APPENDIX E:
West Creek Hydro Technical Review

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Memorandum

To: Forest Pearson P. Eng. – Morrison Hershfield

From: David Morissette P. Eng.

Date: December 4, 2014

Re: Review of West Creek Hydro Site – Viability Analysis of Southeast Alaska and Yukon Economic Development Corridor

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1 CONTEXT

The West Creek hydro site is a key factor in assessing the viability of a potential Skagway-Whitehorse transmission line. West Creek hydro could provide cruise ships in Skagway with power during the summer months and winter power to the Yukon via the transmission line.

A review of the West Creek hydro site has been conducted to identify the hydro potential and value of the site as well as identify the main data gaps in earlier studies. The review was based on available reference studies, a site visit and professional opinion. The Municipality of Skagway reports that they are currently working through a Memorandum of Understanding with Alaska Power and Telephone (AP&T) to advance the Federal Energy Regulatory Commission (FERC) license submission for the West Creek initiative. The Municipality is currently conducting hydrologic analysis of the catchment in support of feasibility and licensing requirements and is also preparing a scope and budget to address the additional FERC licensing requirements. Accordingly, the following review does not necessarily represent to views or opinion of the Municipality of Skagway, Alaska Power & Telephone Company or their technical consultants.

The review included an estimate of the available power and energy potential at the site, a technical review of each of the major components (dam, powerhouse, conveyance, access and transmission) and provides recommendations for future alternatives that can be considered.

2 AVAILABLE STUDIES AND DATA

The West Creek hydro site, as well as the Upper Lynn Canal region of Southeast Alaska, have been the subject of numerous previous studies since the 1960's. The level of detail has been ranging from simple reconnaissance studies to identify most promising sites for hydro development, up to feasibility level studies for the West Creek site. The most relevant studies were completed in the early 1980's, with very limited to no technical work having been completed since (based on the studies that were retrieved or provided to the project team).

The main reference study that was used in the current technical review of the West Creek hydro site is the feasibility study that was completed in 1982-1993 (R.W. Beck) for the Alaska Power Authority. The study first look at a 6 MW installed capacity in 1982 that would meet the project load growth of the Haines-Skagway region, without any interconnection to outside this grid.

There is a significant supporting data set of for the project already available that was mostly completed in 1981 to support the feasibility study. It includes:

- Detailed topographical mapping and aerial photography.
- A preliminary environmental study including supporting fieldwork, to determine the main issues to be considered in the potential development of the site.
- An extensive geotechnical investigation program that included geological mapping, diamond core drilling, water pressure testing, seismic refraction surveys and material testing.

A site reconnaissance was also conducted on August 19, 2014 by a hydrotechnical and a geological engineer. It included a helicopter fly over of the West Creek valley and a ground reconnaissance of the potential dam site and surroundings, with the observations focused on:

- Potential dam and powerhouse sites;
- Conveyance alternatives (penstock or tunnel) and alignments;
- Reservoir boundaries; and
- Key geological features.

3 HYDROLOGY AND POWER STUDIES

3.1 HYDROLOGICAL STUDY

The power and energy generation potential of the West Creek hydro site was estimated on a monthly basis. Hydrological data was retrieved in the 1982 R.W. Beck feasibility report, with 15 years of daily flows recorded at West Creek from 1962 to 1977 by the United States Geological Survey (USGS). The flow gauge was located approximately 200 m upstream of the mouth of the creek. The catchment area at this station is approximately 112 km^2 (42.4 square miles).

There is currently two gauging stations operated by USGS in the Skagway region that are opperational in the area and that have a longer continuouse record of flow data. Previous work in the feasibility study has shown that data correlation was poor between the recorded flows at West Creek and the flows on those larger riers. It may still be worthwile to consider the data recorded at those stations for future hydrologic modelling and to establish a long term flow series on West Creek for power and flood studies. They are:

Skagway River (gage No. 15056100)
Taiya River (gage No.15056210)

Using the data measures at the West Creek station transferred to the catchment area at the proposed dam site (96.3 km^2 or 37.4 square miles), an average yearly flow of 8.2 m^3/s was calculated, for an average flow yeild of 0.085 m^3/s per kilometer square. As comparison, it was reported by CH2MHILL in 1979 that the Haines-Skagway region has an average flow yied per kilometer square of approximately 0.26 m^3/s, while the Taiya and Skagway River has respectively an average flow yield of 0.06 and 0.035 m^3/s. Such a differences can be explained by the generally wetter climate in the Haines region compared to Skagway, due to its closer proximity to the ocean. Precipitation values at the Haines airport are more than twice the values recorded at the Skagway airport. The climates gets noticibly drier further inland, like for part of the Taiya and Skagway River watersheds.

Average historical monthly flows for West Creek at the dam site are presented in Table 1 and Figure 1. Average yearly flow during the recording period did range from 6.8 to 10.2 m^3/s.

Table 1 Average monthly flows on West Creek at the dam site

Month	Monthly average flow (m^3/s)
January	0.6
February	0.7
March	0.7
April	1.3
May	5.2
June	15.3
July	24.0
August	23.2
September	16.1
October	6.2
November	2.9
December	1.1
Yearly average	**8.2**

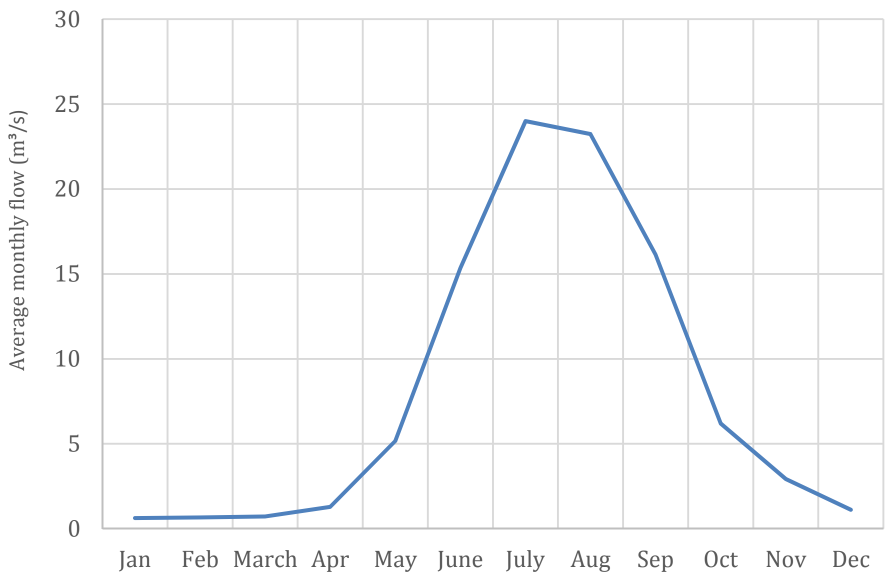

Figure 1 Average monthly flows

3.2 POWER AND ENERGY ESTIMATES

The power and energy generation potential of the West Creek hydro site was estimated. An installed capacity of 25 MW was selected, consistent with the recent FERC Application submitted by AP&T (2014). Calculations were performed by simulating reservoir operations on a monthly basis. The reservoir volume was determined based on the previous storage capacity curve presented in the 1982 feasibility study (R.W. Beck). The storage volume available for power generation was estimated using the operating water levels previously determined in the updated 1983 feasibility study that analyzed operations for a 22.5 MW installed capacity. Further optimization of the minimum and maximum operating water levels should be conducted; however, these 1983 values provide a reasonable estimate of power and energy generation for the purposes of this review.

