2 Study Area Investigation

This chapter describes the field investigations performed at the RDM during the 2010 and 2011 field seasons. It includes descriptions of the number, type, location, and analytical requirements of samples collected; the location and methods used for soil boring and monitoring well installations; and deviations from the Work Plan. This chapter also identifies other studies that are used to characterize the site.

2.1 Surface Soil

Surface soil samples were collected for XRF field screening and for laboratory analyses. Surface soil samples were collected between September 12, 2010, and September 24, 2010, and between July 28, 2011, and August 20, 2011.

The objective of the visual inspection and in-situ XRF field screening of surface soils was to:

- Use visual characteristics and metals concentrations in surface materials to determine the lateral surface extent of tailings at the site

The objectives for the data resulting from the surface soil samples collected for laboratory analyses are:

- Characterization of the nature and extent of COPCs in surface soil.
- Provision of data supporting the delineation of the areal extent of tailings on the ground surface.
- Identification and characterization of possible tailings at the reservoir dam.
- Characterization of the soils within the area of surface mining and exploration.
- Characterization of soil characteristics that may affect contaminant fate, transport, and bioavailability.
- Characterization of chemical and physical characteristics of soils in background areas.
- Provision of data for the human health risk assessment (HHRA) to assess potential exposure to COPCs through direct contact, inhalation, and incidental ingestion. The HHRA will be provided under separate cover at a later date.

- Provision of data for the ecological risk assessment (ERA) to assess potential exposure of biota to COPCs through direct contact and ingestion. The ERA will be provided under separate cover at a later date.
- Characterization of geotechnical properties of tailings and soils that may be subject to excavation.
- Characterization of geotechnical properties of soils at a potential site for an onsite waste repository located within the area of surface mining approximately 700 feet north of the Dolly Shaft Collar.

2.1.1 XRF Field Screening Samples

In 2010, areas where tailings could be present at the surface based on historical data, historical photographs, and aerial imagery were evaluated in the field using a combination of visual observations and in-situ field screening for total metals using a portable XRF device. In-situ XRF field screening results from the 2010 Limited Sampling Event (LSE) (E & E 2010b) indicated that further characterization during the 2011 field season was necessary to fully characterize the lateral extent of tailings at the site. Table 2-1 summarizes the location, number, and objectives of the XRF screening locations.

Table 2-1 XRF Screening Sample Summary

General XRF Sample Location	Number of Samples XRF Screened	Objectives of Samples
Main Processing Area Grid	45	Assess the presence of tailings/waste rock and elevated concentrations of metals in surface soil
Main Processing Area Transects	106	
Surface Mined Area Grid	38	
Surface Mined Area Transects	42	
Dolly Sluice	10	Assess the distribution of metals in the sluice gullies
Rice Sluice	12	
Roads and Abandoned Roads	81	Assess whether tailings material had been used as surface material on roads
Former Building Foundations	4	Assess the possibility that tailings were used as foundation material

Key:
XRF x-ray fluorescence

XRF field screening was performed in-situ (on the soil surface) after removal of any surficial detritus. At each XRF field screening location, three XRF readings were taken at the corners of a one-meter equilateral triangle. The lateral coordinates of each field screening location were surveyed with global positioning system (GPS) instrumentation as described in Chapter 8 of the Field Sampling Plan (FSP), which is Appendix F of the Work Plan.


Surface soil sampling for XRF field screening.

To evaluate the extent of tailings, to assist in characterizing the nature of the tailings, and to characterize elevated concentrations COPCs present at the site, grids were established in the main processing area down to the Red Devil Creek delta and in the surface mined area (Figure 2-1). One location within each grid square was field screened, and visual observations of soil characteristics were recorded.

To define the lateral surface extent of tailings or areas of elevated COPCs, a series of transects located around the perimeter of the expected edge of tailings was established (Figure 2-1). Each transect line was oriented perpendicular to the expected lateral limit of tailings, with one end point located within the expected lateral limit (Transect Station A) and the other end point located outside of the expected lateral limit of tailings (Transect Station B). Initially, field screening was performed at Station A and Station B along each transect. If tailings materials were identified at the Station B location along any transect, the transect line was extended outward from Station B and the soil was re-evaluated for the presence of tailings. Similarly, if it appeared that tailings were not present at the Station A position along a given transect, the transect line was extended inward from Station A. This process was repeated until the lateral extent of tailings at each transect location was identified.

XRF field screening was also performed to delineate and characterize metals concentrations at the Dolly Sluice, Rice Sluice, and roads within the site. XRF field screening was conducted along the apparent centerline of the Dolly Sluice and Rice Sluice areas and at locations on either side of the gully lateral to the centerline (Figure 2-2). Field screening of roads occurred along the apparent centerline of the road and on either side of the road outside of the apparent road surface (Figure 2-2).

Former building foundations in the residential area were XRF field screened to assess the possibility that tailings were used as foundation material (Figure 2-2). Review of historical information and photographs indicate that soils in this area have been disturbed as part of the building and road construction.

2.1.2 Laboratory Surface Soil Samples

Surface soil samples submitted for laboratory analysis are illustrated in Figures 2-3 and 2-4. Surface soil samples were collected from 0 to 6 inches bgs following removal of surficial detritus on the ground surface.

Surface soil sample collection.

All surface soil samples were analyzed for target analyte list (TAL) inorganic elements. A subset of these samples was selected for analysis for mercury selective sequential extraction (SSE), arsenic speciation, arsenic bioavailability, TAL metals synthetic precipitation leaching procedure (SPLP), RCRA metals toxicity characteristic leaching procedure (TCLP), semi-volatile organic compounds (SVOCs), PCBs, DRO, and RRO. In addition, selected soil samples were analyzed for geotechnical parameters, including grain size/Atterburg limits, moisture content, compaction, direct shear, and permeability. Table 2-2 lists the laboratory surface soil samples and analytical parameters by general geographic area. In general, samples were selected for the additional analyses to achieve the following:

- Provide broad areal distribution of data.
- Obtain data for different tailings types (e.g., flotation tailings versus thermally processed tailings, including pre-1955 thermally processed tailings and post-1955 thermally processed tailings) that may be discernible based on chemical or physical characteristics and/or geographic position.
- Obtain data on disturbed soils within the area of surface mining.
- Obtain data for anticipated background locations.

Deviations from the Field Sampling Plan

The surface disturbance south of the power plant was found to be narrow, and the transects planned for the feature bracketed the area well. As a result, the grid point planned for the center of the area of surface disturbance south of the power plant was not collected.

Some abandoned roads in the surface mined area and the area of surface disturbance south of the power plant were not identifiable as roads due to overgrowth or bulldozing that occurred during later mining, or the possibility that the features identified in the FSP as roads were not roads but rather bulldozer paths. The decision was made in the field to not field screen road points unless the identified features were clearly a road that was either currently used or abandoned when surveyed in the field. Roads within the cleared portions of the main processing areas were not sampled because characterization would not reflect road material but rather the tailings material found in the main processing area.

Surface soil samples 11MP80SS, 11MP81SS, 11MP82SS, 11MP86SS, and 11MP87SS were collected from locations discussed with the BLM in the field based on where transformers had been removed in the past.

Table 2-2 Surface Soil Sample Summary

General Geographic Area	Location Description	Sample ID	Date Sampled	Total TAL Metals	Diesel Range Hydrocarbons	Moisture Content	Grain Size	Atterberg Limits Classification	Total Solids	Mercury SSE	Arsenic Speciation	SVOCs	SPLP	TCLP	Arsenic Bioavailability	PCBs
	Red Devil Creek Alluvial Deposits Between Dam and Main Processing Area	10RD13SS	9/17/2010	x												
	Red Devil Creek Alluvial Deposits Upstream of Dam	10RD14SS Duplicate 10RD31SS	9/15/2010	x												
		10RD15SS	9/15/2010	x												
		10RD16SS	9/15/2010	x												
		10RD17SS	9/15/2010	x												
		10RD18SS	9/15/2010	x					x	x	x		x			
		11RD18SS Duplicate 11RD30SS	8/2/2011												x	
		10RD19SS	9/15/2010	x					x	x	x		x			
	Soil derived from bedrock (Kuskokwim Group)	10UP01SS	9/17/2010	x												
		10UP02SS	9/23/2010	x												
		10UP03SS	9/23/2010	x												
		10UP04SS	9/23/2010	x												
		10UP05SS	9/23/2010	x												
		10UP06SS	9/23/2010	x												
		10UP07SS	9/23/2010	x												
		10UP08SS	9/23/2010	x												
		10UP09SS Duplicate 10UP30SS	9/24/2010	x					x	x	x		x			
		10UP10SS	9/24/2010	x					x	x	x		x			
		11UP09SS	8/2/2011												x	
	Red Devil Creek Alluvial Deposits Between Dam and Main Processing Area	10RD10SS	9/17/2010	x												
		10RD11SS	9/17/2010	x					x	x	x		x			
		10RD12SS	9/17/2010	x					x	x	x		x			
Dolly Sluice and Delta	Dolly Sluice Delta	10DS01SS	9/19/2010	x					x	x	x		x			
		10DS02SS	9/19/2010	x												
	Gulley	10DS03SS	9/16/2010	x												
Pre 1955	Along Red Devil Creek West of Gravel Pad	11MP80SS	8/20/2011													x
		11MP81SS	8/20/2011													x
		11MP82SS	8/20/2011													x
	Area between mine access road and Red Devil Creek	10MP64SS	9/17/2010	x												
		10MP65SS	9/17/2010	x												
	Area between Pre-	10MP61SS	9/16/2010	x												

Table 2-2 Surface Soil Sample Summary

General Geographic Area	Location Description	Sample ID	Date Sampled	Total TAL Metals	Diesel Range Hydrocarbons	Moisture Content	Grain Size	Atterberg Limits Classification	Total Solids	Mercury SSE	Arsenic Speciation	SVOCs	SPLP	TCLP	Arsenic Bioavailability	PCBs
Pre 1955 (cont'd)	1955 Retort and Red Devil Creek	10MP63SS	9/17/2010	x												
	Area between Pre-1955 Retort and Red Devil Creek / Pre-1955 Rotary Furnace Burnt Ore Disposal Pile	10MP62SS	9/20/2010	x		x	x	x								
	Area near Monofill #1 / Former Shop Pad / Tailings	10MP45SS	9/21/2010	x	x							x				
		10MP46SS	9/21/2010	x	x							x				
		10MP47SS	9/20/2010	x	x							x				
	Area near Monofill #1 / Shop Pad A / Tailings	10MP48SS	9/16/2010	x												
		10MP49SS	9/16/2010	x												
		11MP83SS Duplicate 11MP92SS	8/15/2011													x
		11MP84SS	8/15/2011													x
		11MP85SS	8/15/2011													x
	Area of Pre-1955 Furnace Building / Tailings/Waste Rock	10MP5051525354SS	9/19/2010	x									x	x		
		10MP50SS	9/19/2010	x												
		10MP51SS	9/19/2010	x												
		10MP52SS	9/19/2010	x					x	x	x					
		11MP52SS	8/2/2011												x	
		10MP53SS	9/19/2010	x												
		10MP54SS	9/19/2010	x												
		11MP86SS	8/20/2011													x
		11MP87SS	8/20/2011													x
	Area of Pre-1955 Retort Building	10MP55565758SS	9/18/2010	x									x	x		
		10MP55SS	9/18/2010	x												
		10MP56SS	9/18/2010	x												
		10MP57SS	9/19/2010	x					x	x	x					
		10MP58SS	9/19/2010	x												
	East of Pre-1955 Retort Building	10MP59SS Duplicate 10MP86SS	9/21/2010	x					x	x	x		x	x		
		11MP59SS	8/2/2011												x	
	Mine Access Road / Downgradient of Pre-1955 Processing Area	10MP66SS	9/17/2010	x												
	Near spring in Red Devil Creek / Downgradient of former	10MP60SS	9/20/2010	x		x	x	x								

Table 2-2 Surface Soil Sample Summary

General Geographic Area	Location Description	Sample ID	Date Sampled	Total TAL Metals	Diesel Range Hydrocarbons	Moisture Content	Grain Size	Atterberg Limits Classification	Total Solids	Mercury SSE	Arsenic Speciation	SVOCs	SPLP	TCLP	Arsenic Bioavailability	PCBs
	mine openings / Tailings															
	Surface of Monofill #1	10MP424344SS	9/19/2010	x									x	x		
		10MP42SS	9/19/2010	x												
		10MP43SS	9/19/2010	x												
		10MP44SS	9/19/2010	x												
	Area Upgradient of Monofill #2 / Post-1955 Retort Building	10MP01SS	9/24/2010	x					x	x	x		x			
Post 1955	Area of Surface Disturbance	11MP71SS	8/2/2011	x						x			x			
	Berm of Settling Pond #2	10MP35SS	9/17/2010	x												
	Berm of Settling Pond #3	10MP37SS	9/17/2010	x												
		10MP68SS	9/19/2010	x												
	Between Settling Ponds #1 and Red Devil Creek	10MP38SS	9/17/2010	x												
	Between Settling Ponds #2 and Red Devil Creek	10MP39SS	9/17/2010	x												
	Between Settling Ponds #3 and Red Devil Creek	10MP40SS	9/17/2010	x												
	Flotation Tailings, Settling Pond #1	10MP32SS	9/20/2010	x	x	x	x		x	x	x	x	x	x		
		11MP32SS	8/2/2011												x	
Post 1955 (cont'd)	Flotation Tailings, Settling Pond #2	10MP34SS	9/20/2010	x	x	x	x		x	x	x	x	x	x		
		11MP34SS	8/2/2011												x	
	Flotation Tailings, Settling Pond #3	10MP36SS Duplicate 10MP84SS	9/20/2010	x	x	x	x		x	x	x	x	x	x		
		11MP36SS	8/2/2011												x	
	Gravel Pad	10MP23SS	9/18/2010	x												
		10MP24SS	9/18/2010	x												
		10MP25SS	9/18/2010	x					x	x	x		x	x		
		11MP25SS	8/2/2011												x	
		11MP76SS (Duplicate 11MP91SS)	8/15/2011													x
		11MP77SS	8/15/2011													x
		11MP78SS	8/15/2011													x
		11MP79SS	8/15/2011													x

