Grant Lake Hydroelectric Project (FERC No. 13212)
Water Resources Studies - Geomorphology
March 18, 2014 – Anchorage, AK

McMillen

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Geomorphology Study

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Geomorphology Study Purpose

Two Separate Studies:

1. The **Shoreline erosion** study to consider changes in shoreline erosion resulting from lake impoundment and drawdown scenarios.
2. The **spawning substrate recruitment study** was to provide a basis for predicting and assessing potential changes to material movement, sedimentation, and gravel recruitment that may occur in Grant Creek with proposed operational management, especially as related to the long-term maintenance of fish spawning substrate.

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Geomorphology – Grant Lake Shoreline Erosion

Background

Two concepts are currently being evaluated for water control at the outlet of Grant Lake:

1. The first option would consist of a natural lake outlet that would provide control of flows out of Grant Lake.
2. The second option, would consist of a concrete gravity diversion structure constructed near the outlet of Grant Lake that would increase Water Surface Elevation (WSE) by 2 feet.

Geomorphology – Grant Lake Shoreline Erosion

- Methods
  - Desk-top GIS analysis
  - Existing shoreline condition inventory (boat-based field assessment, geo-referenced photos, field interpretation and GIS-based mapping product)
  - Prediction of potential geomorphic response classified by “geomorphic unit” integrated with fetch and field indicators to assess “relative erodiblity”.

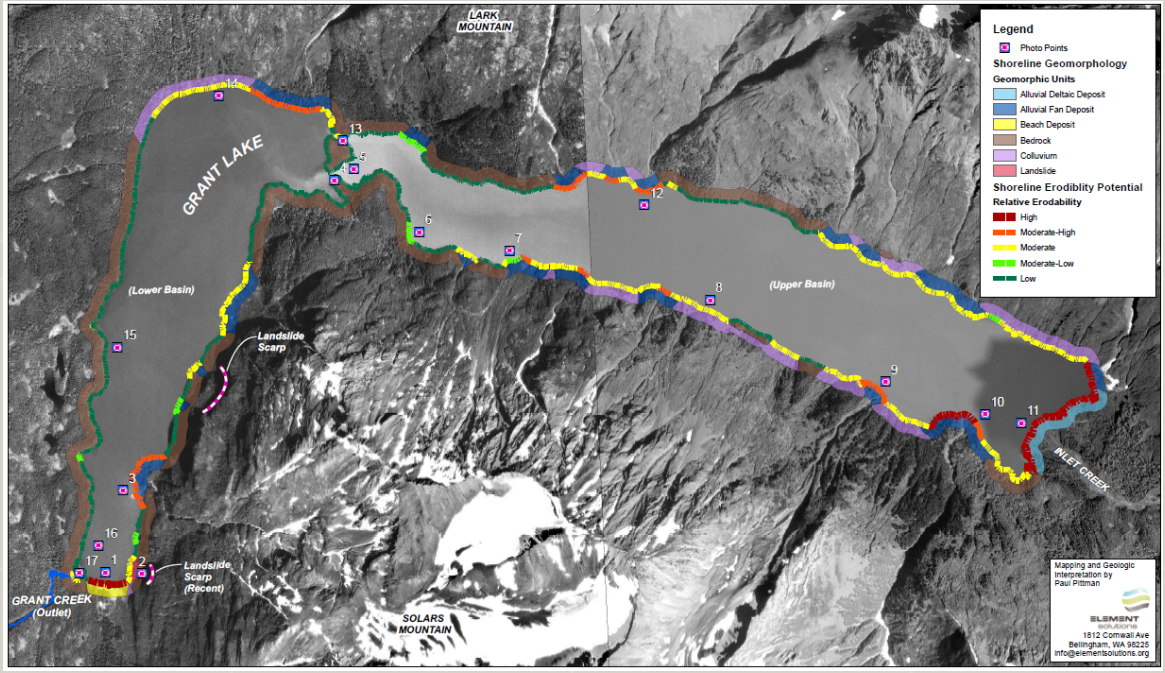
Relative Fetch Distance	Geomorphic Unit					
	Alluvial Deltaic	Alluvial Fan	Beach	Colluvium	Landslide (bedrock)	Bedrock
Short	Moderate	Moderate	Moderate	Low	Low	Low
Medium	Moderate-High	Moderate-High	Moderate-High	Moderate-Low	Moderate-Low	Low
Long	High	High	High	Moderate	Moderate	Low

