Overview of Floodplain Soil and Stream Sediment Data

Leviathan Mine Site, Alpine County, California

December 13, 2016

Presentation Outline (Morning Session)

- Safety Moment
- Terminology – Sediment vs. Floodplain Soil
- Status of Floodplain Soil Investigation
- Sediment Data
  - Sediment Data Quality
  - Other Sediment Data
  - RI Sediment Data
- Conceptual Site Model for Sediment Metals
- Data Quality Objectives
- Sediment Study Design
- Stream Profiles for Selected Metals
- Primary Factors Influencing Metals Distribution

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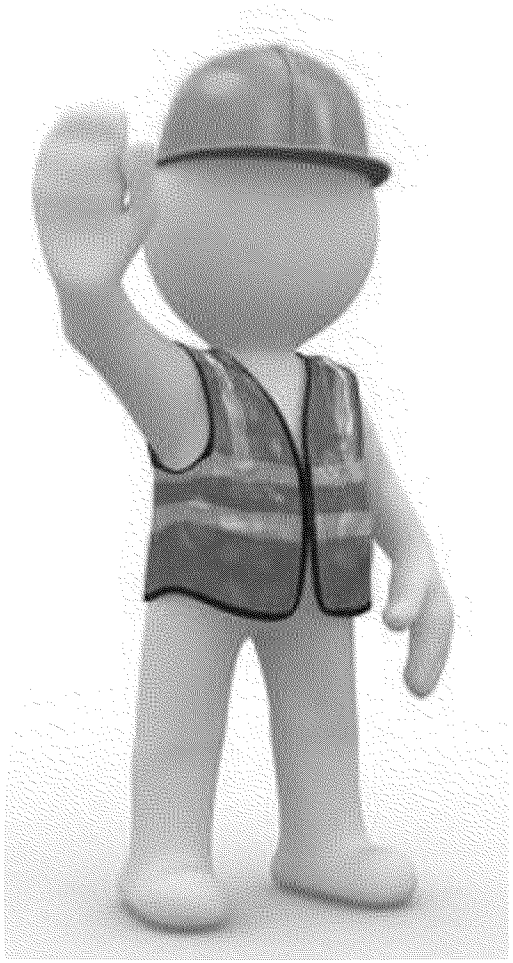
Discussion Outline (Afternoon Session)

- Schedule and Content of Interim RI Deliverables
  - Field Summary Reports (90 days after field work completed)
  - Technical Data Summary Reports (TDSRs)
- RI/FS Field Work Status
  - Remedial Investigation
  - Feasibility Study
  - Work Planned for 2017
- Next Steps and Wrap Up

Safety Moment

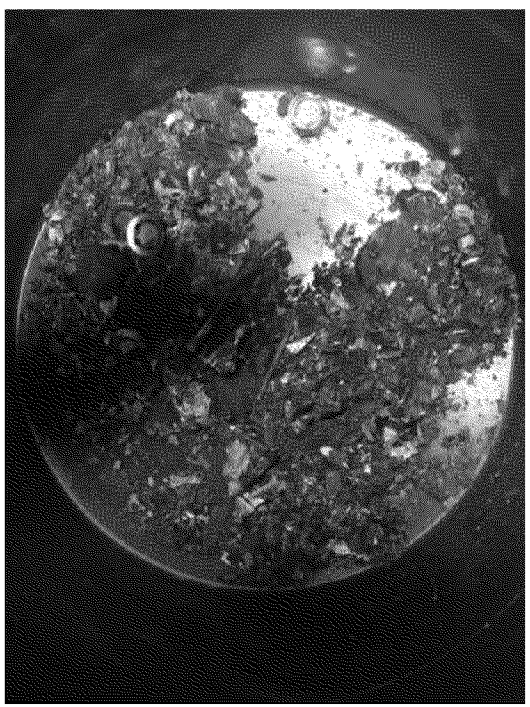


Fire Safety – Exploding Batteries

- Exploding electronic batteries are not just something we see in the news
- Replacement laptop battery exploded causing fire
- Laptop battery composed of six separate battery cell; cells apparently overheated, exploded, and caught fire

Fire Safety – Exploding Batteries

- Battery cells exploded throwing hot and flaming copper foil in a 6-8 foot radius from laptop
- Copper foil stuck to everything it contacted igniting multiple small fires across the room

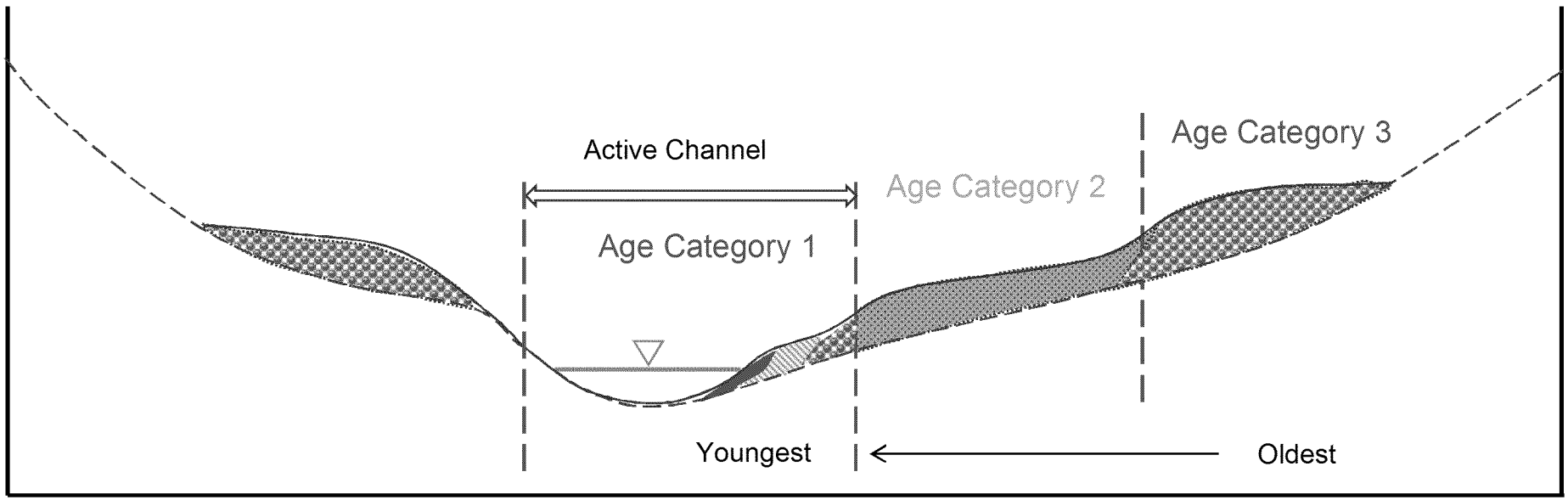


- Battery cells continued to explode ~5 minutes after initial event and seemingly after primary fire was extinguished

Fire Safety – Exploding Batteries

- Standard ABC fire extinguisher sufficient to extinguish flames; however, not sufficient to cool hot batteries or contain further explosion
- Fire blanket can smother fire to extinguish flames and help contain potential small explosions from battery cells

Terminology: Stream Sediment vs. Floodplain Soil



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Chronology and Status of Floodplain Soil Investigations

Work Plan Development and Field Implementation

- 2010 – reconnaissance mapping of On-Property and Downstream Study Areas to identify relative age categories (Category 1, 2, 3) in support of the development of sampling design
- 2012 – detailed intrusive mapping of floodplain soils of soil characteristics in On-Property Study Area
- 2013 – reconnaissance mapping of Reference Study Areas to identify analogue areas for sampling
- 2013 – finalize Addendum No. 2 Off-Property Work Plan and obtained EPA conditional approval of phased sampling approach
- 2014 – no intrusive activities performed due to NHPA constraints
- 2015 – detailed intrusive mapping of soil characteristics in Downstream and Reference Study Areas
- 2015 – implemented floodplain soil sampling in On-Property Study Area and started sampling in Reference Study Areas
- 2016 – finalized work plans for floodplain soil sampling in Downstream and Reference Study Areas
- 2016 – completed floodplain soil sampling in Downstream and Reference Study Areas and conducted deeper sampling (to 6 feet bgs) in the On-Property Study Area

Current Status

- Laboratory analysis of samples collected in 2016 recently completed
- Data validation and data quality reviews of 2016 sampling data are underway

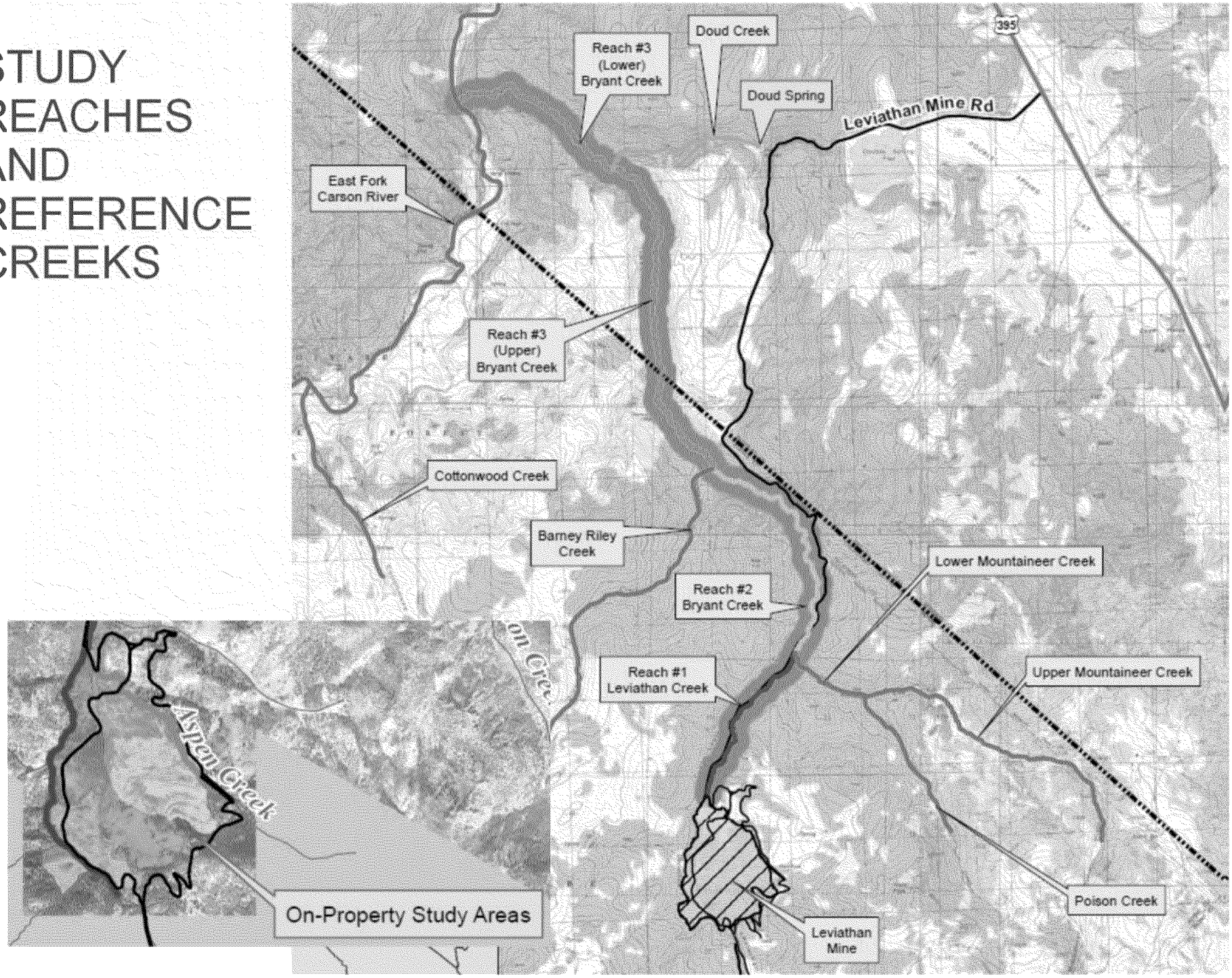
Summary of Floodplain Soil Sampling Design

Three Study Areas
(On-Property, Downstream Study Area, Reference Areas)