Table 2-2 Surface Soil Sample Summary

General Geographic Area	Location Description	Sample ID	Date Sampled	Total TAL Metals	Diesel Range Hydrocarbons	Moisture Content	Grain Size	Atterberg Limits Classification	Total Solids	Mercury SSE	Arsenic Speciation	SVOCs	SPLP	TCLP	Arsenic Bioavailability	PCBs
	Location where the single abandoned drum was identified during the 2010 limited sampling effort	11MP70SS	8/15/2011	x	x							x				
	Monofill #3 Area/ Tailings	10MP22SS	9/16/2010	x												
	North of Monofill #2 / Post-1955 Retort Building / Drum Storage Area	10MP10SS	9/21/2010	x	x							x				
		10MP19SS	9/23/2010	x	x							x				
	Stockpiled ore upgradient from the Ore Hopper	10MP02SS Duplicate 10MP81SS	9/18/2010	x									x			
	Power Plant / Former Drum Storage Area	10MP20SS	9/23/2010	x	x							x				
		10MP21SS	9/23/2010	x	x							x				
		11MP72SS	8/15/2011													x
		11MP73SS	8/15/2011													x
		11MP74SS	8/15/2011													x
		11MP75SS	8/15/2011													x
	Red Devil Creek Alluvial Deposits and/or Soil	10RD06SS	9/17/2010	x					x	x	x		x			
		10RD07SS	9/17/2010	x												
	Road below Monofill #2 / Post-1955 Retort Building	10MP11SS	9/19/2010	x												
		10MP12SS	9/18/2010	x												
		10MP13SS	9/18/2010	x												
		10MP14SS	9/17/2010	x												
		10MP15SS	9/17/2010	x												
		10MP18SS	9/16/2010	x												
	Slope Below Perimeter of Monofill #2 / Post-1955 Retort Building	10MP06070809SS	9/17/2010	x									x	x		
		10MP06SS	9/17/2010	x												
		10MP07SS	9/17/2010	x												
		10MP08SS	9/17/2010	x												
		10MP09SS	9/18/2010	x												
	Surface of Monofill #2	10MP030405SS	9/18/2010	x									x	x		
		10MP03SS	9/18/2010	x												
		10MP04SS	9/18/2010	x												
		10MP05SS	9/18/2010	x												

Table 2-2 Surface Soil Sample Summary

General Geographic Area	Location Description	Sample ID	Date Sampled	Total TAL Metals	Diesel Range Hydrocarbons	Moisture Content	Grain Size	Atterberg Limits Classification	Total Solids	Mercury SSE	Arsenic Speciation	SVOCs	SPLP	TCLP	Arsenic Bioavailability	PCBs
Post 1955 (cont'd)	Tailings	10MP26SS	9/18/2010	x					x	x	x		x	x		
		10MP28SS	9/18/2010	x												
		10MP29SS	9/20/2010	x		x	x		x		x		x	x		
		10MP30SS	9/18/2010	x												
		10MP67SS	9/18/2010	x					x	x						
	Tailings Borrow Area	11MP17SS Duplicate 11MP90SS	8/2/2011												x	
		10MP27SS	9/18/2010	x					x	x	x		x	x		
		10OP01SS	9/18/2010	x					x		x		x	x		
	Tailings borrow area, near former chute	10MP16SS Duplicate 10MP89SS	9/18/2010	x					x	x	x		x	x		
		10MP17SS Duplicate 10MP82SS	9/20/2010	x		x	x		x	x	x		x	x		
	Upgradient of Settling Pond #1	10MP31SS	9/18/2010	x												
	Upgradient of Settling Ponds #2 and #3	10MP33SS	9/17/2010	x												
Red Devil Creek Delta	Red Devil Creek Alluvial Deposits Between Main Processing Area and delta	10RD05SS	9/17/2010	x												
		10RD20SS	9/17/2010	x												
	Red Devil Creek Delta	10RD01SS	9/16/2010	x												
		10RD02SS	9/16/2010	x												
		10RD03SS	9/16/2010	x												
		10RD04SS	9/16/2010	x					x	x	x		x			
Reservoir Dam	Dam	10RD08SS Duplicate 10RD30SS	9/15/2010	x												
		10RD09SS	9/15/2010	x					x	x	x		x			
Rice Sluice and Delta	Gulley	10RS03SS	9/16/2010	x												
	Rice Delta	10RS01SS	9/19/2010	x					x	x	x		x			
		10RS02SS	9/19/2010	x												
	Trenched Area West of Residential Structures	10SM30SS	9/19/2010	x												
Surface Mined Area	Bulldozed Area Away from Known Ore Trend	10SM13SS	8/2/2011	x					x	x	x		x			
		11SM13SS	9/24/2010												x	
		10SM14SS	9/24/2010	x												
		10SM15SS	9/23/2010	x												
		10SM16SS	9/23/2010	x												

Table 2-2 Surface Soil Sample Summary

General Geographic Area	Location Description	Sample ID	Date Sampled	Total TAL Metals	Diesel Range Hydrocarbons	Moisture Content	Grain Size	Atterberg Limits Classification	Total Solids	Mercury SSE	Arsenic Speciation	SVOCs	SPLP	TCLP	Arsenic Bioavailability	PCBs
Surface Mined Area (cont'd)		10SM17SS	9/24/2010	x												
		10SM18SS	8/2/2011	x					x	x	x		x			
		11SM18SS	9/23/2010												x	
		10SM19SS	9/23/2010	x					x	x	x		x			
	Central Surface Mined Area	10SM20SS	9/19/2010	x												
		10SM21SS	9/19/2010	x					x	x	x		x			
	Dolly Ore Zone	10SM04SS	9/24/2010	x												
		10SM05SS	9/24/2010	x					x	x	x		x			
		10SM06SS	9/24/2010	x												
	Northern Surface Mined Area	10SM22SS	9/19/2010	x												
		10SM23SS	9/19/2010	x					x	x	x		x			
	Originally Mined Ore Zone	10SM01SS	9/24/2010	x												
		10SM02SS	9/24/2010	x												
		10SM03SS Duplicate 10SM41SS	9/24/2010	x					x	x	x		x			
	Potential Site of On-Site Repository / Bulldozed Area Away from Known Ore Trend	10SM10SS	9/21/2010	x		x	x									
		10SM11SS	9/21/2010	x		x	x									
		10SM12SS Duplicate 10SM40SS	9/21/2010	x		x	x	x	x	x	x		x			
	Rice Ore Zone	10SM07SS	9/24/2010	x					x	x	x		x			
		10SM08SS	9/24/2010	x												
		10SM09SS	9/24/2010	x												
	Trenched Area West of Bulldozed Area	10SM24SS	9/21/2010	x												
		10SM25SS	9/21/2010	x												
		10SM26SS	9/21/2010	x												
		10SM27SS	9/23/2010	x					x	x	x		x			
	Trenched Area West of Residential Structures	10SM28SS	9/19/2010	x					x	x	x		x			
		11SM28SS	8/2/2011												x	
		10SM29SS	9/19/2010	x												
	Upslope of Pre-1955 processing facilities and Monofill #1	10MP41SS	9/19/2010	x					x	x	x		x			

Key
ID identifier
PCBs polychlorinated biphenyls
SPLP synthetic precipitation leaching procedure
SSE selective sequential extraction
SVOC semi-volatile organic compound
TAL target analyte list
TCLP toxicity characteristic leaching procedure

2.2 Subsurface Soil

Subsurface soil samples were collected between August 3, 2011, and August 27, 2011.

Seventy-two boreholes were drilled within the study area. Twenty-six of the 72 boreholes were completed as monitoring wells. The location and identifiers of the boreholes and monitoring wells are shown in Figure 2-5, Figure 2-6, and Table 2-3. A total of 237 subsurface soil samples were collected from the boreholes, with sample collection guided by on-site XRF screening and geological logging, and the sample selection criteria described by the FSP. The data objectives of the soil investigation are summarized below:

- Determine the nature and extent of COPCs in subsurface soil, including tailings/waste rock and underlying native soil.
- Determine the depth of tailings/waste rock up to the total depth of the boring.
- Identify and characterize possible tailings/waste rock at the reservoir dam.
- Identify tailings/waste rock within alluvial deposits of Red Devil Creek, including its delta in the Kuskokwim River up to the total depth of the boring.
- Identify mining-related material (expected to consist of sluiced overburden) within alluvial deposits of the Dolly Sluice delta and possible Rice Sluice delta up to the total depth of the boring.
- Assess lithologic characterization of subsurface soils.
- Identify soil characteristics that may affect the fate and transport of COPCs.
- Provide data for the HHRA to assess potential exposure to COPCs through direct contact.
- Characterize the geotechnical properties of tailings/waste rock and soils that may be subject to excavation.
- Characterize the geotechnical properties of the subsurface for use in the FS.

Subsurface soil sampling was conducted with a CME 850 drill rig mounted to a Nodwell (mobile tracked vehicle) operated by Discovery Drilling, Inc. The drilling method varied depending on application and the type of subsurface material encountered. In general, direct push driven by a hydraulic hammer was utilized for soft, shallow soils near the surface; hollow stem augers were utilized for overburden soils deeper than approximately 15 feet, and a downhole hammer (air rotary) was utilized for weathered bedrock and competent bedrock. A 2-foot-long split spoon sampler was used for all sampling occurring during direct push and hollow stem auger drilling. Downhole hammer drilling is incompatible with split spoon sampling, and therefore subsurface materials were not sampled when using this drilling method.

All drill pipe, split spoon samplers, and augers were decontaminated prior to commencing drilling on a new hole. Typically, a hole began with a direct push

drilling method, using the hydraulic hammer to impact the split spoon sampler into the ground. If the hole extended beyond the depth at which the hole could be expected to stay open on its own, augers were then drilled in around the drill stem. During hollow stem auger drilling, the split spoon sampler was advanced out in front of the auger, and then after the sample was collected, an auger-compatible tip was placed on the end of the drill string and advanced back to the position of the auger head. The combined drill string and auger assembly was then rotated downwards via a Kelly drive for 2 feet to the end of the split spoon borehole. This method was utilized for a majority of the boreholes that extended beyond approximately 15 feet in depth. For locations where a monitoring well was to be placed in the bedrock aquifer, the use of the downhole (air rotary) hammer was necessary. The downhole hammer attaches directly to the drill string and uses injected compressed air to power an impact slide hammer while the drill string is being rotated via the Kelly drive. The impact hammer has a face with buttons of tungsten carbide and channels allowing air to pass out of the hammer and into the annular space, effectively pulverizing the rock face and blasting the rock chips out of the borehole. Because the use of the downhole precludes the use of the split spoon sampler, efforts were made to pause the downhole hammer drilling and collect a split spoon sample within the projected screened interval of the monitoring well to be installed for lithological identification and geotechnical sample collection.

Once a split spoon sample was collected, it was opened on site and geologically logged by a geologist. Particular attention was paid to the presence of cursor minerals and lithologies that signified the presence of processed mine tailings. After geological logging was complete the sample was collected and analyzed with an XRF field screening instrument to further aid in the determination of potentially contaminated materials from undisturbed native soils and other uncontaminated soil types. Split spoon samplers were decontaminated between each use. Samples were processed and prepared for analysis in the field laboratory; any Investigation-Derived Waste (IDW) resulting from drilling or discarded sample intervals was disposed of onsite in accordance with the Work Plan.

Subsurface soil samples were analyzed for total TAL metals, mercury SSE, arsenic speciation, SPLP TAL metals, TCLP RCRA metals, SVOCs, DRO/RRO, grain size, and a combined test of Atterberg limits and moisture content. Table 2-3 provides a summary of the subsurface soil samples and analyses performed. In general, samples were selected for the various analyses to achieve the following:

- Provide broad areal distribution of data.
- Obtain data from multiple depth intervals within tailings/waste rock to assess vertical variability based on depth and/or lithologic characteristics.
- Obtain data for different tailings types (e.g., flotation tailings versus thermally processed tailings, including pre-1955 thermally processed tailings and post-1955 thermally processed tailings).

Deviations from the Field Sampling Plan

Several deviations from the FSP were made based upon field conditions and evolving data needs. The benefit of comparing groundwater movement through lithologies at different depths was realized in the addition of borehole MP91, adjacent to the existing borehole MP30. While paired shallow/deep wells were planned in other locations, creating this well pair allowed for a vertical comparison of hydrogeology to be made in the vicinity of the settling ponds, an area undergoing detailed examination. Additionally, this pairing benefited the subsurface soil sampling program by increasing the depth of geological logging and subsurface soil sampling in this location.

Opposingly, a lack of groundwater in shallower soils caused the removal of borehole MP89. The subsurface soils were logged and sampled during the drilling of the adjacent and deeper borehole MP41, so there was no need to drill the borehole for the benefit of the subsurface soils investigation. As a result, plans to drill MP89 were abandoned.

Groundwater study concerns caused boreholes MP12 and MP17 to be advanced as shallow borings for comparison to the deeper borehole MP14. These shallow boreholes were set based upon the groundwater study needs of a 20-foot gap between the deep monitoring well and shallow monitoring wells screened intervals. This was the primary deciding factor for the depth of borehole advancement, which deviates from the borehole drilling and monitoring well installation protocol described in the FSP. This deviation was performed at the request of the Bureau of Land Management in order to measure vertical hydraulic gradient between the three monitoring wells installed into boreholes MP12, MP17, and MP14. However, unlike a typical monitoring well pair, all three boreholes were geologically logged and sampled separately due to their spatial separation.

RD08 and RD09 were located on the dam of the reservoir. These were not sampled because it was determined that the dam was composed of native material rather than tailings. RD06 was not sampled because a new access road was built over the location, excessively redistributing the subsurface soil.