The following operating water levels and operation parameters were used for the simulations:

- Maximum operating water level = 238.4 m (782 ft)
- Minimum operating water level = 201.8 m (662 ft)
- Water level range of operation = 36.6 m (120 ft)
- Tailwater level = 11.2 m (38 ft)
- Storage volume in reservoir = 100 Mm^3
- Average net head = 200 m (estimated, including head losses)
- Turbine flow = 15 m^3/s
- Turbine efficiency = 85% (constant)
- Minimum environmental flow of 10% of average monthly flow

A turbine flow of 15 m^3/s was selected to match the proposed 25 MW installed capacity. It does however exceed signifiantly the average yearly flow of 8.2 m^3/s at the dam site. It appears that the optimal installed capacity at the site would be more in the 15 to 18 MW range based on available flow data.

Reservoir operations were simulated to maximize winter energy generation. Such an objective appears to be the most optimal approach if the site was to be built with a transmission interconection between Skagway and the Yukon. Summer energy could be provided to Skagway via the surplus of energy from the Yukon, while the highly valued winter energy would be available to the Yukon during the winter months.

It is assumed that the reservoir would refill during the summer months (mainly June to August) and constant releases (when possible) were assumed during the winter months (from mid-November to mid-April) to increase the flows available for power generation. Calculations were made using a volume balance approach. This calcultes the change in available storage in the reservoir and the associated monthly volume of water available for power generation. The following reservoir operational scheme was generally applied in the calculations.

Summer filling (target volume to be retained in each month, if possible)

June: 15 Mm^3
July: 40 Mm^3
August: 35 Mm^3
September: 10 Mm^3

Winter releases from the reservoir

November: 10 Mm^3
December to March: 20 Mm^3 per month
April: 10 Mm^3

Filling of the reservoir with these simple rules occurred on all years except one of the flow series (14 years total). The average monthly power production is presented in Table 2, while the average energy generated from the West Creek hydro site is presented in Figure 2.

Total average yearly energy generation for the proposed operational scheme was estimated at 106 Gwh, varying between 87 and 126 GWh over the duration of the 14 year flow series. It should be noted that with the proposed operation scheme, the maximum average monthly power generated is 18 MW in September. The full 25 MW was only achieved (on a monthly average) 5 times in September over the duration of the flow series. Further optimization of the operational scheme or a change in priorities (i.e. favor summer energy over winter energy) could likely increase slightly the total energy generation at the site. A firm winter power between 11 and 13 MW can be achieved with such an operation scheme, if winter releases are optimized to achieve the largest possible firm power.

Table 2 Average Power Production from 1963 to 1977

Month	Average Power Production (MW)
January	13.2
February	12.9
March	12.8
April	8.5
May	7.4
June	9.6
July	10.7
August	14.5
September	18.1
October	9.3
November	13.5
December	13.9
Yearly average	**12.0**

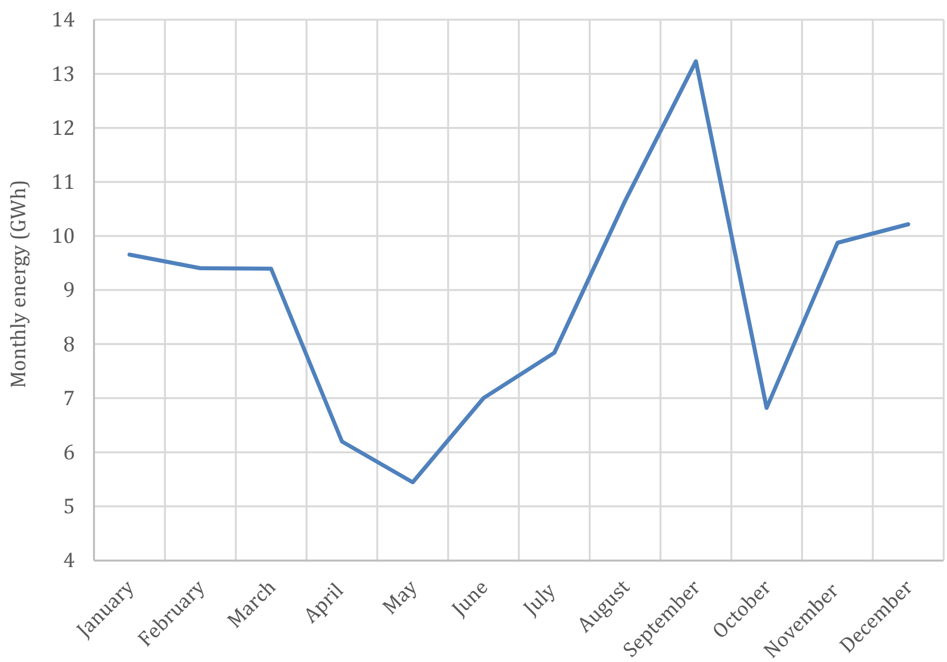

Figure 2 Average monthly energy generation with 25 MW installed capacity

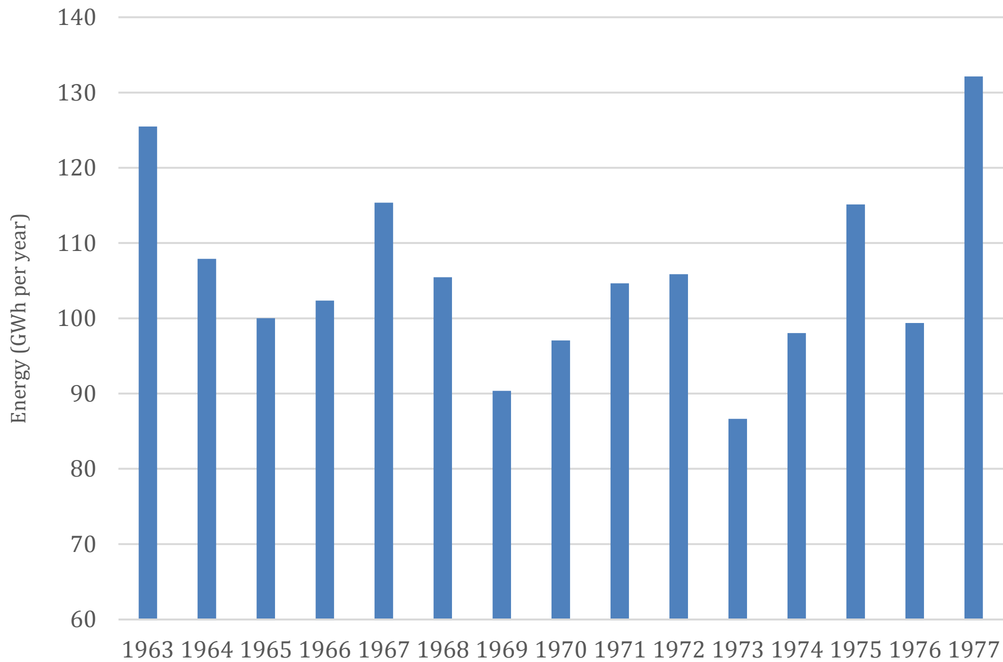

Figure 3 Energy generation year-by-year from 1963 to 1977

Future Considerations

The available hydrological information on West Creek is adequate for preliminary power and energy estimates, but should be updated for future estimates. The available data set is limited (14 years) and dates back to more than 30 years. All of Southeast Alaska are experiencing significant climate change and a rapid melting of glaciers, which covers a noticeable part of the West Creek watershed. Hydrological monitoring is currently underway on West Creek and should continue until the project is developed. A single gauge near the mouth of the creek, or alternatively near the dam site, is adequate to measures flows. Meteorological and climate change studies would also help to understand and predict the hydrology of West Creek.