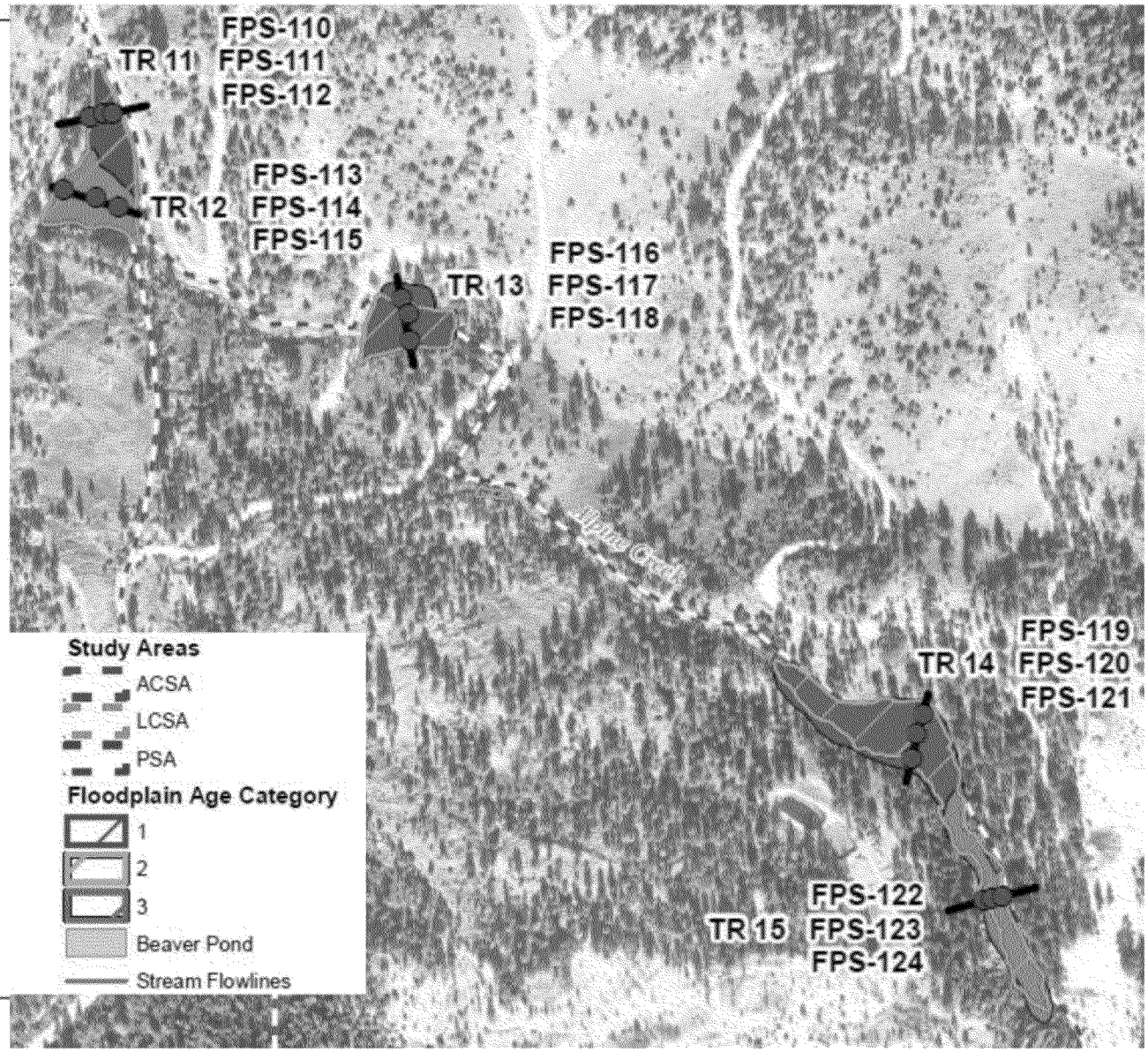
Study Areas Divided into Eight Reaches

- On-Property
  - **Aspen Creek** – ~0.95-mile reach of Aspen Creek extending downstream from Station 22 to the confluence with Leviathan Creek
  - **Leviathan Creek** – ~0.45-mile reach of Leviathan Creek between Station 1 to the confluence with Aspen Creek
- Downstream Study Area (DSA)
  - **Reach 1 (Leviathan Creek)** – ~1.7 -mile reach extending from the confluence of Leviathan and Aspen creeks to the confluence with Mountaineer Creek
  - **Reach 2 (Bryant Creek)** – ~2.4-mile reach extending from the Bryant Creek headwaters (confluence of Leviathan and Mountaineer creeks) downstream to the confluence with Barney Riley Creek
  - **Reach 3 Upper (Bryant Creek)** – ~3.2-mile reach extending downstream from the confluence with Barney Riley Creek to the confluence with Doud Creek
  - **Reach 3 Lower (Bryant Creek)** – ~1.8-mile reach extending downstream from the confluence with Doud Creek to the confluence with the East Fork Carson River
- Reference Study Areas (RSA)
  - **Upper Mountaineer Creek** – ~1.8-mile reach extending from the headwaters of Mountaineer Creek to the confluence with Poison Creek
  - **Lower Mountaineer Creek** – ~0.75-mile reach downstream of confluence with Poison Creek to confluence with Bryant Creek
  - **Cottonwood Creek** – ~1.5-mile reach extending from headwaters of to confluence with the East Fork Carson River

STUDY REACHES AND REFERENCE CREEKS



Floodplain Soil Sampling Locations



Explanation

- Floodplain Sample Locations
- Sample Transects

Soil Type

- coarse-loamy
- coarse-loamy, shallow water table
- fine
- fine, shallow water table
- fine-loamy

Other Sediment Data

USGS Data Collected by Thomas and Lico

- 8 sampling location in the study area in 1998

EPA Sediment Data Collected by Ned Black's Team

- Annual sampling (once or twice per year during June and/or September)
- Surficial sediment (0 to 3 cm) available from Sept. 2000 through Sept. 2013
- 16 locations sampled consistently; occasional samples at other locations
- 19 RI/FS metals (no hexavalent chromium)

Dave Herbst Index of Biotic Integrity for Benthic Community

- Index comprised of 10 metrics that measures the health of benthic community
- Score ranges from 0 to 10. Higher values represent worsening condition
- Annual sampling (once or twice per year during June and/or September)
- Sampling data from 1995 to present – data available only through 2014
- Samples only from riffle habitat
- Provides indirect information on sediment metal's bioavailability

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Herbst Index of Biological Integrity Monitoring

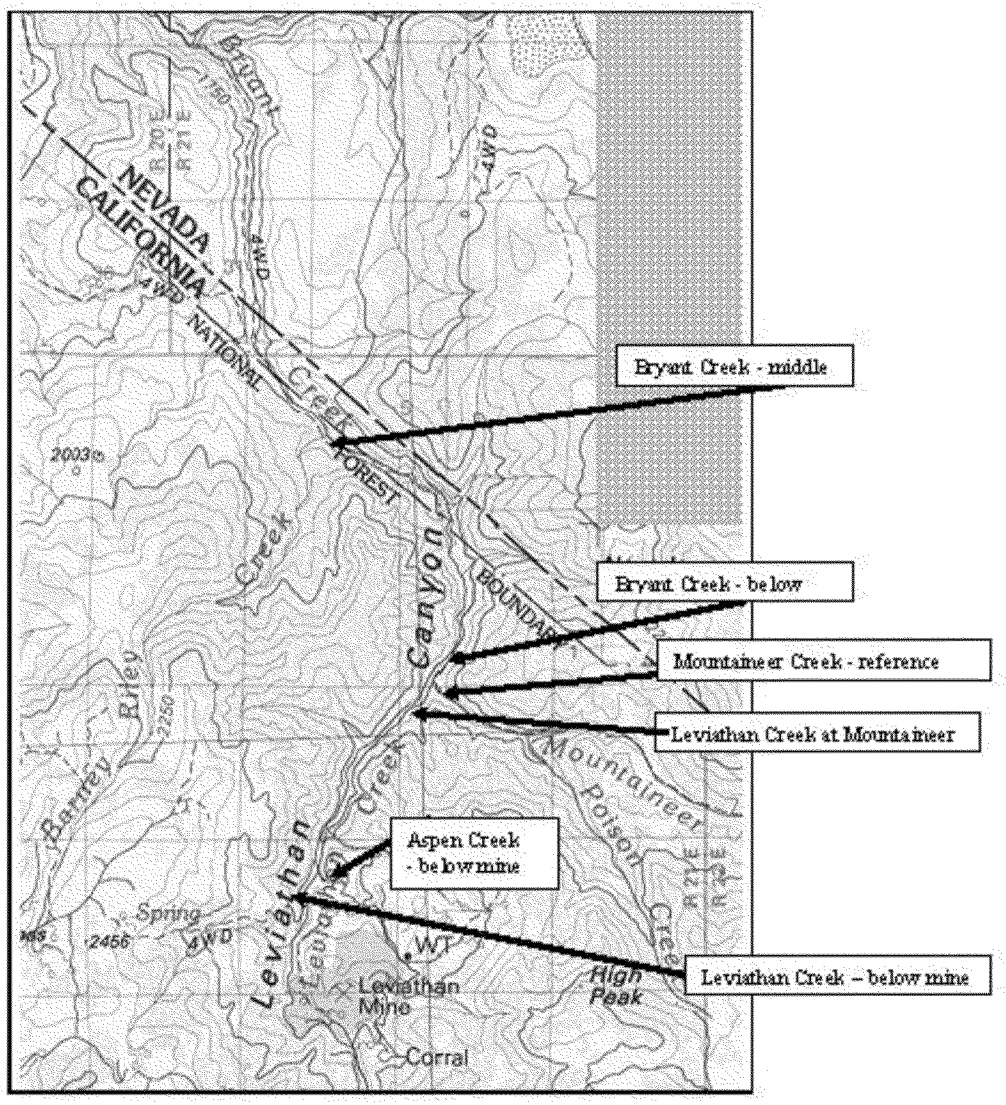
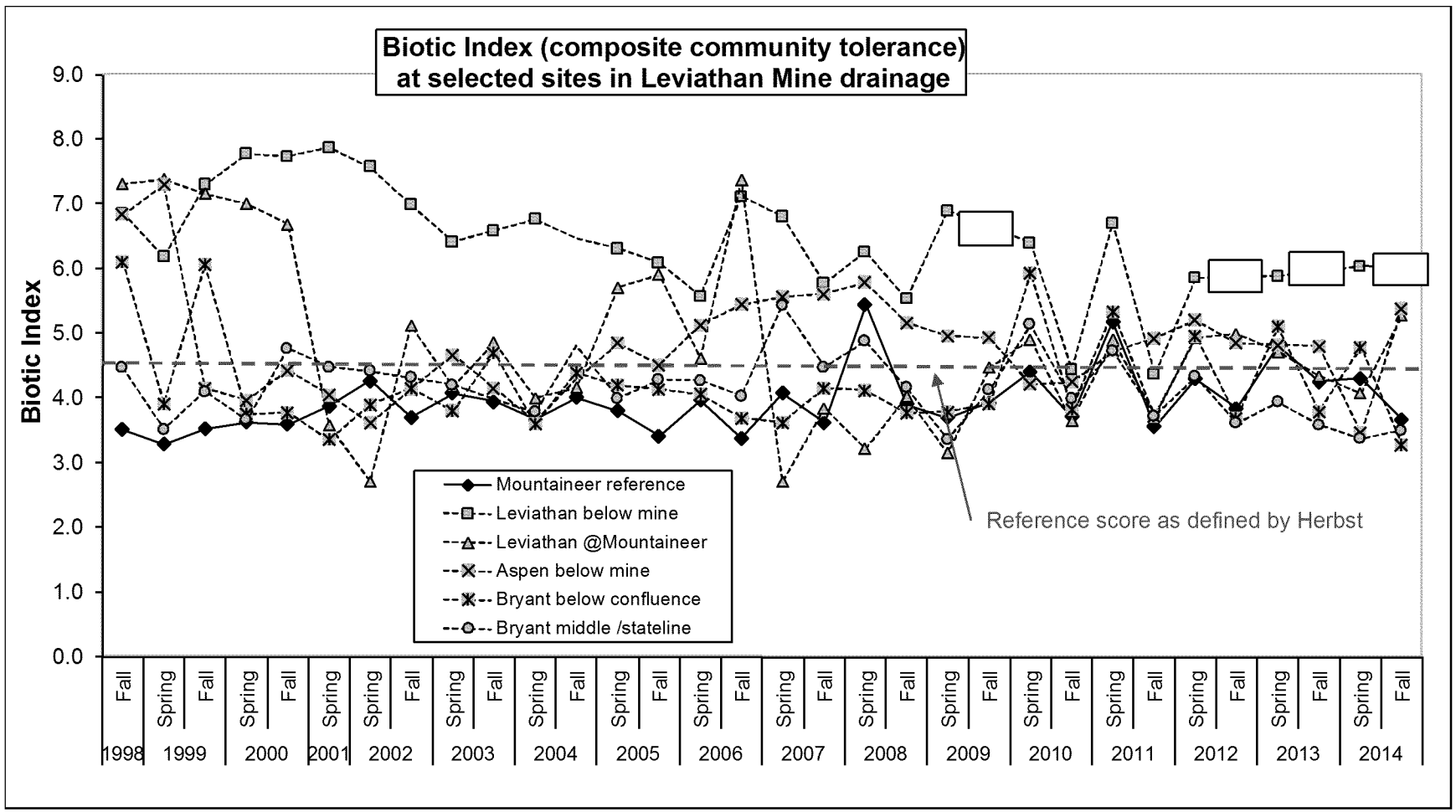


Figure 1. Locations of key sample sites surveyed for aquatic invertebrate biomonitoring of the Leviathan Mine watershed.

