB Transportation System

Assumed ACB Start Operations Date: 1-Jan-09

Plan #	Monitoring Program / Month No. / Month / Operational Mode	1 Jan-09 Non-aquatic	2 Feb-09 Non-aquatic	3 Mar-09 Non-aquatic	4 Apr-09 Non-aquatic[1]	5 May-09 Aquatic	6 Jun-09 Aquatic	7 Jul-09 Aquatic	8 Aug-09 Aquatic	9 Sep-09 Aquatic	10 Oct-09 none	11 Nov-09 Non-aquatic[1]	12 Dec-09 Non-aquatic
1	**Wake Induced Turbidity of Clear Water Fish Habitat**												
	Operational Monitoring					w[1],F	w[2],F			w,F	R		
2	**Wake Induced Juvenile Stranding**												
	Operational Monitoring					w[1]	w,F	w,F	w,F	w,F			
3	**LWD Relocation[3]**												
	Reconnaissance Survey				1 - low flow, after breakup; 2 - just before ACB ops.; F			x (post jokulhlaup); F	x (post jokulhlaup); F	x (post jokulhlaup); F			
	Field Assessment				x (if LWD relocation potentially required); F	x (if LWD relocation potentially required); F		x (if LWD relocation potentially required); F	x (if LWD relocation potentially required); F	x (if LWD relocation potentially required); F	R		
4	**Wake Induced Bank Erosion**												
	Operational Monitoring								w[2],F	w,F	R		
5	**Bow Wake Induced Sediment Mobilization**												
	Operational Monitoring					w[1],F	w[2],F		w[2],F	w,F	R		
6	**Thickening of Thalweg Ice from Snow Packing**	w,F											
	Operational Monitoring			w,F	w[1],F	R						w[1],F	w,F
7	**Winter Open Lead Crossing**												
	Operational Monitoring	e (for first week), w, F	w	w	w[1]	R						w[1]	w
8	**Canyon Island Salmon Monitoring**												
	Operational Monitoring					w[1],F	w,F	w,F	w,F	w,F	R		
9	**Adaptive Management Committee**												
	Operational Monitoring						M	R				M	R

Notes:

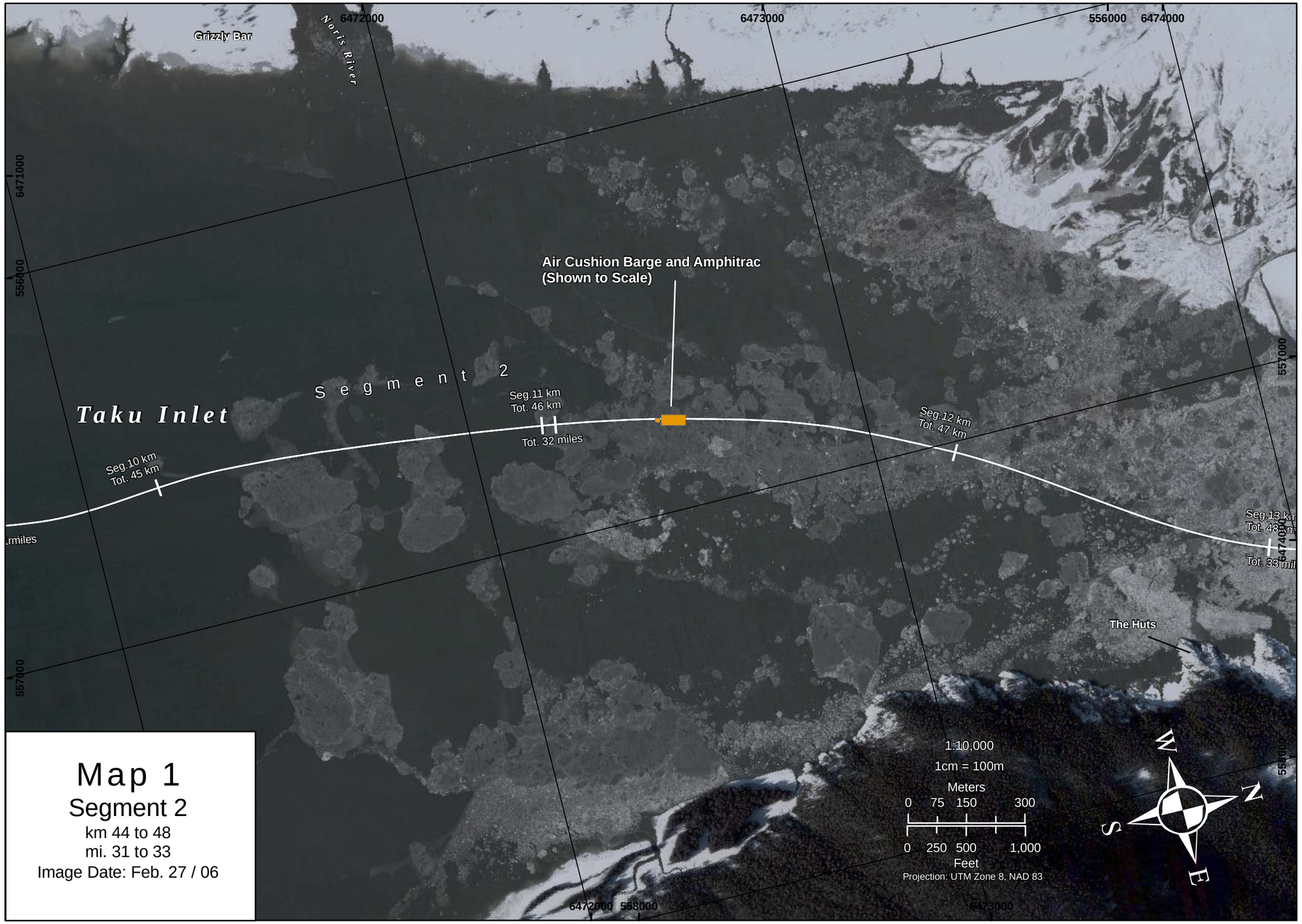
- *F* — *Field report due.*
- *R* — *Annual/seasonal report due.*
- *M* — *Meeting.*
- *w* — *Weekly monitoring.*
- [1] *Partial season - will depend on freeze-up/break-up schedule.*
- [2] *Partial season - river levels / flows.*
- *e* — *Each trip.*
- [3] *Note that LWD relocation is anticipated only on the Canadian portion of the route, not on the U.S. side of the Taku River.*

Appendix A

Aquatic Effects Monitoring and Mitigation Plan Monitoring Sites. Taku River Barging Route Atlas

Aquatic Effects Monitoring & Mitigation Plan Monitoring Sites

Taku River Barging: Route Atlas



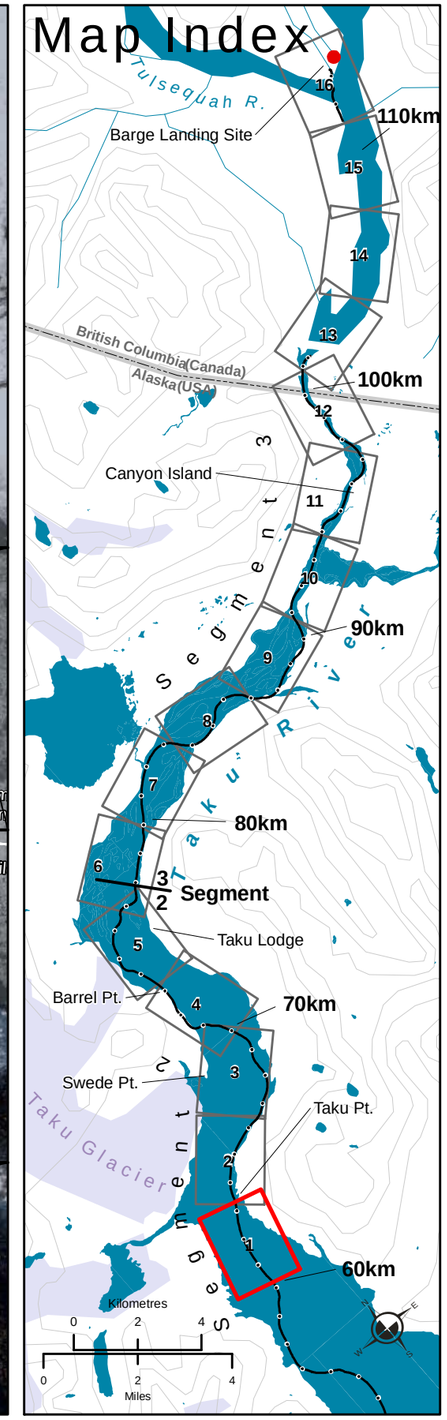
Map 1

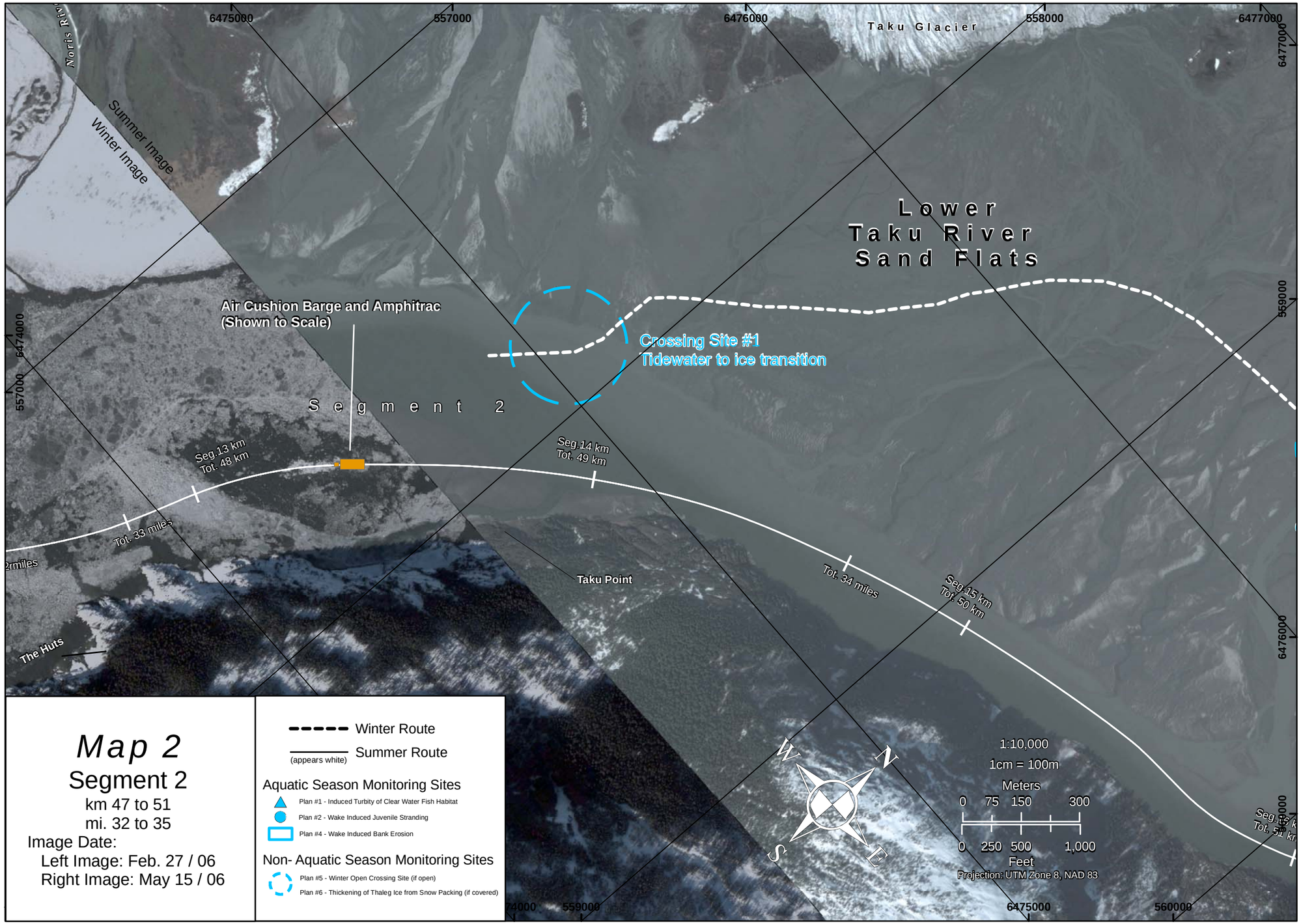
Segment 2

km 44 to 48

mi. 31 to 33

Image Date: Feb. 27 / 06





Map 2

Segment 2

km 47 to 51

mi. 32 to 35

Image Date:

Left Image: Feb. 27 / 06

Right Image: May 15 / 06

Winter Route

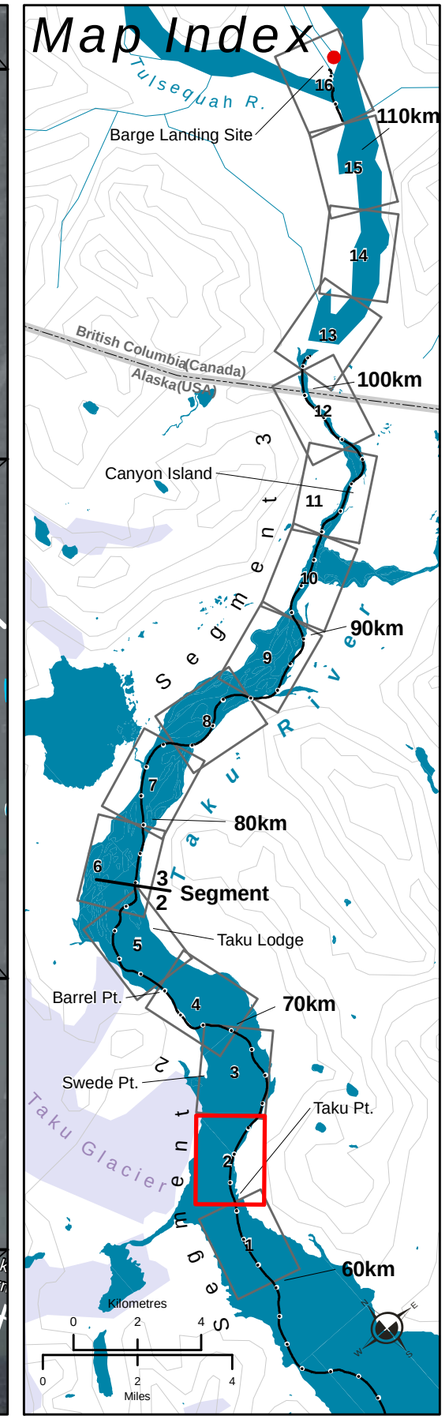
Summer Route (appears white)

Aquatic Season Monitoring Sites

- Plan #1 - Induced Turbity of Clear Water Fish Habitat
- Plan #2 - Wake Induced Juvenile Stranding
- Plan #4 - Wake Induced Bank Erosion

Non- Aquatic Season Monitoring Sites

- Plan #5 - Winter Open Crossing Site (if open)
- Plan #6 - Thickening of Thaleg Ice from Snow Packing (if covered)



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Printed: September 2008

82636__DFIG_Taku_River_Barging_Route_AEMMP_Map2_ver1.mxd

Map 3

Segment 2

km 50 to 55

mi. 34 to 37

Image Date: May 15 / 06

Winter Route

Transition Season Alternate Route

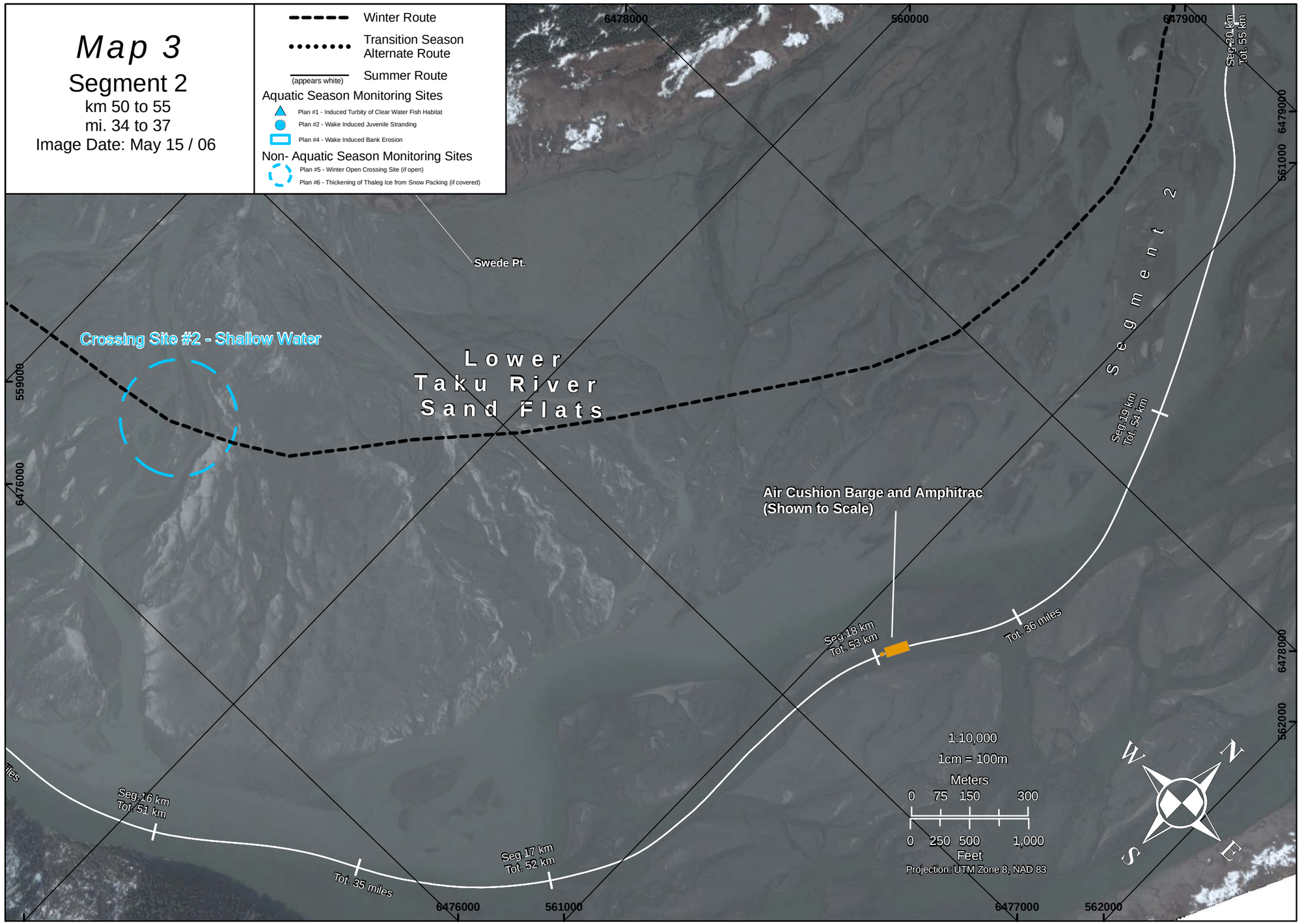
Summer Route (appears white)

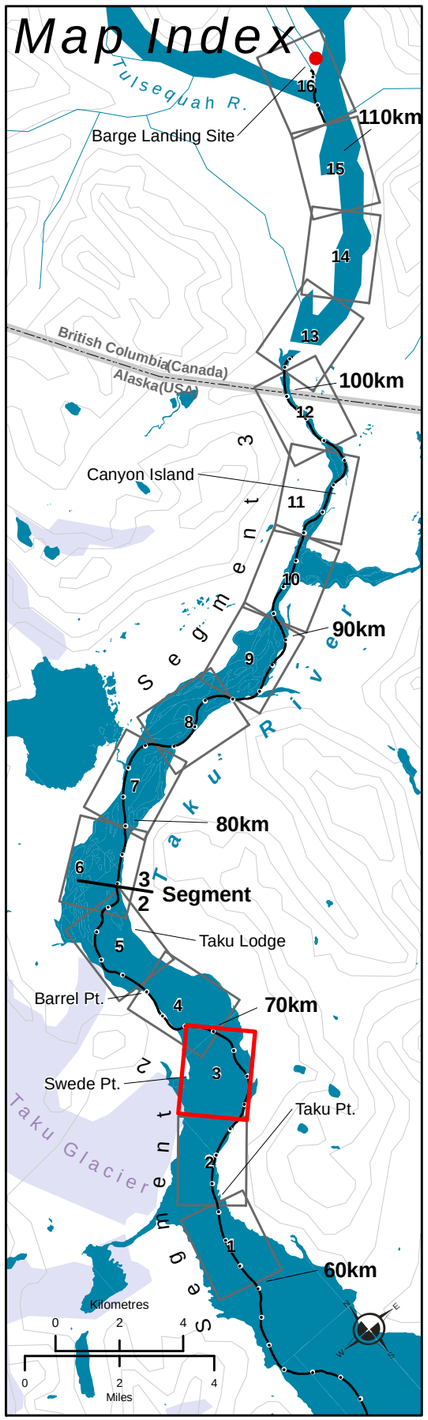
Aquatic Season Monitoring Sites

- Plan #1 - Induced Turbity of Clear Water Fish Habitat
- Plan #2 - Wake Induced Juvenile Stranding
- Plan #4 - Wake Induced Bank Erosion

Non- Aquatic Season Monitoring Sites

- Plan #5 - Winter Open Crossing Site (if open)
- Plan #6 - Thickening of Thaleg Ice from Snow Packing (if covered)





