Yukon River Report
Visit to Eagle, AK
Time of visit September 10-14, 2007

A. Activities

1. River Survey

Performed by TerraSond over a period from Sept.7 through Sept.13, resulted in the preliminary findings discussed below. The survey data collected will be post processed in the following weeks and a formal report will be released by the end of the month.

Photo 1 - TerraSond survey boat in river channel in front of Eagle

1.1. Bathymetry

1.1.1. The bathymetric data shows clearly the shape of the bottom of the channel from approximately 160 meters upstream of the island to approximately 160 meters from the downstream end. The main thalweg of the channel forms downstream of the entrance and dissipates at the confluence of the stream [Mission Creek] downstream of the town. The depth of the thalweg is constant through its length. The width of the thalweg changes slightly with the widest point at the apex of the bend. The thalweg initially forms near the middle of the channel and moves towards the outside of the bend with its nearest point at the apex after which it again moves to the middle of the channel. At the north end of the island where the two channels collect the thalweg that is formed is 2 to 3 meters deeper than the main thalweg in front of town.

1.1.2. It appears from the sounding data that there could be, in progress, a buildup of sediment at the upstream end of the west channel. Residents report that it appears that the island is lengthening at the upstream end approaching the western shore [town side].

1.1.3. Bathymetry and all other data collected are referenced from the USGS gauging station. Accurate GPS measurements have been collected for all features of the project.

1.2. Discharge profiles

1.2.1. Discharge profiles were performed along the USGS transect approximately 2km upstream of the USGS gauging station and at Washington Street.

1.2.2. Finding will be compared to the USGS records and a correlation developed to allow extrapolation of data to predict flows and velocities in the channel based on the USGS data.

1.2.3. Profiles were taken twice as the river rose approximately two feet over the duration of the survey trip.

1.3. Velocity profiles

1.3.1. Transects were performed parallel to the channel thalweg and perpendicularly across the channel at the Amundsen and Washington Street locations.

1.3.2. Preliminary findings indicate that the velocities in the thalweg of the channel do not change much and at the time of measurement ranged from ~1.5 m/s at ~1 meter from the bottom to 2.5 m/s at 0.5 meter below the surface.

1.3.3. The observed velocities using the acoustic Doppler current profiler [ADCP] were very erratic and inconsistent suggesting that the turbulence in the water effects the direction and magnitude of the velocities.

1.4. Sub-bottom profiles

1.4.1. Profiles were performed in the thalweg in the anchor locations at Amundsen and Washington Streets.

1.4.2. Preliminary finding indicate that the sub bottom material does not change in density in these areas and that no bedrock is present.

1.5. Bottom material sampling

1.5.1. A scoop was fabricated out of 6” pipe and lowered to the bottom of the thalweg to collect a sample of the bottom surface material.

1.5.2. Two samples were taken each sample included a single fist sized round river rock. There were no traces of finer sediments indicating that the surface at the bottom of the thalweg consists of mostly of rock.

2. Site Studies for Land-Side Equipment

2.1. Installation Alternatives

2.1.1. General Site Selection Discussion

The survey data indicates that velocities through the thalweg in front of Eagle do not appear to appreciably change from its beginning to its end. There is noticeable turbulence in the water throughout this distance and it will not be understood clearly what its effect is on water velocity until additional data is collected. The thalweg does move from approximately the middle of the channel at its beginning at the upstream [south] end of the channel to the outside of the bend with the nearest point at the apex of the bend after which it moves back to the middle of the stream before dissipating and becoming erratic at the confluence of Mission Creek from the western shore at the downstream [north] end. The bottom material does not appear to change in make-up throughout the thalweg. These results appear to indicate that one part of the thalweg will not provide any better generation than another. So the turbine location then is more dependent upon the economics of the associated infrastructure.

2.1.2. Three different sites for the location of the land-side equipment were considered. These are briefly described below and compared against each other in the table below.

2.1.2.1. Washington Street – original site considered and included in the agency permit applications.

Photo 2 - Station would be located on the undeveloped property in the upper right corner of the picture. The building to the left is the city Fire Hall.

2.1.2.2. Amundsen Street – a site located adjacent to the apex of the thalweg where the turbine could be located closest to the shore.