Herbst Index of Biological Integrity Monitoring



RI Sediment Data (Atlantic Richfield 2013)

In 2013, in-stream and SQT sediment samples collected

- In-stream samples collected from July 8 through July 25, 2013 and September 24 through October 3, 2013
- SQT samples collected June 17 through June 27, 2013, and September 30 through October 4, 2013 (two sampling events)
- Samples collected by hand using stainless steel sampling equipment

In-stream sediment samples

- Samples collected from 0 to 3 cm
- Bulk samples submitted for RI/FS metals, TOC, AVS, and AVS/SEM metals, and particle-size distribution analysis
- Samples collected from 84 locations in the DSA (Leviathan and Bryant creeks)

SQT sediment samples

- During the first sampling event, samples collected from the upper 10 cm, during the second sampling event, samples collected from 0 to 3 cm
- Bulk samples submitted for bioassay testing, RI/FS metals, TOC, AVS, AVS/SEM metals, and particle-size distribution analysis
- Samples collected from 8 locations during each event in Aspen, Leviathan, Bryant, and Mountaineer creeks

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RI Sediment Data (Atlantic Richfield 2015)

In 2015, sediment samples collected On-Property and RSA

- On-property samples collected from September 3 through September 15, 2015, and September 28 through October 27, 2015
- RSA samples collected September 29 through October 26, 2015
- Samples collected from 0 to 3 cm
- Bulk samples submitted for RI/FS metals, TOC, AVS, and AVS/SEM metals, and particle-size distribution analysis
- Samples collected by hand using stainless steel sampling equipment

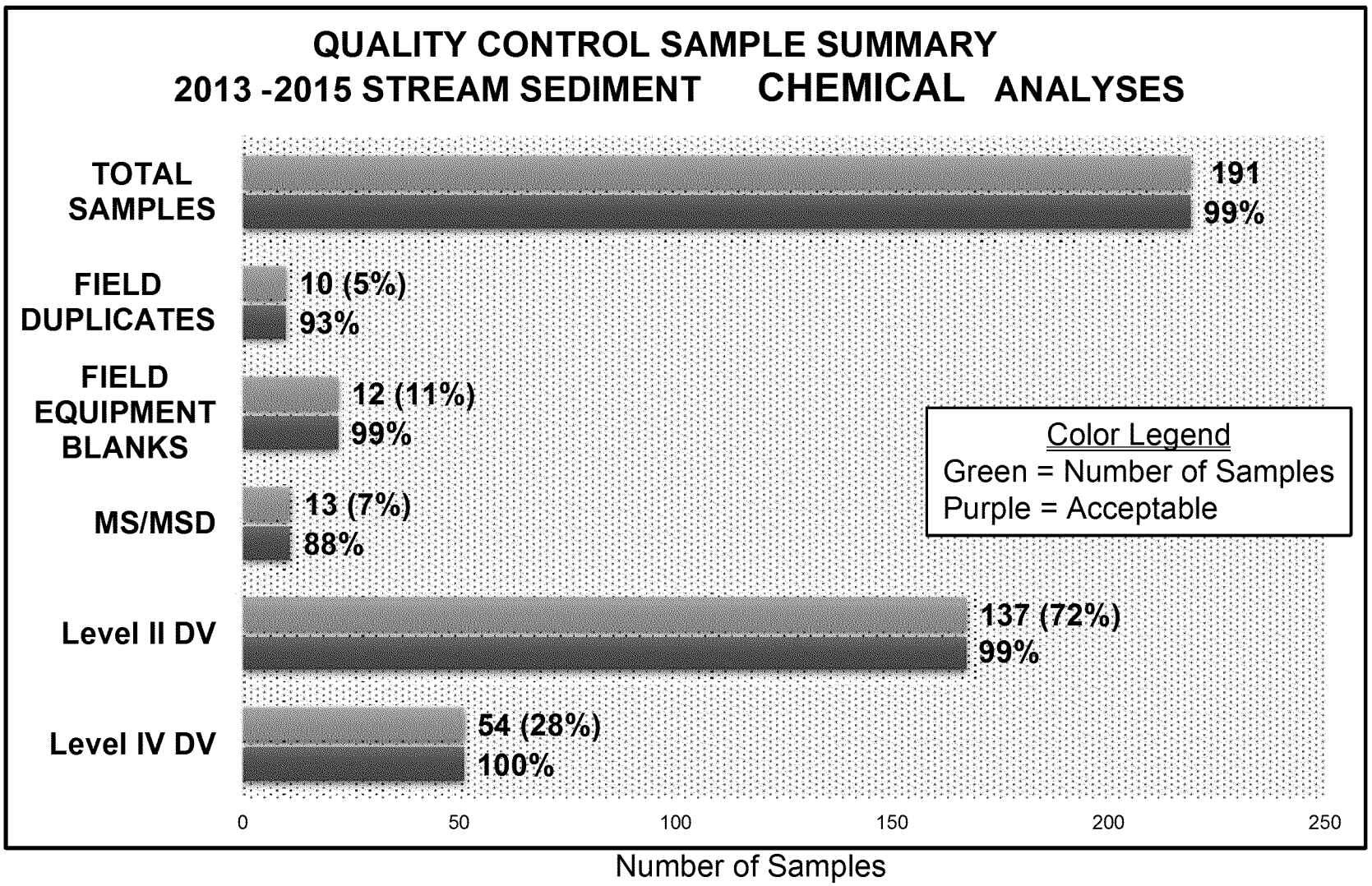
On-Property sediment samples

- Samples collected from 36 locations in Aspen and Leviathan creeks
- Samples also collected from 4 locations in the BDPC on Leviathan Creek

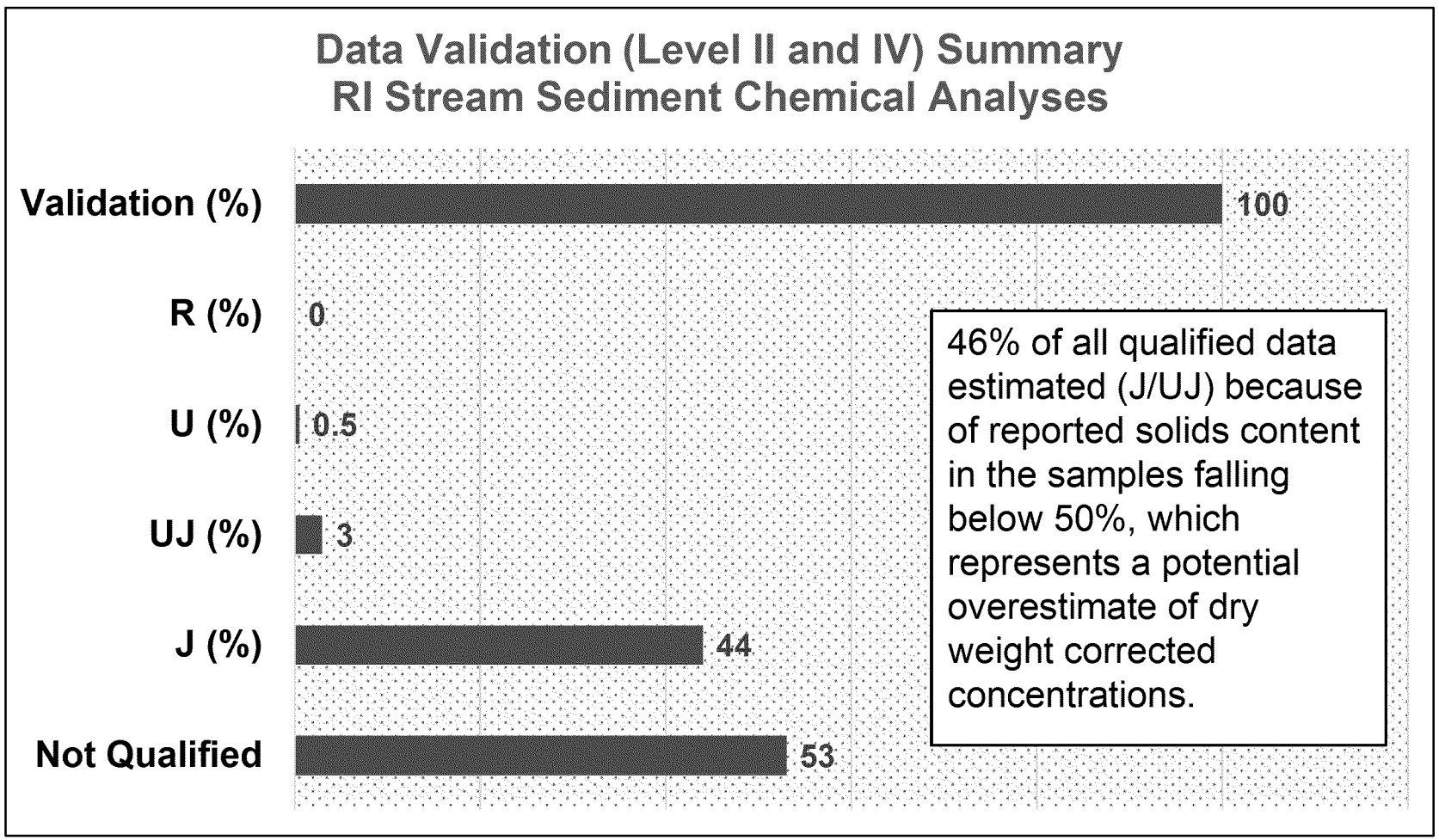
RSA sediment samples

- Samples collected from 50 locations in Cottonwood and Mountaineer creeks

RI Sediment Data Quality



RI Sediment Data Quality



Sediment Data Usability

Data Use in Analysis

- Estimated values (flagged J or UJ) are used as the reported value for the purposes of statistical calculations and geostatistical evaluations
- Laboratory results reported as non detect (< RL) or qualified as U at an adjusted RL are used in statistical calculations at a value equal to the RL
- Only results from primary samples have been used for statistical calculations and geostatistical evaluations. Field duplicate samples (FD) have been retained in the database, but are not used in the evaluations
- No results were qualified as rejected for the stream sediment samples
- Data collected by others were used to make qualitative comparisons

Sediment Conceptual Model

Waste Rock Weathering – Pyrite Oxidation

- Enhanced by small particle size of mine waste
- Primary end products – sulfate, iron, proton acidity
- Mobilizes other trace metals

Hydroxide Formation & Precipitation

- Increasing surface water pH downstream leads to iron and aluminum hydroxide formation, precipitation, and sediment deposition
- Trace metals adsorbed onto precipitated iron and aluminum hydroxides

Primary Sources

- Mine waste
- In situ Rock

Sedimentation

- Higher metal concentrations associated with the fine grain fraction (e.g., hydroxides, silts & clays)
- Fine grain fraction preferentially deposited in low energy vs. high energy environments (e.g. pools vs. cascades)

Mine Waste Erosion

- Transport of mine waste and downstream deposition

Summary of Data Quality Objectives: Stream Sediment / Floodplain Soil Investigations

Step 1 - Problem Statement:
Extent and magnitude of COPCs/COPECs in stream sediment/floodplain soil in the On-Property Study Area are not sufficiently understood to make comparisons to reference concentrations and ARARs, evaluate risk to human or ecological receptors, and evaluate the need for future remedial action.

Step 2 - Study Question:
Is stream sediment/floodplain soil chemistry in the On-Property Study Area sufficiently characterized for the purposes of comparisons to reference concentrations and ARARs, supporting human health and ecological risk evaluation, and evaluation of remedial alternatives if necessary?

Step 3 – Information Inputs:
- Location and extent of depositional and nondepositional features and relative ages of floodplain soils
- Location and extent of sediment bedforms (pool, riffle, glide, step pool, and cascade)
- Floodplain soil classification, grain size, mineralogy
- Extent of armoring and bank configuration (stability, topography)
- Stream sediment chemistry (RI/FS metals, general chemistry, AVS/SEM,etc)
- Chemical-specific ARARs
- Screening level risk benchmarks

Step 4 – Define Boundaries:
- Stream sediment and floodplain soils in On-Property reaches of Leviathan and Aspen creeks
- Stream sediment and floodplain soils in the Downstream Study Area (Leviathan and Bryant creeks)

Summary of Data Quality Objectives: Stream Sediment / Floodplain Soil Investigations

Step 5 – Analytical Approach:
If RI/FS metals concentrations and other general chemistry parameters in stream Sediments and floodplain soils are obtained from representative depositional environments, these chemistry data can be used to evaluate human health and ecological risk, comparison to ARARs and reference concentrations, and evaluate remedial alternatives if necessary.

Step 6 – Acceptance Criteria:
Data collection goal is to characterize range and distribution of RI/FS metals concentrations and other general chemistry parameters in stream sediments and floodplain soils. A multiple lines of evidence evaluation of each dataset will be conducted using professional judgment and exploratory data analysis methods to assess the spatial and temporal variability in the chemical data for the media of interest to ensure that the datasets are representative and have an adequate sample size.

Both qualitative and quantitative acceptance criteria will be considered.

Qualitative criteria will consider whether:
(1) investigative samples were collected for targeted environmental media and analyzed for RI/FS metals,
(2) investigative samples were collected within areas that are considered representative of the investigation area, and
(3) investigative samples were collected over time periods that are representative of temporal variability in site conditions, if applicable.

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Summary of Data Quality Objectives: Stream Sediment / Floodplain Soil Investigations

Step 6 - Acceptance Criteria (continued):

Quantitative criteria to be evaluated prior to the comparison of datasets in statistical analyses will consider whether:

(1) detectable concentrations of individual RI/FS metals were present in more than four samples in sample populations with less than 40 samples or the frequency of detection of individual RI/FS metals was greater than 10 percent in sample populations with more than 40 samples,

(2) the dataset consists of 10 or more samples representative of a specific medium, and

(3) the dataset represents a single population as determined by exploratory data analysis.

Comparison to Chemical-Specific ARARs or TBCs

Null hypothesis: The concentrations of RI/FS metals in media in potentially affected areas of the On-Property and Off-Property study areas **are significantly greater** than chemical-specific ARARs (e.g., MCLs) or TBCs (e.g., screening risk levels).

Comparison to Reference Concentrations

Null hypothesis: The concentrations of RI/FS metals in media in potentially affected areas of the On-Property and Off-Property study areas **are significantly greater** than reference concentrations.

Acceptance Criteria: The limits of the likelihood of making decision errors are calculated to be: Type 1 error, false rejection at 0.05 (95 percent confidence level); and Type 2 error, false acceptance at 0.20 (80% confidence level).

Summary of Data Quality Objectives: Stream Sediment / Floodplain Soil Investigations

Step 7 – Study Design:

Preliminary Investigations

Reconnaissance mapping of the location and extent of stream sediment and floodplain soil depositional areas

Detailed Investigations – Stream Sediment

- Use professional judgment to establish location and extent of in-channel environments based on the sediment mapping completed in 2012
- Collect stream sediment samples within stream thalweg from 0 to 3 cm in wetland, glide, pool, step pool, cascade, and vegetated channel environments
- Conduct laboratory analysis of RI/FS metals, AVS/SEM, TOC, and grain-size distribution.