Table 2-3 Subsurface Soil Collection Summary

General Geographic Area	Location Description	Soil Boring Location	Depth (feet)	Sample ID	Total TAL Metals	Mercury SSE	Arsenic Speciation	SPLP TAL Metals	TCLP RCRA Metals	SVOCs	DRO/RRO	Particle Size / Atterberg Limits (ASTM D2487) and Moisture Content	Grain Size (ASTM D422)
Background Areas	Upgradient Area	MP01	2-4	11MP01SB04	3 (11MP01SB04, 11MP01SB12 (DUPLICATE: 11MP01SB18 @ 1203) , 11MP01SB16)	1 (All ND)	1 (11MP01SB16)	1 (11MP01SB16)					1 (11MP01SB10)
			8-10	11MP01SB10									
			10-12	11MP01SB12									
			14-16	11MP01SB16									
	Upland Area West of Surface Mined Area	UP11	2-4	11UP11SB04	3 (11UP11SB04) and 11UP11SB06, 11UP11SB08	1 (11UP11SB04)	1 (11UP11SB04)	1 (11UP11SB04)				1 (11UP11SB04)	
			4-6	11UP11SB06									
			6-8	11UP11SB08									
Post-1955 Main Processing Area	Road below Monofill #2 / Post-1955 Retort Building	MP11	2-4	11MP11SB04	3 (11MP11SB04, 11MP11SB06, 11MP11SB08)	2 (11MP14SB04, 11MP12SB06)	1 (11MP11SB04)	2 (11MP14SB04, 11MP11SB04)	2 (11MP14SB04, 11MP11SB04)				
			4-6	11MP11SB06									
			6-8	11MP11SB08									
		MP12	4-6	11MP12SB06	3 (11MP12SB06, 11MP12SB12, 11MP12SB16)							1 (11MP12SB08) and Moisture content	2 (11MP12SB14, 11MP12SB16)
			6-8	11MP12SB08									
			10-12	11MP12SB12									
			12-14	11MP12SB14									
			14-16	11MP12SB16									
		MP13	2-4	11MP13SB04	3 (11MP13SB04, 11MP13SB06)								
			4-6	11MP13SB06									
		MP14	2-4	11MP14SB04	3 (11MP14SB04, 11MP14SB58, 11MP14SB14)							2 (11MP14SB08, 11MP14SB16) both with Moisture Content	2 (in bedrock)
			6-8	11MP14SB08									
			12-14	11MP14SB14									
			14-16	11MP14SB16									
			56-58	11MP14SB58									
		MP15	2-4	11MP15SB04	3 (11MP15SB04, 11MP15SB06, 11MP15SB08)	2 (11MP18SB04, 11MP17SB14)	1 (11MP18SB20)	2 (11MP18SB04, 11MP18SB20)	2 (11MP18SB04, 11MP18SB20)				
			4-6	11MP15SB06									
			6-8	11MP15SB08									
		MP16	2-4	11MP16SB04	3 (11MP16SB04, 11MP16SB08, 11MP16SB10)							1 (11MP16SB04)	
			6-8	11MP16SB08									
			8-10	11MP16SB10									
		MP17	2-4	11MP17SB04	3 (11MP17SB14, 11MP17SB04, 11MP17SB30 (DUPLICATE: 11MP17SB34 @ 1642))					11MP17SB30 Sent due to diesel oder	11MP17SB30 Sent due to diesel oder		2 (11MP17SB28) Dry well. Only sending one from screened interval.
			12-14	11MP17SB14									
			28-30	11MP17SB30									
		MP18	2-4	11MP18SB04	3 (11MP18SB20, 11MP18SB04, 11MP18SB10)								
			8-10	11MP18SB10									
			18-20	11MP18SB20									
	North of Monofill #2 / Post-1955 Retort Building / Drum Storage Area	MP10	2-4	11MP10SB04	3 (11MP10SB04, 11MP10SB06)	2(11MP19SB06) Detection on 1 only	1(11MP19SB04)	2 (11MP19SB04, 11MP10SB06)	2 (11MP19SB04, 11MP10SB06)	1 (No diesel odor noted or water table encountered)	1 (No diesel odor noted or water table encountered)		
			4-6	11MP10SB06									

Table 2-3 Subsurface Soil Collection Summary

General Geographic Area	Location Description	Soil Boring Location	Depth (feet)	Sample ID	Total TAL Metals	Mercury SSE	Arsenic Speciation	SPLP TAL Metals	TCLP RCRA Metals	SVOCs	DRO/RRO	Particle Size / Atterberg Limits (ASTM D2487) and Moisture Content	Grain Size (ASTM D422)
		MP19	2-4	11MP19SB04	3 (11MP19SB04, 11MP19SB06)							1(11MP19SB06)	
			4-6	11MP19SB06									
			4-6	11MP27SB06									
	Tailings / Waste Rock	MP26	2-4	11MP26SB04	3 (11MP26SB10, 11MP26SB04, 11MP26SB16)								
			8-10	11MP26SB10									
			14-16	11MP26SB16									
		MP28	4-6	11MP28SB06	3 (11MP28SB06, 11MP28SB08, 11MP28SB10 (DUPLICATE: 11MP28SB12 @ 1022)								
			6-8	11MP28SB08									
			8-10	11MP28SB10									
		MP29	4-6	11MP29SB06	3 (11MP29SB16, 11MP29SB06 (DUPLICATE: 11MP29SB28 @ 1448), 11MP29SB10)							1 (11MP29SB08) with Moisture Content	2 (11MP29SB18, 11MP29SB22)
			6-8	11MP29SB08									
			8-10	11MP29SB10									
			14-16	11MP29SB16									
			16-18	11MP29SB18									
			20-22	11MP29SB22									
		MP91	N/A	N/A (not sampled)									
		MP30	4-6	11MP30SB06	3 (11MP30SB06, 11MP30SB16, 11MP30SB12)							1 (11MP30SB08) and moisture content	2 (11MP30SB14, 11MP30SB18)
			6-8	11MP30SB08									
			10-12	11MP30SB12									
			12-14	11MP30SB14									
			14-16	11MP30SB16									
			16-18	11MP30SB18									
	Gravel Pad	MP23	8-10	11MP23SB10	3 (11MP23SB20, 11MP23SB10, 11MP23SB14)	2 (11MP23SB20, 11MP24SB12)	1 (11MP23SB20)	2 (11MP23SB20) High As and Hg in same sample	2 (11MP23SB20) High As and Hg in same sample DUPLICATE: 11MP23SB24 @ 1748)	1 (No diesel odor noted or water table encountered)	2 (No diesel odor noted or water table encountered)		
			12-14	11MP23SB14									
			18-20	11MP23SB20									
		MP24	2-4	11MP24SB04	3 (11MP24SB12, 11MP24SB04, 11MP24SB18)					1 (No diesel odor noted or water table encountered)	1 (No diesel odor noted or water table encountered)		
			10-12	11MP24SB12									
			16-18	11MP24SB18									
		MP25	Post-1955 Main Processing Area (cont'd)	Tailing Borrow Area	MP27					2 (11MP28SB06, 11MP29SB16)	3 (11MP30SB06, 11MP28SB06, 11MP29SB10)	2 (11MP30SB06, 11MP28SB06)	
			18-20	11MP25SB20									
			24-26	11MP25SB26									
			28-30	11MP25SB30									
			32-34	11MP25SB34									

Table 2-3 Subsurface Soil Collection Summary

General Geographic Area	Location Description	Soil Boring Location	Depth (feet)	Sample ID	Total TAL Metals	Mercury SSE	Arsenic Speciation	SPLP TAL Metals	TCLP RCRA Metals	SVOCs	DRO/RRO	Particle Size / Atterberg Limits (ASTM D2487) and Moisture Content	Grain Size (ASTM D422)
Post-1955 Main Processing Area (cont'd)	Monofil #3 Area / Tailings / Waste Rock	MP22	2-4	11MP22SB04	3 (11MP22SB04, 11MP22SB08, 11MP22SB12)								
			6-8	11MP22SB08									
			10-12	11MP22SB12									
	Power Plant / Former Drum Storage Area	MP20	2-4	11MP20SB04	3 (11MP20SB04, 11MP20SB12 (DUPLICATE 11MP20SB16 @1747), 11MP20SB08)					1 (No diesel odor noted or water table encountered)	1 (No diesel odor noted or water table encountered)		2 (no samples below water table)
			10-12	11MP20SB12									
		MP21	2-4	11MP21SB04	3 (11MP21SB04, MP21SB14, 11MP21SB08)					1 (No diesel odor noted or water table encountered)	1 (No diesel odor noted or water table encountered)		
			6-8	11MP21SB08									
			12-14	11MP21SB14									
	Upgradient of Settling Pond #1	MP31	2-4	11MP31SB04	3 (11MP31SB04)								2 (no samples below water table)
	Flotation Tailings, Settling Pond #1	MP32	2-4	11MP32SB04	3 (11MP32SB04, 11MP32SB06, 11MP32SB08)	1 (11MP32SB08)	1 (11MP32SB06)	1 (11MP32SB06)	1 (11MP32SB06)	2 (11MP32SB04)	1 (11MP32SB04)	1 (11MP32SB04)	
			4-6	11MP32SB06									
			6-8	11MP32SB08									
	Upgradient of Settling Ponds #2 and #3	MP33	2-4	11MP33SB04	3 (11MP33SB04) (DUPLICATE: 11MP33SB06 @ 1535)								2 (no samples below water table)
	Flotation Tailings, Settling Pond #2	MP34	2-4	11MP34SB04	3 (11MP34SB04,11MP34SB06) and 11MP34SB08 (DUPLICATE: 11MP34SB22 @ 1715) (mid-range)	1 (11MP34SB04)	1 (11MP34SB06)	1 (11MP34SB06)	1 (11MP34SB06)	2(11MP34SB04, 11MP34SB12)	1 (11MP34SB14)	1(11MP34SB04)	
			4-6	11MP34SB06									
			6-8	11MP34SB08									
			10-12	11MP34SB12									
			12-14	11MP34SB14									
	Berm of Settling Pond #2	MP35	4-6	11MP35SB06	3 (11MP35SB12,11MP35SB16,11MP35SB06)								
			10-12	11MP35SB12									
			14-16	11MP35SB16									
	Flotation Tailings, Settling Pond #3	MP36	2-4	11MP36SB04	3 (11MP36SB04, 11MP36SB08 and 11MP36SB16 (low-range)	1 (11MP36SB04)	1 (11MP36SB04)	1 (11MP36SB04)	1 (11MP36SB04)	2(11MP36SB08 (DUPLICATE: 11MP36SB18 @ 1505) , No Samples Above Water Table)	1(11MP36SB08 (DUPLICATE: 11MP36SB18 @ 1505))	1 (No Samples Above water table)	
			6-8	11MP36SB08									
			14-16	11MP36SB16									
	Berm of Settling Pond #3	MP37	4-6	11MP37SB06	3 (11MP37SB06 (DUPLICATE: 11MP37SB24 @ 1230),11MP37SB08,11MP37SB16)					1 (11MP37SB16) Diesel Odor	1 (11MP37SB16) Diesel Odor		
			6-8	11MP37SB08									
			14-16	11MP37SB16									
	Between Settling Pond #1 and Red Devil Creek	MP38	8-10	11MP38SB10	3 (11MP38SB10) and 11MP38SB14, 11MP38SB16 (mid and low-range)	1 (11MP38SB10)	1 (11MP38SB10)	1 (11MP38SB10)					2 (11MP38SB12, 11MP38SB14)
			10-12	11MP38SB12									
			12-14	11MP38SB14									
			14-16	11MP38SB16									

Table 2-3 Subsurface Soil Collection Summary

General Geographic Area	Location Description	Soil Boring Location	Depth (feet)	Sample ID	Total TAL Metals	Mercury SSE	Arsenic Speciation	SPLP TAL Metals	TCLP RCRA Metals	SVOCs	DRO/RRO	Particle Size / Atterberg Limits (ASTM D2487) and Moisture Content	Grain Size (ASTM D422)
Pre-1955 Main Processing Area (cont'd)	Between Settling Pond #2 and Red Devil Creek	MP39	4-6	11MP39SB06	3 (11MP39SB06, 11MP39SB08) and 11MP39SB12 (low-range)	1 (11MP39SB08)	1 (11MP39SB06)	1 (11MP39SB06) (DUPLICATE 11MP39SB16 @1011)					2 (11MP39SB10, 11MP39SB14)
			6-8	11MP39SB08									
			8-10	11MP39SB10									
			10-12	11MP39SB12									
			12-14	11MP39SB14									
	Between Settling Pond #3 and Red Devil Creek	MP40	4-6	11MP40SB06	3 (11MP40SB08, 11MP40SB06, 11MP40SB10)	1 (11MP40SB08)	1 (11MP40SB08)	1 (11MP40SB08)					2 (11MP40SB10, 11MP40SB06)
			6-8	11MP40SB08									
			8-10	11MP40SB10									
	Near spring in Red Devil Creek / Downgradient of former mine openings / Tailings/Waste Rock	11MP60 (Shallow) (Paired with 11MP88)	2-4	11MP60SB04	3 (11MP60SB14, 11MP60SB04, 11MP60SB24)	1 (11MP60SB14)	1 (11MP60SB14)	1 (11MP60SB14)	1 (11MP60SB14)				2 (11MP60SB24)
			12-14	11MP60SB14									
			22-24	11MP60SB24									
		11MP88 (Deep) (Paired with 11MP60)	N/A	N/A (not sampled)									
	Area between Pre-1955 Retort and Red Devil Creek	MP63	2-4	11MP63SB04	3 (11MP63SB04, 11MP63SB06)								
			4-6	11MP63SB06									
	Mine Access Road / Downgradient of Pre-1955 Processing Area	MP66	4-6	11MP66SB06	3 (11MP66SB06, 11MP66SB18, 11MP66SB10 (DUPLICATE: 11MP66SB24@1050))					0 (11MP66SB16) DUPLICATE 11MP66SB26 @ 1059	0 (11MP66SB16) DUPLICATE 11MP66SB26 @ 1059		2 (11MP66SB20, 11MP66SB22)
			8-10	11MP66SB10									
			14-16	11MP66SB16									
			16-18	11MP66SB18									
			18-20	11MP66SB20									
			20-22	11MP66SB22									
	Area near Monofill #1 / Former Shop Pad / Tailings/Waste Rock	MP45	2-4	11MP45SB04	3 (11MP45SB04, 11MP45SB10, 11MP45SB12)					1 (11MP45SB04)	1 (11MP45SB04)		
			8-10	11MP45SB10									
			10-12	11MP45SB12									
		MP46	2-4	11MP46SB04	3 (11MP46SB04, 11MP46SB12) No major variability					1 (Petroleum odor not noted)	1 (Petroleum odor not noted)		
			10-12	11MP46SB12									
		MP47	2-4	11MP47SB04	3 (11MP47SB04, 11MP47SB22, 11MP47SB26)					1 (Petroleum odor not noted)	1 (Petroleum odor not noted)		
			20-22	11MP47SB22									
			24-26	11MP47SB26									
	Area near Monofill #1 / Shop Pad A / Tailings/Waste Rock	MP48	2-4	11MP48SB04	3 (11MP48SB12, 11MP48SB08, 11MP48SB04)			1 (11MP48SB12 (DUPLICATE: 11MP48SB16@1655))	1 (11MP48SB08 (DUPLICATE: 11MP48SB18@1700))				
			6-8	11MP48SB08									
			10-12	11MP48SB12									
		MP49	4-6	11MP49SB06	3 (11MP49SB06, 11MP49SB14(DUPLICATE:								
			8-10	11MP49SB10									