Geomorphology – Grant Lake Shoreline Erosion

- Observations
  - Grant Lake is located in a deep glacially-carved basin flanked by the high bedrock peaks of Lark and Solars Mountains

Geomorphology – Grant Lake Shoreline Erosion

- Observations
  - Grant Lake encompasses two almost separate bathymetric lake basins that are separated by a shallow submerged ridge at a narrow “neck” that connects the two basins

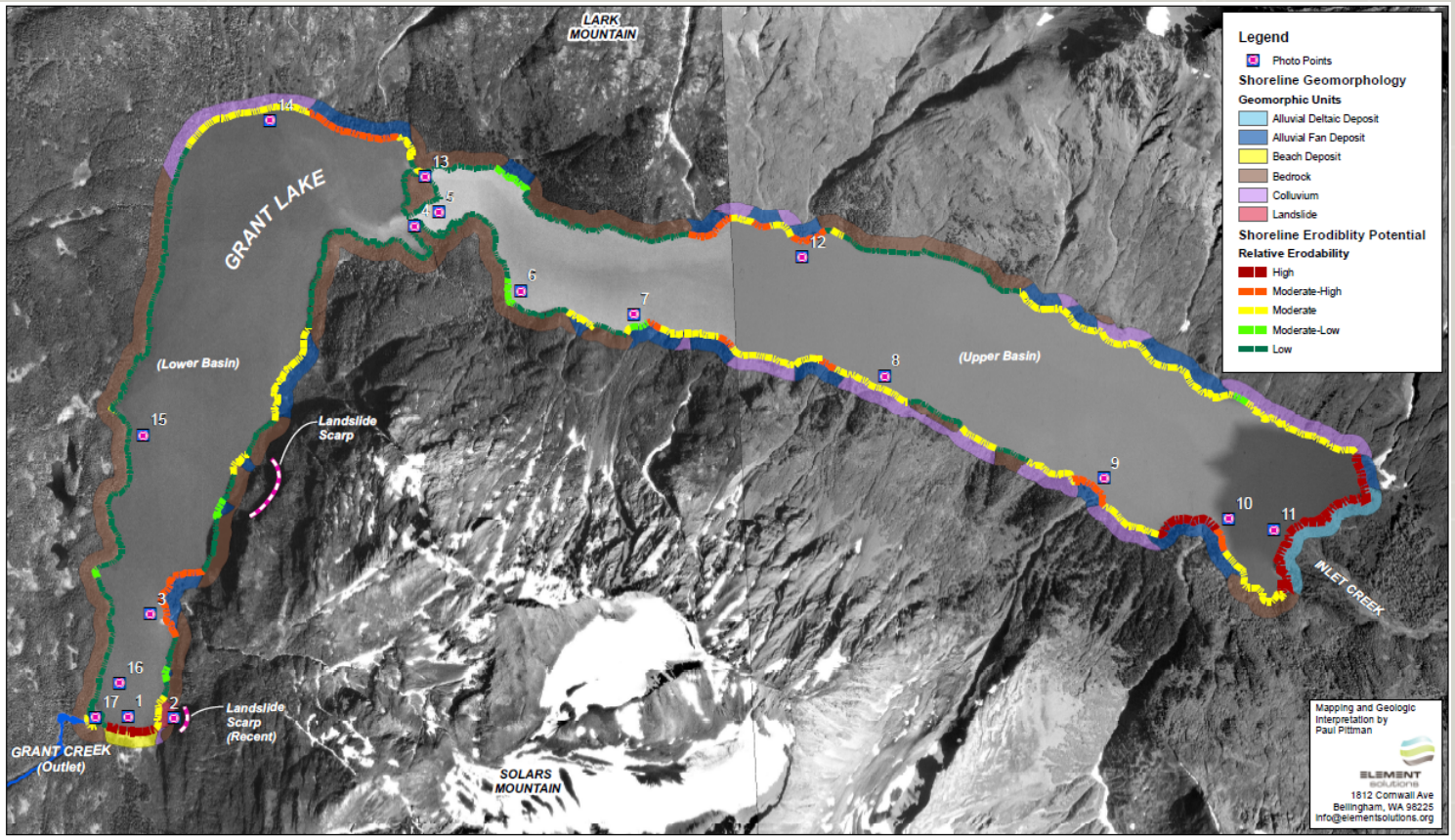


Geomorphology – Grant Lake Shoreline Erosion

- Observations
  - Much of the overall shoreline zone is steep bedrock

Geomorphology – Grant Lake Shoreline Erosion

Findings



Geomorphology – Grant Lake Shoreline Erosion

- Findings

  Operations will affect the timing, duration and range of WSE, and thus change the Grant Lake shoreline erosional patterns. In summary, an increase in WSE under the diversion structure scenario will cause:

  - Landward regression, more prominent in areas of low sloping shoreline
  - Loss of shoreline vegetation within the zone between existing OHWM and management scenario OHWM
  - Higher erosion potential in areas with large fetch and more erodable, unconsolidated shoreline geology, but wind wave erosion is anticipated to be relatively minor and localized
  - Stream incision from reduced WSE will result, but effects will be localized to deltaic and alluvial fan areas adjacent to the shoreline

Geomorphology – Grant Lake Shoreline Erosion

- Conclusions
  - Effects of wind-driven waves limited by fetch
  - Steep, bedrock or coarse sediment dominant shoreline
  - Impacts are greater for weir alternative, but they are anticipated to be temporary and limited to area within OHWM
  - Net changes to shoreline erosion from WSE variability resulting from proposed management scenarios are anticipated to be relatively minor and localized

Geomorphology – Grant Creek Sediment Transport

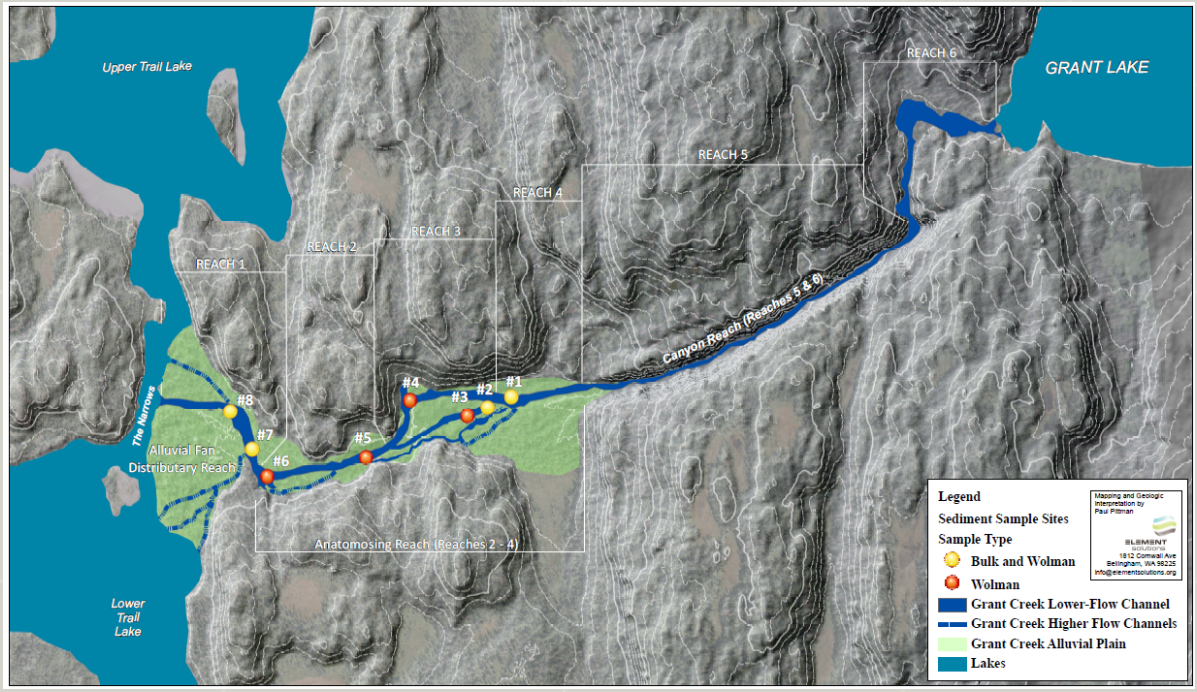
- Background
  - Operation of the Project would alter the flow regime and create a situation where flow will bypass the canyon reach

Geomorphology – Grant Creek Sediment Transport

- Methods
  - Desktop analysis (geomorphic mapping and characterization)
  - Field sediment characterization (surface and subsurface) at anticipated spawning areas (*see map handout*)
  - Field geomorphic characterization (sediment inputs, channel form, transport/deposition)
  - Considered use of existing transport equations to predict potential bedload sediment transport changes under management scenarios

Geomorphology – Grant Creek Sediment Transport

- Observations
  - In its upper half, Grant Creek passes through a steep bedrock canyon with three substantial waterfalls. The canyon is the primary bedload sediment source.
  - In its lower half, Grant Creek becomes less steep with boulder and cobble dominant alluvial substrate .