Detailed Investigations – Floodplain Soil

- Use professional judgment to select transects/locations where there is likely to be 2 feet or more of fine-grained soil. Establish transects for sampling of age-category 1, 2, and 3 floodplain soils.
- Perform FPXRF analysis in surficial soil samples (approximately 0 to 6-inches) of the mapped soil types to identify the variability within and among the floodplain soil deposit.
- Collect floodplain soil samples at depths up to 6 feet bgs at 3 locations along each transect.
- Conduct laboratory analysis of RI/FS metals, general chemistry, TOC, and grain-size distribution.

Sediment Study Design (Spatial Distribution)

Three Study Areas
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Study Areas Divided into Eight Reaches

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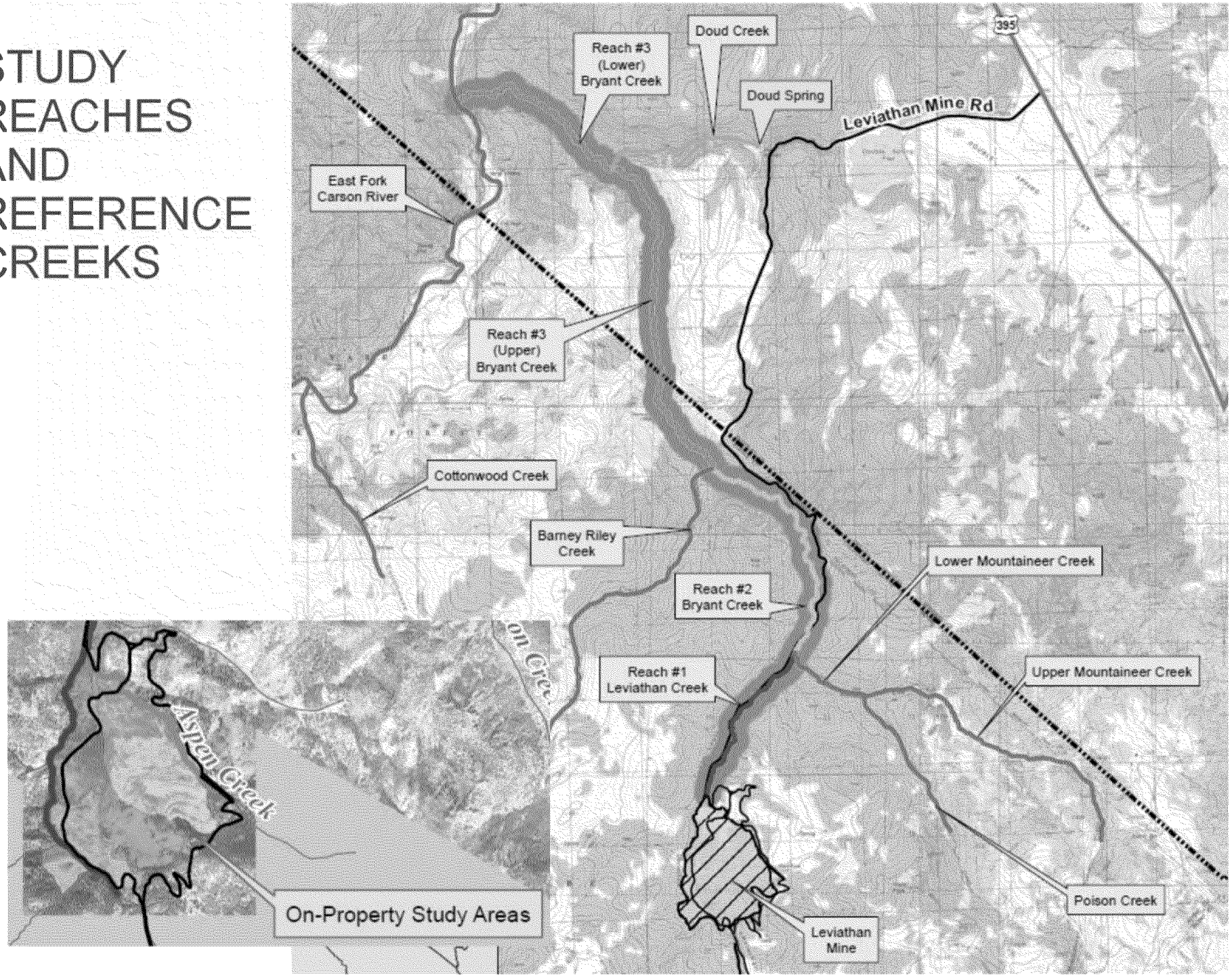
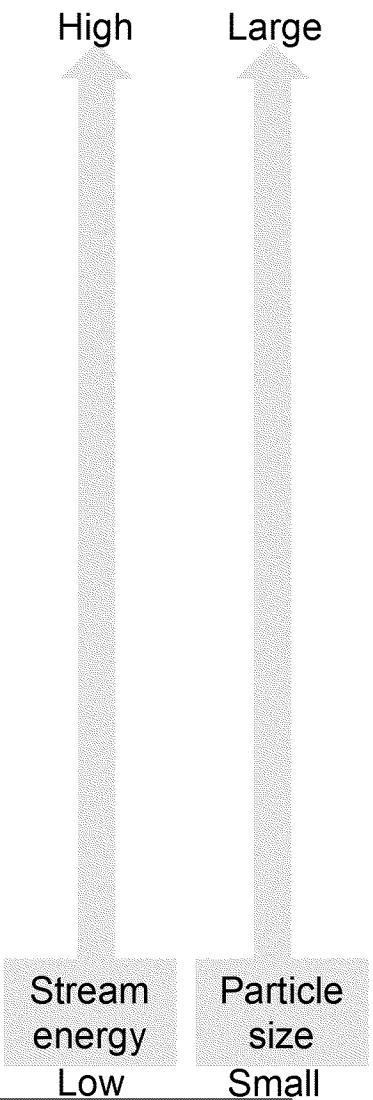
STUDY REACHES AND REFERENCE CREEKS



Sediment Study Design (Channel Type)

Channel Unit	Description
Cascade	A high-gradient segment of the stream with tumbling flow.
Riffle	A shallow and fast segment of the stream with visible turbulence and coarser substrates.
Glide	A shallow- to mid-depth segment of the stream with fast but laminar flow.
Step-Pool	A series of small pools and drops formed either by aggregation of large clasts or wood debris.
Pool	A deep and slow segment of the stream formed either by scour or damming.
Vegetated Channel	A confined and homogeneous segment of the stream with vegetation growing in the active channel, typically human-modified
Wetland	An unconfined segment of the stream where flow diffuses into multiple channels and across a broad vegetated area.
Beaver Pond	A backwatered segment of the stream where water level is controlled by a beaver dam, typically larger than a pool.



Sediment Study Design (Channel Types)

Channel Units	On-Property			DSA Reaches					Reference Study Area				Grand Total
	Aspen	Leviathan	On-Property Subtotal	1	2	3U	3L	DSA Subtotal	Lower Mountaineer	Upper Mountaineer	Cottonwood	RSA Subtotal	
Cascade	3	3	6							1	6	7	13
Glide	3	1	4	5	9	5	1	20	1	3	6	10	34
Pool		3	3	4	4	2	1	11	4	1	6	11	25
Riffle		6	6	9	5	5	1	20	4	3	6	13	39
Step pool	3	2	5	6	6	5	2	19	6		3	9	33
Vegetated Channel	3	3	6										6
Wetland	3	3	6										6
Beaver Pond		4	4		6	7	1	14					18
Grand Total	15	25	40	24	30	24	6	84	15	8	27	50	174

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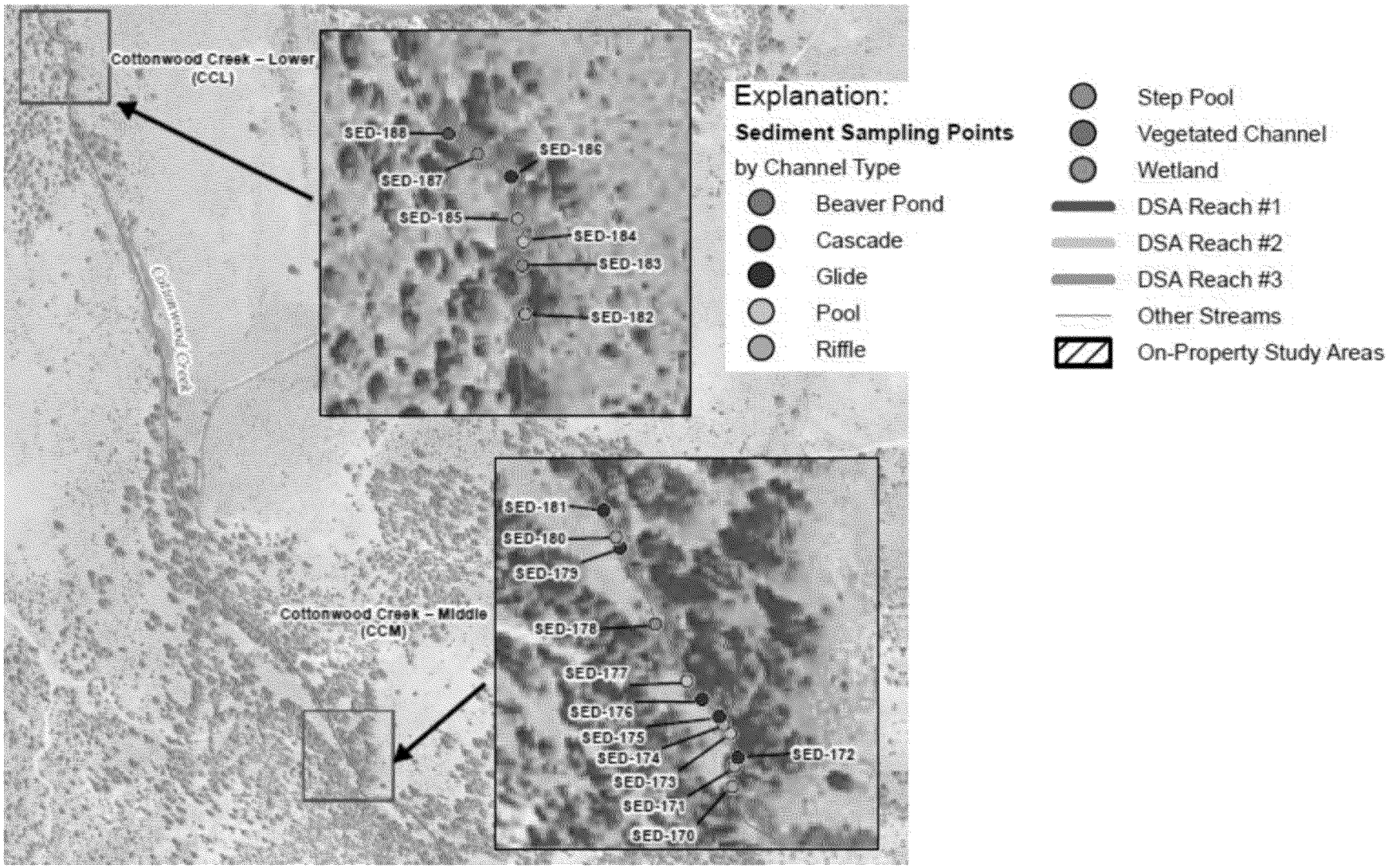
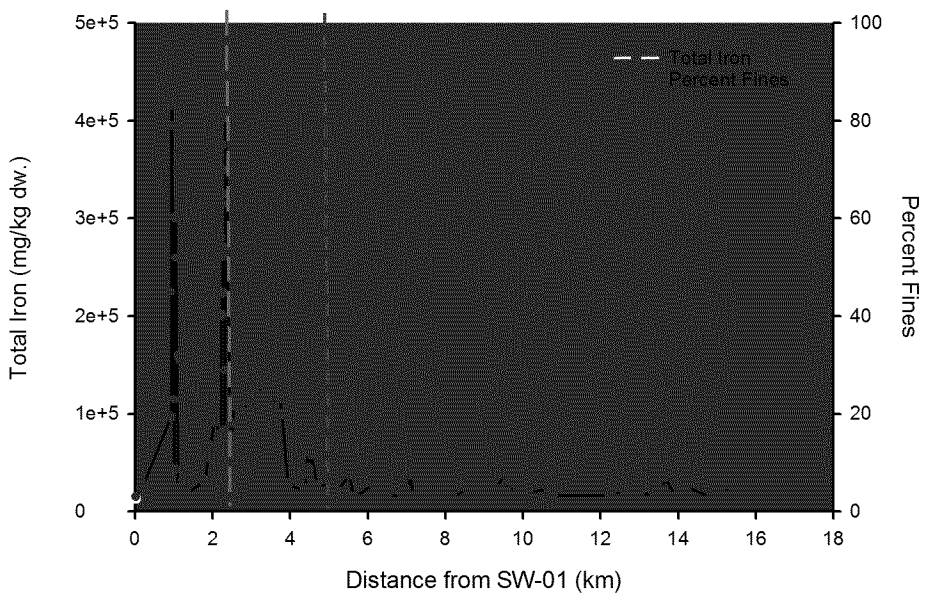
Sediment Sample Locations and Channel Types