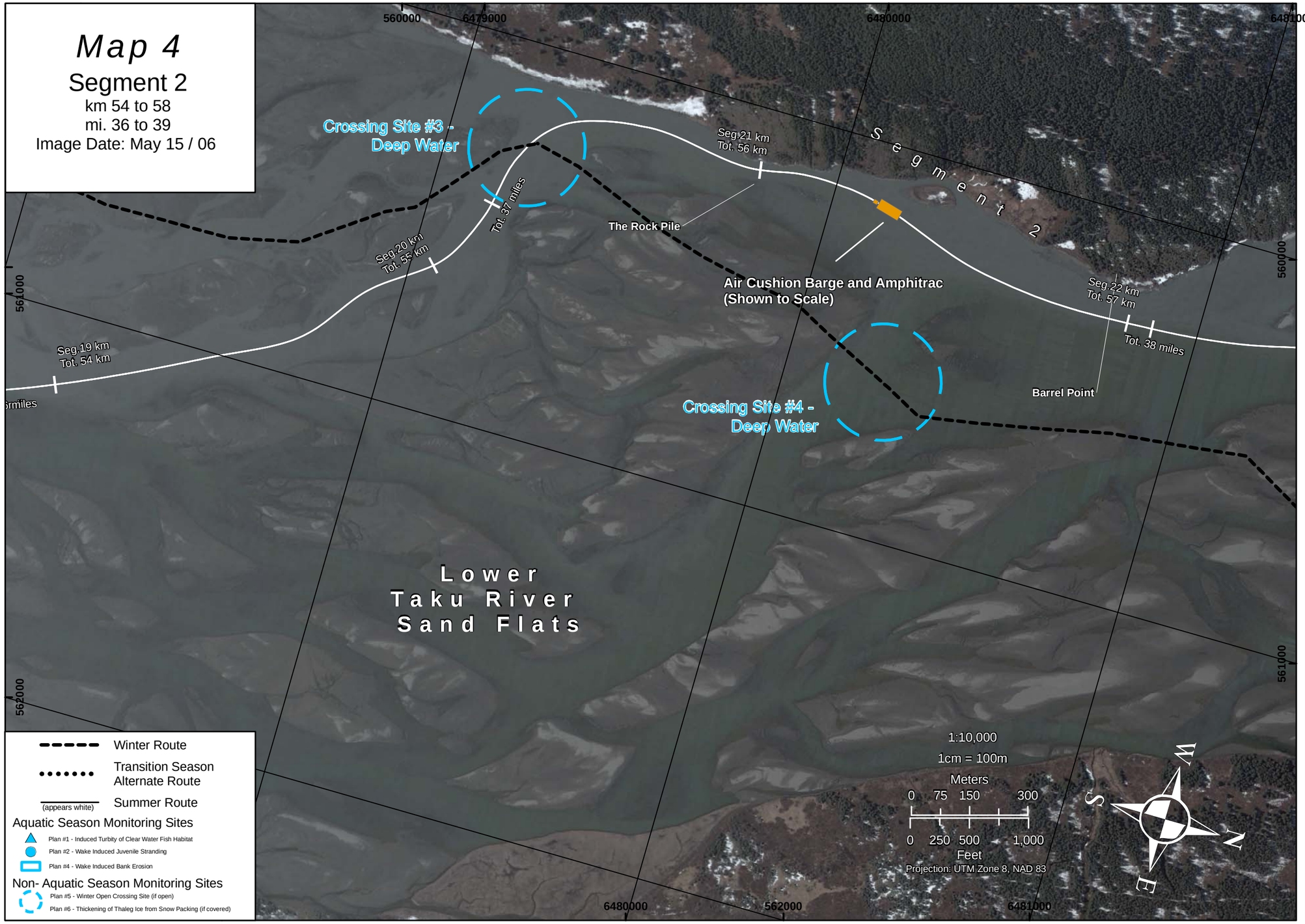
Map 4

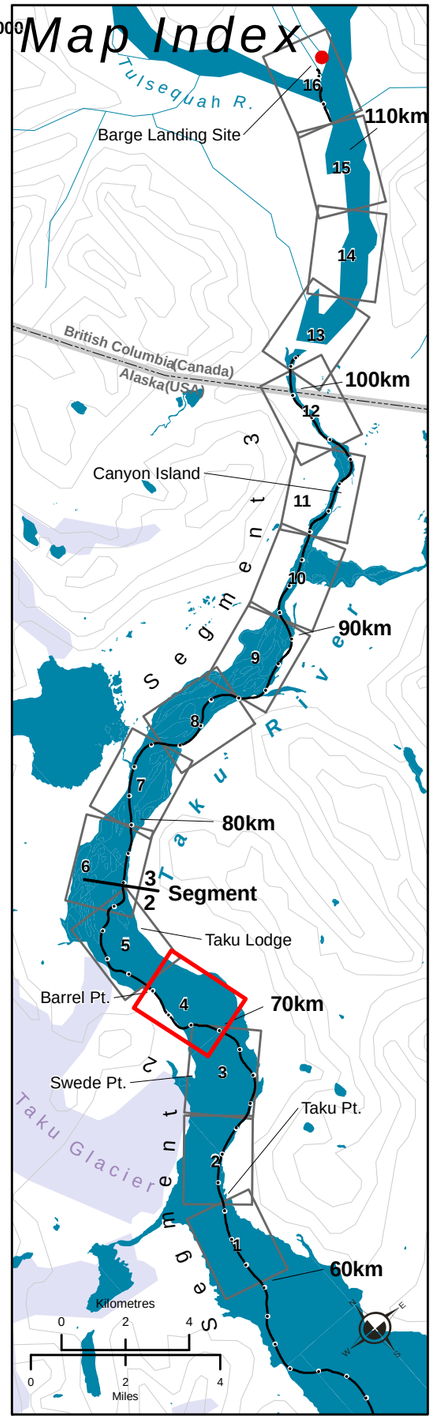
Segment 2

km 54 to 58

mi. 36 to 39

Image Date: May 15 / 06





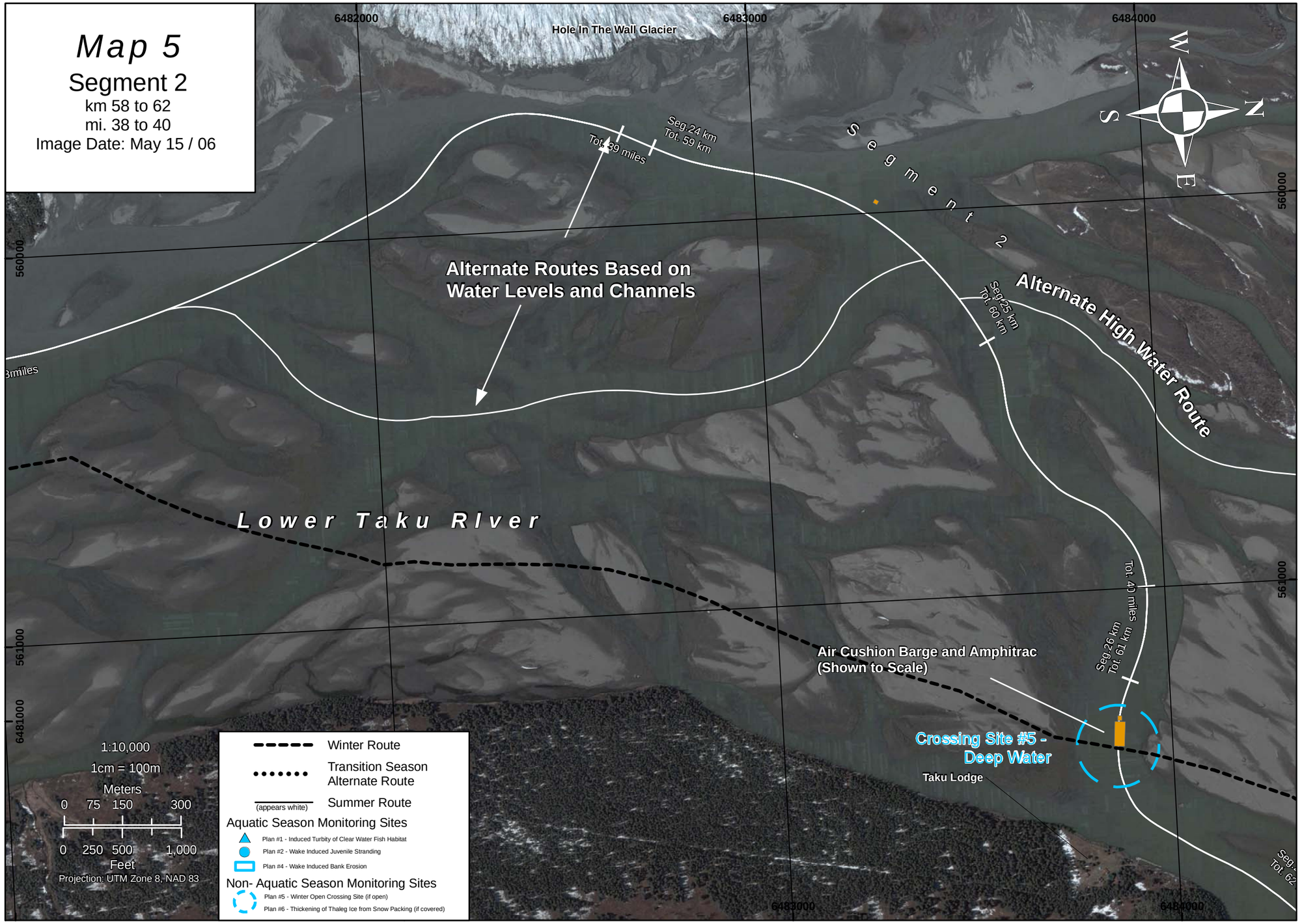
Map 5

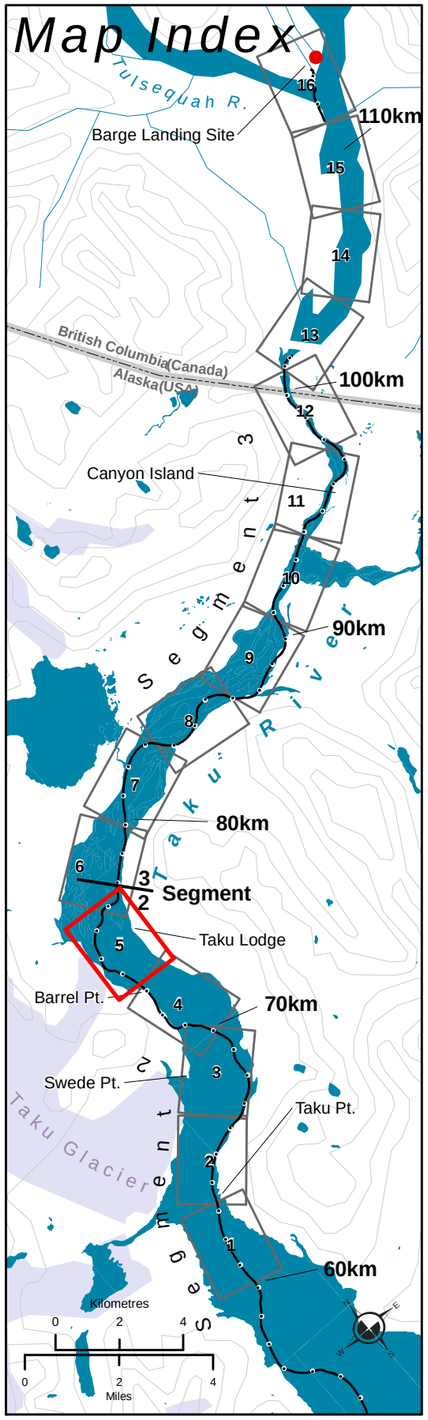
Segment 2

km 58 to 62

mi. 38 to 40

Image Date: May 15 / 06





Gartner Lee Limited

Aquatics Effects Monitoring & Mitigation Plan Monitoring Sites

Tulsequah Chief Mine - ACB Transportation System

Redfern Resources Ltd.

Map 6

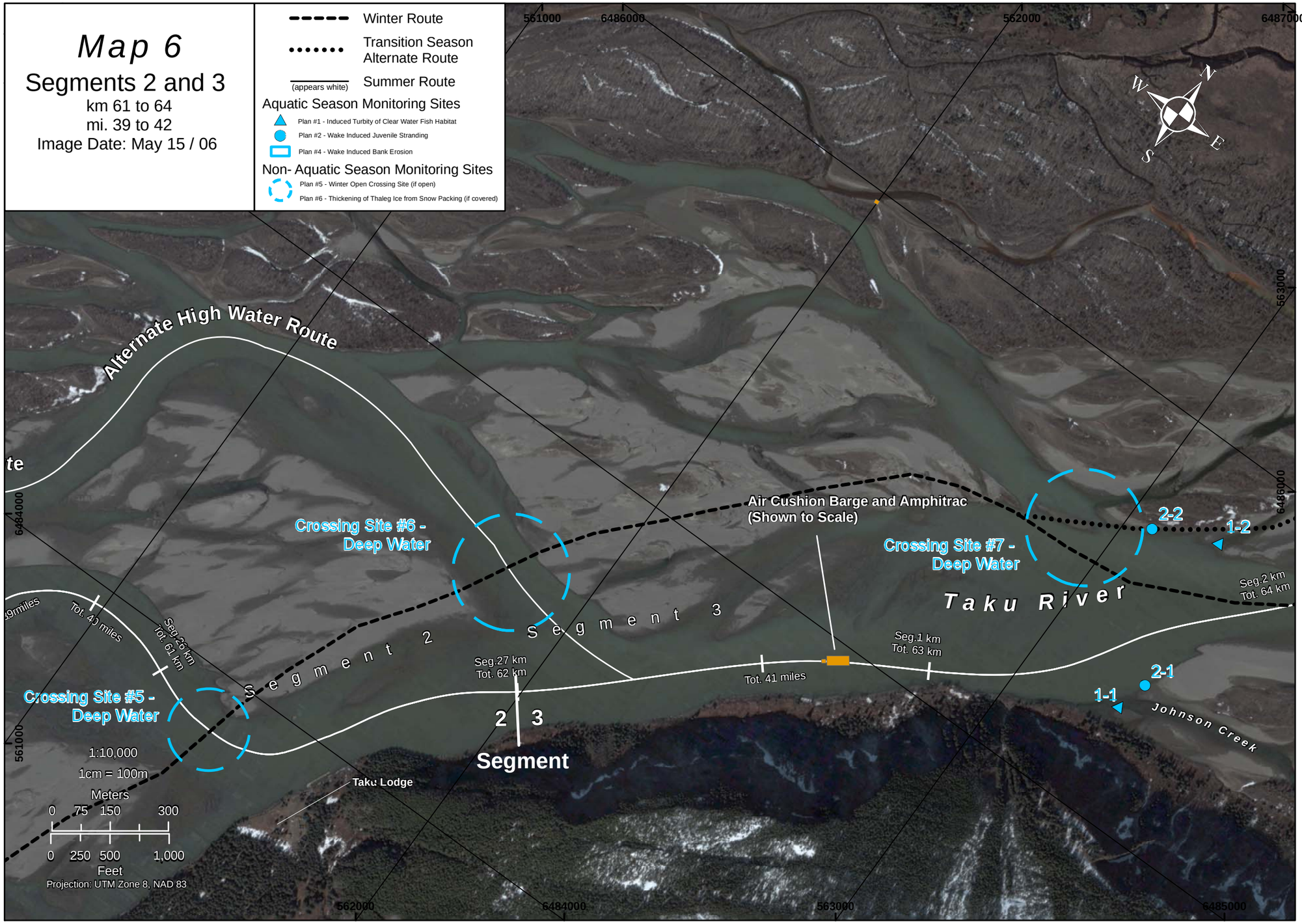
Segments 2 and 3

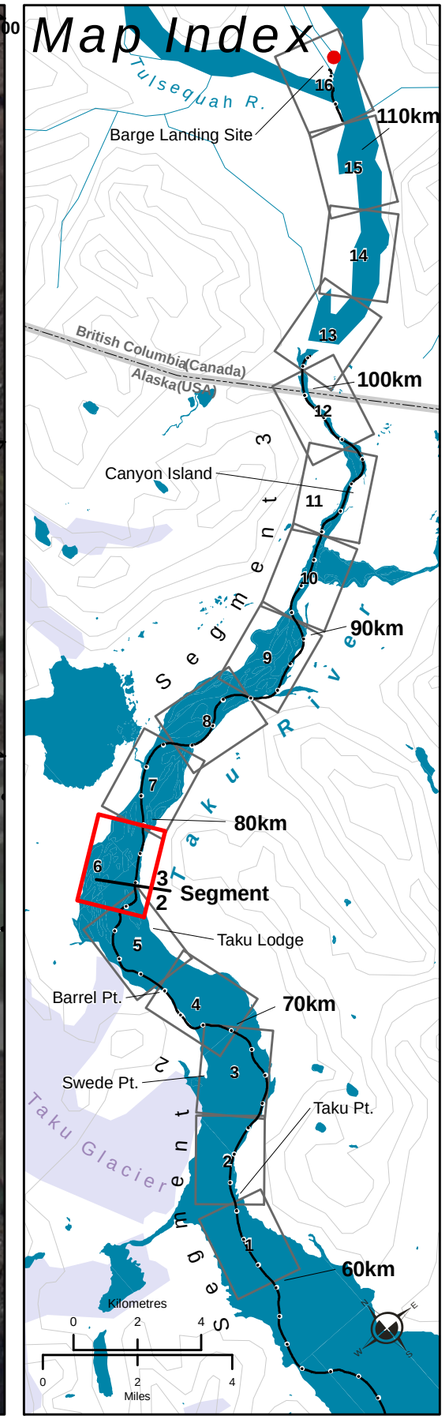
km 61 to 64
mi. 39 to 42
Image Date: May 15 / 06