Based on the above calculations and the selected turbine flow (15 m^3/s) to match the proposed 25 MW capacity, it appears that the most economical installed capacity would be smaller, likely in the 15 to 18 MW range. Since one of the objectives of the West Creek hydro site is to provide shore power to the cruise ships visiting Skagway, 25 MW was originally proposed to fully meet that demand. In the eventuality that a transmission line gets build to the Yukon, excess summer power could be provided by the Yukon to Skagway. Further studies based on power demand in both Skagway and Whitehorse are needed to determine the optimal installed capacity to develop at West Creek. At this stage, it does not appear warranted to build 25 MW of installed capacity.

Reservoir operations should also be studied on a daily basis, incorporating the geometry of the proposed spill structures (overflow or gated). The reservoir size (and dam height) could potentially be slightly increased, to generate a larger winter firm power at the site. There is sufficient inflows during the summer available to achieve approximately 12 MW of firm winter power. The need for environmental flows below the dam, the resulting impact on the power and energy output of the site, would also need to be investigated.

4 REVIEW OF PROPOSED LAYOUT

The main project layout for the West Creek hydro site has been proposed in the 1982-1983 feasibility Study (R.W. Beck). Various potential layouts have been analyzed to develop between 5 and 25 MW of installed capacity, with a storage reservoir. The layouts that were considered were proposing a powerhouse near the mouth of West Creek on the Taiya River. In 2014, an alternate layout with a powerhouse near tidewater on the Taiya Inlet has been presented in the Preliminary Permit Application to the Federal Energy Regulatory Commission (FERC) by Alaska Power and Telephone Company (AP&T). No technical information regarding the recent layout was made available for this review.

The following sections present a review of the proposed infrastructures, key challenges and potential alternatives that should be considered in further studies. A photo log of the site visit is presented at the end of the current memorandum with reference to the photos presented in the text. A set of drawings and figures presenting the proposed layouts from previous studies (1982-1983 R.W. Beck feasibility study and 2014 FERC Application) is also included at the end of the memorandum.

4.1 DAM AND SPILLWAY

The proposed dam site is located approximately 3.5 km upstream from the mouth of West Creek. At this location the creek has a steep gradient and is flowing through a narrow valley bordered by two medium size hills. This location is suitable for the construction of a dam, limiting the volume of material required for the structure and containing the reservoir behind the natural hills. Only one small closing dike (or saddle dam) is required for the largest development alternative (22.5 MW as proposed in the 1982 feasibility study) on the left (north) abutment. It was reported that bedrock at the dam site consists of a strong, massive granodiorite. This rock is suitable for supporting a dam at the site and also providing construction materials for the shells of an earth dam. Bedrock was observed near the surface at many locations during the site visit. It appears to be of fairly good quality, although foundation treatment is to be expected under the dam. (Photos 1 to 3)

An earthfill dam with a concrete face was first proposed in 1982 in the feasibility study. It is stated that the absence of quality impervious material (i.e. till or clay) in the area was the main reason to select such a dam instead of an earthfill dam with an impervious core. Additional optimization studies in 1983 proposed a roller-compacted concrete dam (RCC) as the most economical dam type for the project. For both type of dams, it was proposed that a cutoff slab of about 60 cm in thickness and 3.5 m width and a grout curtain would allow to provide foundation water barrier and cutoff. The RCC dam was also the option presented in the latest 2014 FERC Application (AP&T).

The reservoir lies in a fairly flat and narrow valley that is bordered by steep slopes coming down from high mountain peaks. A significant landslide has occurred upstream of the reservoir near the West Creek glacier in the last decade, dramatically changing the landscape at the upstream end of the valley. The location of this landside is however upstream and above the potential reservoir limits. There are numerous visible avalanche paths on both sides of the reservoir. The risk of landslide or avalanche in the reservoir is a risk to the project to be considered in the design. (Photo 4)

An ungated overflow spillway excavated into bedrock on the dam right abutment was first selected in 1982. It is design to accommodate the probable maximum flood (PMF). Following the selection of a roller-compacted concrete dam (RCC) in 1983, a modified spillway part of the main dam was selected. An overflow concrete spillway in the middle of the main dam was the selected option. This latter option is only suitable if a RCC dam is selected. No gated spillway structure was proposed in either design.

Diversion during construction was proposed with two concrete pipes of approximately 3.5 m diameter to convey the 1:10 year flood. Tunnel alternatives on the right and left abutment were also considered. The proposed dam site would require the construction of small cofferdams both upstream and downstream of the alignment to build the dam in the dry.

Future Considerations

The proposed dam location is the most optimal one, +/- 200 meters. The final alignment should be updated based on additional geotechnical investigation and the type of dam selected (including dam height). From the available information and previous geological reports, it appears that the site geology is adequate to support a dam of the size proposed. A roller-compacted concrete dam is a suitable dam for such a site but would be rather expensive to build compared to an earthfill dam with impervious core. It may be worthwhile to investigate additional borrow sources for impervious material in the area, or consider alternate core material.

Consideration should be given to an asphalt core dam that is an emerging technology first implemented in Scandinavian countries. Hydro-Quebec in eastern Canada has also recently build a series of asphalt core dams - the first such works in North America. The West Creek dam is large enough to merit consideration of this option which may potentially reduce project costs.

It is likely that a gated structure with a low invert would be required to discharge environmental flows below the dam site. It could also be used to flush sediment accumulation in the reservoir. Significant sediment build-up is not expected to occur on a regular basis, but the potential risk of landslides or avalanches deposited in the reservoir could affect sediment accumulation.

Furthermore, landslides or avalanches in the reservoir could generate a large wave that could threaten (overtop) the dam crest. Such events are considerations that must be taken into account in selecting the dam type. Depending on the severity of the effects on the reservoir (resulting flood-wave), a certain dam type may be preferable.

4.2 CONVEYANCE AND POWERHOUSE

Various powerhouse locations were considered in the 1982-1983 feasibility study, all located near the mouth of West Creek. These locations would allow development of the full head available and to provide the shortest conveyance possible. The selection of the optimal location for the powerhouse was based on the results of the geotechnical investigations and the preferred route for the water conveyance. A 2.7 km long power tunnel was proposed for water conveyance, running from a gate shaft build immediately downstream from the intake structure located near from the dam. The proposed diameter of the tunnel was 2.9 m and the tunnel would be unlined for most of its length except at its upstream and downstream ends. A 440 m surface steel penstock would complete the power conduit to the powerhouse. A surface powerhouse founded on rock was proposed, equipped with two horizontal axis Francis turbines. (Photos 5 and 6)

An alternate layout has been proposed in the recent 2014 FERC Application (AP&T). It proposes a powerhouse located at the head of Taiya inlet near tidewater A 4.9 km tunnel with a diameter of 3 m running down the Taiya

River valley would convey the water from the intake structure at the dam to the powerhouse. This layout would avoid having the transmission line crossing through the Klondike Gold Rush National Historic Park. Note that AP&T already has a buried power line through the Park, extending almost to the West Creek Bridge. (Photos 7 and 8)

The original powerhouse location proposed in the 1982-1983 feasibility study appears to be the most optimal location, strictly based on a technical review of the available information and observations gathered during the site visit. It does provide a shorted conveyance with less technical challenges, and the access to the powerhouse is much easier. A powerhouse on the Taiya Inlet would have many disadvantages:

- Will likely require the use of a barge to access the site for construction
- Significant visual footprint on the road to Dyea and on the Dyea flats
- Large tailwater level variation that would be challenging to accommodate
- Longer conveyance that may have to cross fault zones (to be determined based on further site investigations)

A surface powerhouse appears adequate based on the site characteristics for both locations, however the Taiya Inlet site would require a large bedrock cut into the steep mountain side at tidewater to accommodate the powerhouse. The use of Francis turbine also appears to be adequate for the proposed head and turbine flow, although Pelton turbines could still be considered. Finally, the need for a surge chamber/tank can't likely be avoided based on the head to be developed at the site

Future considerations

The land use challenges associated with constructing a powerhouse near the mouth of West Creek should first be determined and include discussions with land owners in the area and the National Historic Park. The location at the mouth of West Creek is the preferred location from a technical and cost perspective. A powerhouse on Taiya Inlet presents significant technical challenges and would likely be more costly to develop. This option cannot be eliminated at this stage, but an adequate geotechnical investigation program would be necessary to determine its feasibility.