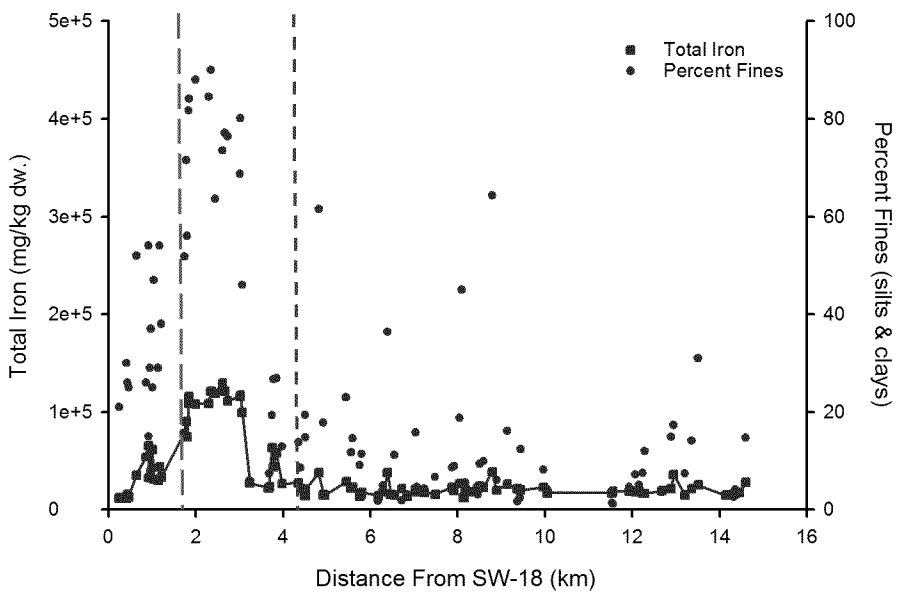


Stream Profiles of Total Iron & Percent Fines

A. Leviathan & Bryant Creeks



B. Aspen & Bryant Creeks



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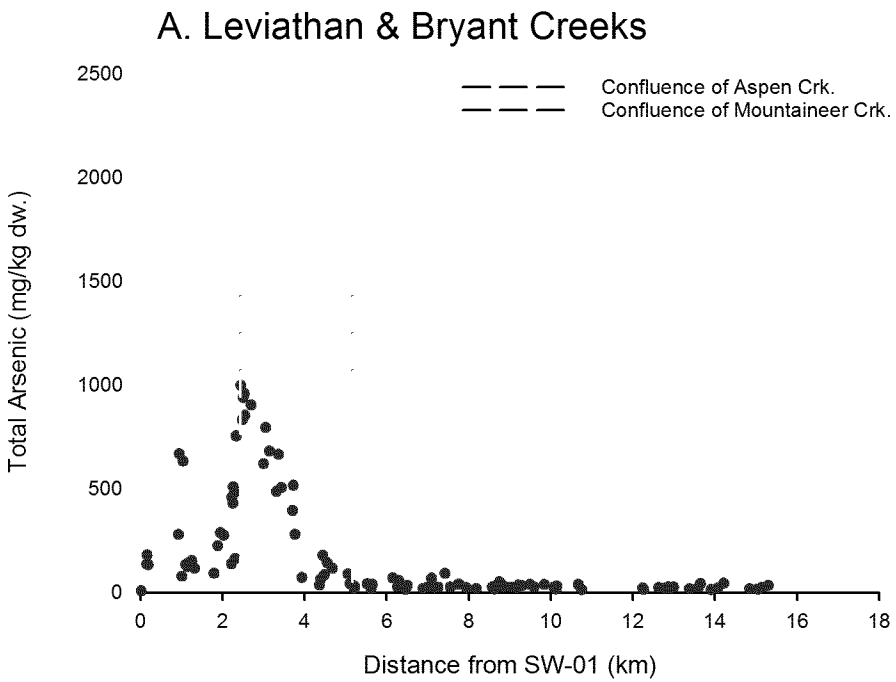
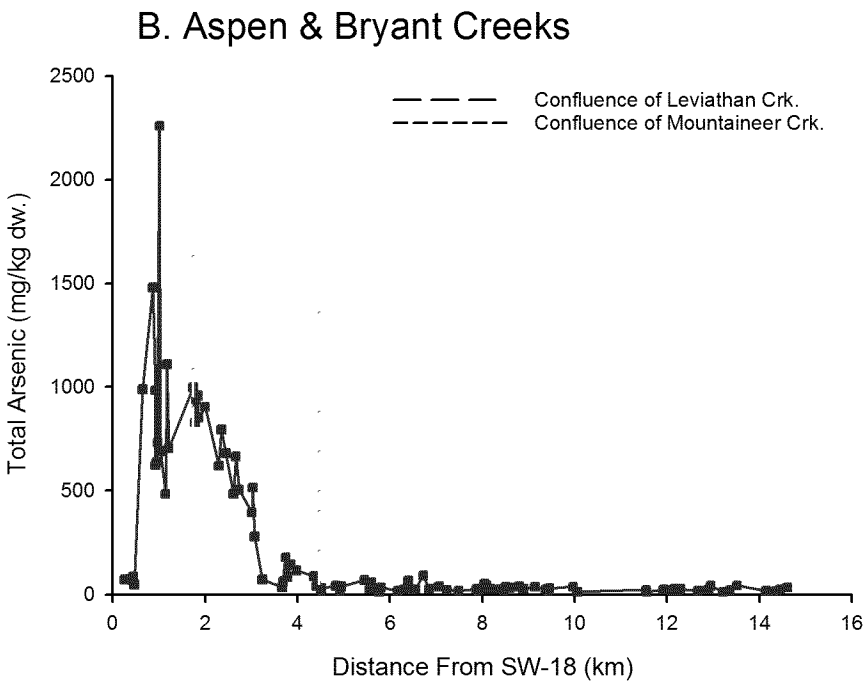
Stream Profiles of Total Arsenic





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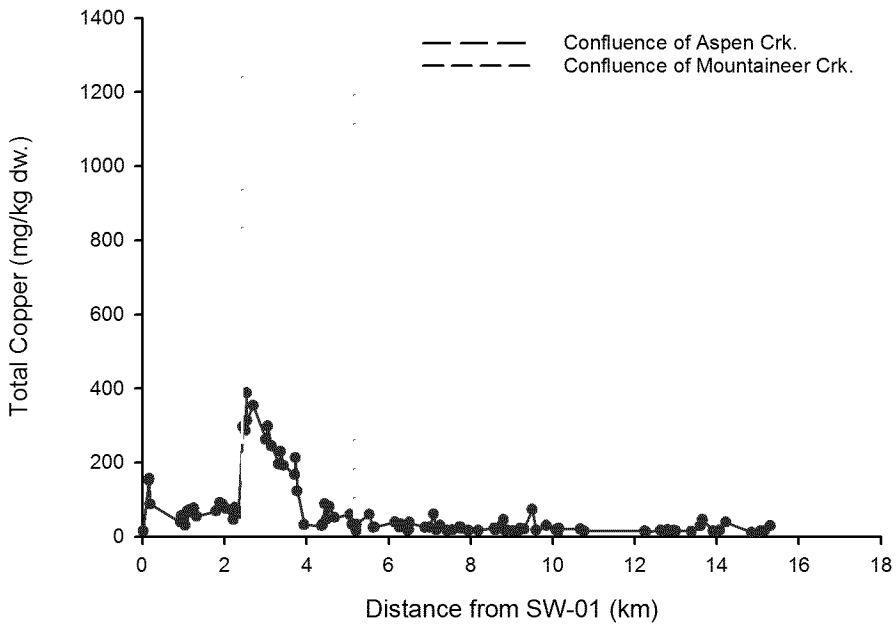
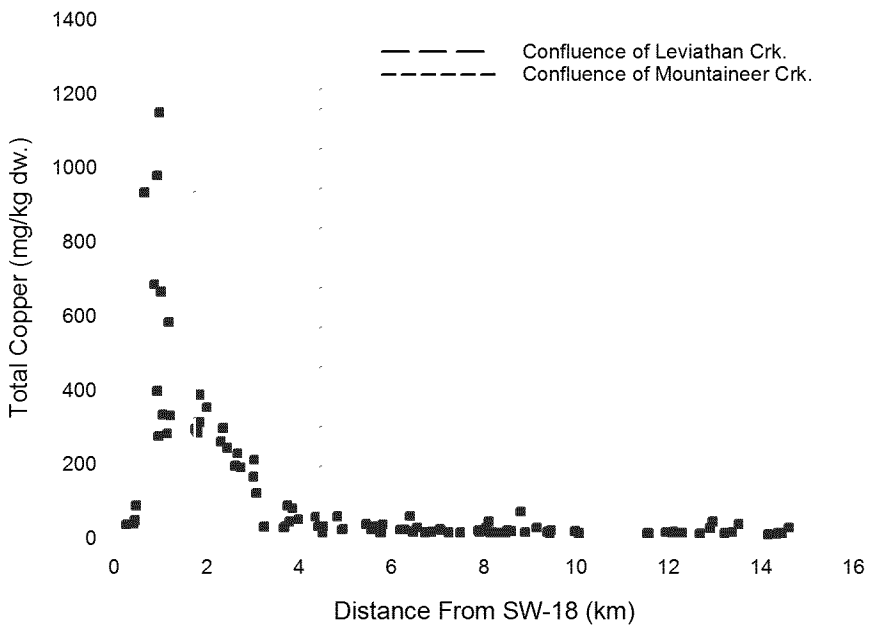
Stream Profiles of Total Copper