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

Aquatic Season Monitoring Sites
- Plan #1 - Induced Turbity of Clear Water Fish Habitat
- Plan #2 - Wake Induced Juvenile Stranding
- Plan #4 - Wake Induced Bank Erosion

Non- Aquatic Season Monitoring Sites
- Plan #5 - Winter Open Crossing Site (if open)
- Plan #6 - Thickening of Thaleg Ice from Snow Packing (if covered)





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Printed:September 2008

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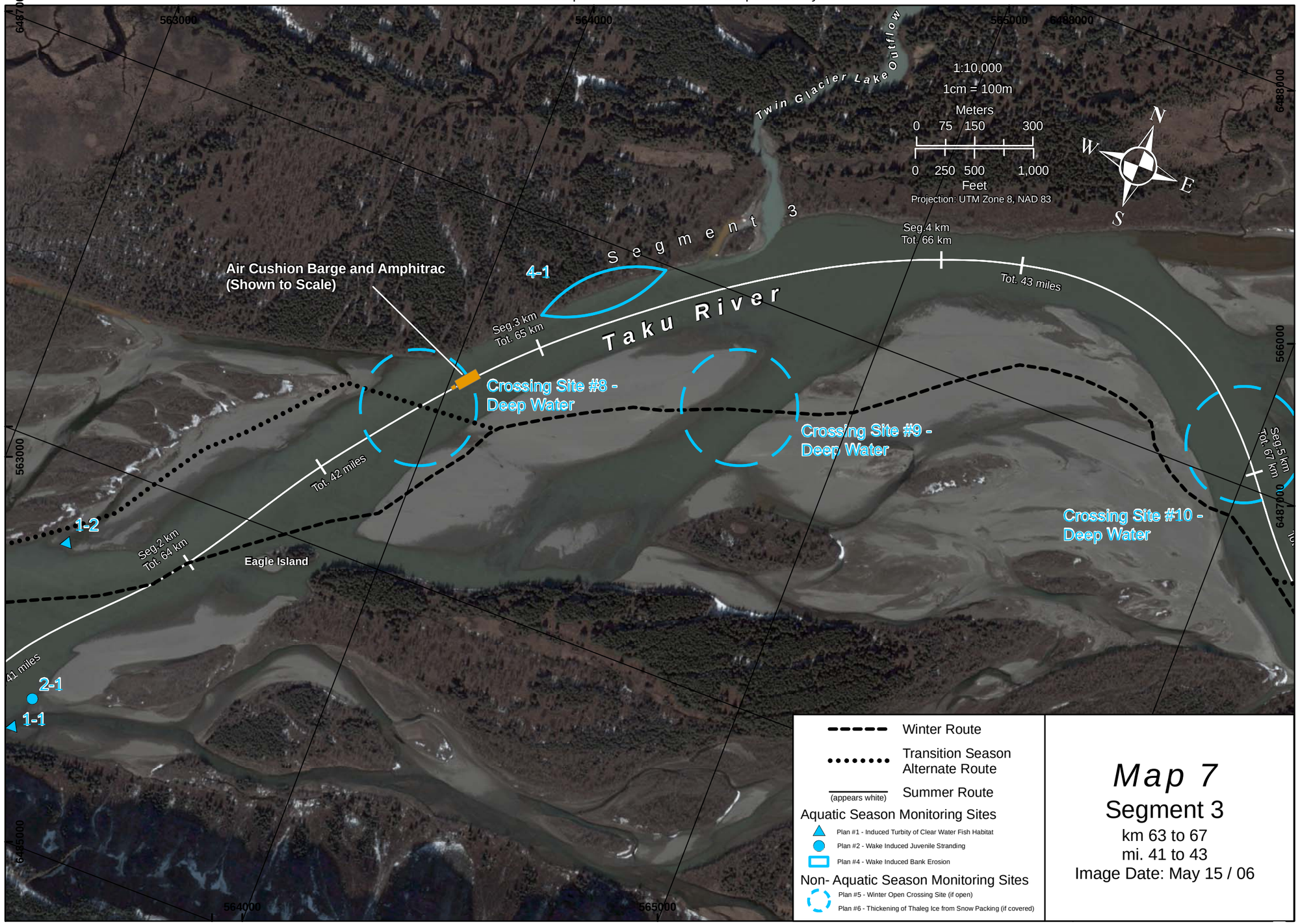
Aquatics Effects Monitoring & Mitigation Plan Monitoring Sites

Tulsequah Chief Mine - ACB Transportation System

Redfern Resources Ltd.



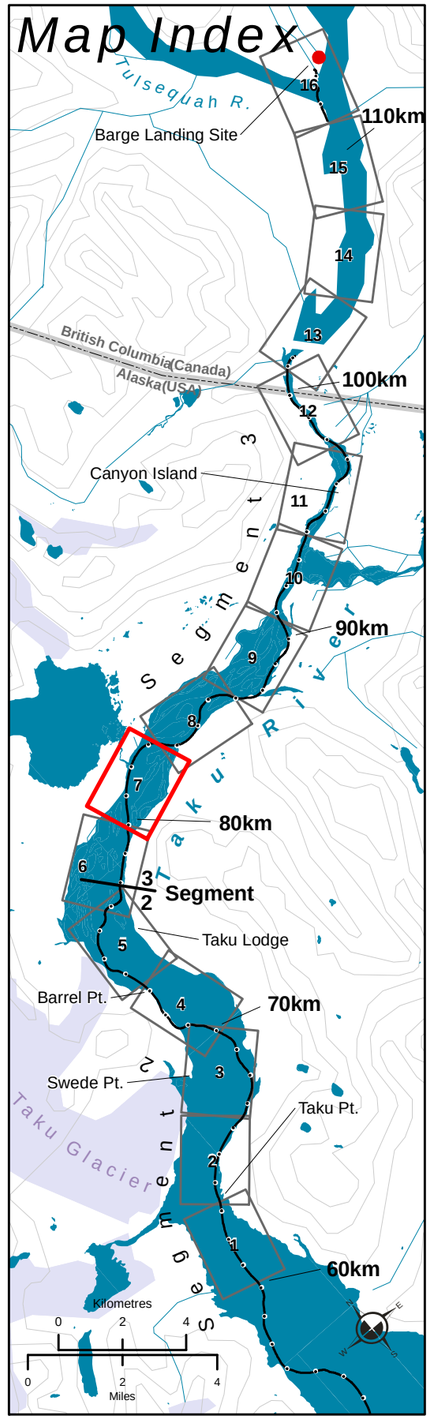
Map 7

Segment 3

km 63 to 67

mi. 41 to 43

Image Date: May 15 / 06



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Printed:September 2008

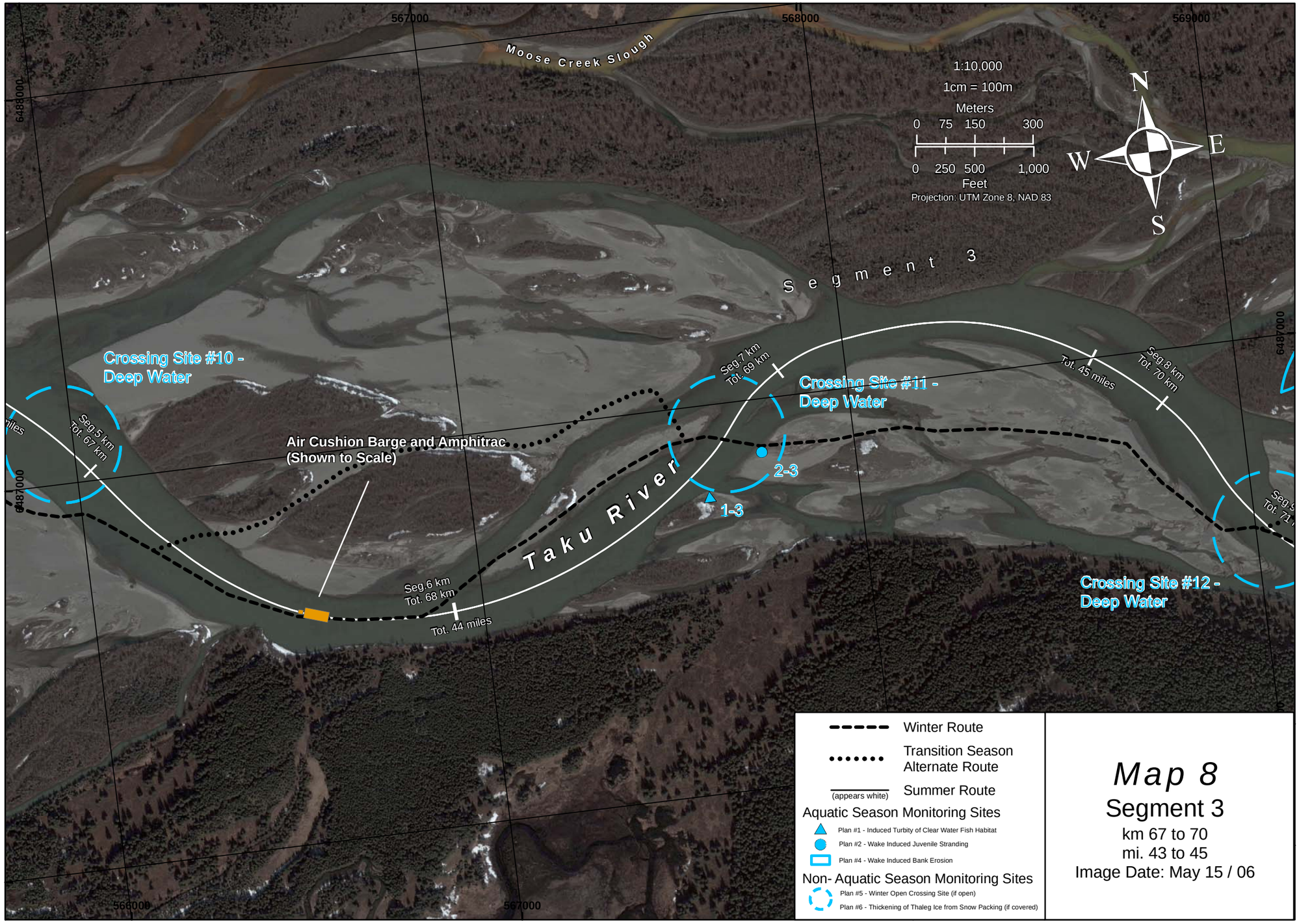
82636_DFIG_Taku_River_Barging_Route_Atlas_AEMMP_Map7_GS_ver1.mxd

Gartner Lee Limited

Aquatics Effects Monitoring & Mitigation Plan Monitoring Sites

Tulsequah Chief Mine - ACB Transportation System

Redfern Resources Ltd.