Table 2-3 Subsurface Soil Collection Summary

General Geographic Area	Location Description	Soil Boring Location	Depth (feet)	Sample ID	Total TAL Metals	Mercury SSE	Arsenic Speciation	SPLP TAL Metals	TCLP RCRA Metals	SVOCs	DRO/RRO	Particle Size / Atterberg Limits (ASTM D2487) and Moisture Content	Grain Size (ASTM D422)
			12-14	11MP49SB14	11MP49SB16@950), 11MP49SB10)								
	Area near Monofill #1 / Shop Pad B / Tailings/Waste Rock	MP89	4-6	11MP89SB06	3 (11MP89SB30, 11MP89SB12, 11MP89SB06)								2 (11MP89SB34, 11MP89SB37)
			10-12	11MP89SB12									
			28-30	11MP89SB30									
			32-34	11MP89SB34									
			35-37	11MP89SB37									
	Area of Pre-1955 Retort Building	MP55	2-4	11MP55SB04	3 (11MP55SB04, 11MP55SB06)	3 (11MP56SB06, 11MP56SB10, 11MP58SB08)	2 (11MP56SB06, 11MP58SB04 (DUPLICATE: 11MP58SB16@1030)	3 (11MP58SB08, 11MP56SB06)	3 (11MP58SB08, 11MP56SB06)	11MP55SB06	11MP55SB07		
			4-6	11MP55SB06									
		MP56	2-4	11MP56SB04	3 (11MP56SB06, 11MP56SB10, 11MP56SB04)								
			4-6	11MP56SB06									
			8-10	11MP56SB10									
		MP57	2-4	11MP57SB04	3 (11MP57SB04 (DUPLICATE: 11MP57SB12@1450), 11MP57SB08, 11MP57SB06)					11MP57SB06	11MP57SB06		
			4-6	11MP57SB06									
			6-8	11MP57SB08									
		MP58	2-4	11MP58SB04	3 (11MP58SB04, 11MP58SB08, 11MP58SB12 (DUPLICATE: 11MP58SB16@1025))							1 (11MP58SB10)	
			6-8	11MP58SB08									
			8-10	11MP58SB10									
			10-12	11MP58SB12									
Pre-1955 Main Processing Area (cont'd)	Burnt Ore near Pre-1955 Retort	MP59	2-4	11MP59SB04	3 (11MP59SB12, 11MP59SB04, 11MP59SB14 (DUPLICATE: 11MP59SB18@1920)	1 (11MP59SB12)	1 (11MP59SB04 (DUPLICATE: 11MP59SB18@1920))	1 (11MP59SB12)	1 (11MP59SB12)			1 (11MP59SB16)	
			10-12	11MP59SB12									
			12-14	11MP59SB14									
			14-16	11MP59SB16									
	Area between Pre-1955 Retort and Red Devil Creek	MP61	2-4	11MP61SB04	3 (11MP61SB04 (DUPLICATE: 11MP61SB08@1525), 11MP61SB06)								2 (Well not indicated on figure or groundwater table)
			4-6	11MP61SB06									
	Area between Pre-1955 Retort and Red Devil Creek / Pre-1955 Rotary Furnace Burnt Ore Disposal Pile	MP62	2-4	11MP62SB04	3 (11MP62SB04, 11MP62SB24, 11MP62SB14)								2 (11MP62SB20, 11MP62SB24)
			12-14	11MP62SB14									
			18-20	11MP62SB20									
			22-24	11MP62SB24									
	Area of Pre-1955 Furnace Building / Tailings/Waste Rock	MP50	2-4	11MP50SB04	3 (11MP50SB04)	3 (11MP51SB04, 11MP52SB10 (DUPLICATE: 11MP52SB28@1445), 11MP52SB06)	2 (11MP52SB06, 11MP51SB06)	3 (11MP51SB06, 11MP52SB10, 11MP52SB06)	3 (11MP51SB06, 11MP52SB10, 11MP52SB06)				
		MP51	2-4	11MP51SB04	3 (11MP51SB04, 11MP51SB06, 11MP51SB14)					11MP51SB08	11MP51SB08		
			4-6	11MP51SB06									
			6-8	11MP51SB08									
			12-14	11MP51SB14									
		MP52	4-6	11MP52SB06	3 (11MP52SB06, 11MP52SB10, 11MP52SB26)					11MP52SB26	11MP52SB26	1 (11MP52SB08)	2 (Bedrock, No samples from screened inter-
			6-8	11MP52SB08									
			8-10	11MP52SB10									

Table 2-3 Subsurface Soil Collection Summary

General Geographic Area	Location Description	Soil Boring Location	Depth (feet)	Sample ID	Total TAL Metals	Mercury SSE	Arsenic Speciation	SPLP TAL Metals	TCLP RCRA Metals	SVOCs	DRO/RRO	Particle Size / Atterberg Limits (ASTM D2487) and Moisture Content	Grain Size (ASTM D422)
			24-26	11MP52SB26									val)
		MP53	2-4	11MP53SB04	3 (11MP53SB04, 11MP53SB08)								
			6-8	11MP53SB08									
		MP54	2-4	11MP54SB04	3 (11MP54SB04, 11MP54SB06)					0 (11MP54SB04)	0 (11MP54SB04)		
			4-6	11MP54SB06									
Dolly Sluice and Delta	Dolly Sluice Delta	DS01	2-4	11DS01SB04	3 (11DS01SB06) and 11DS01SB10 (DUPLICATE: 11DS01SB18 @ 1630), 11DS01SB16 (mid and low-range)	1 (11DS01SB06)	1 (11DS01SB06)	1 (11DS01SB06 (DUPLICATE: 11DS01SB18 @ 1630))				1(11DS01SB04)	
			4-6	11DS01SB06									
			8-10	11DS01SB10									
			14-16	11DS01SB16									
		DS02	2-4	11DS02SB04	3 (11DS02SB04, 11DS02SB10 (Duplicate 11DS02SB16 @ 1335), 11DS02SB14)								
			8-10	11DS02SB10									
			12-14	11DS02SB14									
Rice Sluice and Delta	Rice Sluice Delta	RS01	2-4	11RS01SB04	3 (11RS01SB12) and 11RS01SB08, 11RS01SB04	1 (11RS01SB12)	1 (11RS02SB04)	1 (11RS01SB12)				1 (11RS01SB06)	
			4-6	11RS01SB06									
			6-8	11RS01SB08									
			10-12	11RS01SB12									
		RS02	2-4	11RS02SB04	3 (11RS02SB04) and 11RS02SB08, 11RS02SB14								
			6-8	11RS02SB08									
			12-14	11RS02SB14									
Surface Mined Area	Potential Site of On-Site Repository / Bulldozed Area Away from Known Ore Trend	SM10	2-4	11SM10SB04	3 (11SM10SB10) and 11SM10SB04, 11SM10SB12	1 (11SM10SB10)	1 (11SM10SB10)	1 (11SM10SB10)				3 (11SM10SB06, 11SM10SB08)	
			4-6	11SM10SB06									
			6-8	11SM10SB08									
			8-10	11SM10SB10									
			10-12	11SM10SB12									
		SM11	2-4	11SM11SB04	3 (11SM11SB04, 11SM11SB14 (Duplicate 11SM11SB20 @ 1325), 11SM11SB16)							3 (11SM11SB10, 11SM11SB08, 11SM11SB12)	
			6-8	11SM11SB08									
			8-10	11SM11SB10									
			10-12	11SM11SB12									
			12-14	11SM11SB14									
			14-16	11SM11SB16									
	Upslope of Pre-1955 processing facilities and Monofill #1	SM31	4-6	11SM31SB06	3 (11SM31SB06) Only 1 sample	1 (11SM31SB06)	1 (11SM31SB06)	1 (11SM31SB06)					2 (No Water)
		11SM32 (Shallow) (Paired with 11SM31)	N/A	N/A (Not Sampled)									
	Upslope of Pre-1955 processing facilities and Monofill #1	MP41	2-4	11MP41SB04 (11SM41SB04)	3 (11MP41SB06) and 11MP41SB04 (Only 2 samples in borehole)	1 (11MP41SB06)	1 (11MP41SB06)	1 (11MP41SB06)					2 (No Water)
			4-6	11MP41SB06									

Table 2-3 Subsurface Soil Collection Summary

General Geographic Area	Location Description	Soil Boring Location	Depth (feet)	Sample ID	Total TAL Metals	Mercury SSE	Arsenic Speciation	SPLP TAL Metals	TCLP RCRA Metals	SVOCs	DRO/RRO	Particle Size / Atterberg Limits (ASTM D2487) and Moisture Content	Grain Size (ASTM D422)
				(11SM41SB06)									
		11MP90 (Deep) (paired with 11MP41)	N/A	N/A (not sampled)									
Red Devil Creek	Dam	11RD08	N/A	N/A (not sampled)									
		11RD09	N/A	N/A (not sampled)									
	Red Devil Creek Alluvial Deposits and/or Soil	RD05	4-6	11RD05SB06	3 (11RD05SB08, 11RD05SB12, 11RD05SB16)	3 (11RD20SB20, 11RD20SB18, 11RD07SB12)	2 (11RD20SB20, 11RD05SB16 (DUPLICATE: 11RD05SB18 @ 1900)	2 (11RD20SB20, Highest As and Hg in same sample)				3 (11RD05SB06, 11RD05SB08, 11RD05SB14)	2 (no samples below water table)
			6-8	11RD05SB08									
			10-12	11RD05SB12									
			12-14	11RD05SB14									
			16-18	11RD05SB16									
		RD06	2-4	11RD06SB04	3 (11RD06SB04, 11RD06SB08, 11RD06SB12)								
			6-8	11RD06SB08									
			10-12	11RD06SB12									
		RD07	2-4	11RD07SB04	3 (11RD07SB12) and 11RD07SB04, 11RD07SB10)							3 (11RD07SB04, 11RD07SB08, 11RD07SB12)	
			6-8	11RD07SB08									
			8-10	11RD07SB10									
			10-12	11RD07SB12									
		RD20	4-6	11RD20SB06	3 (11RD20SB18, 11RD20SB20) and 11RD20SB06								2 (11RD20SB12) Not enough volume from other samples
			10-12	11RD20SB12									
			16-18	11RD20SB18									
			18-20	11RD20SB20									
Red Devil Creek Delta Area	Red Devil Creek Delta	RD01	2-4	11RD01SB04	3 (11RD01SB04, 11RD01SB10, 11RD01SB14)	3 (11RD03SB06, 11RD03SB08, 11RS03SB10)	2 (11RD03SB06, 11RD02SB04,)	2 (11RD03SB06, Highest As and Hg in same sample)					
			8-10	11RD01SB10									
			12-14	11RD01SB14									
		RD02	2-4	11RD02SB04	3 (11RD02SB04) and 11RD02SB06, 11RD02SB10)								
			4-6	11RD02SB06									
			8-10	11RD02SB10									
		RD03	4-6	11RD03SB06	3 (11RD03SB06, 11RD03SB08, 11RS03SB10)							3 (11RD03SB12)	
			6-8	11RD03SB08									
			8-10	11RD03SB10									
			10-12	11RD03SB12									
		RD04	2-4	11RD04SB04	3 (11RD04SB04, 11RD04SB08 (Duplicate: 11RD04SB16 @1545), 11RD04SB12)								
			6-8	11RD04SB08									
			10-12	11RD04SB12									

Table 2-3 Subsurface Soil Collection Summary

General Geographic Area	Location Description	Soil Boring Location	Depth (feet)	Sample ID	Total TAL Metals	Mercury SSE	Arsenic Speciation	SPLP TAL Metals	TCLP RCRA Metals	SVOCs	DRO/RRO	Particle Size / Atterberg Limits (ASTM D2487) and Moisture Content	Grain Size (ASTM D422)
Red Devil Creek	Red Devil Creek Alluvial Deposits Between Dam and Main Processing Area	RD13	2-4	11RD13SB04	3 (11RD13SB06, 11RD13SB04, 11RD13SB14)	3 (All ND)	3 (11RD13SB06, 11RD13SB04, 11RD13SB14 (DUPLICATE 11RD13SB18 @ 1545)	3 (11RD13SB10, 11RD13SB06) Hg Non-Detect					2 (11RD13SB08, 11RD13SB12)
			4-6	11RD13SB06									
			6-8	11RD13SB08									
			8-10	11RD13SB10									
			10-12	11RD13SB12									
			12-14	11RD13SB14									
		Totals		**237**	**195**	**36**	**33**	**35**	**20**	**14**	**13**	**27**	**26**
		Additional Duplicates			**20**	**1**	**4**	**3**	**2**	**2**	**2**	**0**	**0**

Key:
DRO diesel range organics
RCRA Resource Conservation Recovery Act
RRO residual range organics
SPLP synthetic precipitation leaching procedure
SSE selective sequential extraction
SVOCs semivolatile organic compounds
TAL Target Analyte List
TCLP toxicity characteristic leaching procedure

2.3 Groundwater

Groundwater samples were collected between August 24, 2011, and September 1, 2011.

In total, 31 monitoring wells were installed at the RDM. Of those 31, 26 monitoring wells were installed in 2011. The remaining five monitoring wells were installed by Harding Lawson Associates/Wilder Construction Company Joint Venture in 2000. All monitoring wells are shown in Figure 2-7. Of the 31 monitoring wells onsite, 26 were successfully sampled. The five wells that were not sampled were either dry or were not productive enough to meet low-flow stabilization sampling requirements at the time of sampling. Results from the groundwater sampling will be used to:

- Characterize the nature and extent of COPCs in groundwater.
- Characterize the cation-anion signature of the groundwater to assess potential sources and migration patterns of groundwater and COPCs.
- Characterize groundwater depth, flow direction, gradient, and migration patterns of COPCs.
- Assess groundwater-surface water interactions, including the potential for COPCs in groundwater to enter surface water.
- Provide data for the HHRA to assess potential exposure to COPCs through ingestion of drinking water.

Monitoring wells were constructed with PVC pipe with an inside diameter of 2.5 inches. The screened interval was 10 feet for all wells. The screened interval was pre-constructed with a pre-pack of Colorado Silica Sand filling the annular space between the inner monitoring well pipe and an outer slotted PVC pipe with an outside diameter of 4 inches. Both the inner and outer pipes were slotted with 0.010-inch slots. A 1-foot-deep sump was added to the bottom of every pre-pack. The pre-pack was used to ensure that a layer of sand existed around the screened interval at depths that required the use of the downhole hammer, or whenever sloughing of the borehole occurred. The wells were then packed with additional Colorado Silica Sand to a height of 2 feet above the top of the screened interval, and then completed with bentonite chips to the top of the hole. The monitoring wells were completed with a lockable steel monument placed with concrete and 2 feet of stick up of the PVC pipe above the ground surface.


Groundwater sample collection.

Samples were collected with prescreened Teflon tubing connected to a peristaltic pump for wells with a sampling depth of less than 25 feet, or connected to a decontaminated positive pressure Fultz pump for wells of a greater depth. Low flow sampling methods were used, with a maximum purge rate of 0.5 liters per minute (L/min) and an attempted draw down of 0.1 meters or less. Purge water was passed through a Horiba

flow-through cell and, with the exception of one hour time limit, were sampled only once certain criteria were met (see Table 2-4).

Table 2-4 Water Quality Parameters Stabilization Criteria

Parameter	Stabilization Criteria
pH	+/- 0.1
Specific Conductance	+/- 3%
Oxidation Reduction Potential	+/- 10 mV
Turbidity	+/- 10% (when turbidity is > 10 NTUs)
Dissolved Oxygen	+/- 0.3 mg/L
Temperature	+/- 1° C

Key:
° C degrees Celsius
mg/L milligrams per liter
mV millivolts
NTU nephelometric turbidity unit

Samples were collected directly from the pre-screened Teflon tubing and placed into sampling vessels that were pre-preserved according to analysis by Columbia Analytical Services, where required. When specified, clean-hands/dirty-hands technique and double bags were used for ultraclean sampling. Teflon tubing was discarded after a single use, and the positive pressure Fultz pump was decontaminated externally and internally between uses. Samples were placed on ice for the duration of their residence time at the field site and during transportation from the field site to the analytical laboratory.