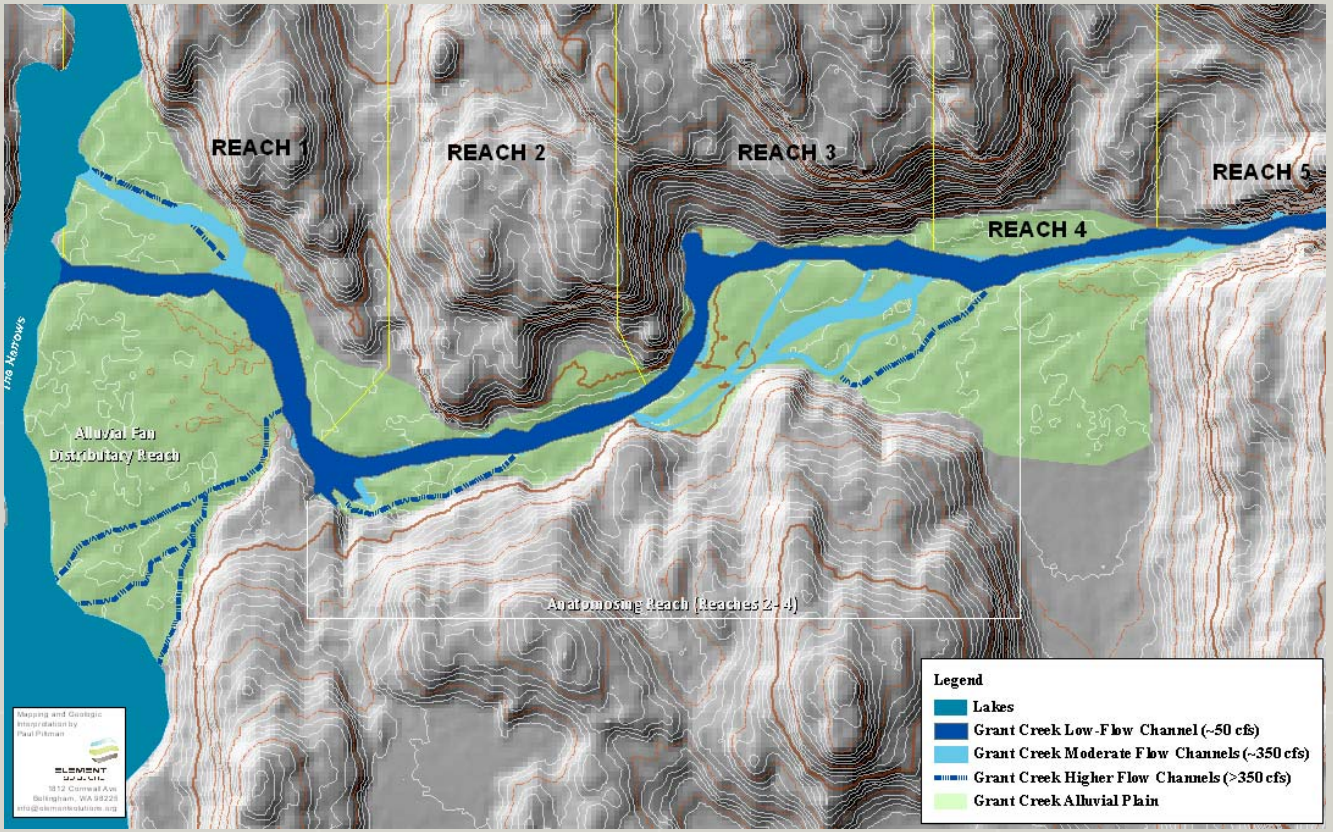


Geomorphology – Grant Creek Sediment Transport

- Observations
  - Grant Creek is a high energy, turbulent stream with a wide variability in flow regime.