Photo 3 – View looking north up First Avenue, station would be on property in upper right hand corner of picture located behind the AP&T office [green roof] or next to the dish antenna, there is an alley on the far side of the AP&T office building

2.1.2.3. Adams Avenue – a site that would allow the converter station to be closest to the shoreline.

Photo 4 – View looking north on Front Street, station would be located adjacent to metal building in upper left hand corner of picture, the river bulkhead is on the right side of the picture

Land-Side Equipment Location Alternatives			
Item	Descriptions		
Street	Adams Avenue	Amundsen Street	Washington Avenue
Property Owner	Dennis Layman	Ralph Helmer	City
Size	As required	As required	50’ x 100’
Lot Description	NW corner at intersection of Front Street and Adams, container would be located adjacent to existing lean-to metal building. Site preparation would be minimal requiring only the removal of a small amount of gravel stacked along the existing metal building. Future expansion might mean removal of existing metal building	NE corner at intersection of First Street and Amundsen several alternatives to positioning container possibly in space adjacent to existing communication equipment or in lot presently occupied by dilapidated log house. Either space would require clearing and removal of building and/or outbuildings	SW corner at intersection of First Street and Washington, lot is undeveloped currently covered with small tress and bushes. Lot would need to be cleared and brought up to grade with fill material. An access driveway would be built from Washington Avenue. An overhead 3Ø 7200 volt line runs along Washington. Currently at the foot of Washing Avenue the city has allowed dumping of brush and other land waste / debris. This material may need to be removed to provide access to the bank and beach for conduit trenching.

To Generator	Distance	625 ft	815 ft	1020 ft
	Route	Across Front Street down bulkhead across beach and into river	Down Amundsen or alley adjacent to AP&T office across Front Street down bulkhead across beach and into river	Down Washington down drilled hole through short tunnel across beach and into river
To 3 Phase Line	Distance	1200 ft	900 ft	50 ft
	Route	Buried or overhead circuit that will travel along Adams Avenue to First Street turn left and run down First to overhead three phase line on Washington.	Buried or overhead circuit that will travel along Amundsen Street to overhead three phase line on Third Street	Short connection to adjacent overhead three phase circuit.
Beach Trench Distance	Distance	520 ft	450 ft	660 ft
	Route	Across beach day-lighting through slope adjacent to thalweg across bottom and along anchor line to generator	Across beach day-lighting through slope adjacent to thalweg across bottom and along anchor line to generator	Across beach day-lighting through slope adjacent to thalweg across bottom and along anchor line to generator
Road Trench Distance [DC]	Distance	80 ft	340 ft	320 ft
	Route	Vault at bulkhead across Front Street to Station	Vault at bulkhead along bulkhead to intersection with alley up alley to Station	Vault at grade along Washington to Station
Bank Drop Distance	Distance	25 ft	25 ft	40 ft
	Route	Surface mounted conduit in bulkhead depression	Surface mounted conduit in bulkhead depression	Drilled hole from street level to sub beach level

Advantages	Shortest distance to anchor	Thalweg is closest to shore	Low cost from the city [$50/month?]
	No cost through pilot testing period	Bulkhead conduit drop	Short distance to three phase connection
	Large enough for expansion	Located next to AP&T office	Away from the tourist center low visual impact
	Bulkhead conduit drop	Large enough for expansion	Large enough for expansion
	Minimum lot improvement required minor leveling and brush removal		
2.1.2.3.1. Disadvantages	Future rent/lease or purchase would need to negotiated with owner if permanent station were built	Long distance to 3 phase line [~] overhead or buried	Longest distance to anchor, thalweg further from shore
	Long distance to 3 phase line [~] overhead or buried	Cost would need to be negotiated with owner	Bank conduit drop will require drilling vertical hole 40 foot deep
	High visual impact	High visual impact	More excavation effort on the beach
	Located at major intersection with high foot and vehicular traffic during summer months	Some lot improvement required brush and grass removal gravel foundation	Major lot improvement required vegetation clearing excavation and lifting with gravel

2.2. Location Features and Required Infrastructure

2.2.1. Bulkhead and Conduit Drop

2.2.1.1. In front of town through the apex of the river bend there is a steel bulkhead that was built after the last major ice break-up/flood event that occurred in 1992 and caused severe erosion to the earth bank partially destroying the road in front of town. The bulkhead wall is built from 40' long interlocking Z section sheet piles driven roughly half their length.