Samples were variously analyzed for total TAL metals, dissolved TAL metals with silicon, total low level mercury, dissolved low level mercury, methylmercury, arsenic speciation, inorganic ions, total dissolved solids (TDS), total suspended solids (TSS), nitrate and nitrite, carbonate and bicarbonate, SVOCs with TICs, DRO and RRO, gasoline range organics (GRO) and benzene toluene, ethylbenzene, xylenes (BTEX), and PCBs. Table 2-5 identifies the analyses conducted at each monitoring well.

Deviations from the Field Sampling Plan

Several deviations from the FSP were made based upon evolving data needs and the field conditions encountered. Two planned monitoring wells were not installed because they were both the shallower of a paired monitoring well station where the deeper well was successfully installed into a bedrock aquifer but the overlying soil did not contain viable amounts of groundwater. An additional monitoring well was installed to create a paired monitoring well station out of MW16. The additional well, MW17, was set as a deep well in the bedrock aquifer to com-

plement the groundwater data collected from MW16, located in the overlying saturated soil aquifer.

In the area immediately downgradient of Monofill #2, an area of notable concern for the RDM investigation, a deviation was made at the request of the BLM to create the ability to measure vertical hydraulic gradient between wells. This involved installing MW11 and MW09 as shallow wells and MW10 as a deep well, with a 20-foot gap between the bottom of the screened intervals of MW11 and MW09 and the top of the screened interval of MW10. As a result, MW10 was installed well into the bedrock aquifer and MW11 and MW09 were installed into the overlying soils. Several wells were not productive enough to produce viable groundwater samples that conformed to the low flow sampling procedure described in the FSP.

Table 2-5 Ground Water Sample Collection Summary

General Geographic Area	Location Description	Sample Location ID (Existing Monitoring Well or RI/FS Soil Boring)	Monitoring Well designation	Sample Date	Total TAL Metals	Dissolved TAL Metals with Silicon	Total Low Level Mercury	Dissolved Low Level Mercury	Methylmercury	Arsenic Speciation	Inorganic Ions (Cl, F, SO4)	Total Dissolved Solids	Total Suspended Solids	Nitrate / Nitrite	Carbonate, Bicarbonate	SVOCs with TICs	DRO / RRO	GRO / BTEX	PCBs
Background Areas	Upgradient Area	11MP01	MW08	8/30/2011	1	1	1	1	1	1	1	1	1	1	1				
	Upland Area West of Surface Mined Area	11UP11	MW31	8/29/2011	1	1	1	1	1	1	1	1	1	1	1				
Post-1955 Main Processing Area	Downgradient from Monofill #2 / Post-1955 Retort Building	11MP12	MW11	DRY															
		11MP14	MW10	8/29/2011	1	1	1	1	1	1	1	1	1	1	1				
		11MP17	MW09	Recharge too slow to sample															
	Tailings / Waste Rock	11MP29	MW15	8/30/2011	1	1	1	1	1	1	1	1	1	1	1				
		11MP30	MW16	8/30/2011	1	1	1	1	1		1	1	1	1	1				
		11MP91	MW17	8/30/2011	1	1	1	1	1		1	1	1	1	1				
	Gravel Pad	11MP25 (MS/MSD)	MW14	8/31/2011	1	1	1	1	1		1	1	1	1	1		1	1	
		11MP100 (Duplicate of 11MP25)		8/31/2011	1	1	1	1	1		1	1	1	1	1		1	1	
	Gravel Pad / Downgradient from Monofill #3	MW-01 (Existing well previously referred to as MW-1)	MW01	8/24/2011	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	Downgradient from Power Plant / Former Drum Storage Area	11MP20	MW13	DRY															
		MW-07 (Existing well previously referred to as MW-7)	MW07	Recharge too slow to sample															
	Upgradient of Settling Pond #1	11MP31 (MS/MSD)	MW18	8/31/2011	1	1	1	1	1	1	1	1	1	1	1	1	1		
	Berm of Settling Pond #1	MW-03 (Existing well previously referred to as MW-3)	MW03	8/26/2011	1	1	1	1	1		1	1	1	1	1				
	Upgradient of Settling Ponds #2 and #3	11MP33	MW19	9/1/2011	1	1	1	1	1	1	1	1	1	1	1	1	1		

Table 2-5 Ground Water Sample Collection Summary

General Geographic Area	Location Description	Sample Location ID (Existing Monitoring Well or RI/FS Soil Boring)	Monitoring Well designation	Sample Date	Total TAL Metals	Dissolved TAL Metals with Silicon	Total Low Level Mercury	Dissolved Low Level Mercury	Methylmercury	Arsenic Speciation	Inorganic Ions (Cl, F, SO4)	Total Dissolved Solids	Total Suspended Solids	Nitrate / Nitrite	Carbonate, Bicarbonate	SVOCs with TICs	DRO / RRO	GRO / BTEX	PCBs
	Berm / Downgradient of Settling Pond #3	11MP40	MW22	8/31/2011	1	1	1	1	1		1	1	1	1	1	1	1		
	Downgradient of Settling Pond #1	11MP38	MW20	8/31/2011	1	1	1	1	1	1	1	1	1	1	1	1	1		
	Downgradient of Settling Pond #1	11MP101 (Duplicate of 11MP38)		8/31/2011	1	1	1	1	1	1	1	1	1	1	1	1	1		
	Downgradient of Settling Pond #2	11MP39	MW21	8/31/2011	1	1	1	1	1	1	1	1	1	1	1	1	1		
Pre-1955 Main Processing Area	Well pair near spring in Red Devil Creek / Downgradient of former mine openings / Tailings	11MP60	MW28	8/30/2011	1	1	1	1	1	1	1	1	1	1	1				
		11MP88	MW27	8/30/2011	1	1	1	1	1	1	1	1	1	1	1				
	Near Shop Pad B	11MP89	MW25	8/30/2011	1	1	1	1	1	1	1	1	1	1	1				
	Downgradient of Former Shop Pad	MW-04 (Existing well previously referred to as MW-4)	MW04	8/22/2011	1	1	1	1	1		1	1	1	1	1	1	1		1
	Possibly downdradient of Pre-1955 Retort Area	MW-06 (Existing well previously referred to as MW-6)	MW06	8/24/2011	1	1	1	1	1		1	1	1	1	1				
	Possibly downdradient of Pre-1955 Retort Area	11MP66	MW23	8/30/2011	1	1	1	1	1		1	1	1	1	1				
	Downgradient from Pre-1955 Retort and Pre-1955 Rotary Furnace Burnt Ore Disposal Pile	11MP62	MW24	8/30/2011	1	1	1	1	1	1	1	1	1	1	1				

Table 2-5 Ground Water Sample Collection Summary

General Geographic Area	Location Description	Sample Location ID (Existing Monitoring Well or RI/FS Soil Boring)	Monitoring Well designation	Sample Date	Total TAL Metals	Dissolved TAL Metals with Silicon	Total Low Level Mercury	Dissolved Low Level Mercury	Methylmercury	Arsenic Speciation	Inorganic Ions (Cl, F, SO4)	Total Dissolved Solids	Total Suspended Solids	Nitrate / Nitrite	Carbonate, Bicarbonate	SVOCs with TICs	DRO / RRO	GRO / BTEX	PCBs
	Area of Pre-1955 Furnace Building / Tailings	11MP52	MW26	8/30/2011	1	1	1	1	1		1	1	1	1	1				
Red Devil Creek	Red Devil Creek Alluvial Deposits	11RD05	MW33	8/31/2011	1	1	1	1	1	1	1	1	1	1	1	1	1		
		11RD20	MW12	8/31/2011	1	1	1	1	1	1	1	1	1	1	1	1	1		
		11RD21 (Duplicate of 11RD20)		8/31/2011	1	1	1	1	1	1	1	1	1	1	1	1	1		
	Red Devil Creek Alluvial Deposits Between Dam and Main Processing Area	11RD10	MW32	8/31/2011	1	1	1	1	1	1	1	1	1	1	1	1	1		
Surface Mined Area	Well pair upgradient from Main Processing Area	11MP41	MW29	9/1/2011	1	1	1	1	1	1	1	1	1	1	1				
		11MP90		Not Installed															
	Well pair upgradient from Main Processing Area	11SM31	MW30	DRY															
		11SM32		Not Installed															
		Total	**31**	**26**	**26**	**26**	**26**	**26**	**26**	**17**	**26**	**26**	**26**	**26**	**26**	**10**	**11**	**2**	**1**
		Additional Duplicates	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**2**	**3**	**3**	**3**	**3**	**3**	**2**	**3**	**1**	**0**

Key:

BTEX	benzene toluene, ethylbenzene, xylenes
Cl	chlorine
DRO	diesel range organic
F	fluoride
GRO	gasoline range organics
ID	identifier
PCBs	polychlorinated biphenyls
RI/FS	remedial investigation/feasibility study
RRO	residual range organic
SO4	sulfate
SVOC	semi-volatile organic compound
TAL	target analyte list
TIC	tentatively identified compound

2.4 Surface Water

Surface water samples were collected in Red Devil Creek on September 22, 2010, and August 26–27, 2011.

Surface water sample collection in Red Devil Creek.

In 2010, surface water grab samples were collected from nine locations along Red Devil Creek between the creek's mouth at the Kuskokwim River and a point upstream of the reservoir south of the Main Processing Area. Surface water grab samples collected in 2011 were obtained from 12 locations along Red Devil Creek between the creek's mouth at the Kuskokwim River and a point upstream of the reservoir south of the Main Processing Area (Figure 2-8). Surface water sample locations between the Kuskokwim River and the reservoir were intended to characterize the contribution of COPCs from overland runoff from tailings and/or contaminated soil and from groundwater contribution. One surface water sample was collected from the seep in the Main Processing Area for characterization of mine shaft discharge, and one sample was collected upstream of the reservoir to characterize natural background, as shown in Figure 2-8. Surface water sample locations along Red Devil Creek were co-located with surface sediment sample locations. The additional 2011 surface water sample locations were added to characterize the water at the location of the drum that was removed in October 2010 and to gather more information about surface water in the main processing area. Sample results will be used to:

- Characterize the nature and extent of COPCs in the surface water of Red Devil Creek.
- Characterize the cation-anion signature of the surface water to assess contribution from groundwater sources.
- Characterize chemical attributes affecting contaminant fate and transport of COPCs in the surface water Red Devil Creek.
- Provide data for the HHRA to assess potential exposure to COPCs through direct contact and incidental ingestion.
- Provide data for the ERA to assess potential exposure of creek biota to COPCs through direct contact and ingestion.

To the greatest extent feasible, surface water samples were collected from mid-depth water in the creek at a single location. Surface water samples from Red Devil Creek were collected first from near the confluence of Red Devil Creek and the Kuskokwim River. Sampling proceeded upstream to avoid disturbing sediments that could impact turbidity and contaminant concentrations in downstream locations. Samples were collected using a battery-operated peristaltic pump with single-use silicone tubing and by hand-dipping the sample container directly into the creek water. Preserved samples were only collected using the peristaltic pump with single-use silicone tubing. Dissolved metals aliquots were collected follow-

ing collection of the other aliquots using a dedicated in-line 0.45-micrometer filter.

All of the Red Devil Creek surface water samples were analyzed for total TAL inorganic elements, dissolved TAL inorganic elements, methylmercury, low-level total mercury, low-level dissolved mercury, inorganic ions, nitrate/nitrite, carbonate/bicarbonate, TDS, and TSS (Table 2-6). Selected surface water samples were also analyzed for arsenic speciation and SVOCs. Field measurements for pH, temperature, specific conductance, oxidation-reduction potential, dissolved oxygen, and turbidity were collected at each sample station.

No deviations from the FSP were necessary during surface water sampling.

Table 2-6 Surface Water Sample Summary

Sub-Area	Location Description	Sample Location ID	Number of Samples											
			Total TAL Metals	Dissolved TAL Metals	Methylmercury	Arsenic Speciation	Inorganic Ions (Cl, F, SO4)	Total Low-Level Hg	Dissolved Low-Level Hg	Total Dissolved Solids	Total Suspended Solids	Nitrate/Nitrite	SVOCs with TICs	Carbonate, Bicarbonate
Upstream from Main Processing Area	50 feet upstream from reservoir	RD01	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011		2010 and 2011
	50 feet downstream from reservoir dam	RD02	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011		2010 and 2011
	Approximately 300 feet upstream from the Main Processing Area	RD03 (Duplicate 11RD21SW in 2011)	2010 and 2011	2010 and 2011	2010 and 2011		2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011
	Downgradient from abandoned drum	RD11	2011										2011	
Main Processing Area	10 feet upstream from where the access road crosses Red Devil Creek	RD04	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011
	Seep on Left Bank of Red Devil Creek	RD05	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011
	Near Settling Pond #2	RD09 (Duplicate 10RD20SW in 2010)	2010 and 2011	2010 and 2011	2010 and 2011		2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011
	Near Settling Pond #3	RD06	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011
	Upstream end of the Main Processing Area	RD10	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011
	Within Red Devil Creek, adjacent to Main Processing Area seep	RD12	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011	2011
Downstream from Main Processing Area	250 feet upstream from confluence with Kuskokwim River	RD07	2010 and 2011	2010 and 2011	2010 and 2011		2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011
	Confluence of Red Devil Creek and Kuskokwim River	RD08 (Duplicate 11RD20SW in 2011)	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011	2010 and 2011

Key:
Cl chlorine
F fluoride
ID identifier
SO4 sulfate
SVOC semi-volatile organic compound
TAL target analyte list
TIC tentatively identified compound

2.5 Sediment

Sediment samples were collected from Red Devil Creek, along the shoreline of the Kuskokwim River, and in off-shore locations in the Kuskokwim River.

2.5.1 Red Devil Creek Sediment Samples

Red Devil Creek sediment sampling was performed on September 24, 2010, and on August 20, 2011.

A total of 12 sediment samples were collected from Red Devil Creek. One sediment sample was collected adjacent to the seep in the Main Processing Area. One surface sediment sample was collected upstream of the reservoir. The locations are co-located with Red Devil Creek surface water locations and are shown in Figure 2-9. Results from samples collected from Red Devil Creek will be used to:

- Characterize the nature and extent of COPCs in Red Devil Creek sediment.
- Characterize chemical attributes affecting contaminant fate and transport of COPCs in surface sediment.
- Characterize grain size distribution of sediment.
- Provide data for the HHRA to assess potential exposure to COPCs through direct contact and incidental ingestion.
- Provide data for the ERA to assess potential exposure of creek biota to COPCs through direct contact and ingestion.

Sediment sample collection in Red Devil Creek.

Red Devil Creek sediment samples were collected from the top 3 inches of the sediment bed using a plastic scoop. During collection of the 2010 samples, a biologist described benthic macroinvertebrates encountered at the sampling locations. Each sample was then logged by a geologist, placed into a disposable plastic mixing container, and homogenized with the plastic scoop. The disposable plastic scoop was then used to place the sample into the appropriate lab container. The exception to this method was mercury aliquots for selective sequential extraction analysis, which were collected prior to homogenization of the sediment in order to preserve any mercury vapors that may have been present.