As an alternative to a tunnel, a surface penstock for the full length of the water conveyance should be re-assessed. A power tunnel of the size required for the proposed turbine flow would most likely require the use a tunnel boring machine which is expensive to purchase. . If the tunnel was to be built in drill and blast, larger dimensions would probably have to be selected for constructability reasons. An HDPE (plastic) penstock potentially could provide a lower cost alternative to a tunnel. The penstock could be buried to protect it against potential landslides or avalanches as well as against freezing. Based on topographical information, a penstock would be located on the north side of the creek, extending for about 3.4 km. The feasibility of locating the powerhouse on the north side of the creek would be assessed in parallel. Finally, the potential intake location is another factor that can influence the selection of a specific alignment or conveyance type for the site. Due to the large water level variations (37 m) in the reservoir, an intake excavated into bedrock is mandatory for stability purposes

Optimization studies should consider all components describe above as a package (intake structure, water conveyance and powerhouse) to determine the most optimal layout. Multiple alternatives should be re-assess since technologies have evolved and unit construction costs have increased significantly since the early 1980's. The decision to proceed with a given layout will be based on technical and economic aspects.

4.3 SITE ACCESS

Road access to the West Creek hydro site already exists. Road access to Skagway is possible via the South Klondike Highway, and marine access is available via the Lynn Canal. There is an all-season road that runs from Skagway to Dyea that is suitable to bring machinery on site, although it is quite narrow with sharp curves. There is an old logging road that runs parallel to the creek on the north side and extends close to the proposed dam site (approximately 300-400 m). This road could be upgraded for construction access and extended to the proposed reservoir for clearing.

Access to the south side of the creek could be required near the dam or near the mouth of the creek, depending on the selected location for dam components. A bridge over the creek could be built at the dam site if required, while existing road/trails near Dyea do give access to the south side of the creek.

If the powerhouse was located on Taiya Inlet, access would be more challenging as mentioned before. A barge would likely be used to access the powerhouse location, unless suitable road access could be established on the west side of the river. Such an access road would need to extend to the edge of the water on Taiya Inlet. If the use of a barge is selected, landing spots on each side of the inlet would need to be built and be able to accommodate large tides.

There are two options for a transmission line between the West Creek hydro site and Skagway:

An overhead line parallel to the existing road or shortcutting the peninsula;

- An underground line.
- The costs associated with each would need to be assessed, along with land use and effects on viewsheds. The overhead line would probably be the most economical option.

Future Considerations

The cost associated with developing a new access road or the use a barge should be factored into the selection of the powerhouse location (near the mouth of West Creek or at Taiya inlet). In general, access to the site is by virtue of the existing road network, and only a few kilometers of new access road is required. Roads to the dam site and powerhouse site would be maintained for year-round access.

5 PROJECT COST AND CONSTRUCTION SCHEDULE

The 1983 cost estimate that was prepared for a 22.5 MW installed capacity is presented in Table 3. It does not include: escalation during construction, financing costs, interest during construction, or annual operating costs. The cost estimate was divided into direct and indirect costs, with unit costs determined for each key component of the project.

Costs were then inflated up to a 2013 $ value using the U.S. Annual Consumer Price Index[1]. An inflation factor of 134% was used to inflate costs from 1983 to 2013 (30 years).

Table 3 Cost estimate for a 22.5 MW (from 1983)

	Item	Costs ($M US 1983)	Inflated Costs ($M US 2013)
1	Preparatory Work	5.6	13.1
2	Dam and Reservoir	44.5	104.1
3	Power Conduit	11.9	27.8
4	Power Plant	12.0	28.8
5	Switchyard and Transmission Line	4.3	10.1
	Subtotal	78.2	183.2
	Contingencies (25%)	19.6	45.8
	Direct Construction Cost	97.8	229.0
	Engineering and Owner Administration (15%)	14.7	34.4
	Total Construction Cost	112.4	263.4

An overall project cost of approximately $260M US appears to be within the range that would be expected for a 22 to 25 MW hydropower project such as West Creek. Based on recent hydropower project experience elsewhere, it is reasonable to expect project costs to range anywhere between $200M US to $350M US depending on the selected installed capacity and the final layout that is selected. The above estimated cost of $263.4M for a 22.5 MW installed capacity yields a cost per MW of $11.7M. This is on the high side compared to other projects in North America, but does compare favorably with recently developed or studied hydro projects that in the Yukon or Northern BC (Mayo B, Moon Lake, Hoole Canyon, etc).

In the 1983 cost estimate, it appears that the cost related to the power conduit and power plant items are low. If the selected option is to build a power tunnel (instead of a penstock), construction costs for this item could exceed the $27.8M by as much as 200%. Other costs appear to be in a realistic range. If the installed capacity was optimize to match the available inflows in the watershed as discussed previously (in a 15 to 18 MW range), project costs could be reduced by approximately 10% compared to the proposed 25 MW installed capacity. It would yield a higher cost per MW installed, but would likely reduce the cost of energy generation per kWh.

Mobilization and demobilization costs to the site will depend on where the selected contractors are coming from. It is expected that the main contractors would have to either come from Anchorage Alaska or from

[1] From State of Alaska Department of Labor and Workforce Development Consumer Price Index.
http://www.labor.alaska.gov/research/cpi/cpi.htm

somewhere in the lower 48 states, such as Washington State. A significant cost allowance should be planned for those costs in further cost estimates.

A construction schedule was proposed in the 1982-1983 feasibility study based on optimistic timelines regarding acquiring relevant permits. The construction activities were planned over a 3 year period which is realistic with a site of this magnitude. Filling of the reservoir will to occur during the summer-months and so the generating station may only be put in-service on the 4th year following the start of construction.

Year-round construction was planned at the site and appears possible. The lower elevations of the Skagway region generally receive fairly low amount of snowfalls and the climate is relatively mild except for a few cold snaps. Some activities may need to be temporarily stopped during the winter months, such a concrete pouring or placement of the asphalt core in the dam, if this option is retained.

6 RECOMMENDATIONS FOR FUTURE WORK

A high level technical review of the potential West Creek hydro site near Skagway Alaska has been completed. The review was supported by previous reference studies and a site visit. The feasibility engineering study completed in 1982-1983 was the main reference document that presents in detail the proposed layout.

The West Creek site presents a good development potential up to 25 MW. The site could be developed with two main objectives: 1) to provide summer energy to the cruise ship market in Skagway and 2) to provide winter energy to the Yukon via a proposed interconnection. Simple calculation and power estimates in this review have shown that an installed capacity of approximately 15 to 18 MW would be a more economical option to develop the site. A firm winter power of approximately 12 MW is achievable with the largest dam and reservoir previously proposed. Additional capacity would only be valuable to increase summer generation during periods of high inflows.