A. Leviathan & Bryant Creeks

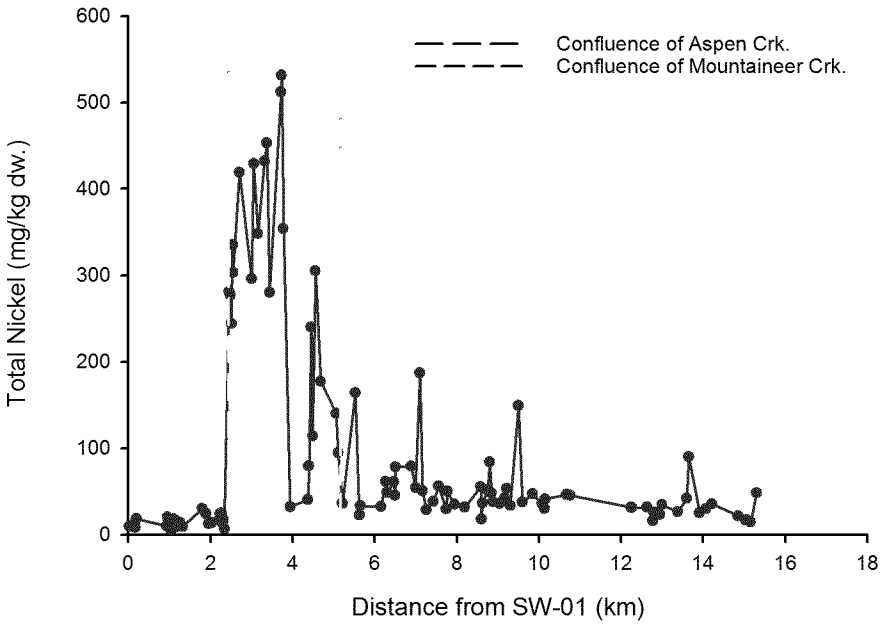


B. Aspen & Bryant Creeks

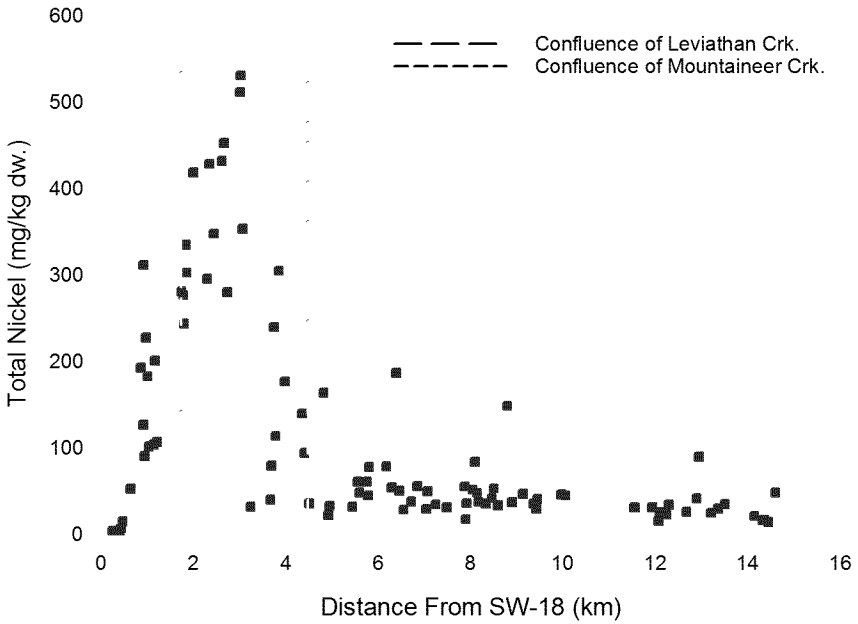


Stream Profiles of Total Nickel

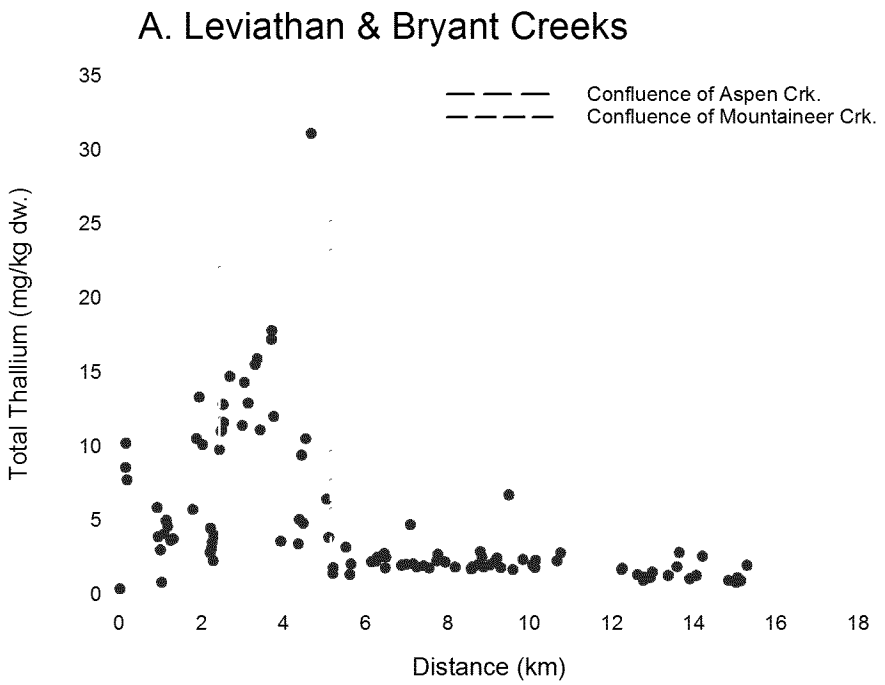
A. Leviathan & Bryant Creeks

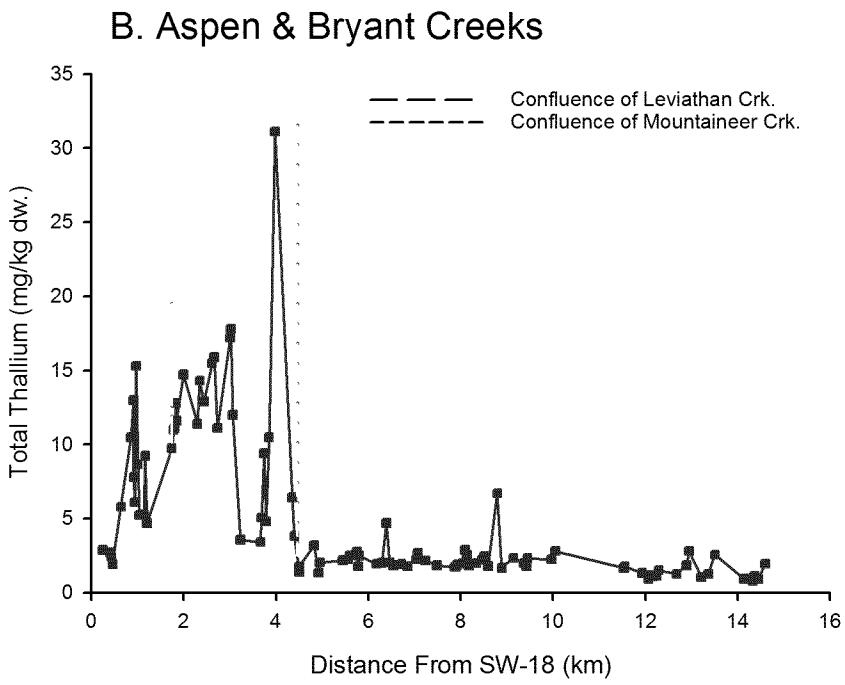


B. Aspen & Bryant Creeks



Stream Profiles of Total Thallium





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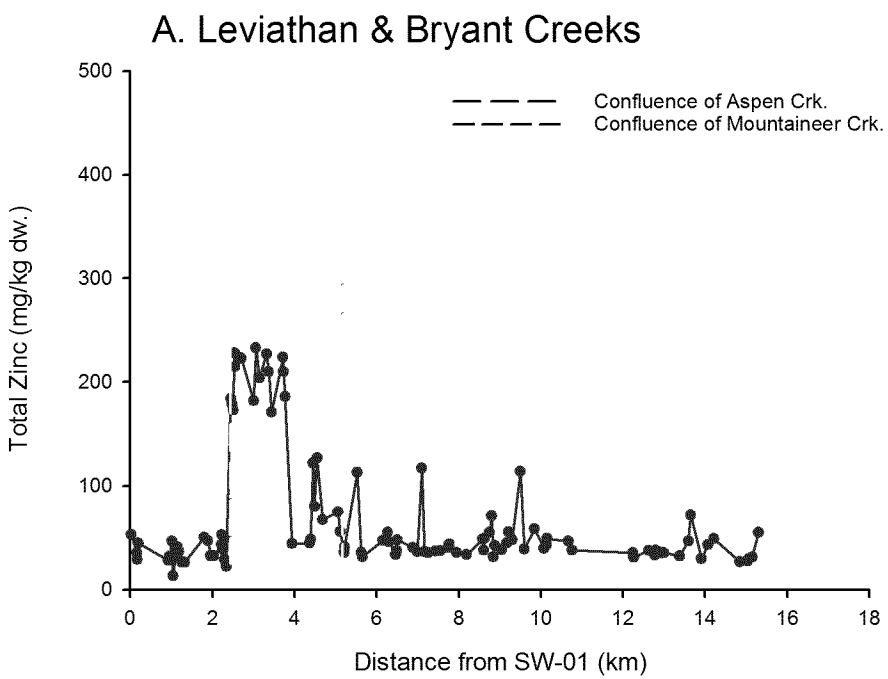
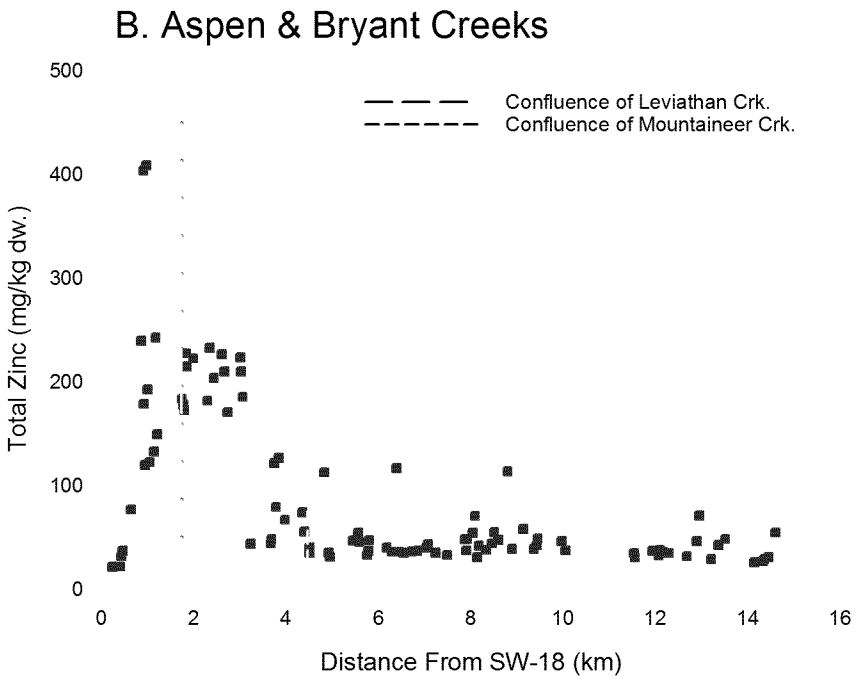
Stream Profiles of Total Zinc





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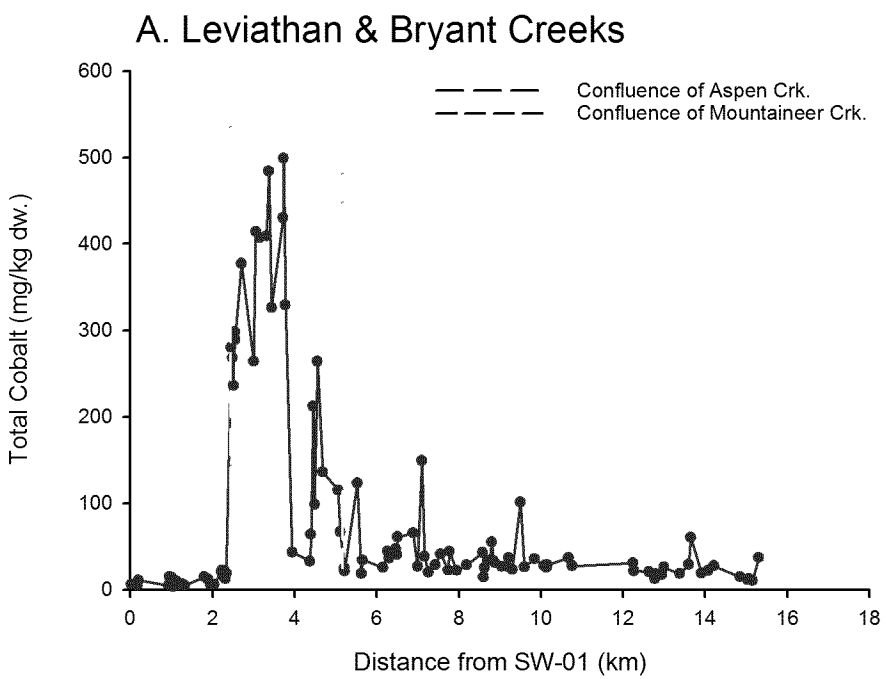
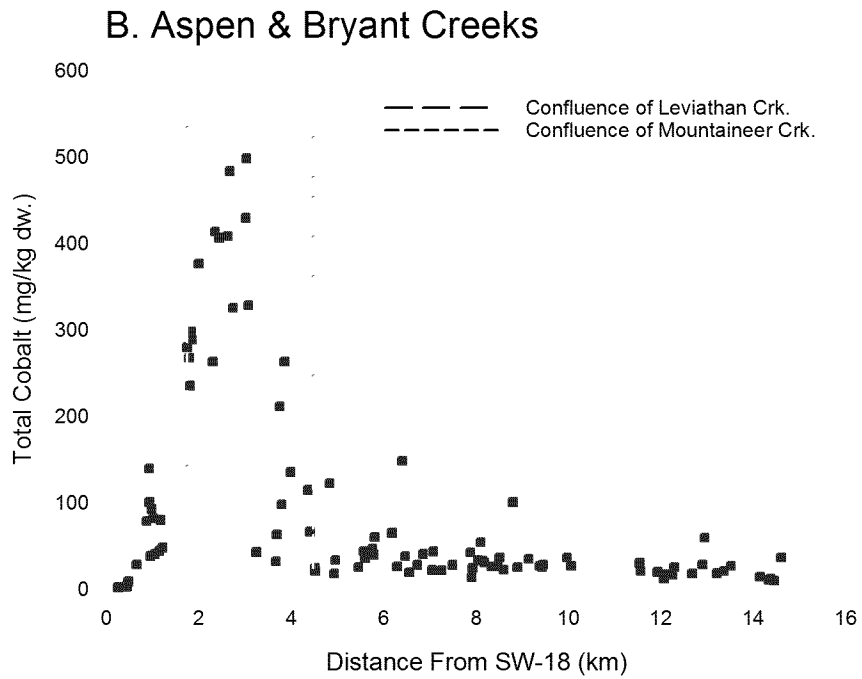
Stream Profiles of Total Cobalt