Samples were selectively analyzed for total TAL metals, grain size, total organic content, methyl-mercury, mercury SSE, and arsenic speciation. Table 2-7 identifies the analyses conducted at each sample location.

Table 2-7 Summary of Red Devil Creek Sediment Samples

Location Description	Sample Location ID	Sample Date	Total TAL Metals	Methylmercury	Arsenic Specia-tion	Mercury SSE	Grain Size	SVOCs with TICs	Total Organic Carbon
Downgradient from abandoned drum identified during the 2010 limited sampling effort	11RD11	8/20/2011	x				x	x	x
Upstream end of the Main Processing Area	11RD10	8/20/2011	x	x	x	x	x	x	x
Within Red Devil Creek, in mixing zone adjacent to Main Processing Area spring	11RD12	8/20/2011	x	x	x	x	x		x
50 feet upstream from reservoir	10RD01	9/24/2010	x	x	x	x	x		x
50 feet downstream from reservoir dam	10RD02	9/24/2010	x	x	x		x		x
Approximately 300 feet upstream from the Main Processing Area	10RD03	9/24/2010	x	x	x	x	x		x
10 feet upstream from where the access road crosses Red Devil Creek	10RD04	9/24/2010	x	x	x	x	x		x
Seep on Left Bank of Red Devil Creek	10RD05 Duplicate 10RD21SD	9/24/2010	x	x	x	x	x		x
Near Settling Pond #2	10RD09	9/24/2010	x	x	x		x		x
Near Settling Pond #3	10RD06	9/24/2010	x	x	x	x	x		x
250 feet upstream from confluence with Kuskokwim River	10RD07	9/24/2010	x	x	x		x		x
Confluence of Red Devil Creek and Kuskokwim River	10RD08 Duplicate 10RD20SD	9/24/2010	x	x	x	x	x		x

Key:
ID identifier
RRO residual range organic
SSE selective sequential extraction
SVOC semi-volatile organic compound
TAL target analyte list
TIC tentatively identified compound

2.5.2 Kuskokwim River Shoreline Sediment Samples

Sediment sampling of the Kuskokwim River shoreline was performed on September 23, 2010, and between September 21, 2011, and September 25, 2011.

A total of 17 sediment samples were collected from the shoreline of the Kuskokwim River adjacent to the RDM site; their location is shown on Figure 2-10. Results from samples collected from the Kuskokwim River will be used to:

- Characterize the nature and extent of COPCs in river sediment.
- Characterize chemical attributes affecting fate and transport of COPCs.
- Provide data for the HHRA to assess potential exposure to COPCs through direct contact, incidental ingestion, and consumption of fish.
- Provide data for the ERA to assess potential exposure of river biota to COPCs through direct contact and ingestion.

Kuskokwim River off-shore sediment sample collection.

Shoreline samples were collected from the shore using a plastic scoop. Once acquired, a sample was then described by a geologist, placed into a disposable plastic mixing container, and homogenized with a disposable plastic stirrer. A disposable plastic scoop was then used to place the sample into the appropriate lab container. The exception to this method was mercury vapor samples (Hg SSE), which were collected prior to homogenization of the sediment in order to preserve any mercury vapors that may have been present.

Samples were selectively analyzed for total TAL metals, grain size, total organic content, methyl-mercury, mercury SSE, and arsenic speciation. Table 2-8 identifies which analyses were conducted at each location.

Table 2-8 Kuskokwim River Shoreline Sediment Sample Summary

Station	TAL Metals	Grain size	TOC	Methyl Hg	Hg SSE	As Spec
11KR01SD	X	X	X	X		X
11KR05SD	X	X	X	X		X
11KR06SD	X	X	X	X		X
11KR08SD	X	X	X	X	X	X
11KR09SD	X	X	X	X		X
11KR12SD	X	X	X	X	X	X
11KR14SD	X	X	X	X	X	X
11KR15SD	X	X	X	X	X	X
11KR16SD	X	X	X	X	X	X
11KR17SD	X	X	X	X	X	X
10KR02SD	X	X	X	X	X	X
10KR03SD	X	X	X	X		X
10KR04SD	X	X	X	X	X	X
10KR07SD	X	X	X	X	X	X
10KR10SD	X	X	X	X		X
10KR11SD	X	X	X	X	X	X
10KR13SD	X	X	X	X		X

Key:
As Spec arsenic speciation
Hg mercury
SSE selective sequential extraction
TAL target analyte list
TOC total organic compound

The Work Plan (E & E 2011) called for 10 shoreline samples to supplement the eight samples collected in the 2010 LSE (E & E 2010). All samples were collected as planned, and no deviations from the FSP were made.

2.5.3 Kuskokwim River Off-Shore Sediment Samples

Sediment sampling of the Kuskokwim River was performed between September 21, 2011 and September 25, 2011.

A total of 37 sediment samples were collected from the Kuskokwim River and its shore; their location is shown in Figure 2-11. Natural background samples were collected from the Holitna River, a tributary to the Kuskokwim located approximately 9 miles upstream from the Red Devil Mine. Other background samples were collected from the Kuskokwim River above and below the Holitna River to establish regional, human-influenced background. This background sampling scheme was designed to conform to the U.S. Geological Survey (USGS) stream sediment sampling protocols (Shelton and Capel 1994). Figure 2-11 shows these samples, as well as the study area samples adjacent to the RDM site. Results from samples collected from the Kuskokwim River will be used to:

- Characterize the nature and extent of COPCs in river sediment.
- Characterize chemical attributes affecting fate and transport of COPCs.
- Provide data for the HHRA to assess potential exposure to COPCs through direct contact, incidental ingestion, and consumption of fish.
- Provide data for the ERA to assess potential exposure of river biota to COPCs through direct contact and ingestion.
- Develop estimates of the area and volume of tailings and/or contaminated sediment in the Kuskokwim River that require remediation.
- Evaluate site-specific remedial technologies on potentially contaminated sediment in the river.

Sediment sampling was performed using two different techniques. Samples collected from near the shore at shallow depths were collected using a hand auger operated from the deck of a sampling vessel. The sampling vessel was a 20-footaluminum Grumman skiff rented locally and operated by Kinetic Laboratories, Inc. Sampling at greater depths was performed with a Van Veen surface sediment grab sampler lowered on a winch from a frame mounted to the bow of the boat. Both the hand auger and Van Veen were decontaminated with Alconox and a de-ionized water rinse between uses.

For both hand augering and Van Veen sampling, the vessel was typically anchored on location before sampling, but in areas of heavy armoring of the bottom that prevented the anchor from holding, the pilot would hold the vessel as stationary as possible against the river current. The Van Veen sampler is a surface sediment grab sampler that is lowered by a steel cable via a powered winch. When the Van Veen sampler strikes the bottom, the pre-sprung jaws clamp shut to capture approximately 20 centimeters (cm) of sediment (under ideal conditions). Irrespective of the collection method, once acquired a sample was then described by a geologist and placed into a disposable plastic mixing container and homogenized with a disposable plastic stirrer. A disposable plastic scoop was then used to place the sample into the appropriate lab container. The exception to this method was mercury samples (Hg SSE), which were collected prior to homogenization of the sediment in order to preserve any mercury vapors that may have been present.

Samples were selectively analyzed for total TAL metals, grain size, total organic content, methyl-mercury, mercury SSE, and arsenic speciation. Table 2-9 identifies which analyses were conducted at each location.

Table 2-9 Kuskokwim River Off-Shore Sediment Sample Summary

Station	Collection Method	TAL Metals	Grain size	TOC	Methyl Hg	Hg SSE	As Spec
11KR18SD	HA	X	X	X	X		
11KR19SD	HA	X	X	X			
11KR20SD	HA	X	X	X			
11KR21SD	HA	X	X	X			
11KR22SD	HA	X	X	X			
11KR23SD	HA	X	X	X			
11KR24SD	HA	X	X	X	X		
11KR25SD	HA	X	X	X			
11KR26SD	HA	X	X	X			
11KR27SD	HA	X	X	X			
11KR28SD	HA	X	X	X	X		
11KR29SD	HA	X	X	X			
11KR30SD	HA	X	X	X	X		
11KR34SD	HA	X	X	X	X		
11KR35SD	HA	X	X	X			
11KR36SD	VV	X	X	X			
11KR37SD	VV	X	X	X	X		
11KR38SD	HA	X	X	X			
11KR39SD	HA	X	X	X			
11KR40SD	HA	X	X	X	X		
11KR41SD	HA	X	X	X			
11KR42SD	HA	X	X	X			
11KR43SD	HA	X	X	X			
11KR44SD	HA	X	X	X			
11KR45SD	HA	X	X	X	X		
11KR46SD	HA	X	X	X			
11KR47SD	HA	X	X	X			
11KR48SD	VV	X	X				
11KR49SD	VV	X	X				
11KR50SD	VV	X	X				
11KR51SD	HA	X	X				
11KR53SD	VV	X	X				

Key:
As Spec arsenic speciation
HA Hand auger
Hg mercury
SSE selective sequential extraction
TAL target analyte list
TOC total organic compound
VV Van Veen grab sampler

Deviations from the Field Sampling Plan

Several planned samples were not collected, as noted in Table 2-9. In some of the planned sampling areas, the bed of the Kuskokwim River exhibited heavy armor-

ing with coarse gravel and cobbles, occasionally to a sufficient degree that the vessel's anchor would not take. In these areas, several attempts were made before abandoning the station. In other locations, minor deviations to position had to be made in order to find an area of the river bottom that produced a sample.

2.6 Vegetation

Vegetation samples were collected between August 18, 2011, and August 23, 2011.

In total, 50 vegetation samples were collected. Seventeen of these samples were spruce, 13 were green alder, 11 were blueberry plants, one was blueberry fruit, and eight were pond vegetation. Blueberry plant occurrence is low in the surface mined area, and no blueberry plants were found in the processing areas. Due to seasonal environmental conditions, blueberry fruit was very limited, and only one sample location in the upland area had enough fruit available to sample.

Results from the vegetation sampling will be used to characterize the nature and extent of COPCs in the vegetation in the RDM area. All plant tissue samples have been analyzed for total TAL metals. In addition, approximately 50 percent of the plant samples were analyzed for methylmercury, and the single blueberry fruit sample were analyzed for arsenic speciation.

The vegetation samples were co-located with the surface soil samples (excluding pond vegetation samples) that were collected during the 2010 LSE (Figure 2-12). Target plant species were sampled within a 3-meter radius of these locations. Composite samples were collected from one to five individual plants, depending on availability, and combined into a single sample until the minimum required sample mass (50 to 100 grams) was reached. Pond vegetation samples were collected at locations within the target areas (the background reservoir on Red Devil Creek upgradient from the site and the settling ponds in the post-1955 area) where sufficient vegetation was available.

Samples were collected with stainless steel scissors, placed in two zipper-sealed plastic bags, and placed on ice. Samples were placed on ice for the duration of their residence at the field site and during transportation from the field site to the analytical laboratory. Samples were variously analyzed for total TAL metals, percent moisture, methylmercury, and arsenic speciation. Table 2-10 identifies which analyses were conducted on vegetation at each sample location.

Table 2-10 Vegetation Sample Summary

Geographic Area	Target Plant	Sample Location	TAL Metals	Percent Moisture	Methylmercury	Arsenic Species
Pre-1955 Main Processing Area	GAB	11MP44GA	X	X		
	WSN	11MP91WS (11MP66WS)	X	X		
Post-1955 Main Processing Area	GAB	11MP34GA	X	X	X	
		11MP38GA	X	X		
		11MP20GA	X	X		
		11MP27GA	X	X	X	
	WSN	11MP34WS	X	X	X	
		11MP38WS	X	X		
		11MP31WS	X	X		
		11MP20WS	X	X	X	
	PVH	11MP84PV	X	X	X	
		11MP85PV	X	X		
		11MP86PV	X	X		
		11MP87PV	X	X		
		11MP88PV (Duplicate of 11MP87PV)	X	X		
Surface Mined Area	GAB	11SM18GA	X	X		
		11SM11GA	X	X	X	
		11SM81GA (Duplicate of 11SM11GA)	X	X	X	
		11SM07GA	X	X	X	
	WSN	11SM18WS	X	X		
		11SM11WS	X	X	X	
		11SM82WS (Duplicate of 11SM11WS)	X	X	X	
		11SM07WS	X	X	X	
	BBL	11SM18BL	X	X	X	
		11SM24BL	X	X	X	
Background Area	GAB	11RD11GA	X	X	X	
		11RD12GA	X	X	X	
		11RD14GA	X	X	X	
		11RD18GA	X	X	X	
	WSN	11UP02WS	X	X	X	
		11UP01WS	X	X		
		11UP07WS	X	X	X	
		11UP09WS	X	X		
		11RD11WS	X	X		
		11RD12WS	X	X	X	

Table 2-10 Vegetation Sample Summary

Geographic Area	Target Plant	Sample Location	TAL Metals	Percent Moisture	Methylmercury	Arsenic Species
		11RD14WS	X	X	X	
		11RD18WS	X	X		
	BBF	11UP04BF	X	X	X	X
	BBL	11UP04BL	X	X	X	
		11UP02BL	X	X		
		11UP07BL	X	X		
		11UP08BL	X	X	X	
		11UP09BL	X	X		
		11RD12BL	X	X	X	
		11RD14BL	X	X	X	
		11RD18BL	X	X		
		11RD40BL (Duplicate of 11RD18BL)	X	X		
	PVH	11RD81PV	X	X	X	
		11RD82PV	X	X		
		11RD83PV	X	X		

Key:
BBF blueberry fruit
BBL blueberry leaves
GAB green alder bark
PVH pond vegetation, horsetail
TAL target analyte list
WSN white spruce needles

Deviations from the Field Sampling Plan

This sampling event included several deviations from the FSP, based upon evolving data needs and the field conditions encountered. Sample 11MP91WS was located approximately 6 meters northeast of location 11MP66. This location was adjusted to include a spruce tree, and it remained similar in soil material and characteristic (roadside) to 11MP66. Only one blueberry fruit sample was collected due to lack of available material. Additionally, not all blueberry plant samples were collected due to lack of blueberry plants available in the surface mined, pre-1955, and post-1955 areas. In another deviation from the FSP, black spruce (*Picea mariana*) was sampled when white spruce (*Picea glauca*) was not available at sample locations.

2.7 Other Studies

Several studies have been conducted at and near the RDM that supplement the RI field investigations discussed above. These studies have been used to supplement

characterization of the site in subsequent chapters of this report, and are summarized below.

2.7.1 2010 USGS Geophysical Study

As noted in Section 1.4.4, the USGS conducted a geophysical investigation at the RDM site in 2010 using direct-current resistivity and electromagnetic induction methods. Eight two-dimensional cross-sections and one three-dimensional grid of direct-current resistivity data, and 5.7 kilometers of electromagnetic induction data were obtained along the Red Devil Creek valley, from the Main Processing Area to Red Devil Creek's confluence with the Kuskokwim River. The results of the geophysical survey are used to augment the interpretation of subsurface conditions and groundwater dynamics in Chapters 4 and 5 of this report.