The site appears suitable to develop the infrastructures required for hydro power generation. The geology of the area is generally favorable to the development of a dam, powerhouse and associated structures. Typical challenge of such works are anticipated in the area, such as foundation treatment and finding adequate borrow sources for construction materials. The previous layout proposed in the feasibility study appears to be the most promising one that is with a powerhouse near the mouth of West Creek.

It is likely that the development of West Creek could yield a fairly competitive unit price per kWh compared to other alternatives in the region (i.e diesel or other potential hydro sites). The construction costs estimated in 1983 and inflated to 2013 value yielded a cost of $263M US which appears to be in a reasonable range based on the review presented in this memorandum. An intertie with the Yukon and sales of winter energy would be required to make the project economically attractive.

It is understood that there is currently some limited technical work being conducted on the West Creek site, mainly collecting hydrological data and conducting preliminary environmental studies. The FERC Application submitted in 2014 by AP&T presented a different layout with a powerhouse on the Taiya Inlet, to avoid the Klondike Gold Rush National Historical Park. It is recommended that the feasibility study from 1982-1983 be updated to refine the layout taking into consideration modern technologies and site specific constraint regarding the land use. Additional geotechnical investigations should also be conducted to account for the larger project scheme. The following aspects deserve attention and potentially further optimization:

- The original powerhouse near the mouth of West Creek should be considered as the most optimal layout. Verifications should be done to determine if this layout is feasible with land use constraints in the area.
- Selection of the dam type, with consideration for an asphalt core dam or other type of embankment type, to replace the previously proposed RCC dam. Spillway and diversion arrangements should be re-assess in parallel.
- Re-assess the economics of a penstock on the north side of the creek (for the original proposed layout) instead of a tunnel. The penstock could be buried to protect against freezing and potential damage from the elements.
- Update the power and energy estimates with new hydrological information, to determine the optimal installed capacity at the site. Optimization of the reservoir operations should also be done to maximize winter generation, if a transmission line between Skagway and Whitehorse was to be built.
- Assess the risk associated with landslides and avalanches in the reservoir.

There is currently a proposal to develop the Lake Connelly Hydroelectric Project in Haines, located upstream from Chilkoot Lake. An installed capacity between 6 and 12 MW is being considered with a storage reservoir, as reported in the AP&T Pre-Application Document to FERC (2012). If developed, this hydro site would have the potential to deliver additional winter energy to the Yukon via the SE Alaska transmission line, and provide an additional source of revenue to Alaska. Other project in the area such as Burrow Creek near Skagway could also provide additional sources of energy to complement West Creek and the proposed transmission line to the Yukon.

Memorandum Prepared by:

David Morissette, P. Eng.
Water Resources Engineer

7 REFERENCES

The following references were consulted as part of the review of the West Creek Hydro Site. They are presented in chronological order.

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Photo 1: View of potential dam site from the air (looking downstream)

Photo 2: Ground reconnaissance near the proposed dam axis, with small rock outcrops visible

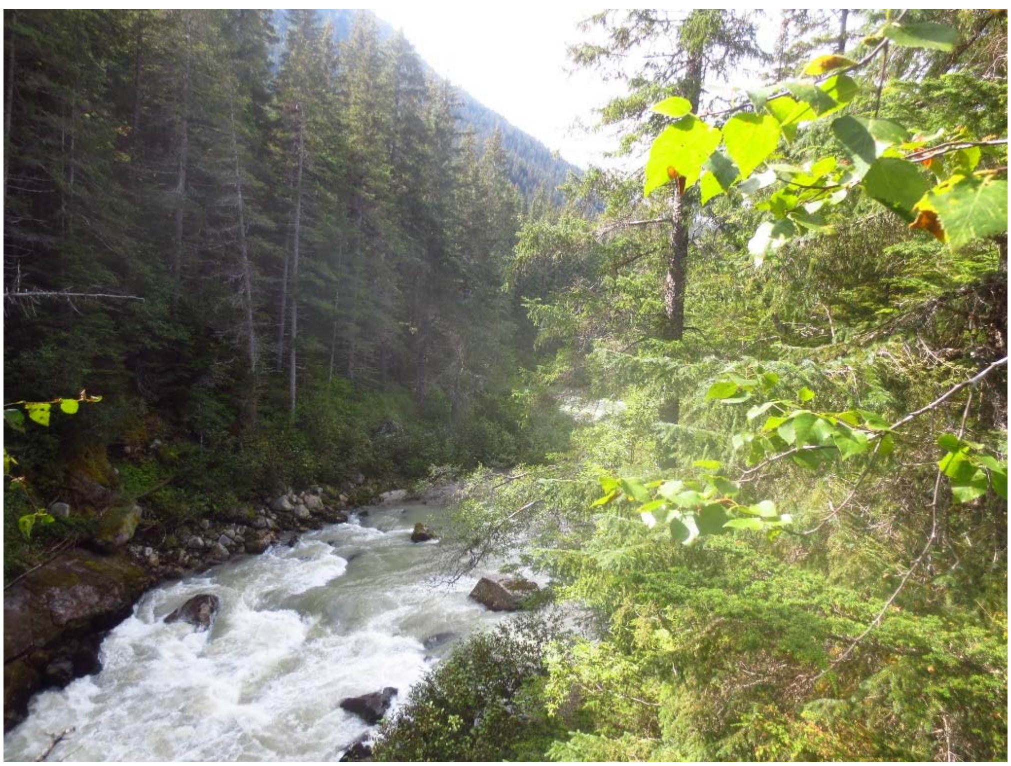


Photo 3: View of dam site towards proposed reservoir

Photo 4: Proposed reservoir in the West Creek valley, with large avalanche paths on the north side