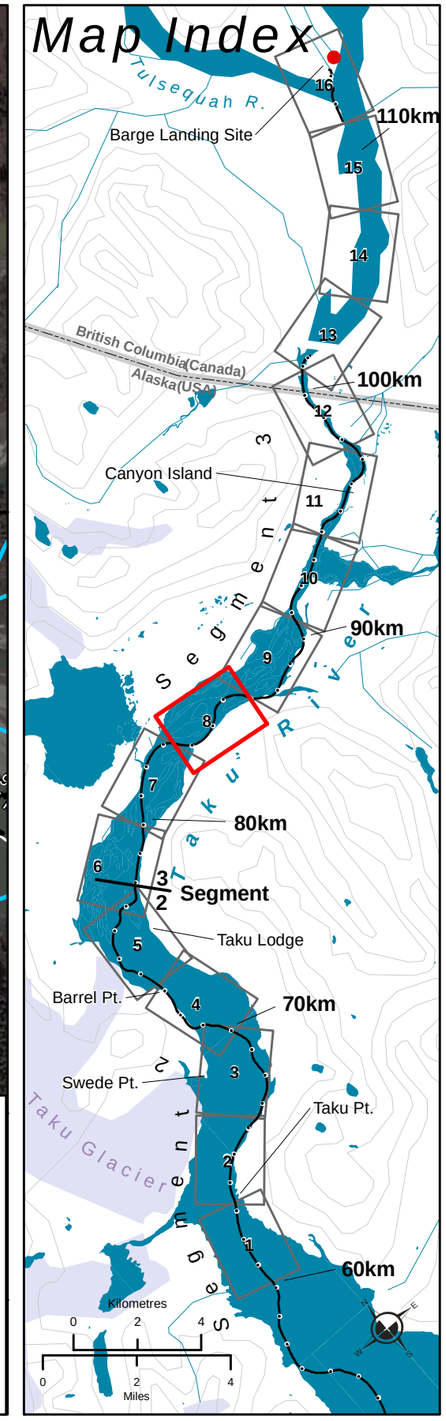
Map 8

Segment 3

km 67 to 70

mi. 43 to 45

Image Date: May 15 / 06



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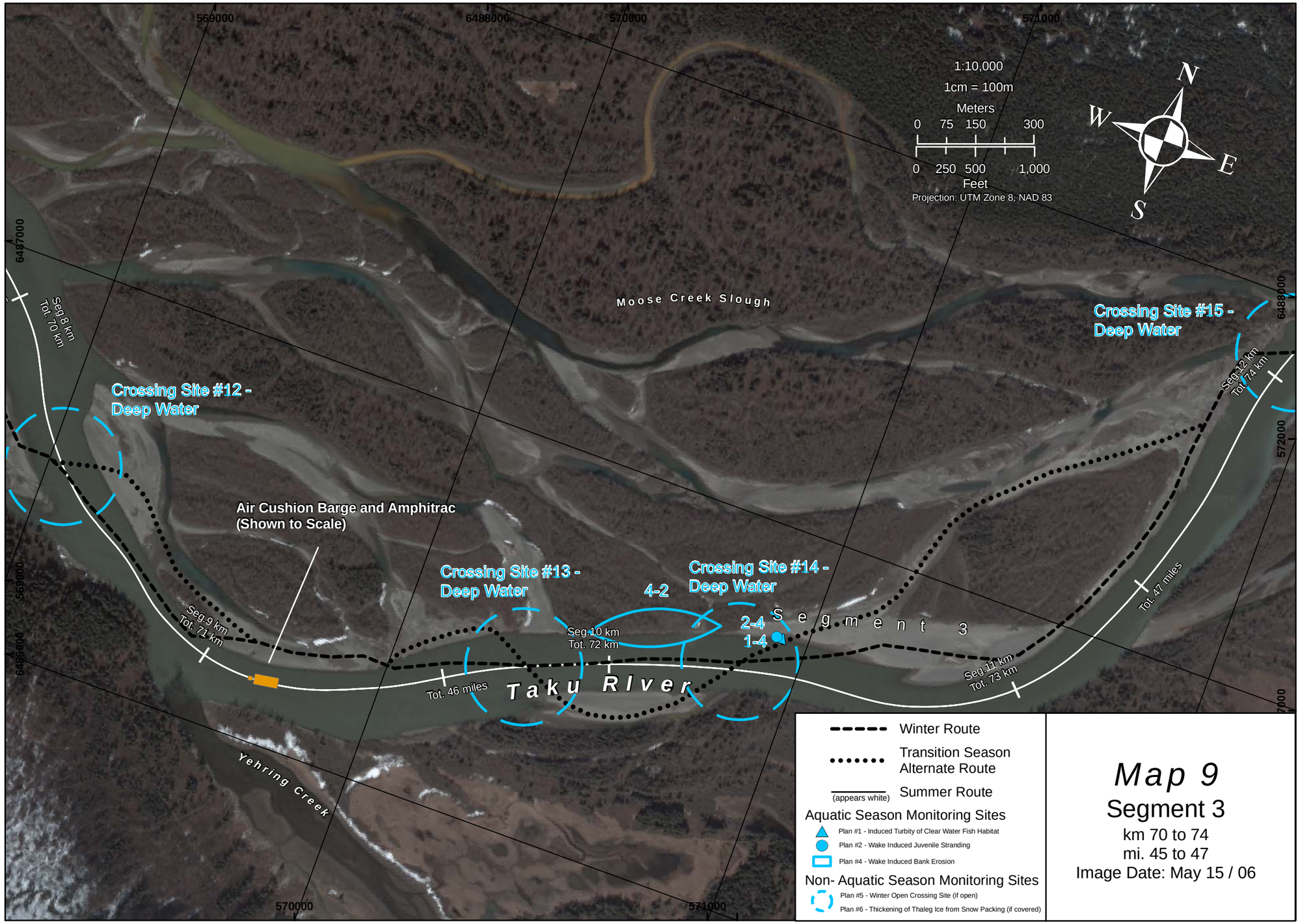
Printed: September 2008

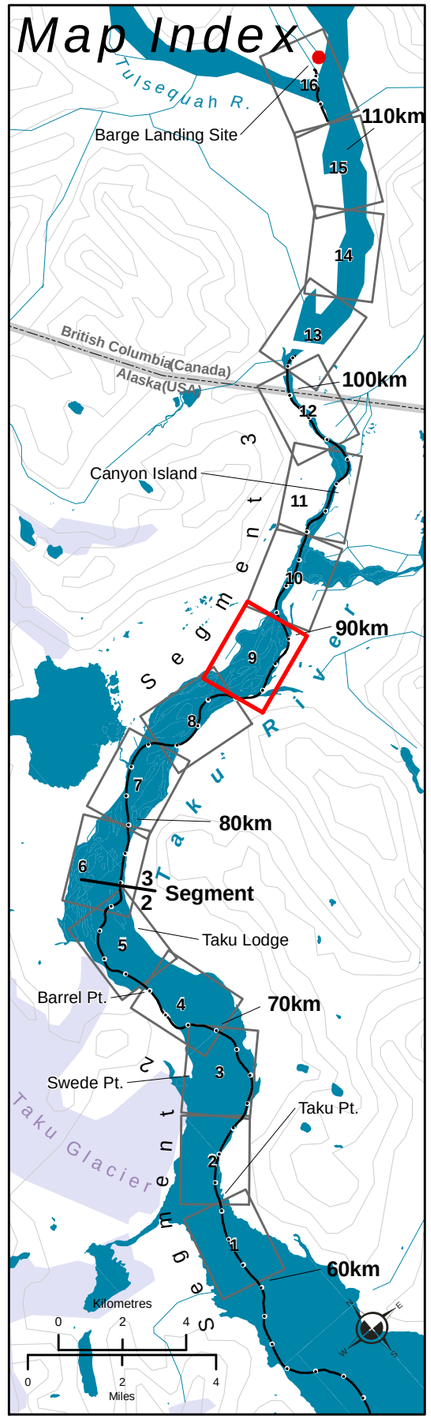
82636__DFIG_Taku_River_Barging_Route_AEMMP_Map8_ver1.mxd



Map 9

Segment 3

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

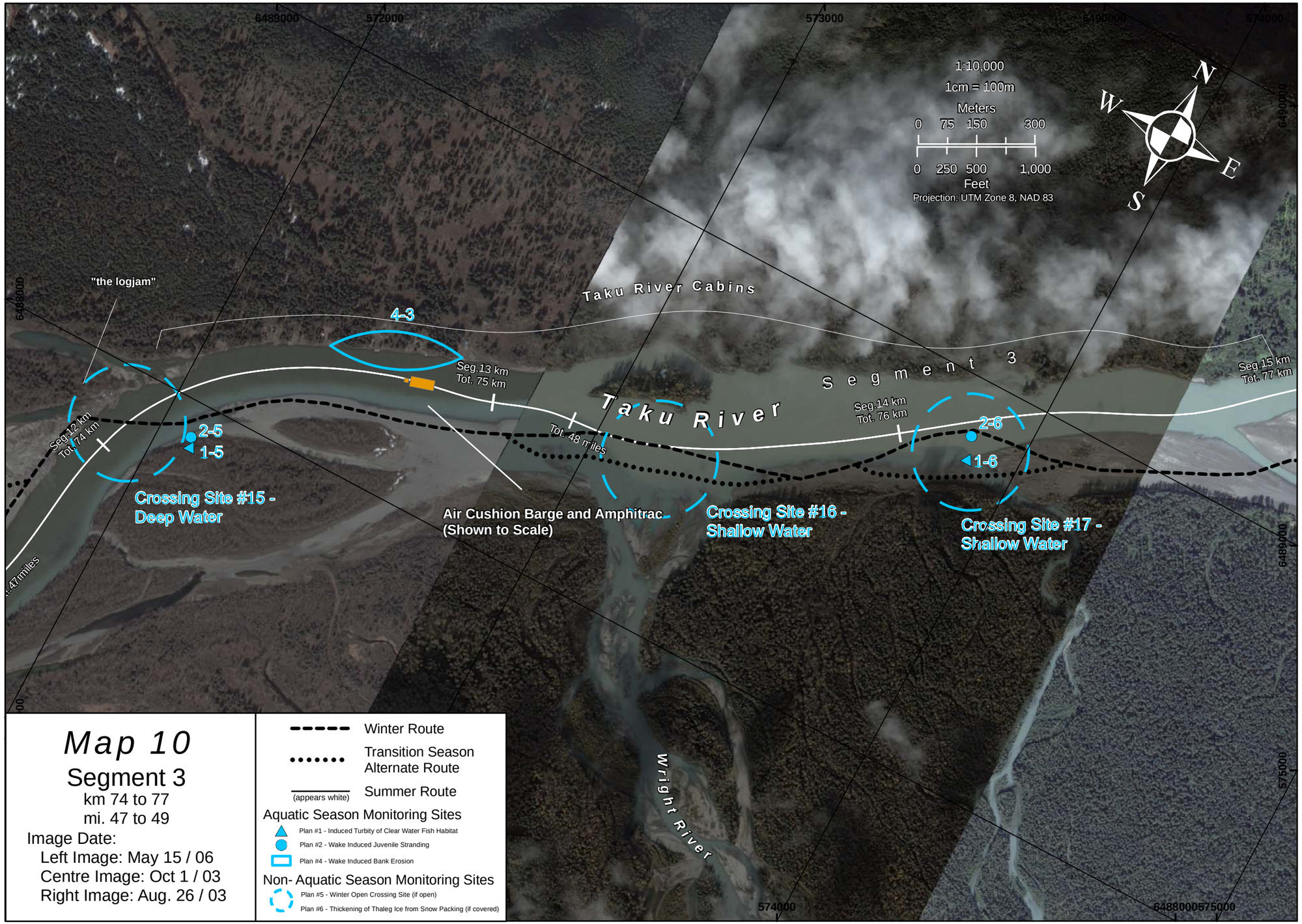


Gartner Lee Limited

Aquatics Effects Monitoring & Mitigation Plan Monitoring Sites

Tulsequah Chief Mine - ACB Transportation System

Redfern Resources Ltd.



Map 10

Segment 3

km 74 to 77

mi. 47 to 49

Image Date:

Left Image: May 15 / 06

Centre Image: Oct 1 / 03

Right Image: Aug. 26 / 03

Winter Route

Transition Season Alternate Route

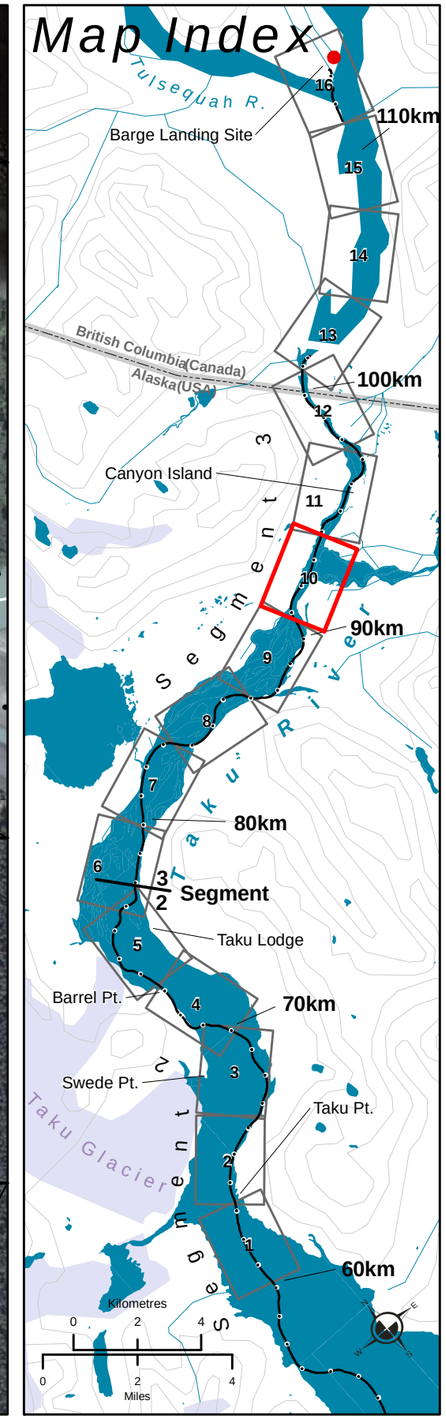
Summer Route (appears white)

Aquatic Season Monitoring Sites

- Plan #1 - Induced Turbity of Clear Water Fish Habitat
- Plan #2 - Wake Induced Juvenile Stranding
- Plan #4 - Wake Induced Bank Erosion

Non- Aquatic Season Monitoring Sites

- Plan #5 - Winter Open Crossing Site (if open)
- Plan #6 - Thickening of Thaleg Ice from Snow Packing (if covered)