2.7.2 2010 BLM Fish Tissue Sampling

In 2010, the BLM, in coordination with the Alaska Department of Fish and Game, sampled forage fish and top-trophic-level fish species in the middle Kuskokwim River region and in eight tributaries, including Red Devil Creek. Fish tissue samples were analyzed for 19 inorganic elements, including total mercury and methylmercury. Tissue data from forage fish samples collected in Red Devil Creek are used in the HHRA and ERA (Chapter 6) to establish exposure levels for human and ecological consumers.

Ecology & Environment, Inc. GIS Department Project:
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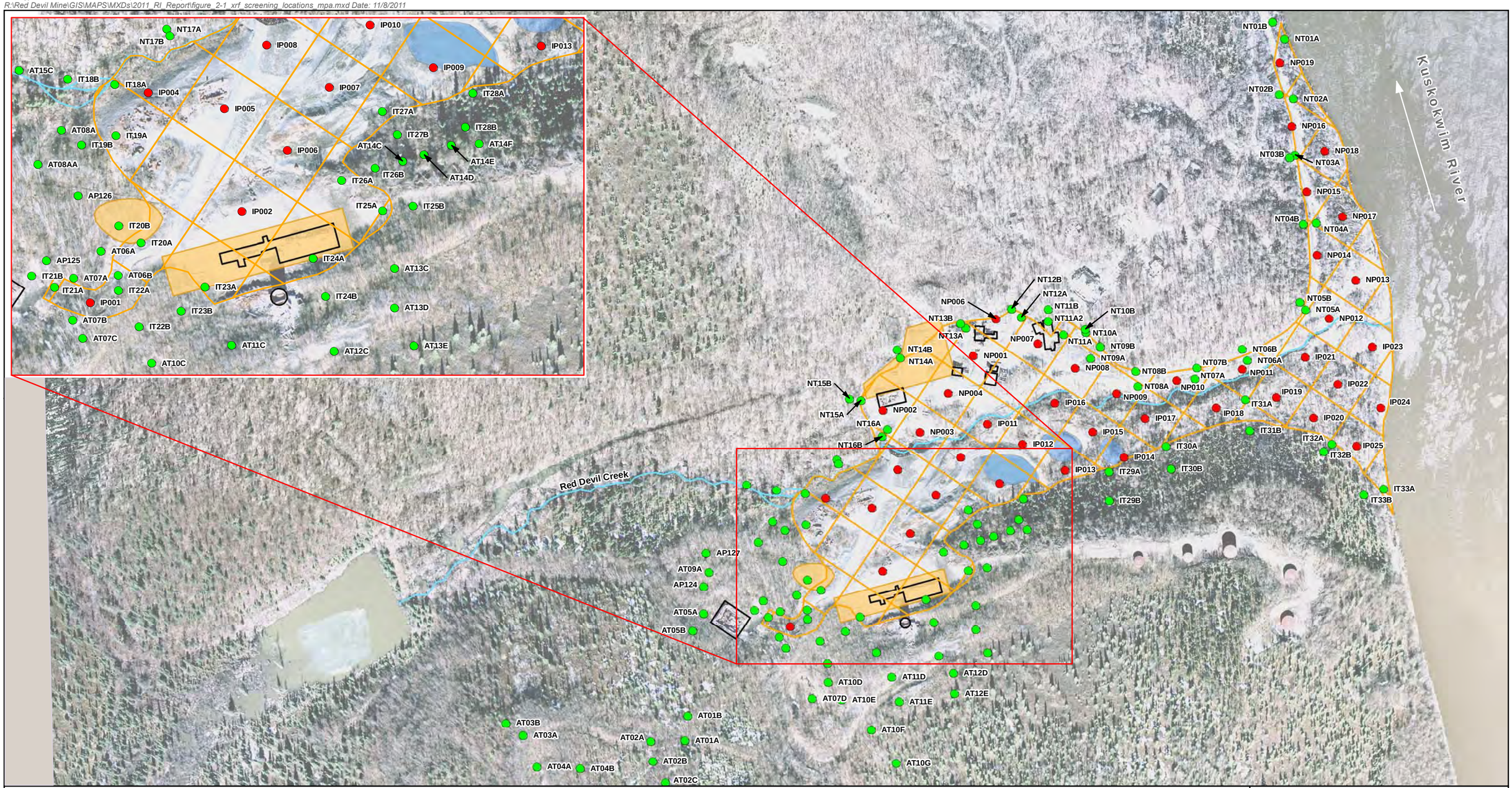

Grid Location
Transect Location
Settling Pond
Monofill
Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 2-1
XRF Screening Locations
Main Processing Area

0 50 100 200 300 400
Feet
0 12.5 25 50 75 100 125
Meters

Image Source: Aero-Metric, Inc 5/29/2001

Ecology & Environment, Inc. GIS Department Project:
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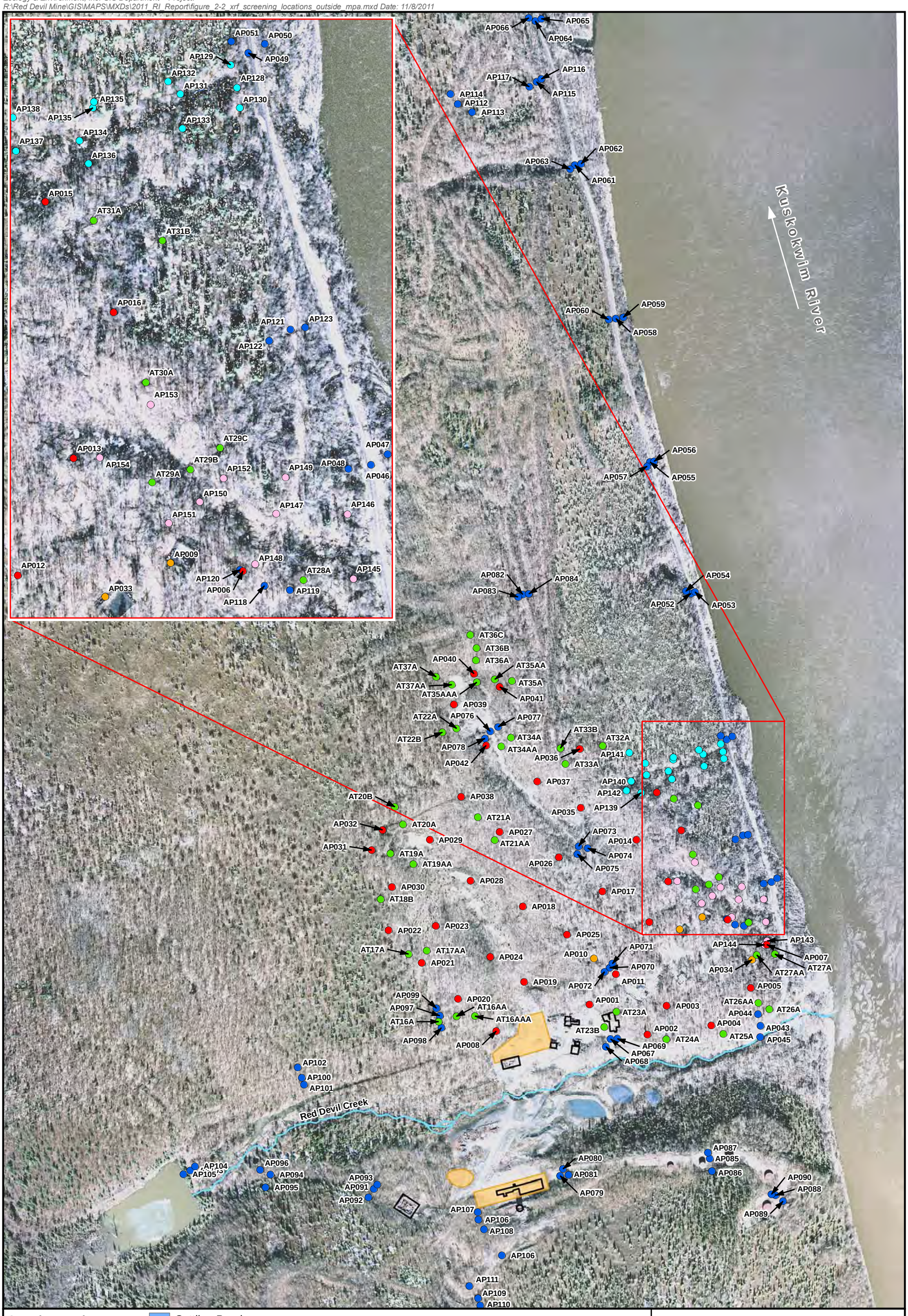


Sample Location

- Grid Point
- Transect
- Building Foundation
- Dolly Sluice
- Rice Sluice
- Road
- Settling Pond
- Monofill
- Historical Structure

RED DEVIL MINE

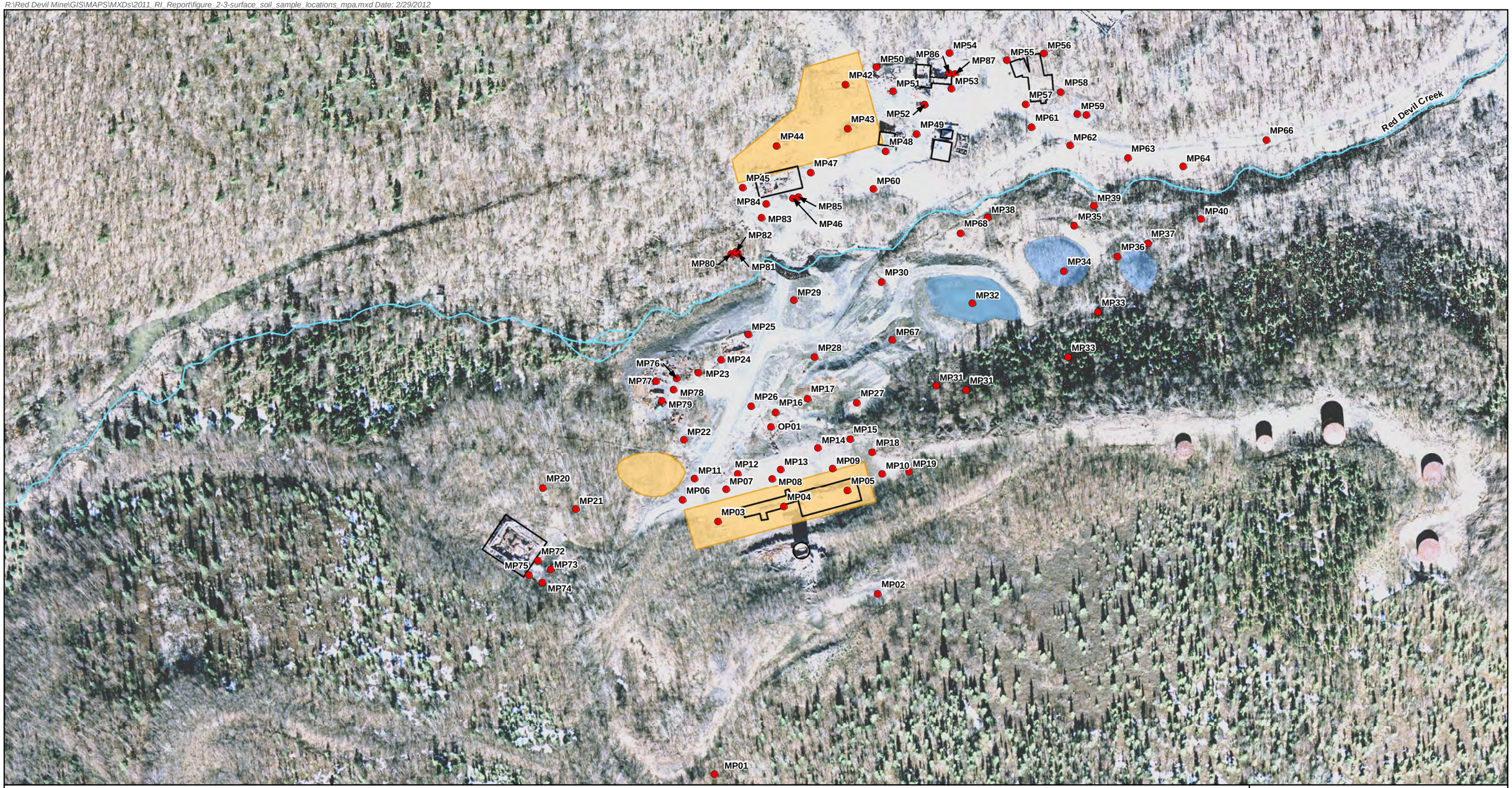
Red Devil, Alaska

Figure 2-2
XRF Screening Locations
Outside Main Processing Area

0 100 200 400 600
Feet
0 25 50 100 150 200
Meters
Scale 1:3,800

Image Source: Aero-Metric, Inc 5/29/2001

Ecology & Environment, Inc. GIS Department Project:
R:\Red Devil Mine\GIS\MAPS\MXDs\2011_RI_Report\figure_2-3-surface_soil_sample_locations_mpa.mxd Date: 2/29/2012



Surface Soil Sample Location
Settling Pond
Monofill
Historical Structure

Image Source: Aero-Metric, Inc 5/29/2001

RED DEVIL MINE

Red Devil, Alaska

Figure 2-3
Surface Soil Sample Locations
Main Processing Area

0 25 50 100 150 200 250
Feet

0 12.5 25 50 75
Meters

Ecology & Environment, Inc. GIS Department Project:
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Surface Soil Sample Location

- Area of Surface Mining
- Area of Surface Exploration South of the Post-1955 Main Processing Area
- Dolly Sluice and Delta
- Red Devil Creek
- Red Devil Creek Downstream Alluvial Area and Delta
- Red Devil Creek Upstream Alluvial Area
- Rice Sluice and Delta
- Upland Background Area
- Settling Pond
- Monofill
- Historical Structure