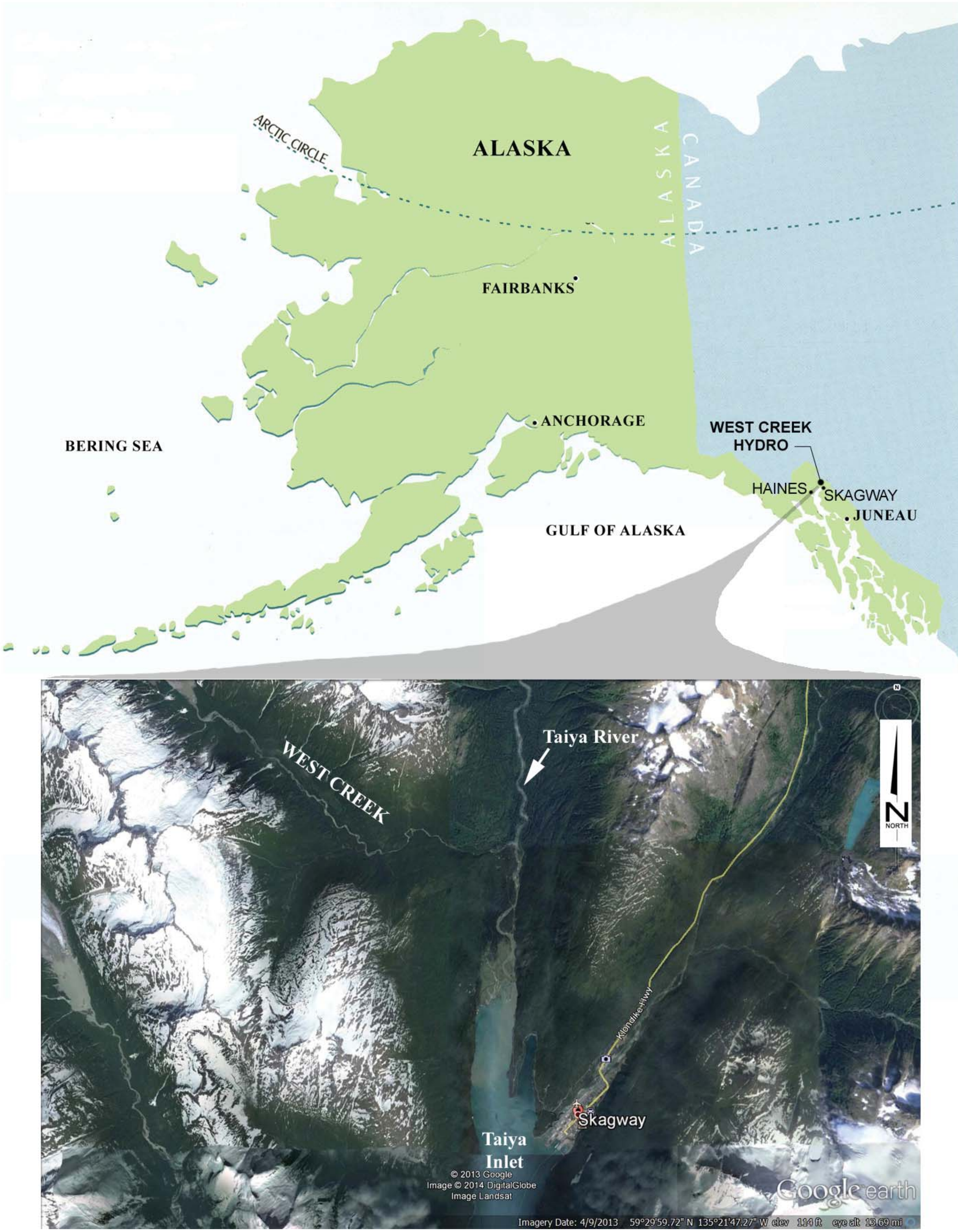
Photo 5: Mouth of West Creek with potential powerhouse locations

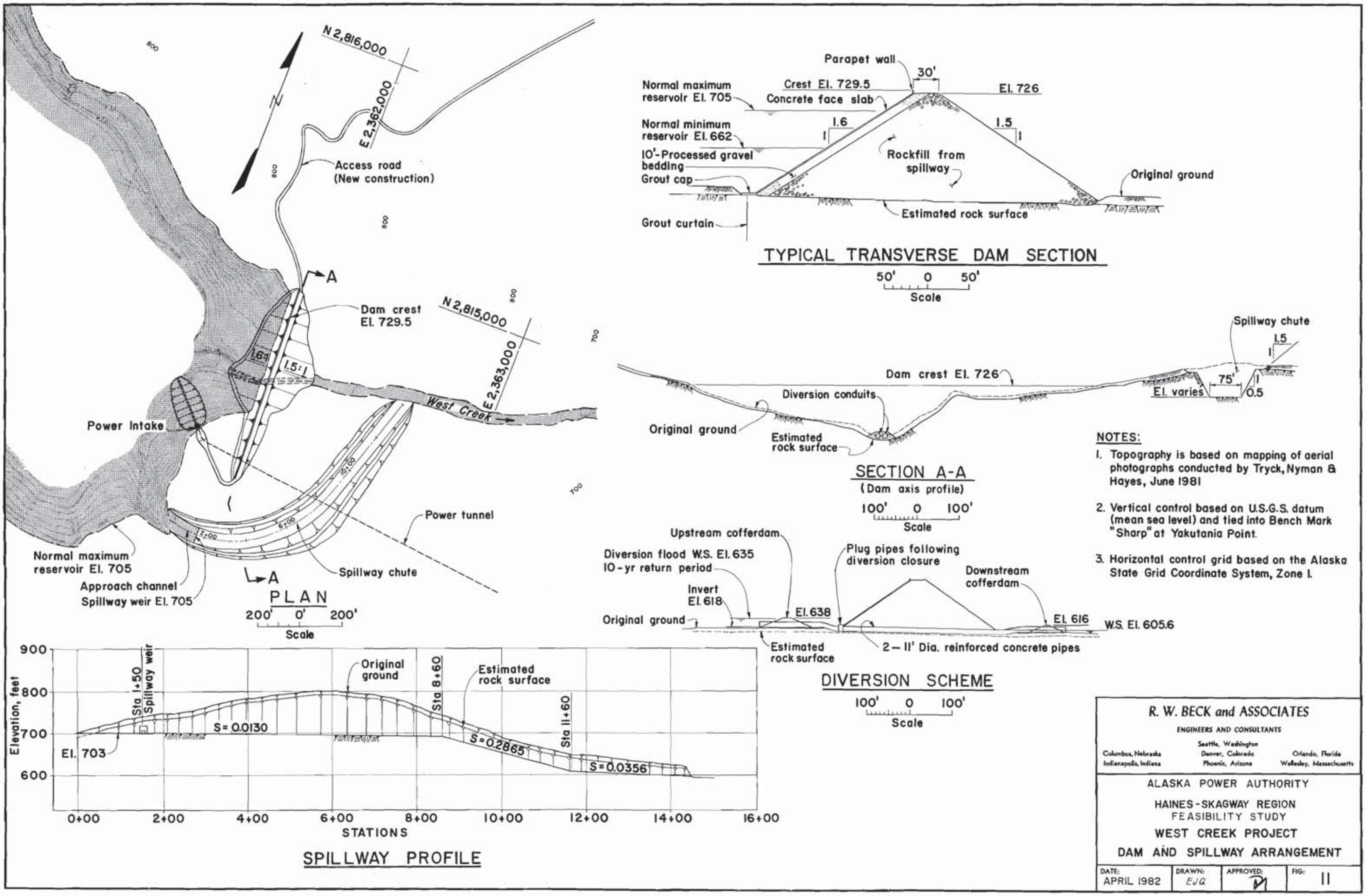
Photo 6: Looking upstream on West Creek from the mouth, with potential conveyance alignments on each side

Photo 7: Alternate conveyance axis (tunnel) with proposed powerhouse on Taiya Inlet (FERC 2014 Application)