Geomorphology – Grant Creek Sediment Transport

- Observations
  - Very large eposidic “events” are the primary drivers of alluvial plain morphology



Geomorphology – Grant Creek Sediment Transport

- Observations
  - Substrate was very angular and either blocky (large a axis, similar b-c axes) or platy (similar a-b axes, small c axis) and related to canyon geology

Geomorphology – Grant Creek Sediment Transport

- Observations
  - Although there is a great variability in spawning substrate size preference between individual fish, different species and different river systems, the salmon in Grant Creek appear to use large substrate limited only by their physical ability to dislodge it

Geomorphology – Grant Creek Sediment Transport

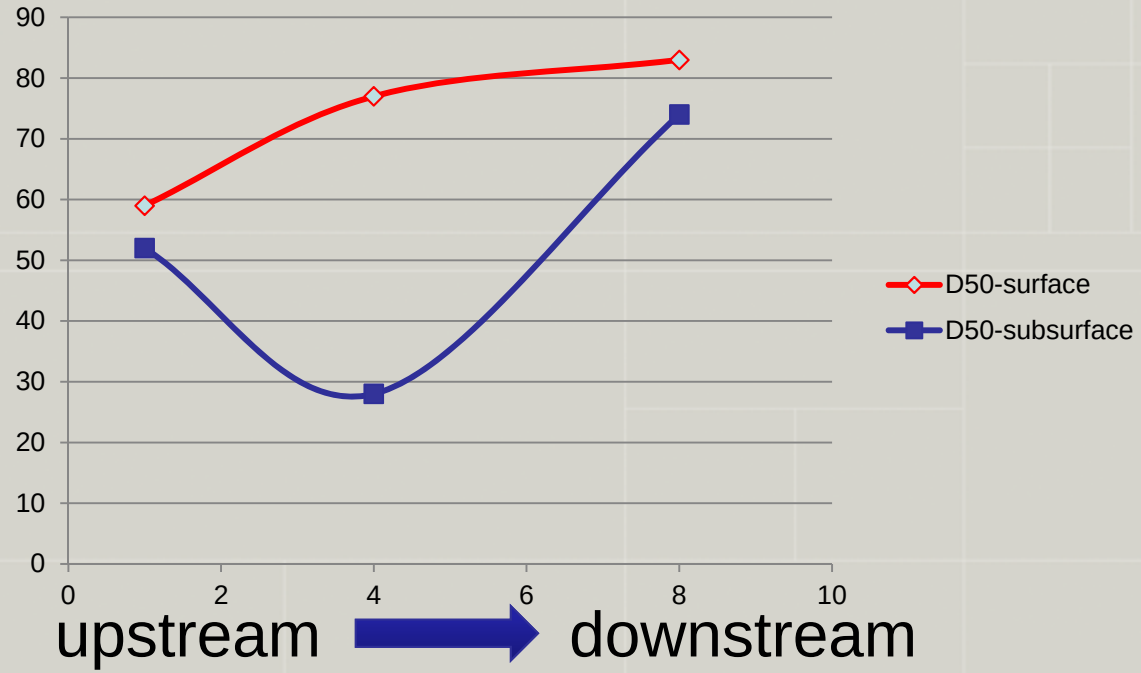
- Observations Continued
  - Sediment deposition demonstrated “hiding” and surface sediment was in general fairly “locked” and locally armored

Geomorphology – Grant Creek Sediment Transport

- Observations Continued
  - Stream flow turbulence exacerbated by boulder “lag” and bedforms and was hydraulically complex

Geomorphology – Grant Creek Sediment Transport

- Observations Continued
  - Bedload sediment in general was course, well-graded, and “clean”
  - No anticipated trends in downstream fining were measured in either surface or subsurface measurements



Geomorphology – Grant Creek Sediment Transport

- Findings
  - Attempts to calculate or measure shear stress values in mountain rivers are complicated by the channel bed roughness and the associated turbulence and velocity fluctuations (Wohl, 2000), in addition to sediment particle shape, lag deposits, and armoring further reduced confidence in qualitative assessments (Yager 2012)
  - It is probable that the flow regime under management scenarios (>385 cfs) is sufficient to only mobilize or re-mobilize some small diameter bedload sediment (~62 mm-*blocky*, but confidence in this value is low)
  - The sediment supply to lower Grant Creek will decrease with the canyon bypass

Geomorphology – Grant Creek Sediment Transport

- Findings continued
  - Channel bed substrate is anticipated to coarsen or armor (surface and near surface) and increase in pavement thickness
  - The diversity of bedform morphology and associated hydraulic complexity is anticipated to decrease under a managed flow regime
  - Channel morphology complexity and floodplain connectivity is anticipated to decrease with reduced sediment input

Geomorphology – Grant Creek Sediment Transport

- Conclusions
  - The anticipated physical changes to the fluvial system are predicted to have ecological impacts, but these potential changes were not quantified
  - Potential mitigation actions to reduce some of the impacts exist
    - Sediment supply mitigation
      - Providing canyon flows
      - Providing sediment nourishment
    - Flow variability mitigation
      - Providing variable “channel maintenance” flows (high to low)

Geomorphology – Questions….?

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