Photo 5 - Steel bulkhead in front of town, brush is accumulation of debris dumped by residents.

2.2.1.2. A bulkhead conduit drop would include a traffic grade concrete vault installed below grade on the road side of the bulkhead, an opening would be cut through bulkhead for cables to pass through and cover plates installed to protect exposed the conduits. Conduits would be installed in the bulkhead depressions and would not protrude into the waterway.

2.2.2. Earth Bank and Drilled Hole

2.2.2.1. At the upstream end of the bulkhead the earth banks dips and then rises 15 to 20' above the top of the bulkhead. The end of Washington Street is located approximately 300' upstream from the bulkhead. The crest of the bank in this location is about 35 feet above the river beach. Presently the bank in this location is covered with three years accumulation of organic debris, dirt, brush, etc. creating a bulge about 40 feet wide and projecting 10 to 15 ' from the bank. The city allowed dumping here to keep the residents from dumping brush over the bulkhead wall. In the eventual high water event this debris should be dragged downstream.

Photo 6 - Bank at foot of Washington Avenue, with debris accumulation from dumping by residents over the last three years.

2.2.2.2. Bank conduit drop well be accomplished with through a vertical or steeply inclined hole drilled [using conventional well drilling equipment?] from road surface down 5 to 6 feet below toe elevation [~40 feet] the toe of the bank and will require that a tunnel [20-30' long] be excavated into the base of the bank. The bank soil composition will require that the tunnel be shored along its entire length using culvert or pipe.

2.2.3. Beach and Beach Trenching

2.2.3.1. The town side beach is made up of sand, silt, gravel and small [fist sized] cobble, This material is common across the river bottom and gradually changes to the lighter sand and silt make up on the opposite beach. The bottom of the thalweg appears to be made up of primarily the cobble sized material.

2.2.3.2. Trenched conduit on the beach would include extra long radius elbows at the base of the bulkhead or bank and conduit trenched 5 to 6 feet deep across beach. Trench excavation would be scheduled to allow that the final reach of conduit would placed when the ice had fully formed at which time the ice would be slotted to water level and trench extended out of the slot below ice level 5 to 6 feet.

2.2.3.3. Trenching will require tracked excavator. Trenching into the river will require the construction of a small diversion structure for below water excavation.

2.2.4. Roads and Road Trenching

2.2.4.1. All roads in the city are unpaved and constructed of compacted material and graded smooth.

2.2.4.2. Road trenching will be at depth required for local load requirements.

2.2.4.3. Trenching will require backhoe

B. Notes/ Observations/ Reports

1. Anchoring
   1.1. Anchor type
      1.1.1. Deadweight - Experience with deadweight anchors locally has been limited. Eco blocks have been used to provide anchorage for floats, etc. but they are prone to snagging debris moving low in the water column and have been dragged along the bottom.
      1.1.2. Pilings
         1.1.2.1. H/Pipe Pile – Pile driving would be a good method for providing a permanent anchor however costs to mobilize pile driving equipment would be high.
         1.1.2.2. Micro Pile – The composition of the bottom material does not appear to be suitable for micro piles and there no bedrock present.
         1.1.2.3. Helical Pile – Helical piles could possibly work they would need to be installed along the edge of the river through the ice when water level is lowest in the winter as it would be very difficult to install the piles underwater as the fast moving current and low visibility in the summer would make such operations very hazardous.
      1.1.3. Ship Anchor
         1.1.3.1. The bottom of the thalweg consists of round river rock as such ship anchors will have very poor performance and would have to be sized for use as deadweights. The Yukon Queen has deployed Danforth type anchors along the shore in the area of their operations and have had good success using them however their operation are in slow moving parts of the river and the bottom material has a higher silt content.
         1.1.3.2. A heavy section of chain [~60’] will be required with any ship anchor.
   1.2. Anchor location
      1.2.1. Two anchor points will be required to provide stability to the turbine platform in times of kiting operations. These points can include multiple anchors.
2. Winter turbine operation and maintenance
   2.1. In river and over ice operations will be hazardous; river ice is typically uneven and inconsistent in makeup.
   2.2. Debris volume in the river typically drops during the winter and removal will be less of a problem however debris volume sharply increases at the time of break-up.
   2.3. Waste heat recovery revenue from school will decrease or be lost with river turbine operation during the winter.
   2.4. Turbine extraction prior to break up will require lifting equipment to raise turbine over the ice. All such equipment will need to be assembled from parts that can be carried on a snow machine or sledge and assembled without a crane. The local equipment contractor is not interested in performing any on ice or other winter operations.
   2.5. Turbine freezing into the ice is a possibility in very cold/dry winters as water level will drop to lowest and ice will become thickest.
   2.6. Frazil ice [slush] 9s reported to move in layers up to 3 feet thick under the ice.
3. River Conditions
   3.1. Current – the river current is very fast with surface velocities of up to 4m/s [8knots]