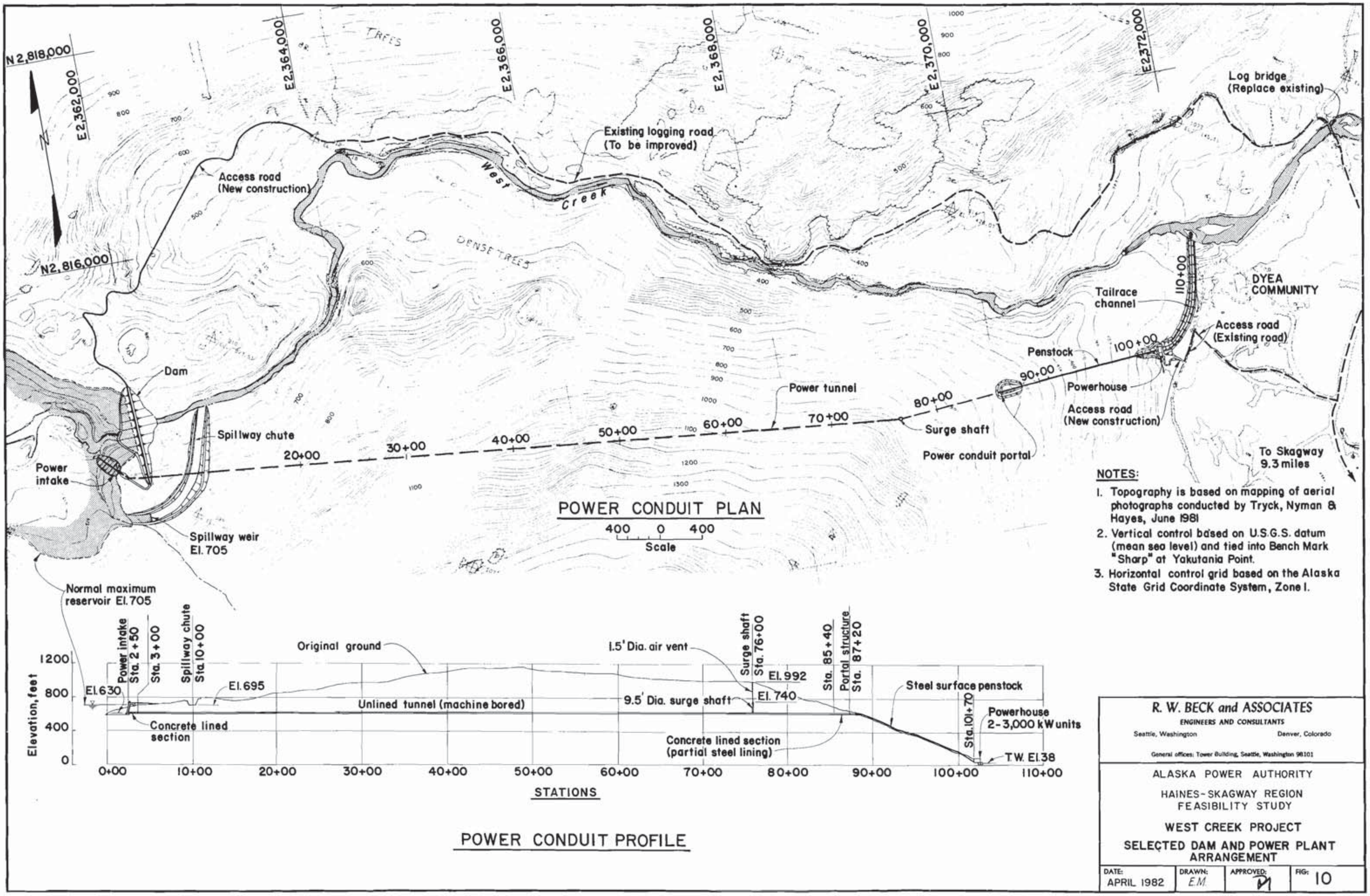
Photo 8: Approximate location of proposed powerhouse on Taiya Inlet in FERC 2014 Application