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Printed: September 2008

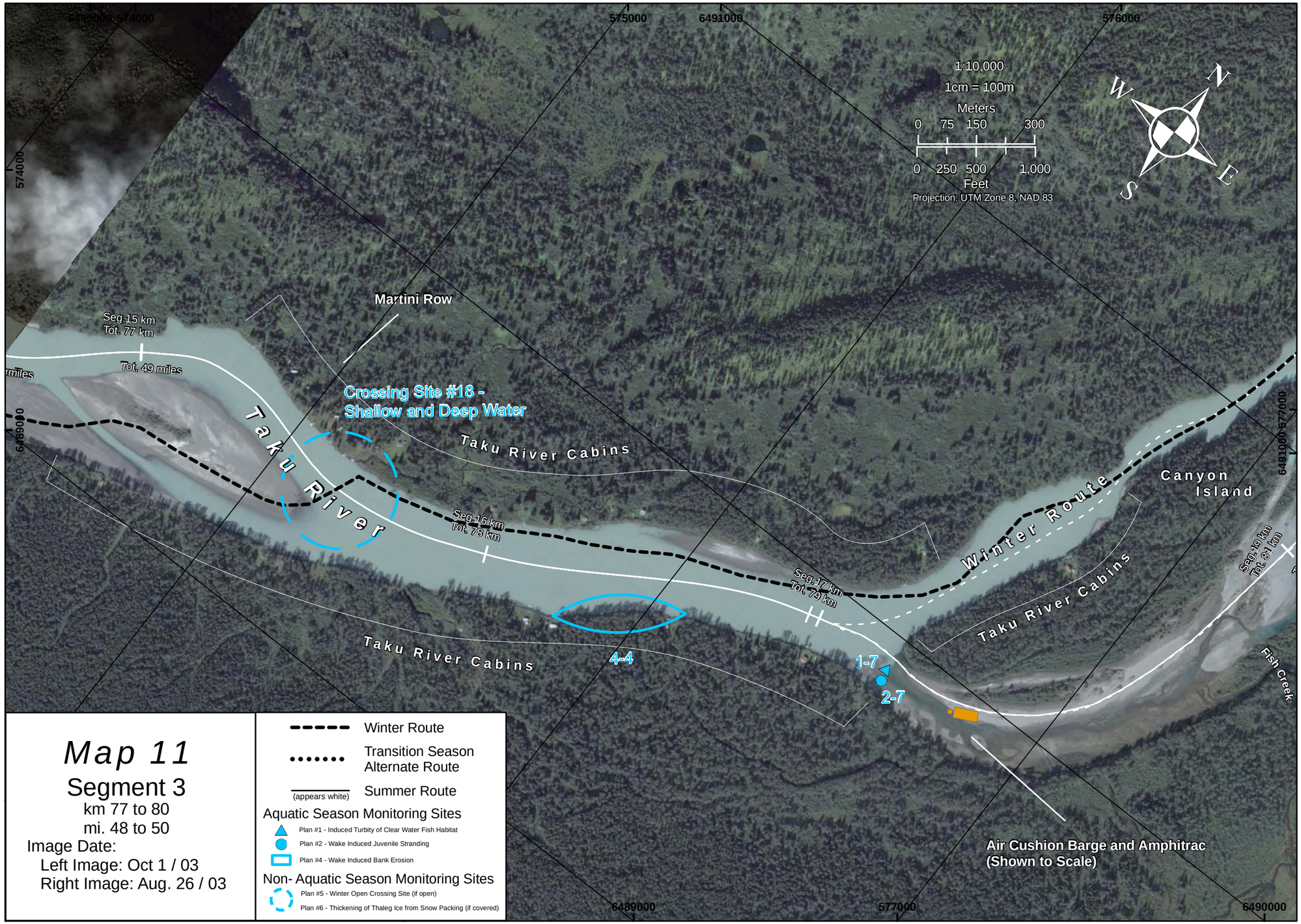
82636__DFIG_Taku_River_Barging_Route_AEMMP_Map10_ver1.mxd

Gartner Lee Limited

Aquatics Effects Monitoring & Mitigation Plan Monitoring Sites

Tulsequah Chief Mine - ACB Transportation System

Redfern Resources Ltd.



Map 11

Segment 3

km 77 to 80

mi. 48 to 50

Image Date:

Left Image: Oct 1 / 03

Right Image: Aug. 26 / 03

Winter Route

Transition Season Alternate Route

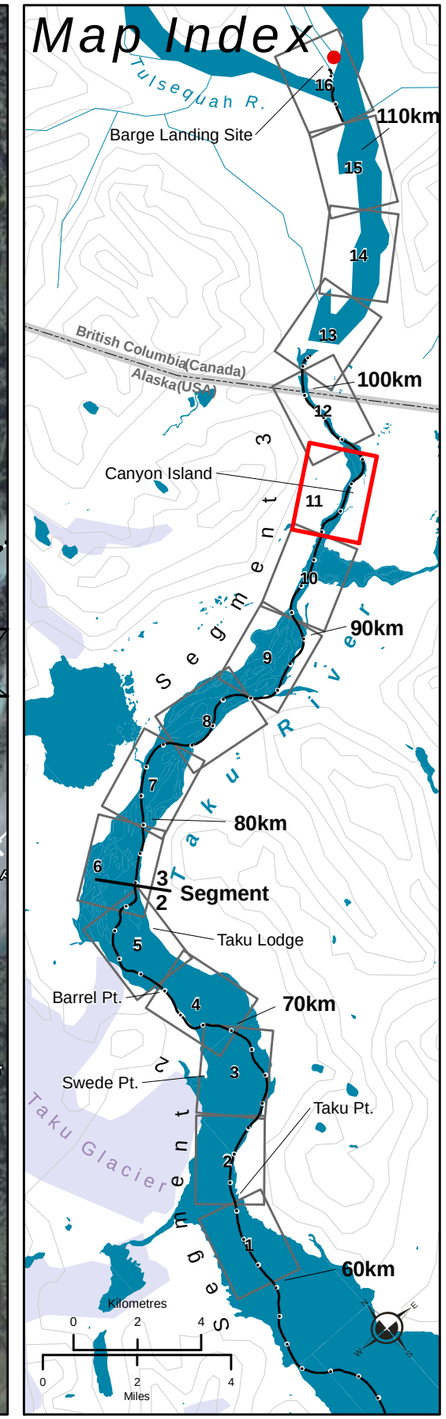
Summer Route (appears white)

Aquatic Season Monitoring Sites

- Plan #1 - Induced Turbity of Clear Water Fish Habitat
- Plan #2 - Wake Induced Juvenile Stranding
- Plan #4 - Wake Induced Bank Erosion

Non- Aquatic Season Monitoring Sites

- Plan #5 - Winter Open Crossing Site (if open)
- Plan #6 - Thickening of Thaleg Ice from Snow Packing (if covered)



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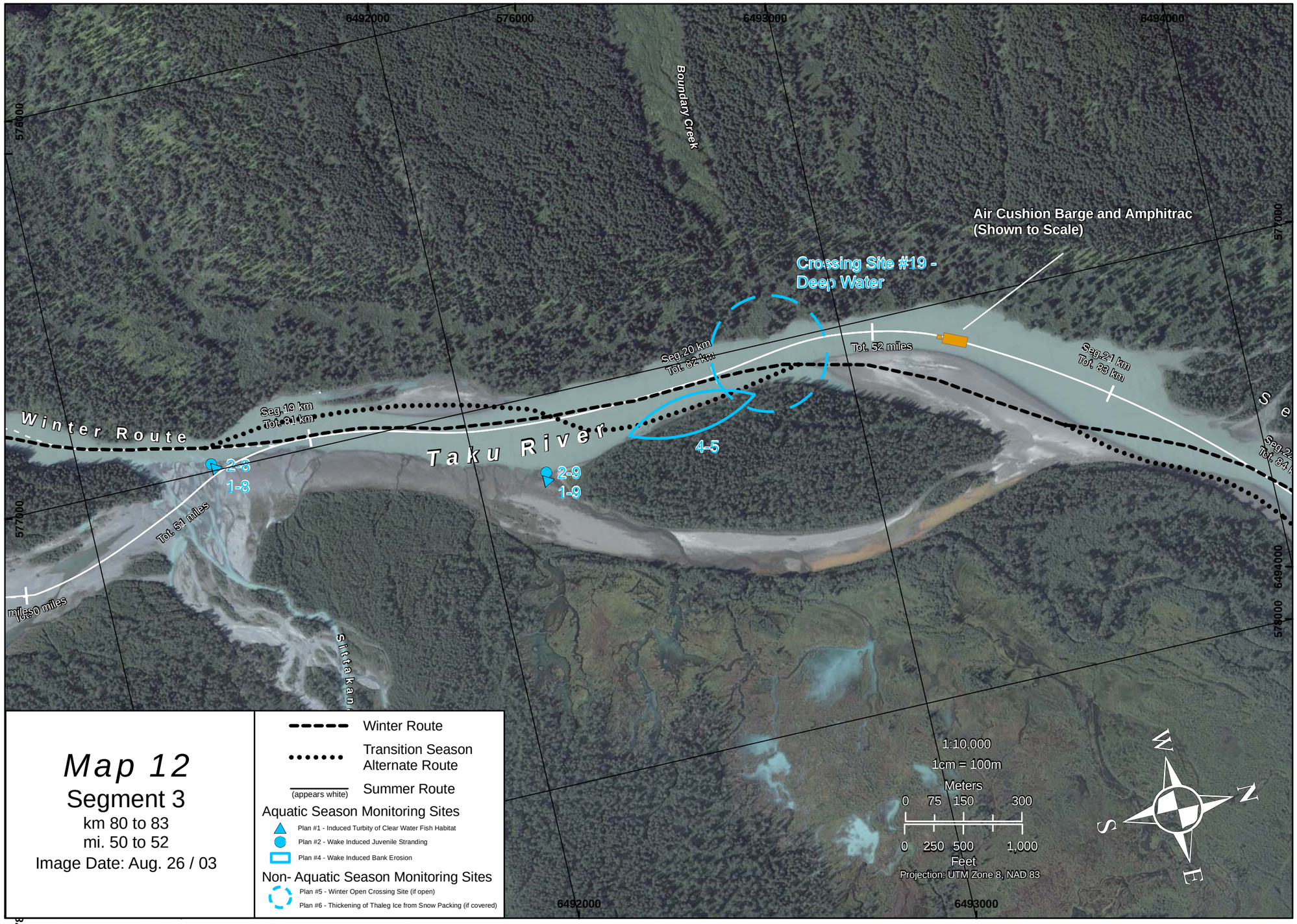
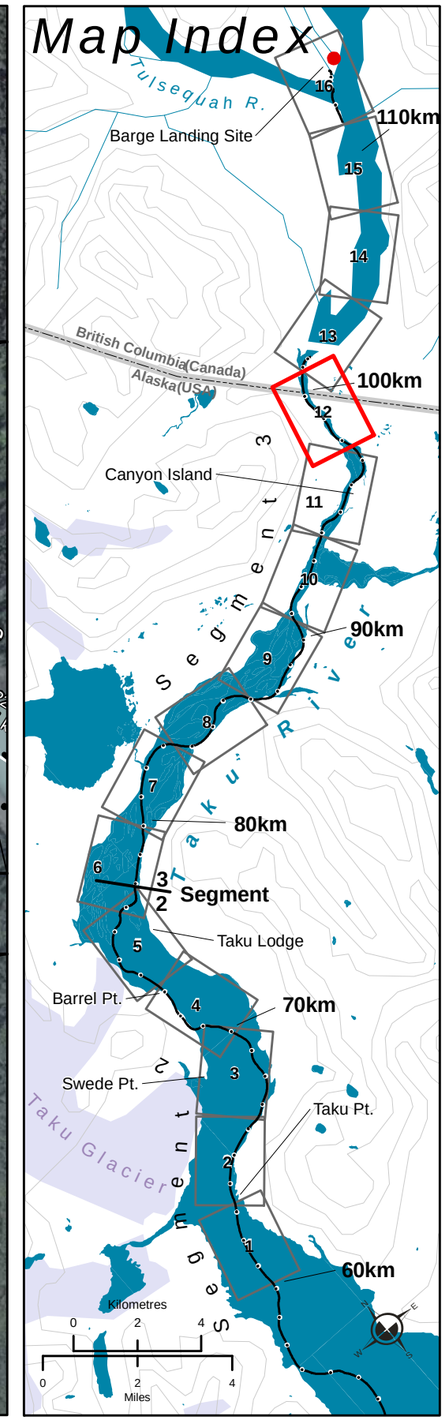
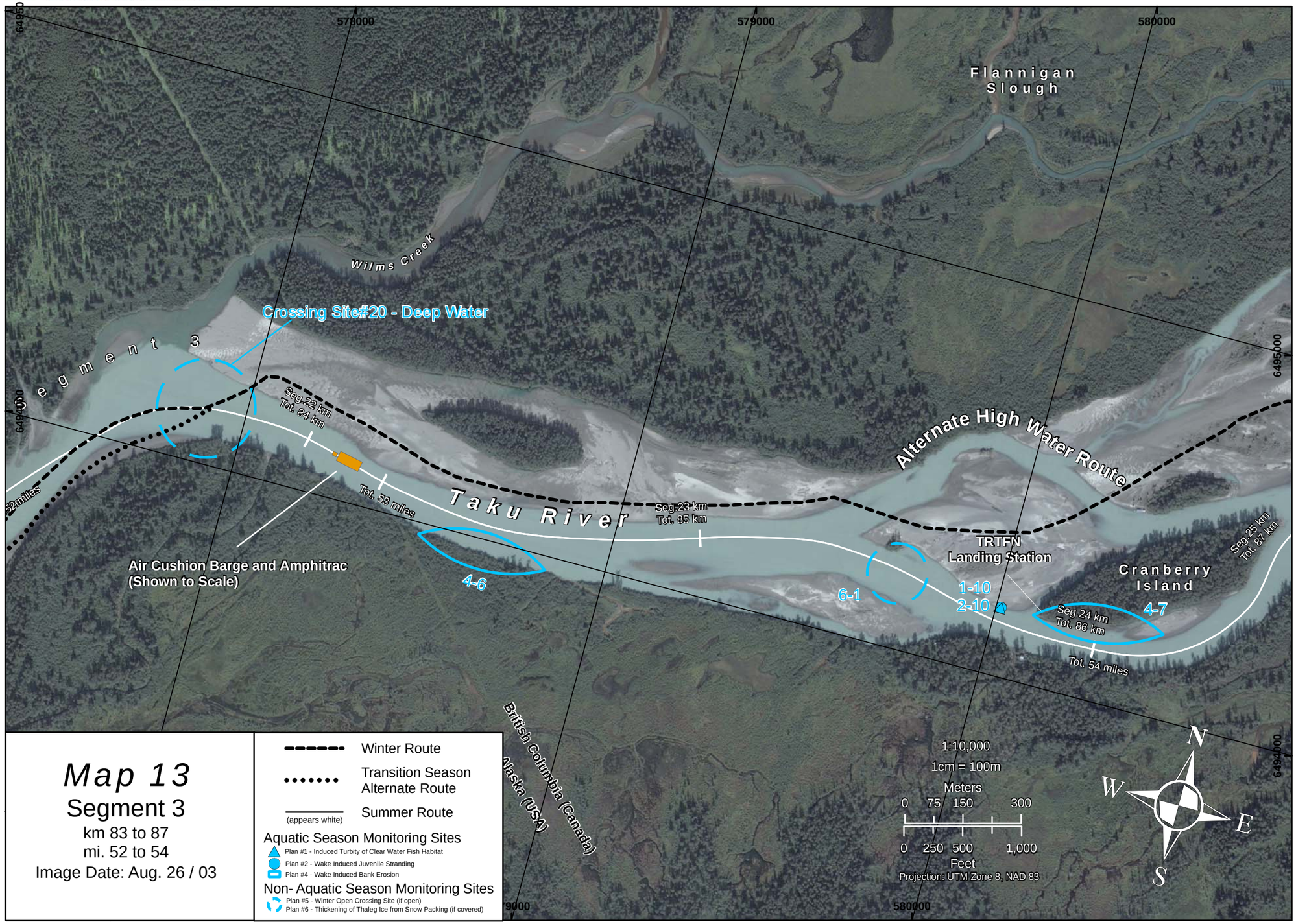