- 3.2. Turbidity – the river in the summer months has high turbidity with levels that limits visibility to a few inches, in the winter turbidity level drops the water becomes clear. Diving and subsurface operations will be difficult.
- 3.3. Vortices and turbulent water – these boils are moving around throughout the width and length of the river, they are generated by the irregular surfaces of the river bottom.
- 3.4. Debris – debris is present most of the year and can be very heavy after an upstream storm event, majority is moving on the surface however there is also considerable material moving below the surface through the water column. The material is irregular in shape and size and rapidly collects on any obstacles in the flow, anchor/moorage lines, hulls, etc.
- 3.5. Ice – River ice begins to form in early October and normally breaks-up by late April, ice thickness is normally in the range of 3-5 feet, is inconsistent in make-up and has a very irregular topside surface
- 3.6. Fish – Fish include migrating salmon and local species.
- 3.7. River access is at a boat ramp upstream of the city. The ramp is constructed of river silt and requires patching and grading regularly.

4. Cabling
   - 4.1. Directional Bore
     - 4.1.1. Washington Street
     - 4.1.2. Amundsen Street / Adams Avenue
   - 4.2. Trench
   - 4.3. Bulkhead
   - 4.4. Ice
5. Landside Equipment
   - 5.1. Location – the converter station that is planned to be a assembled into a single 20’ shipping container will house the power conversion equipment, compressor, nitrogen purging system, switchgear and monitoring systems for the turbine.
   - 5.2. Distance from generator – distance between the station and the turbine should be kept to a minimum to minimize conductor losses and installation costs.
6. Turbine
   - 6.1. Capacity – to be decided
   - 6.2. Physical size– to be decided
   - 6.3. Deployment – planned to be deployed on a floating frame from the river access boat ramp using a portable winching system.
   - 6.4. Recovery – summer time recovery will be performed with the deployment winch, winter time recovery is to be decided.
   - 6.5. Connection – to be decided
7. Fisheries
   - 7.1. AF&G have operated a fish monitoring station downstream of Eagle for the last three years in their effort to quantify the numbers of fish migrating upstream each year. They work in a coordinated effort with other AT&G stations downstream and a Canadian station upstream to gather fish count information to assist in planning commercial catch limits. The Eagle station starts monitoring in early July for the Chinook [King] run and stop in mid October during the Chum run.

7.2. Today they monitor the fish movement with two sonar units an older split beam low resolution sensor and a newer multi-beam [98] high resolution sensor [Ditson].

7.3. Observations

7.3.1. Chinook

7.3.1.1.Run begins in early July and ends in early September.

7.3.1.2.Peak of run is at the end of July and early August.

7.3.1.3.Chinook run from shore to 75 meters from shore on both sides of the river

7.3.2. Chum

7.3.2.1.Run begins in late August and ends in late October

7.3.2.2.Peak of run is at the end of September

7.3.2.3.Chinook run from shore to 40 meters from shore on both sides of the river with the highest concentration along the shore

7.3.3. Smolt run down the river in the spring, this fish migration has not been carefully studied and little is known about the behavior of these fish. It is believed that they run in the fastest moving part of the river and that they run deeper during the day than in the night to avoid predation. This route would put them in the path of the river turbine.

7.3.4. Local fish

7.3.4.1.Consist of Burbot, Whitefish, Pike, Grayling, others

7.3.4.2.Tend to migrate up and down the river and according to the AF&G studies are not always present. Little is know about these species, their movements or their behavior in the Yukon.

7.4. Today fishing in the Yukon in the region of Eagle and upstream is primarily subsistence. There is a small Canadian commercial fishery. US commercial fishing occurs downstream of Eagle. Commercial fishing is for salmon.