RED DEVIL MINE

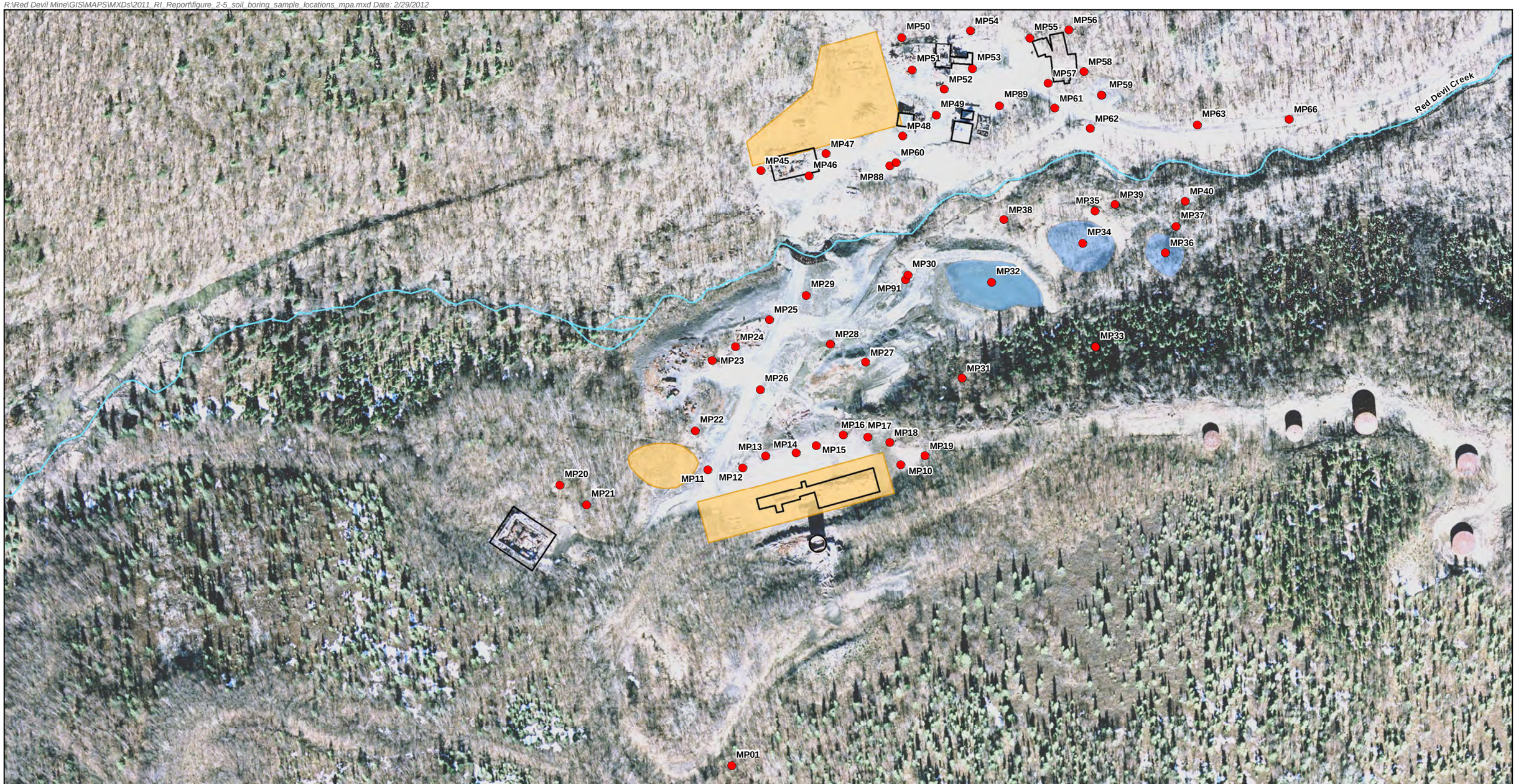
Red Devil, Alaska

Figure 2-4
Surface Soil Sample Locations Outside Main Processing Area

0 100 200 400 600
Feet
0 25 50 100 150 200
Meters
Scale 1:3,800

Image Source: Aero-Metric, Inc 5/29/2001

Ecology & Environment, Inc. GIS Department Project:
R:\Red Devil Mine\GIS\MAPS\MXDs\2011_RI_Report\figure_2-5_soil_boring_sample_locations_mpa.mxd Date: 2/29/2012



Soil Boring Location
Settling Pond
Monofill
Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 2-5
Soil Boring Locations
Main Processing Area

0 25 50 100 150 200 250
Feet
0 12.5 25 50 75
Meters

Image Source: Aero-Metric, Inc 5/29/2001

Ecology & Environment, Inc. GIS Department Project:
R:\Red Devil Mine\GIS\MAPS\MXDs\2011_RI_Report\figure_2-6_soil_boring_sample_locations_outside_mpa.mxd Date: 2/29/2012

Soil Boring Location

- Area of Surface Mining
- Dolly Sluice and Delta
- Red Devil Creek Downstream Alluvial Area and Delta
- Red Devil Creek Upstream Alluvial Area
- Rice Sluice and Delta
- Settling Pond
- Monofill
- Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 2-6
Soil Boring Locations
Outside Main Processing Area

0 100 200 400 600
Feet
0 25 50 100 150 200
Meters
Scale 1:3,800

Image Source: Aero-Metric, Inc 5/29/2001

Ecology & Environment, Inc. GIS Department Project:
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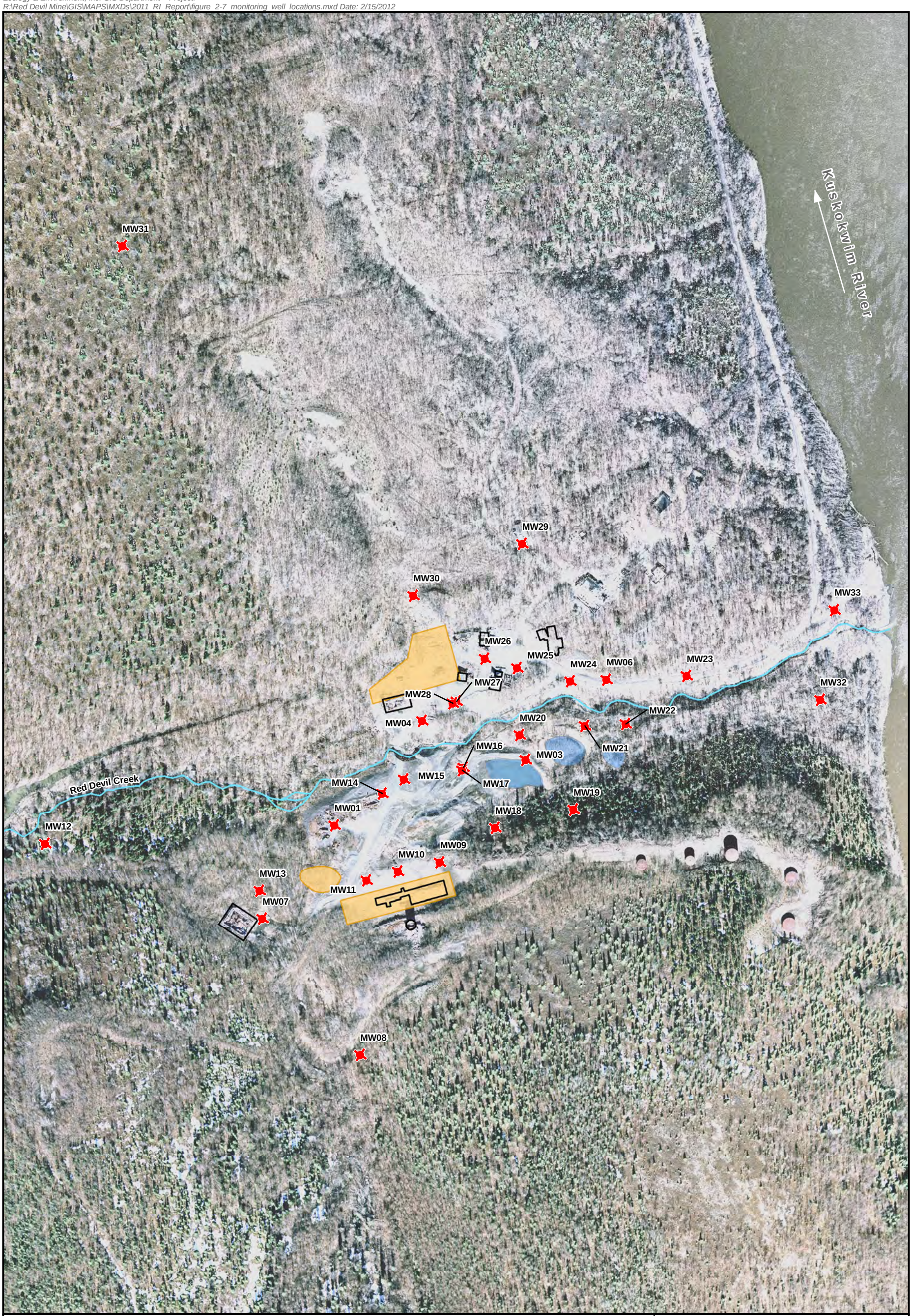

Monitoring Well Location
Settling Pond
Monofill
Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 2-7
Monitoring Well Locations

0 50 100 200 300 400
Feet
0 12.5 25 50 75 100 125
Meters
Scale 1:2,500

Image Source: Aero-Metric, Inc 5/29/2001

Ecology & Environment, Inc. GIS Department Project:
R:\Red Devil Mine\GIS\MAPS\MXDs\2011_RI_Report\figure_2-8_surface_water_sample_locations.mxd Date: 11/8/2011

Surface Water Sample Location
Settling Pond
Monofill
Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 2-8
Surface Water Sample Locations

0 25 50 100 150 200 250 300 350
Feet
0 12.5 25 50 75 100
Meters

Image Source: Aero-Metric, Inc 5/29/2001

Ecology & Environment, Inc. GIS Department Project:
R:\Red Devil Mine\GIS\MAPS\MXDs\2011_RI_Report\figure_2-9_red_devil_crk_sediment_sample_locations.mxd Date: 11/8/2011

Surface Water Sample Location
Settling Pond
Monofill
Historical Structure

RED DEVIL MINE

Red Devil, Alaska

Figure 2-9
Red Devil Creek
Sediment Sample Locations

0 25 50 100 150 200 250 300 350
Feet
0 12.5 25 50 75 100
Meters

Image Source: Aero-Metric, Inc 5/29/2001

Ecology & Environment, Inc. GIS Department Project:
R:\Red Devil Mine\GIS\MAPS\MXDs\2011_RI_Report\figure_2-10_kuskokwim_river_shoreline_sediment_sample_locations.mxd Date: 1/11/2012

Sediment Sample Location

RED DEVIL MINE

Red Devil, Alaska

Figure 2-10
Kuskokwim River Shoreline
Sediment Sample Locations

0 50 100 200 300 400 500
Feet
0 25 50 75 100 125
Meters
Scale 1:2,600

Source Information:
Aerial Photo Reference: Aero-Metric, Inc., 5/29/2001

Sediment Sample Location

RED DEVIL MINE

Red Devil, Alaska

Figure 2-11
Kuskokwim River Off-Shore Sediment Sample Locations

0 50 100 200 300 400
Feet
0 12.5 25 50 75 100
Meters
Scale 1:2,000

Source Information:
Aerial Photo Reference: Aero-Metric, Inc., 5/29/2001

Ecology & Environment, Inc. GIS Department Project:
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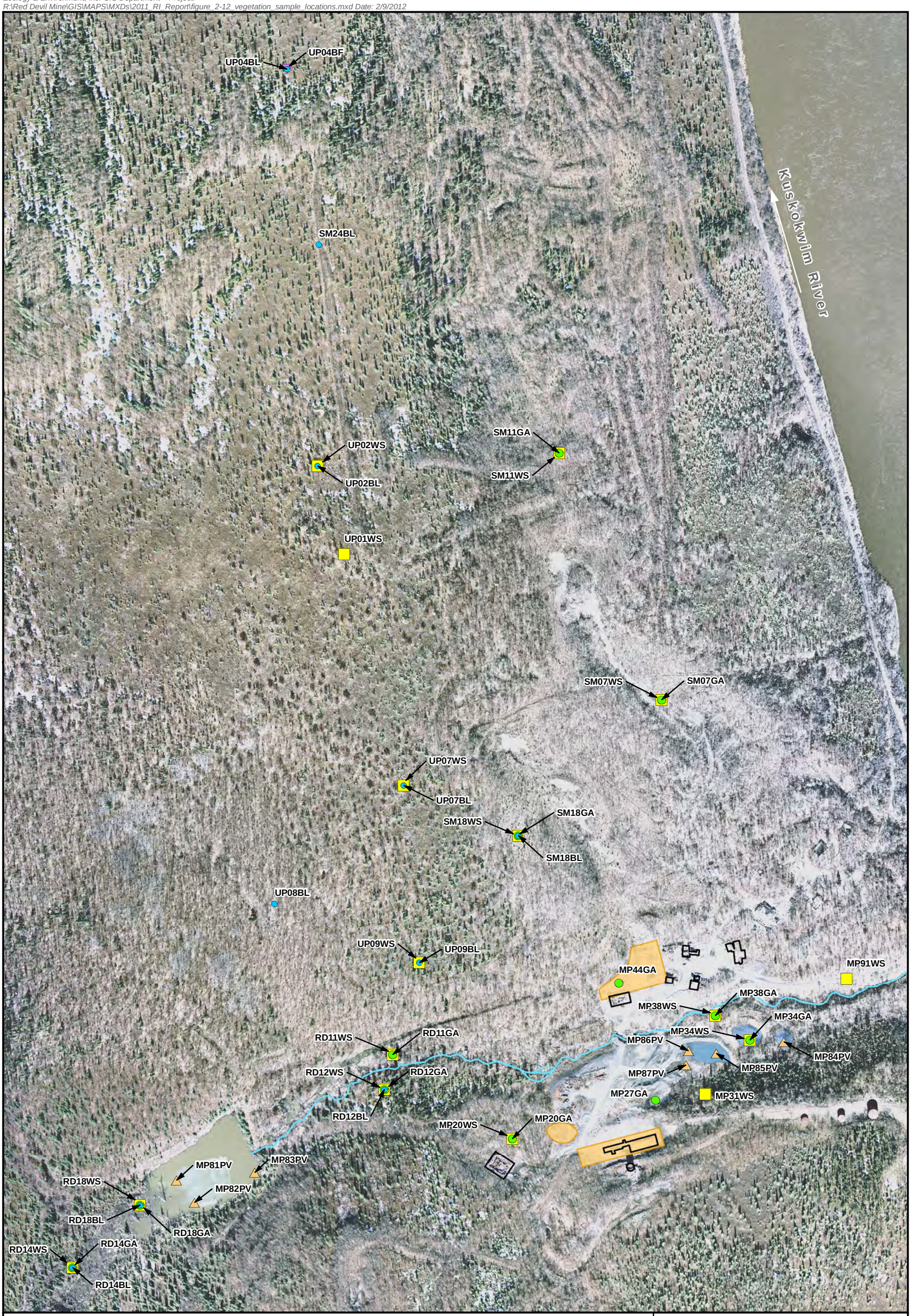

- Blueberry Leaves and Stems
- Blueberry Fruit
- Green Alder
- Horsetail Pond Vegetation
- White Spruce
- Settling Pond
- Monofill
- Historical Structure

Image Source: Aero-Metric, Inc 5/29/2001

RED DEVIL MINE

Red Devil, Alaska

Figure 2-12
Vegetation Sample Locations

0 50 100 200 300 400 500 600
Feet
0 25 50 100 150
Meters
Scale 1:3,300