Map 12

Segment 3

km 80 to 83
mi. 50 to 52
Image Date: Aug. 26 / 03





Map 13

Segment 3

km 83 to 87

mi. 52 to 54

Image Date: Aug. 26 / 03

Winter Route

Transition Season Alternate Route

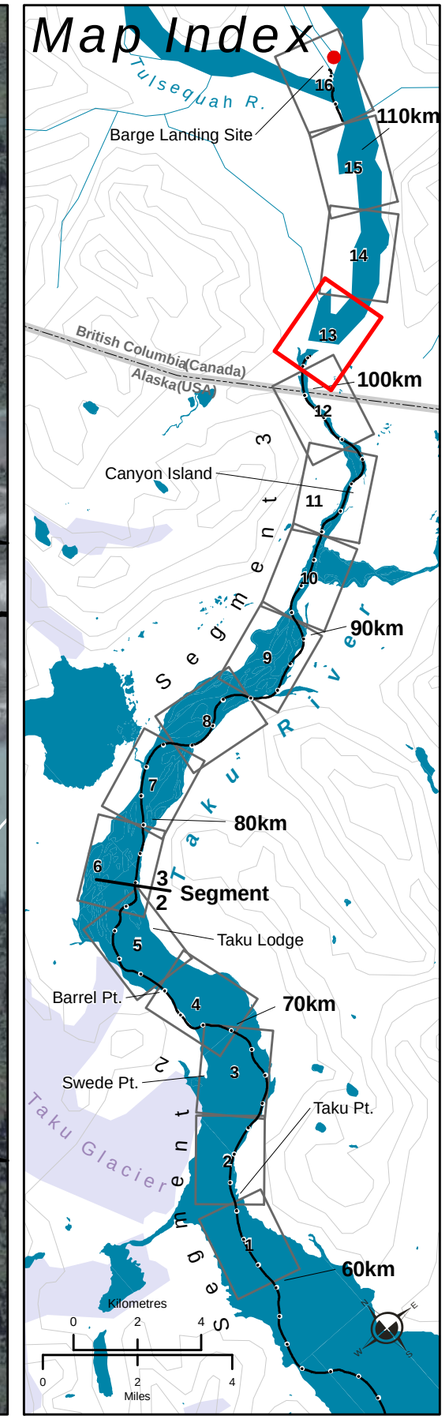
Summer Route (appears white)

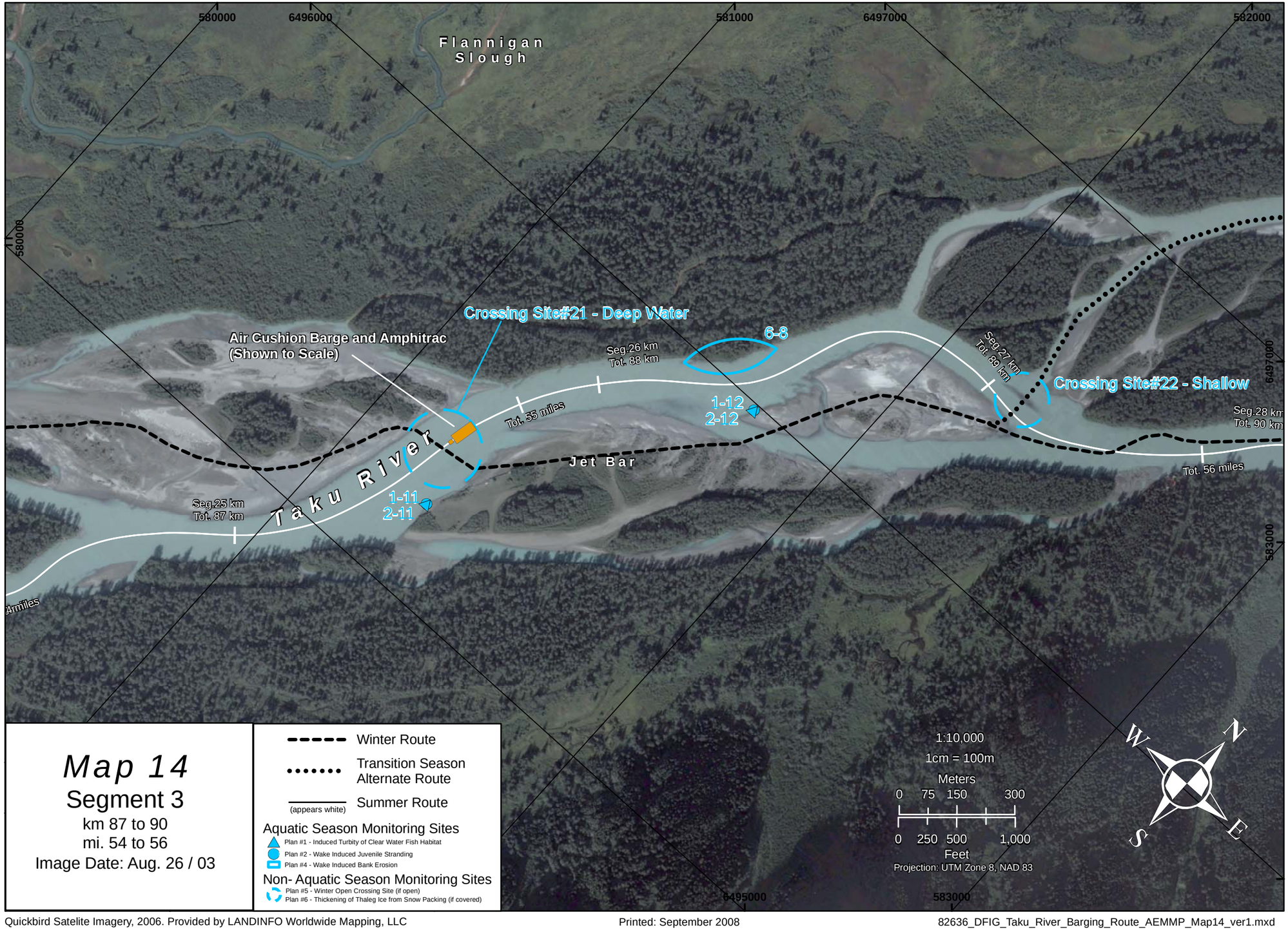
Aquatic Season Monitoring Sites

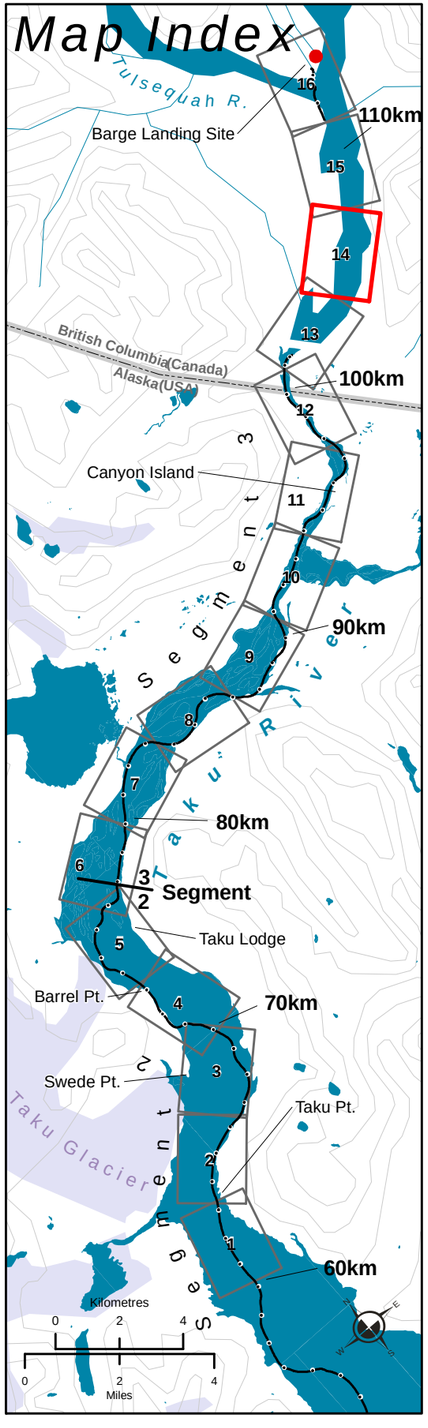
- Plan #1 - Induced Turbity of Clear Water Fish Habitat
- Plan #2 - Wake Induced Juvenile Stranding
- Plan #4 - Wake Induced Bank Erosion