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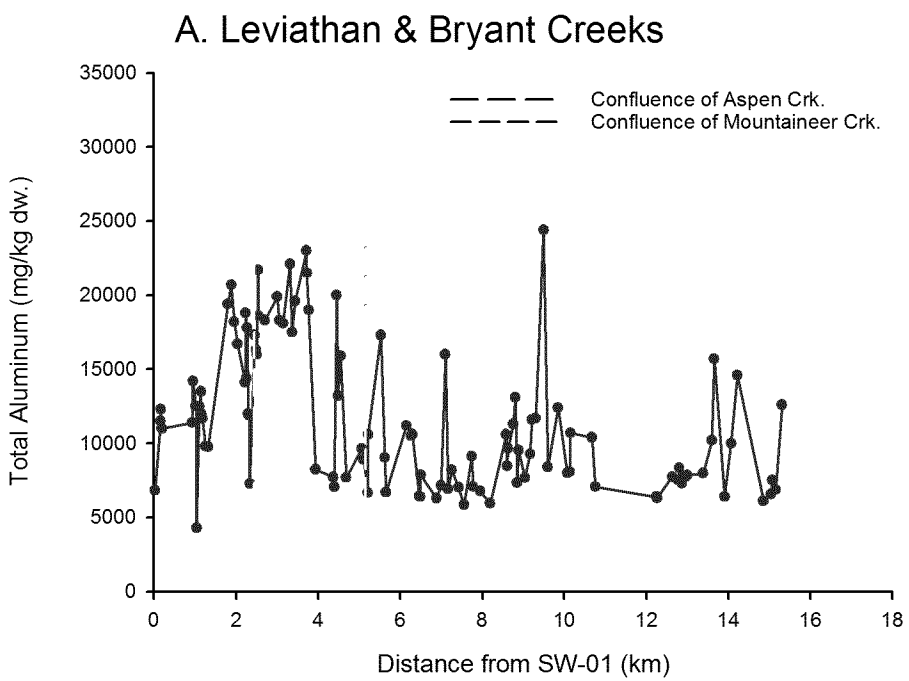
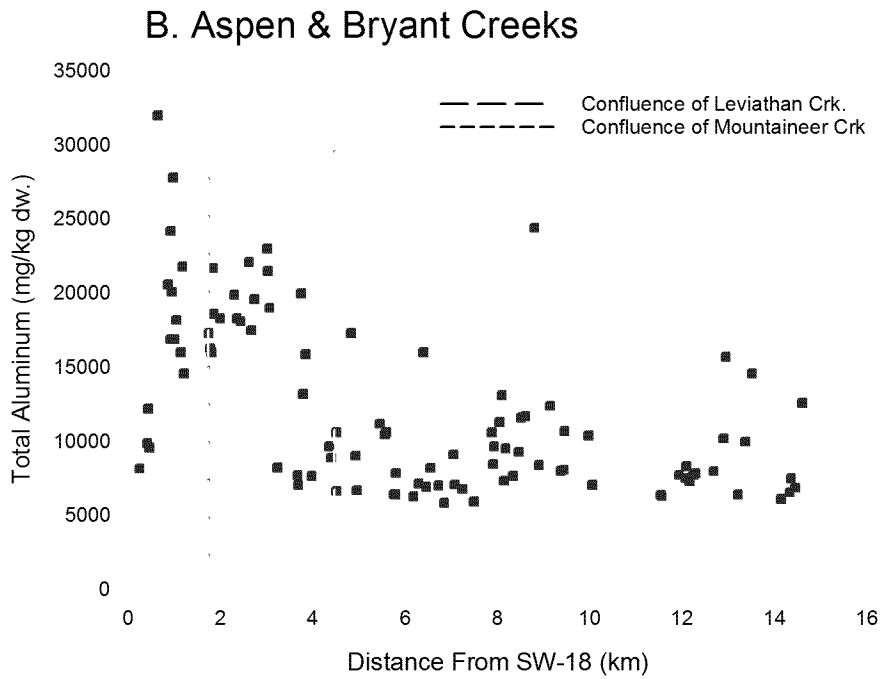
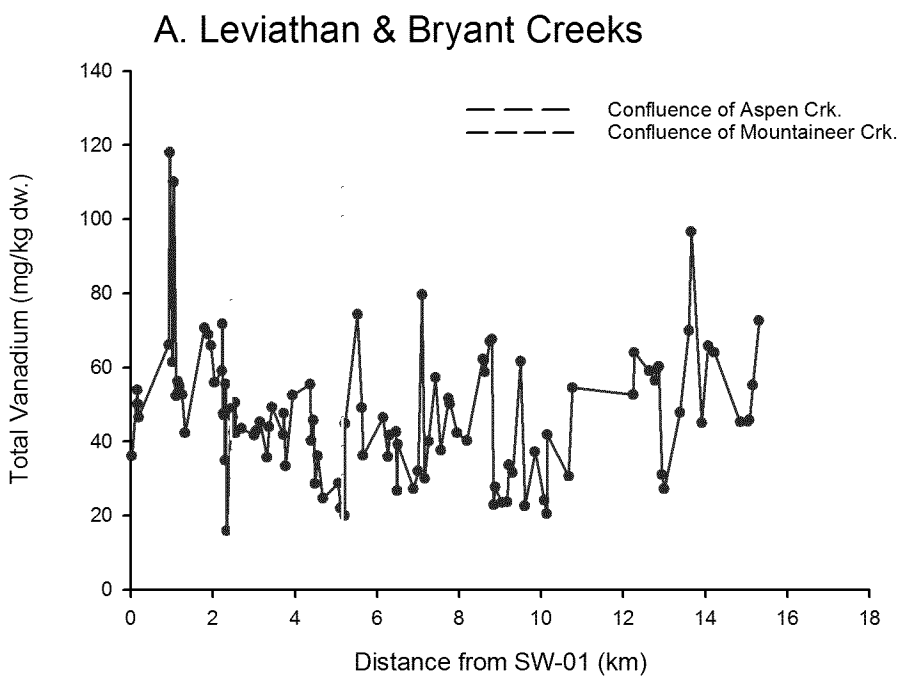
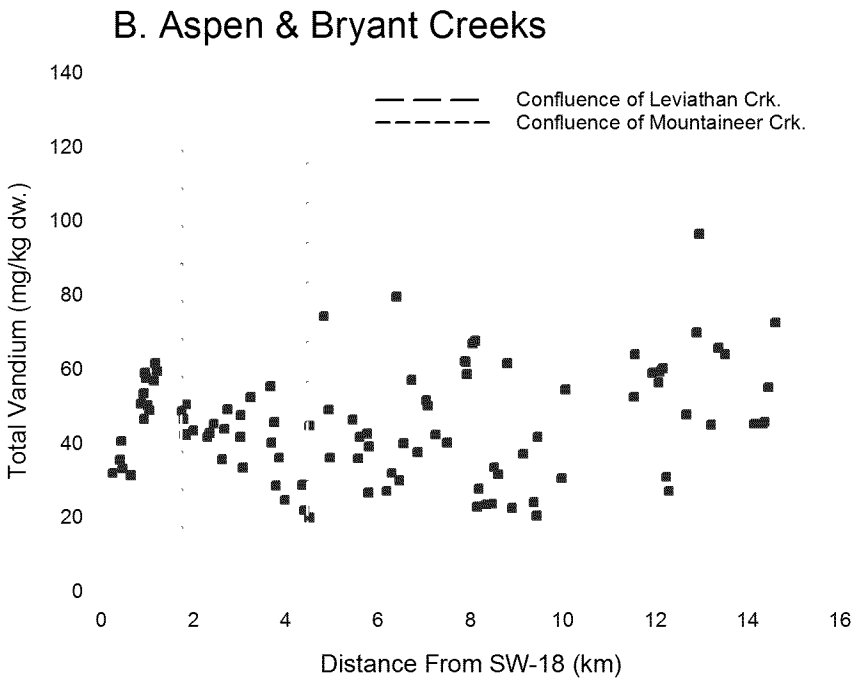
Stream Profiles of Total Aluminum





Stream Profiles of Total Vanadium





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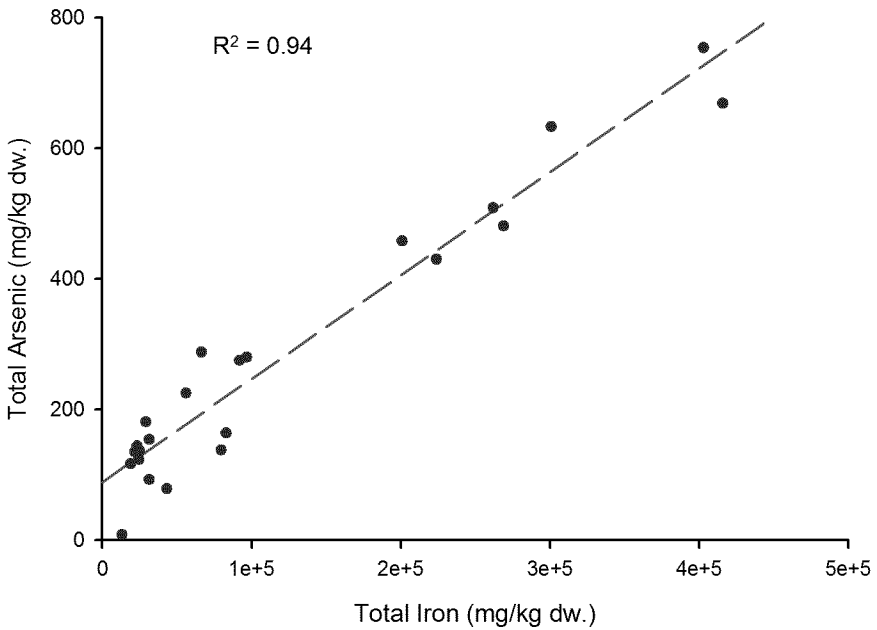
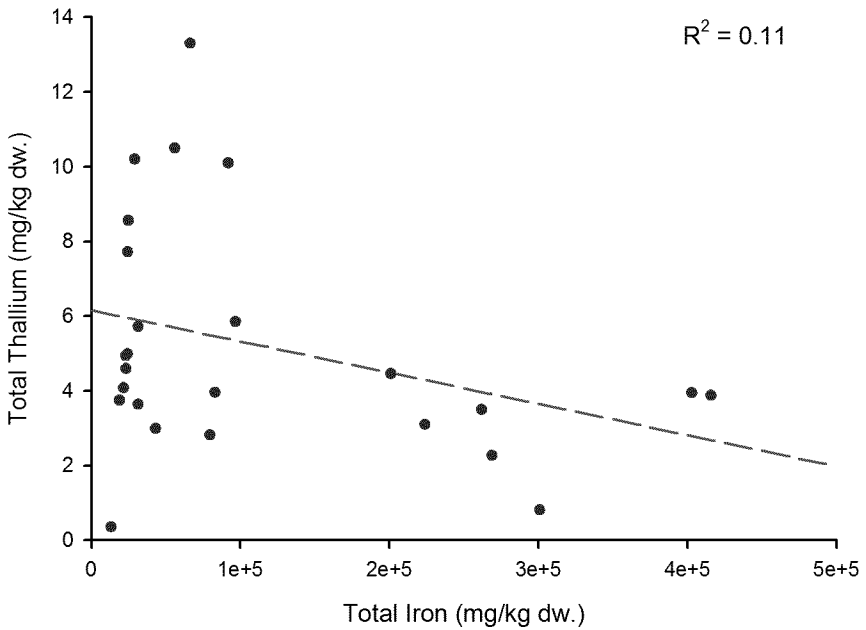
Total Arsenic and Thallium vs. Total Iron





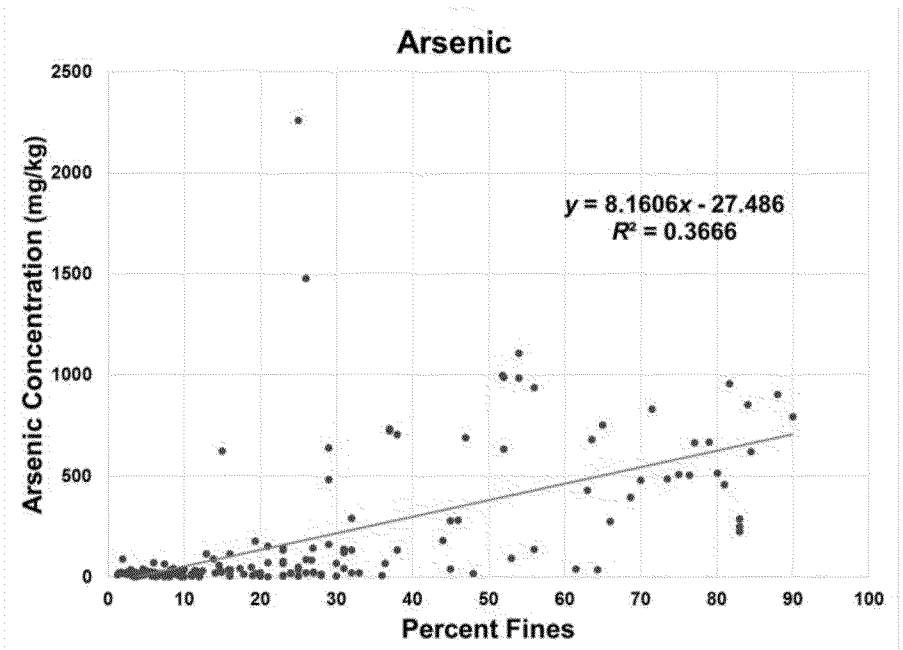
Metals Correlation with Grain Size

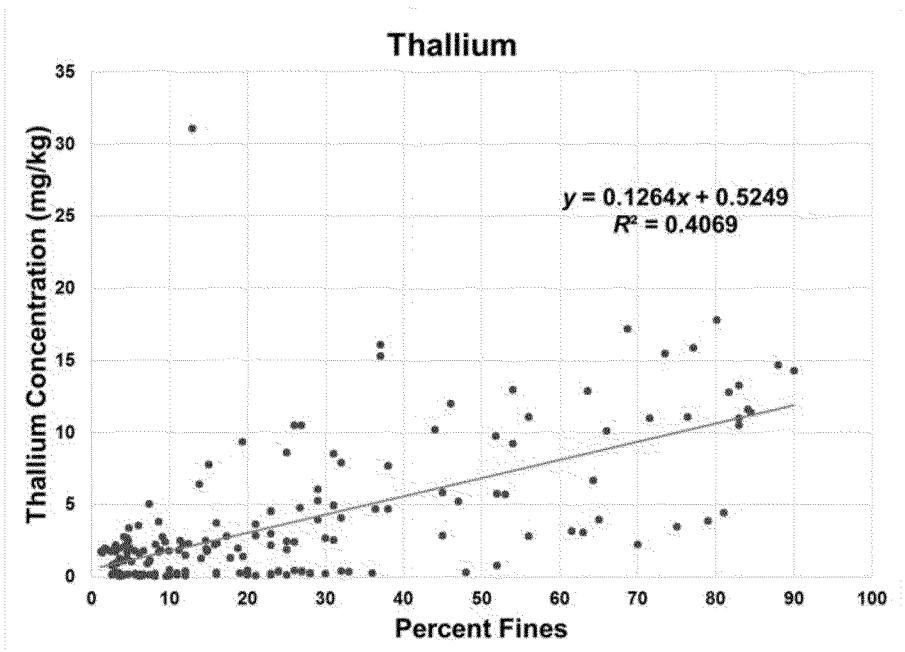
Significant positive correlation with percent fines (silt & clay) ($p < .05$)

- Al, Sb, As, Ba, Be, Cd, Cr, Cr^{+6}, Co, Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, Tl, Zn

No significant correlation with percent fines ($p > .05$)