FIGURE 1
PROJECT LOCATION

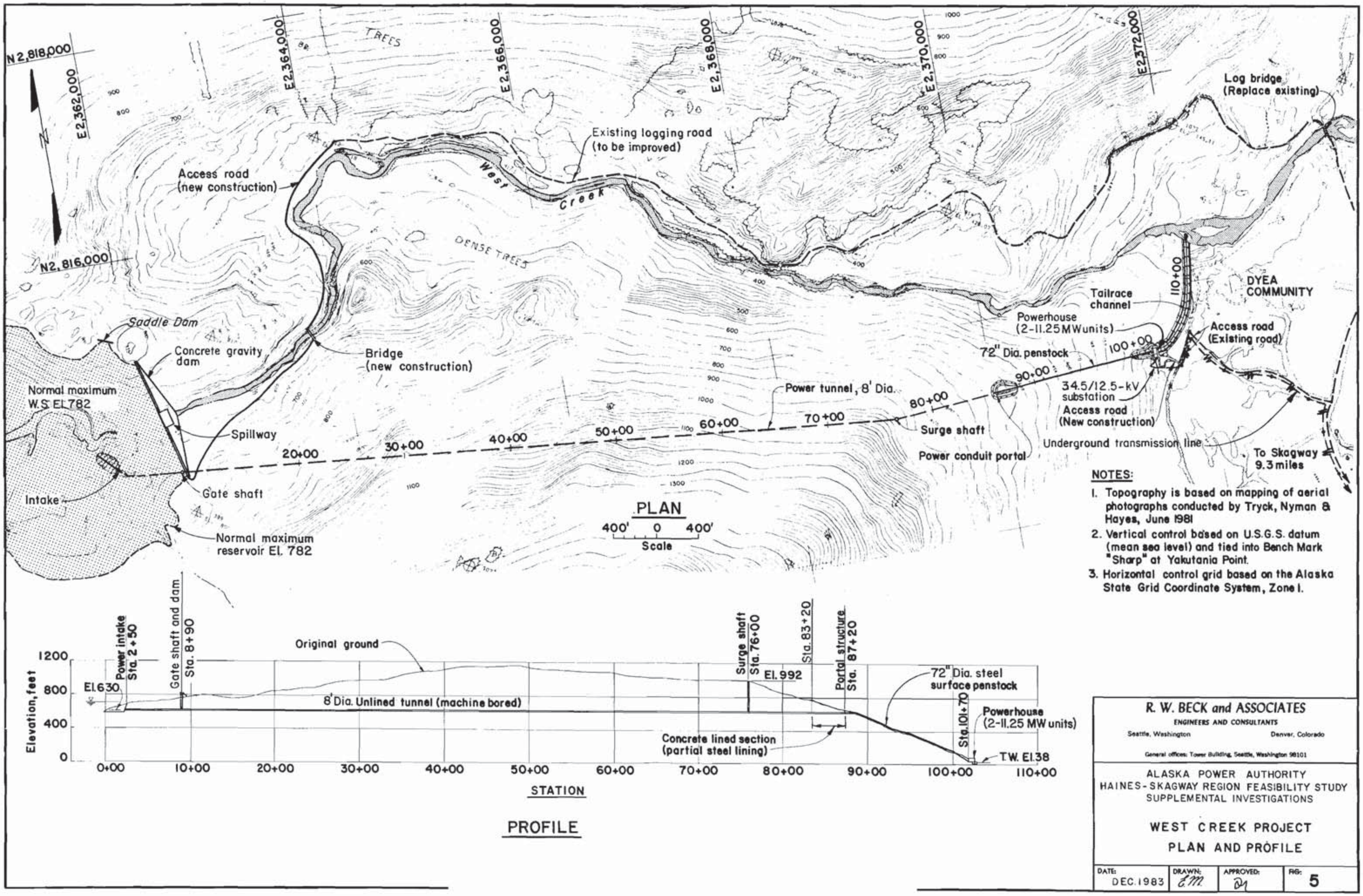




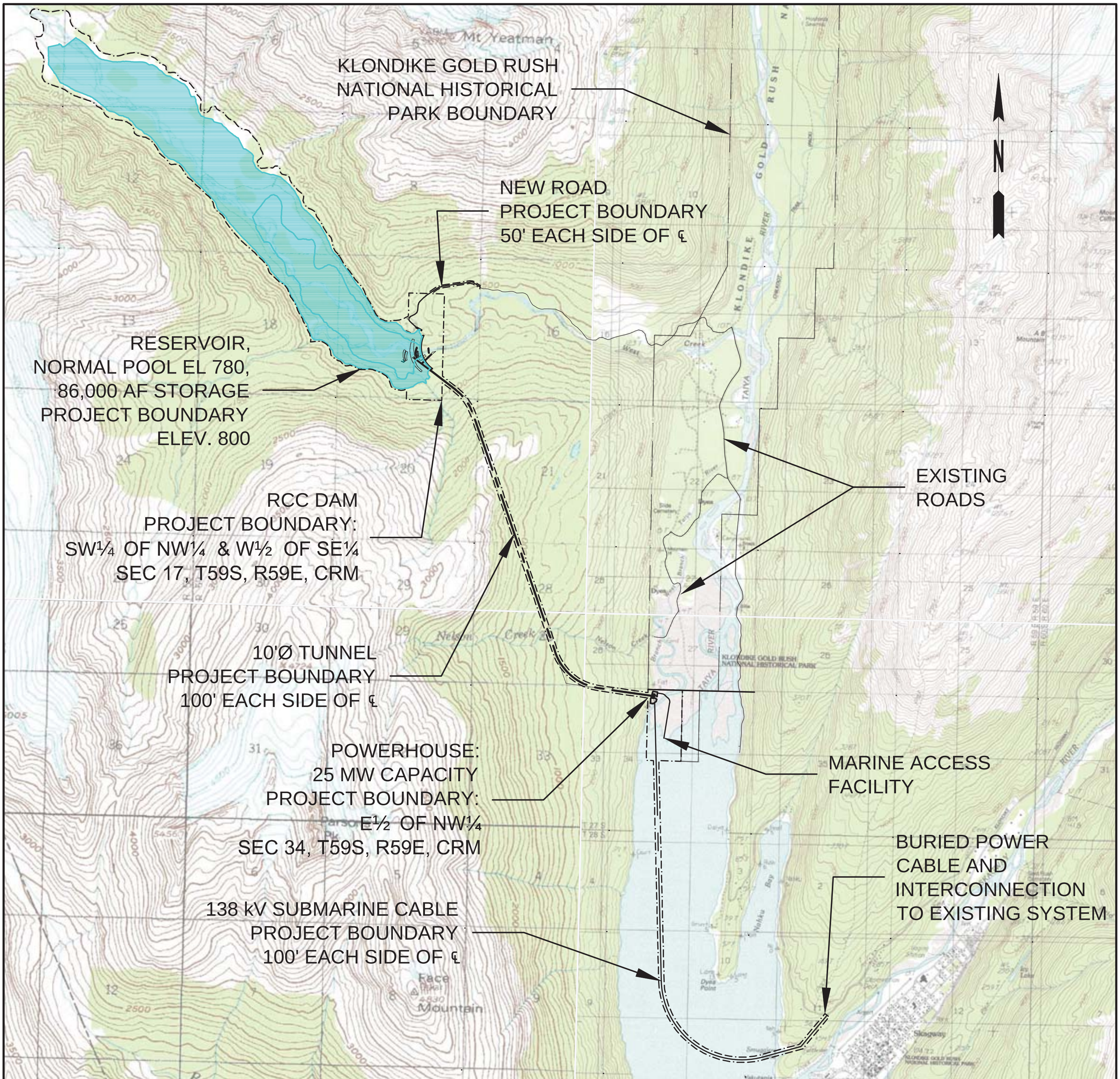
1982 Feasibility Study (R.W. Beck) proposed layout

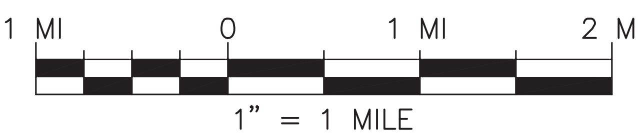


1982 Feasibility Study (R.W Beck) proposed tunnel allignment



1983 Feasibility Study - 22.5 MW (R.W. Beck) proposed layout



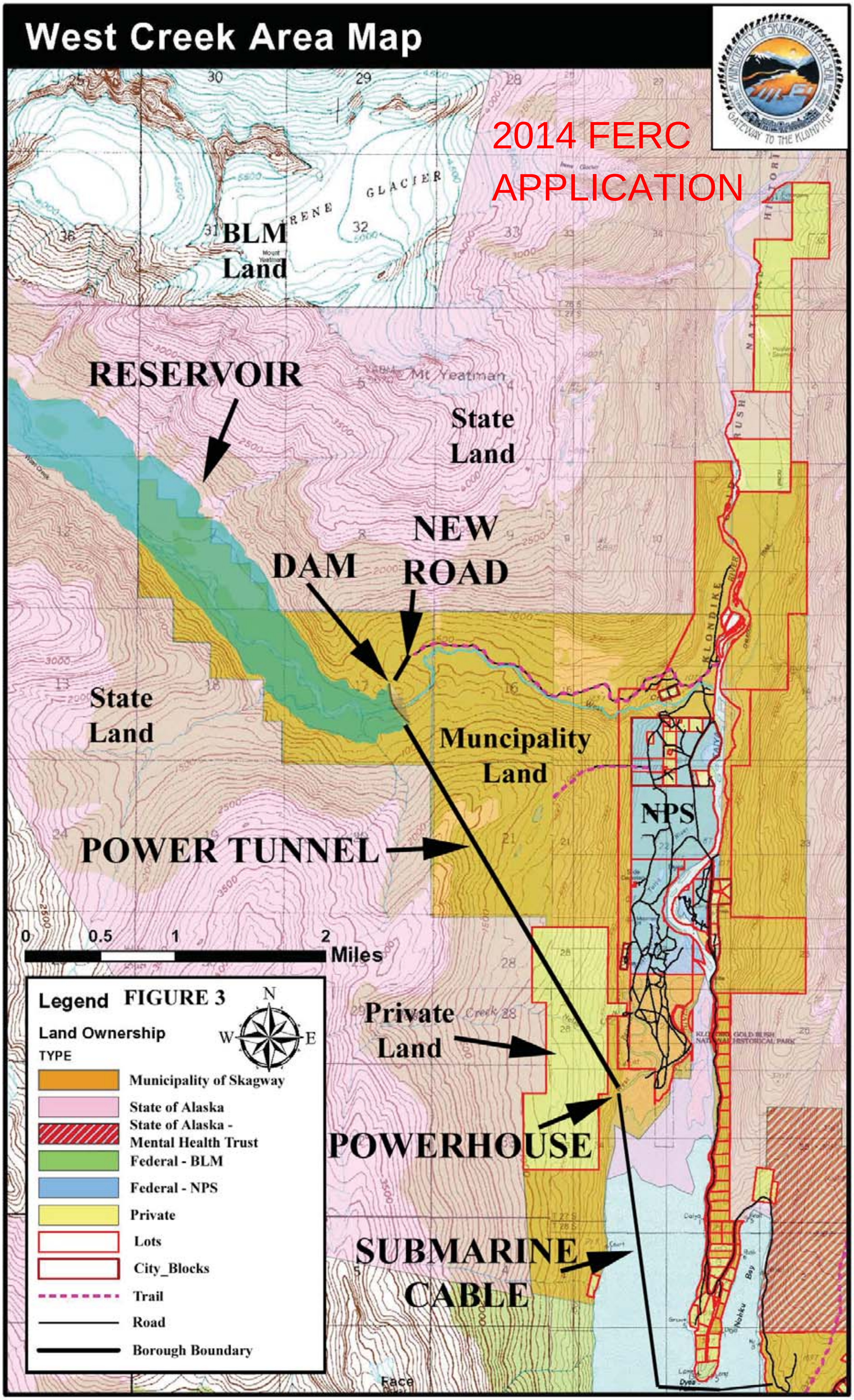


WEST CREEK HYDROELECTRIC PROJECT
APPLICATION FOR PRELIMINARY PERMIT

FIGURE 2
MAP AND PROJECT BOUNDARY

2014 FERC Application
Proposed layout

FIGURE 3: Land Ownership



Map produced by: Permitting Official David Van Horn

November 1, 2012