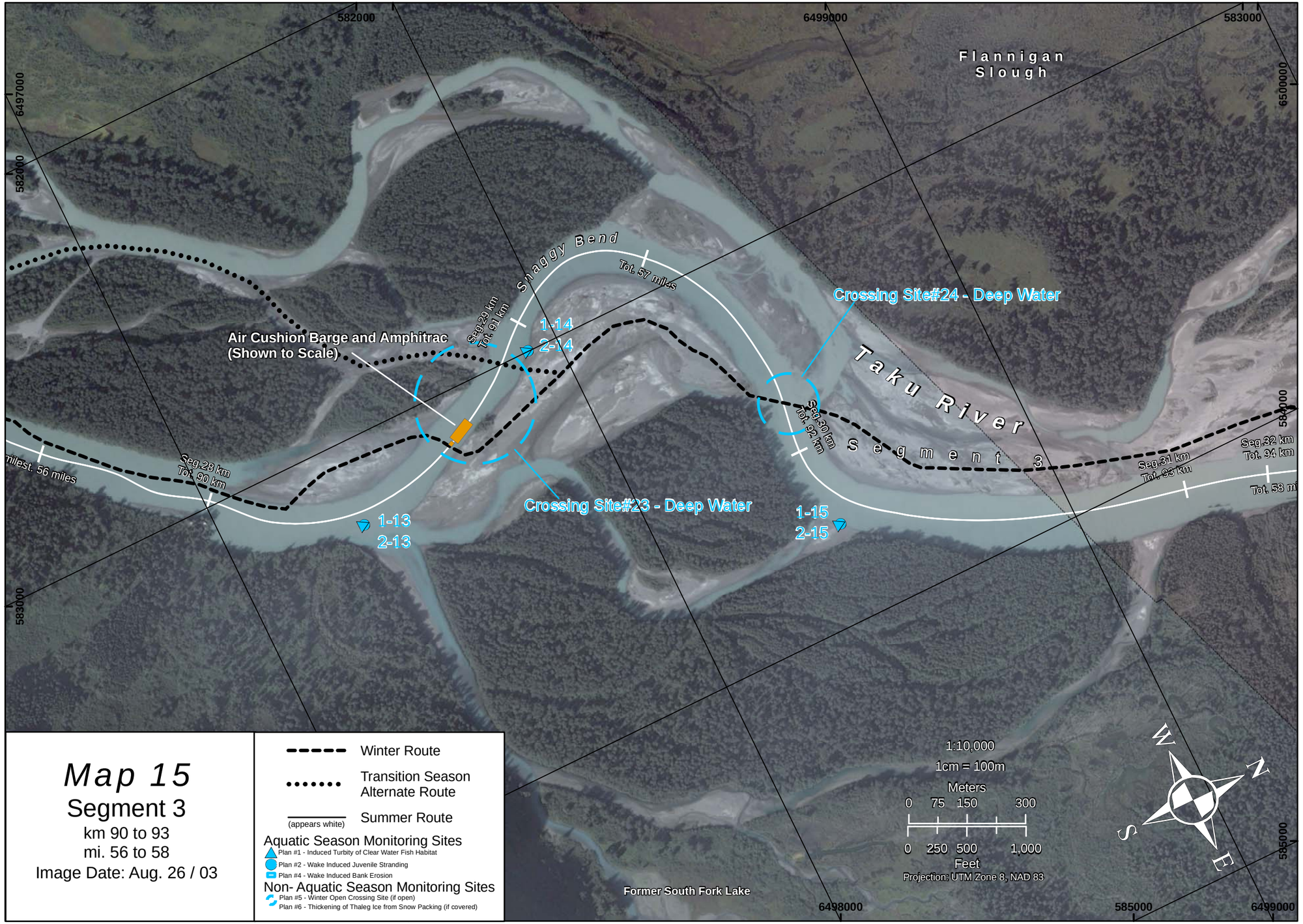
Non- Aquatic Season Monitoring Sites

- Plan #5 - Winter Open Crossing Site (if open)
- Plan #6 - Thickening of Thaleg Ice from Snow Packing (if covered)




580000
6496000
581000
6497000
582000
580000
6497000
583000
6495000
583000
Flannigan Slough
Crossing Site#21 - Deep Water
Air Cushion Barge and Amphitrac (Shown to Scale)
Seg.26 km
Tot. 88 km
6-8
Seg.27 km
Tot. 89 km
Crossing Site#22 - Shallow
1-12
2-12
Tot. 55 miles
Seg.28 km
Tot. 90 km
Jet Bar
Tot. 56 miles
Taku River
Seg.25 km
Tot. 87 km
1-11
2-11
4miles
Map 14
Segment 3
km 87 to 90
mi. 54 to 56
Image Date: Aug. 26 / 03
Winter Route
Transition Season Alternate Route
Summer Route
(appears white)
Aquatic Season Monitoring Sites
Plan #1 - Induced Turbity of Clear Water Fish Habitat
Plan #2 - Wake Induced Juvenile Stranding
Plan #4 - Wake Induced Bank Erosion
Non- Aquatic Season Monitoring Sites
Plan #5 - Winter Open Crossing Site (if open)
Plan #6 - Thickening of Thaleg Ice from Snow Packing (if covered)
1:10,000
1cm = 100m
Meters
0 75 150 300
0 250 500 1,000
Feet
Projection: UTM Zone 8, NAD 83
N
W
E
S


Map Index
Tulsequah R.
Barge Landing Site
110km
British Columbia(Canada)
Alaska(USA)
100km
Canyon Island
Segment 3
90km
Taku River
80km
Segment 2
Taku Lodge
Barrel Pt.
70km
Swede Pt.
Taku Pt.
Taku Glacier
Segment 1
60km
Kilometres
0 2 4
0 2 4
Miles



Map 15

Segment 3

km 90 to 93

mi. 56 to 58

Image Date: Aug. 26 / 03

Winter Route

Transition Season Alternate Route

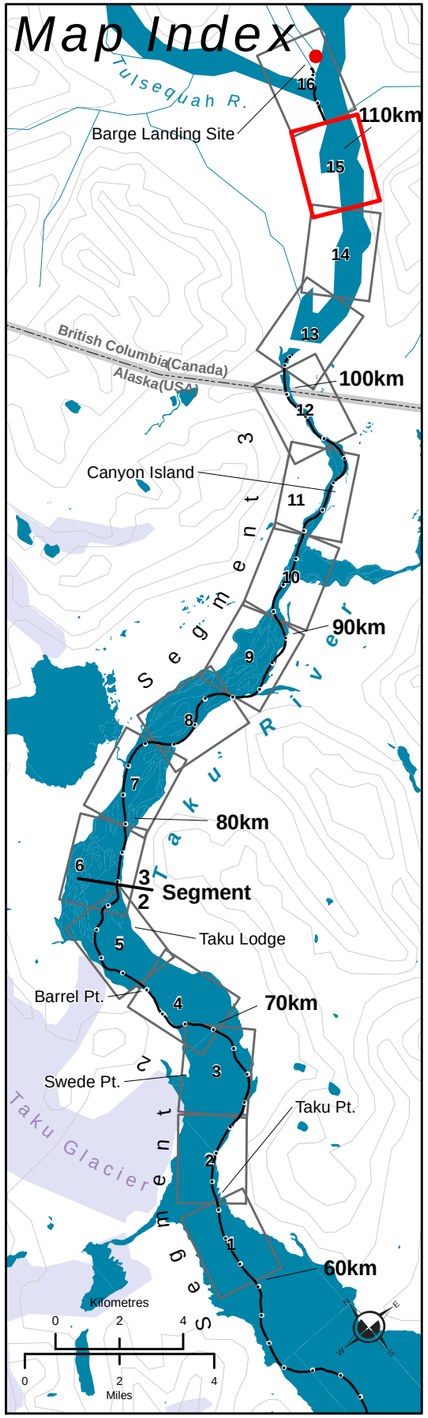
Summer Route (appears white)

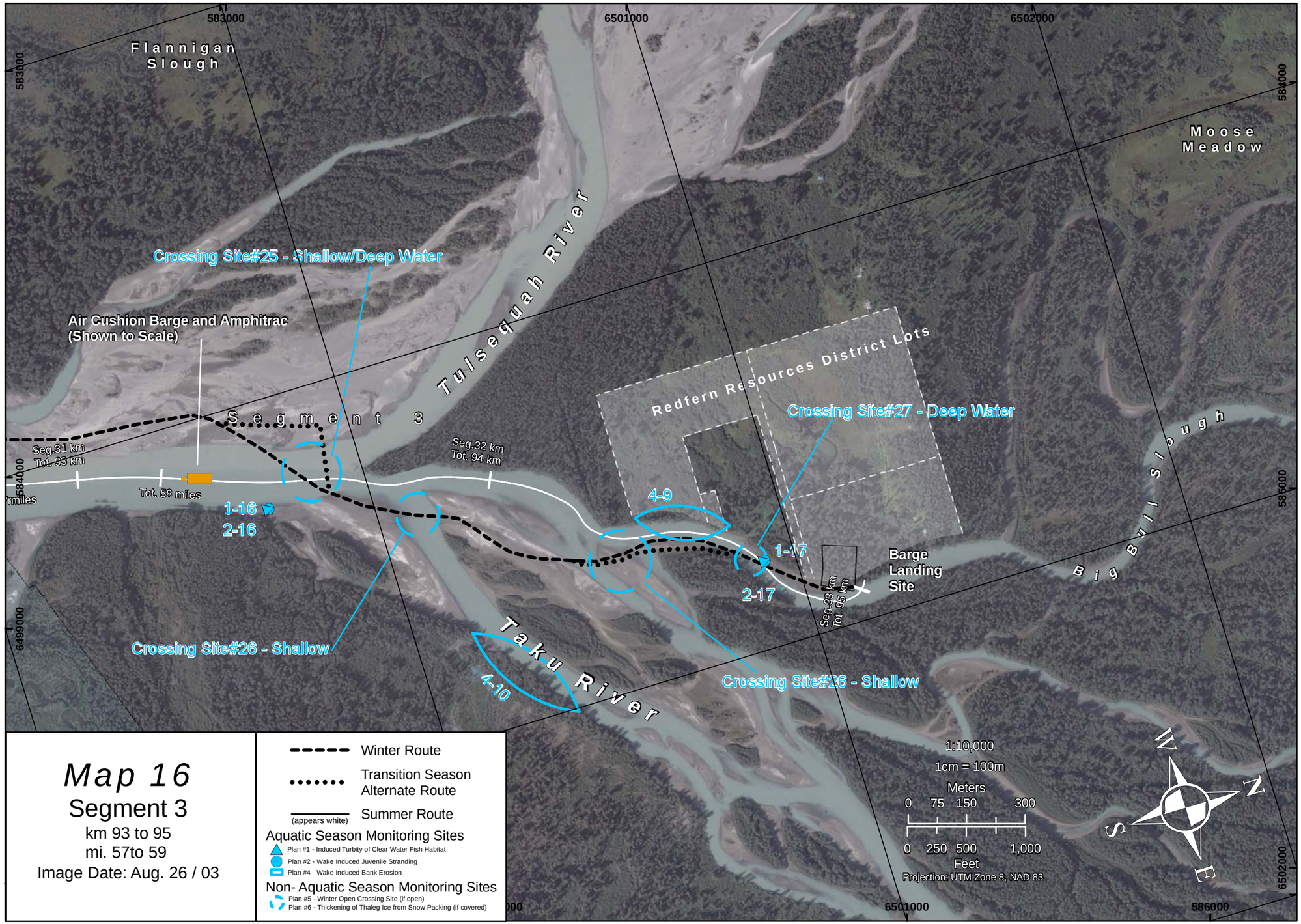
Aquatic Season Monitoring Sites

- Plan #1 - Induced Turbity of Clear Water Fish Habitat
- Plan #2 - Wake Induced Juvenile Stranding
- Plan #4 - Wake Induced Bank Erosion

Non- Aquatic Season Monitoring Sites

- Plan #5 - Winter Open Crossing Site (if open)
- Plan #6 - Thickening of Thaleg Ice from Snow Packing (if covered)





Map 16

Segment 3

km 93 to 95

mi. 57to 59

Image Date: Aug. 26 / 03

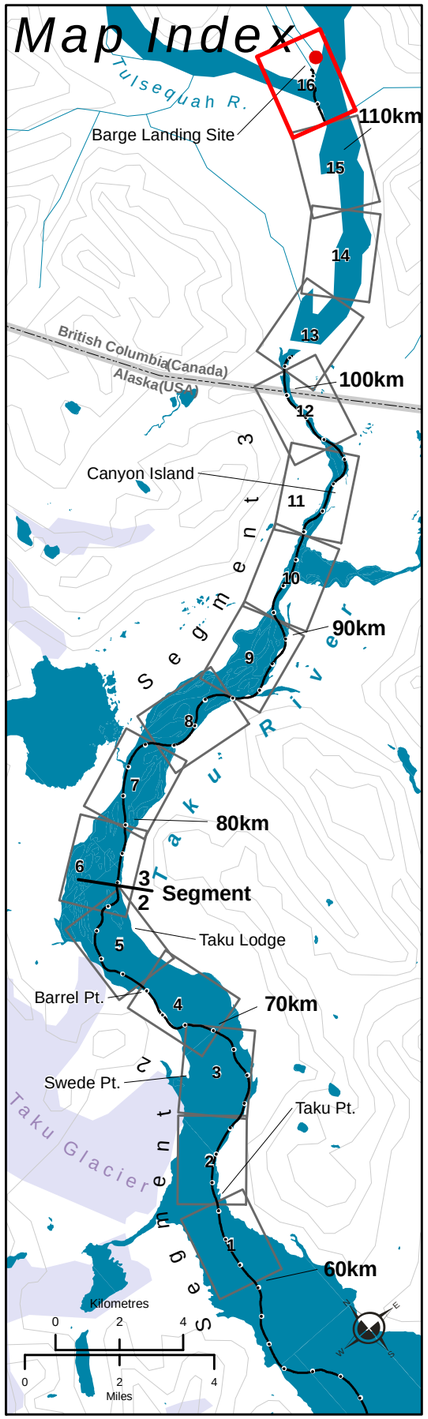
Winter Route

Transition Season Alternate Route

Summer Route (appears white)

Aquatic Season Monitoring Sites

- Plan #1 - Induced Turbity of Clear Water Fish Habitat
- Plan #2 - Wake Induced Juvenile Stranding
- Plan #4 - Wake Induced Bank Erosion

Non- Aquatic Season Monitoring Sites

- Plan #5 - Winter Open Crossing Site (if open)
- Plan #6 - Thickening of Thaleg Ice from Snow Packing (if covered)