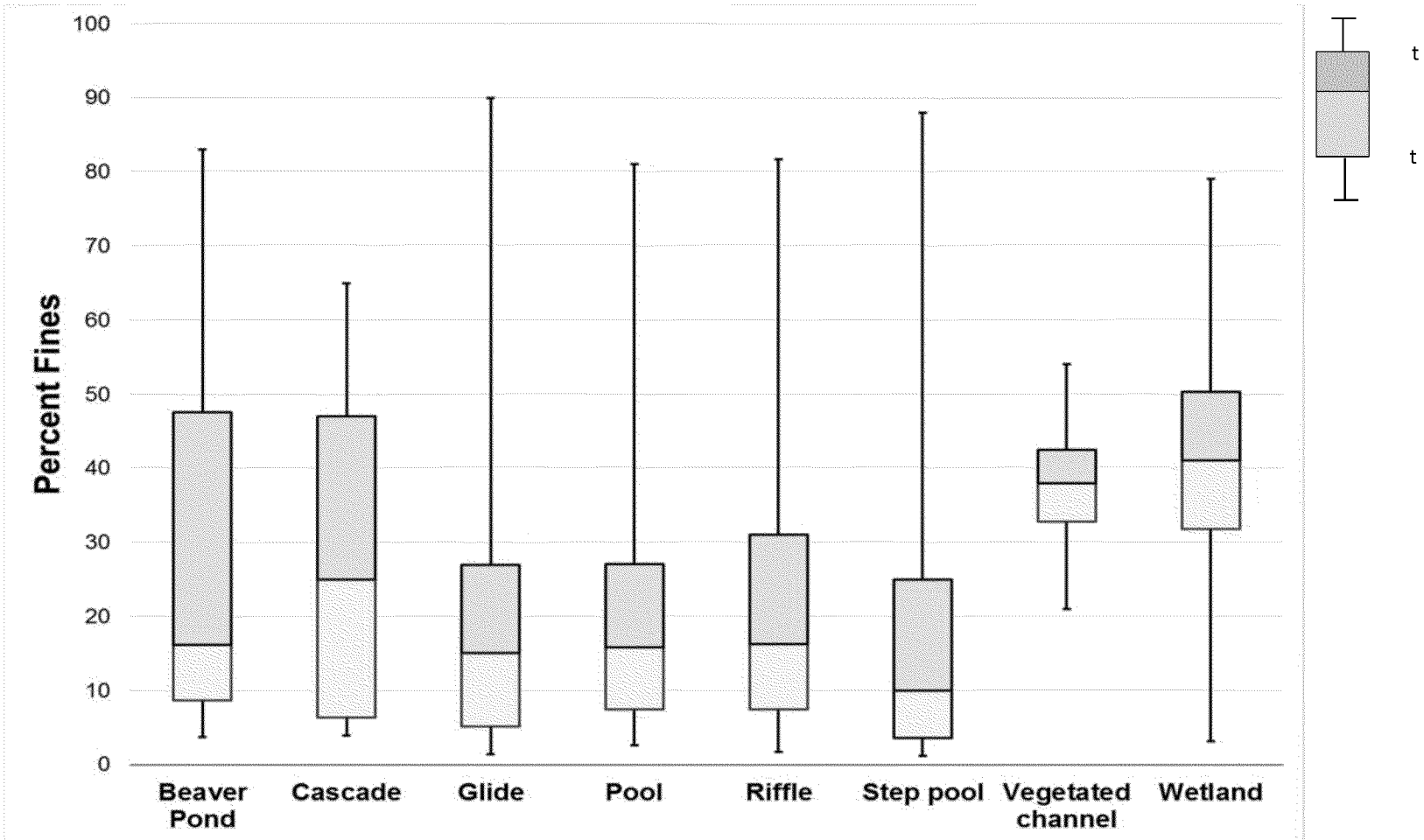
- V



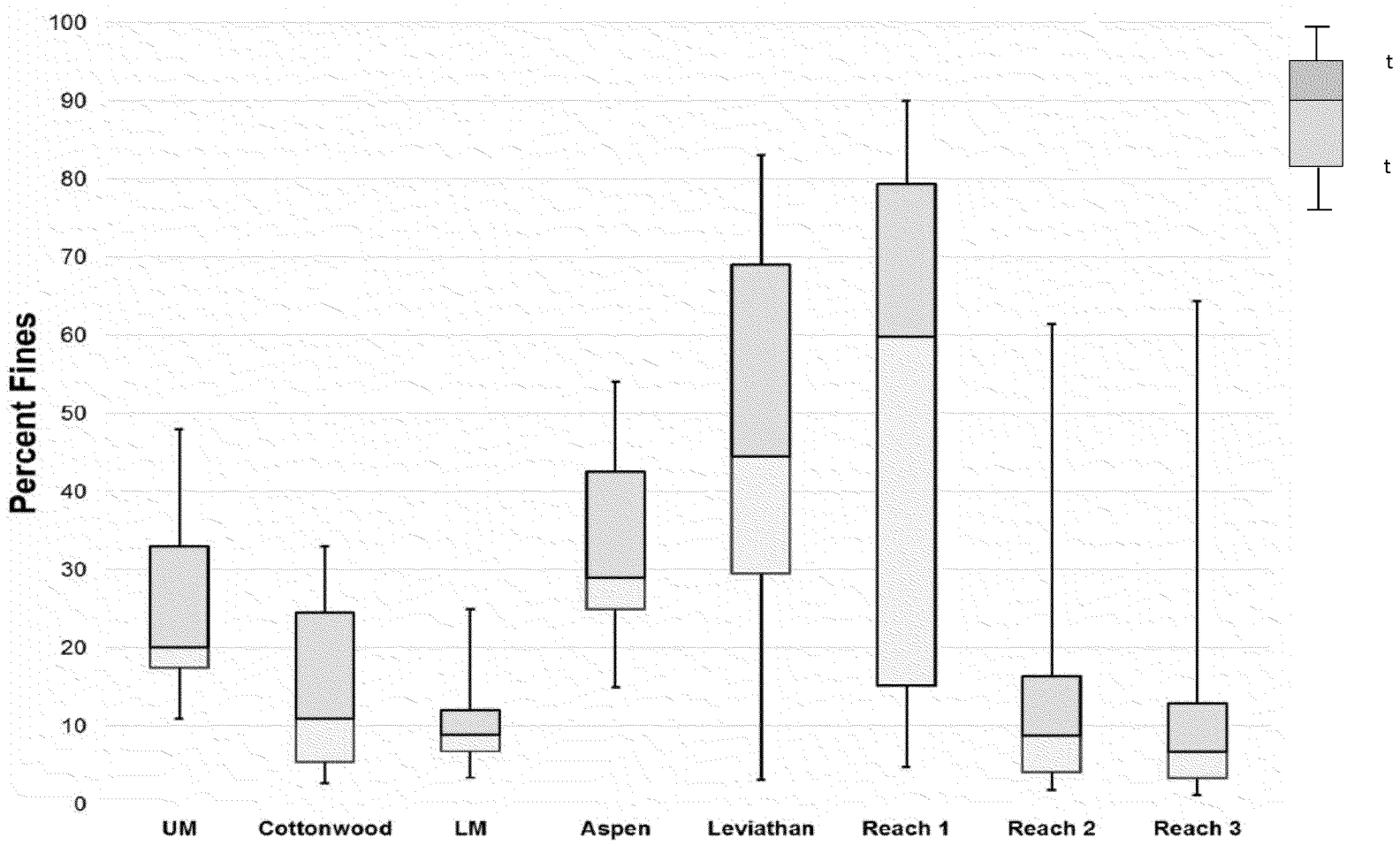


Grain Size Versus Channel Type

No significant difference in grain size (percent fines) among channel types



Grain Size versus Study Reach



Next Steps:
Stream Sediment/Floodplain Soil Investigations

Stream Sediment

- Complete spatial evaluation of stream sediment data collected by Atlantic Richfield
- Conduct comparison to EPA stream sediment sampling results
- Complete interpretation of results of statistical comparisons to reference
- Conduct comparison to risk-based screening levels and results of SQT and AVS/SEM
- Develop exposure areas and exposure point concentrations (EPCs)
- Prepare TDSR for submittal in Q1 2017

Floodplain Soil

- Complete data validation and data quality/usability reviews
- Conduct spatial evaluation of floodplain soil data collected by Atlantic Richfield
- Estimate reference threshold concentrations for reference reaches
- Conduct comparison to risk-based screening levels
- Develop exposure areas and exposure point concentrations (EPCs)
- Prepare TDSR for submittal in late Q2 2017

Reporting Options

- Option 1 - Submit Stream Sediment TDSR and Floodplain Soil TDSRs independently in Q1 and late Q2 2017, respectively
- Option 2 - Combine Stream Sediment and Floodplain Soil TDSRs into a single TDSR for submittal in late Q2 2017

Discussion Outline (Afternoon Session)

- RI/FS Field Work Status
  - Remedial Investigation
  - Feasibility Study
  - Work Planned for 2017
- Interim RI Deliverables
  - Field Summary Reports (90 days after field work completed)
  - Technical Data Summary Reports (TDSRs)
- Next Steps and Wrap Up

RI/FS Field Work Status

Study Area		RI Data Collection Activity															
		Mapping/Field Verification	Drilling/Well Installation	Groundwater Monitoring	Mine Waste Soil Sampling	Floodplain Soil Sampling	Soil Sampling	Stream Sediment Sampling	Meteorological Monitoring	Surface Water Monitoring	Source Monitoring	SW / GW Interaction	Upper Tributary Characterization	Storm Water and Snowmelt Monitoring	Plant/Soil Sampling	Sediment Quality Triad	Fish Surveys and Sampling
On-Property Study Area		X	X	Q2 2018*	X	Q3 2017	X	X	X	X	X	Q4 2017	Q4 2017	Q4 2017*	X	X	X
Off-Property Study Area	Downstream Study Area	X				X		X		Q4 2017					X	X	X
	River Ranch	X					Q2 2017			X							
	East Fork Carson River	X					X			Q2 2017						X	
	Ore Piles	X					X										
	Leviathan Mine Road	X					X										
Reference Study Area		X	Q3 2017	Q4 2017		X	X	X		X				Q4 2017*	X	X	X

X

Q1

RI/FS Field Work Status

FS Investigation/Study	Field Data Collection	Treatability Study	Monitoring
Geotechnical Investigation	Q3 2017		Q3 2018
Revegetation Treatability Study	X	X	Q3 2018

X = Task complete
= Task in progress
= Task not started
Q1 = Quarter field work estimated to be complete (may change based on time required, weather conditions, and contractor availability).

2016 Remedial Investigation Field Status

Completed All Field Work Outlined in Governing Documents as Approved, Conditionally Approved, or Directed:

- Floodplain Soil
  - Included additional deep samples on property and in reference to be consistent with DSA
- Surface Water / Groundwater Interaction Acidic Pond & Leviathan Creek
- Hydrocarbons
- Bryant Creek Surface Water
- Fish
- River Ranch
  - Except deep samples at 6 locations
- East Fork Carson River
  - Except spring surface water sampling
  - Included additional sampling for luminescence dating
- Suspected Ore Piles
- Leviathan Mine Road

2016 Remedial Investigation Field Status

Completed All Field Work Outlined in Governing Documents as Approved, Conditionally Approved, or Directed:

- Mine Waste Reference Soil
- Benthic Invertebrates Reference Creeks
- Plants and Habitat-Related Soil
  - To the extent possible
- Drilling
  - Except hydraulic testing
  - Groundwater sampling

2016 RI Field Work Status

2016 Drilling Plan

- Drilled, installed, developed, and surveyed 9 wells
  - One in ACSA, two in RSA, and six in perimeter of LCSA and ACSA
  - Based on field conditions, deep wells installed at LOC-39 and LOC-40 instead of shallow wells; need for shallow wells to be evaluated when lab data received
  - Hydraulic testing not completed
- Sampling
  - Reference and perimeter wells sampled monthly (October and November) as planned
  - ACSA well sampled once during fall groundwater monitoring event as planned

2016 RI Field Work Status

Plants and Habitat-Related Soil

- Full objectives met for 14 of 22 target species
- Partial objectives met for 7 species (less than 2 samples collected because not present in all study areas
  - Snowberry
  - Yellow sweet clover
  - Wooly mules ear
  - Tansy mustard
  - Sand seed
  - Mormon tea
  - Watercress
- No samples collected for one species (Wapato) because not present in any study area
- Biologists conducted field reconnaissance with Washoe Tribe representative to attempt to locate species that were not observed in all study areas
- Associated soil samples collected at all locations where plant samples collected
- Objectives met to extent possible

2016 Feasibility Study Field Status

Completed All Field Work Outlined in Governing Documents as Approved, Conditionally Approved, or Directed:

- Revegetation Study
  - Except double-ring infiltrometer testing
- Geotechnical Investigation
  - Except rock coring, televiewer survey, and inclinometer installation in GB-01

RI Work Planned for 2017 as of 12/13/16

- Surface Water / Groundwater Interaction Acidic Pond & Leviathan Creek
  - For 36 DPZs, monthly water levels and surface water and groundwater samples in spring and fall
  - Data Gaps Identified:
    - Isolate uncaptured portion of Delta Seep to measure flow and collect samples
    - Install additional DPZs and weir in Leviathan Creek above concrete channel; monthly flow and water levels
- Beaver Dam/Pond Complex:
  - Data Gaps Identified:
    - Collect additional floodplain samples to evaluate total and leachable metals and potential acid generation
    - Install DPZs adjacent to floodplain soil samples to evaluate the corresponding concentrations in groundwater
    - Collect additional precipitate samples for total and leachable metals
    - Collect surface water samples for laboratory analysis along beaver pond complex to refine spatial resolution of RI/FS metals and general chemistry data
    - Identify mineralogy of precipitate and floodplain soil if possible to refine geochemical model

RI Work Planned for 2017 as of 12/13/16

- Drilling
  - Hydraulic testing of 5 wells installed in 2015 and 9 wells installed in 2016
- Reference
  - Mapping in Upper Leviathan and Aspen Creeks
  - Reference and Perimeter Wells – continue monthly monitoring (water levels and groundwater samples)
- River Ranch
  - Deep samples at 6 locations
- East Fork Carson River
  - Collect surface water samples at 8 locations in spring
- Bioaccessibility Testing
- Plant Biomass Estimation
- On-Going Monitoring Programs
  - Groundwater
  - Surface Water
  - Acid Drainage Discharges and Weirs
  - Storm Water and Snowmelt
  - Upper Tributary
  - Meteorological

Feasibility Study Field Work Planned for 2017

- Revegetation Study
  - Continue monitoring of hydrology and revegetation plots
  - Double-ring infiltrometer testing
- Geotechnical Investigation
  - Rock coring, televiewer survey, and inclinometer/pressure transducers installation in GB-01
  - Monitor slope inclinometer/pressure transducers

Next Steps and Wrap Up

- Complete Stream Sediment and Floodplain Soil TDSR(s)
- Management Meeting in January
- TAC Meeting in January