CAPTAIN JACK MILL SUPERFUND SITE

Pre-Design Investigation and Subsurface Remedy Design Concept

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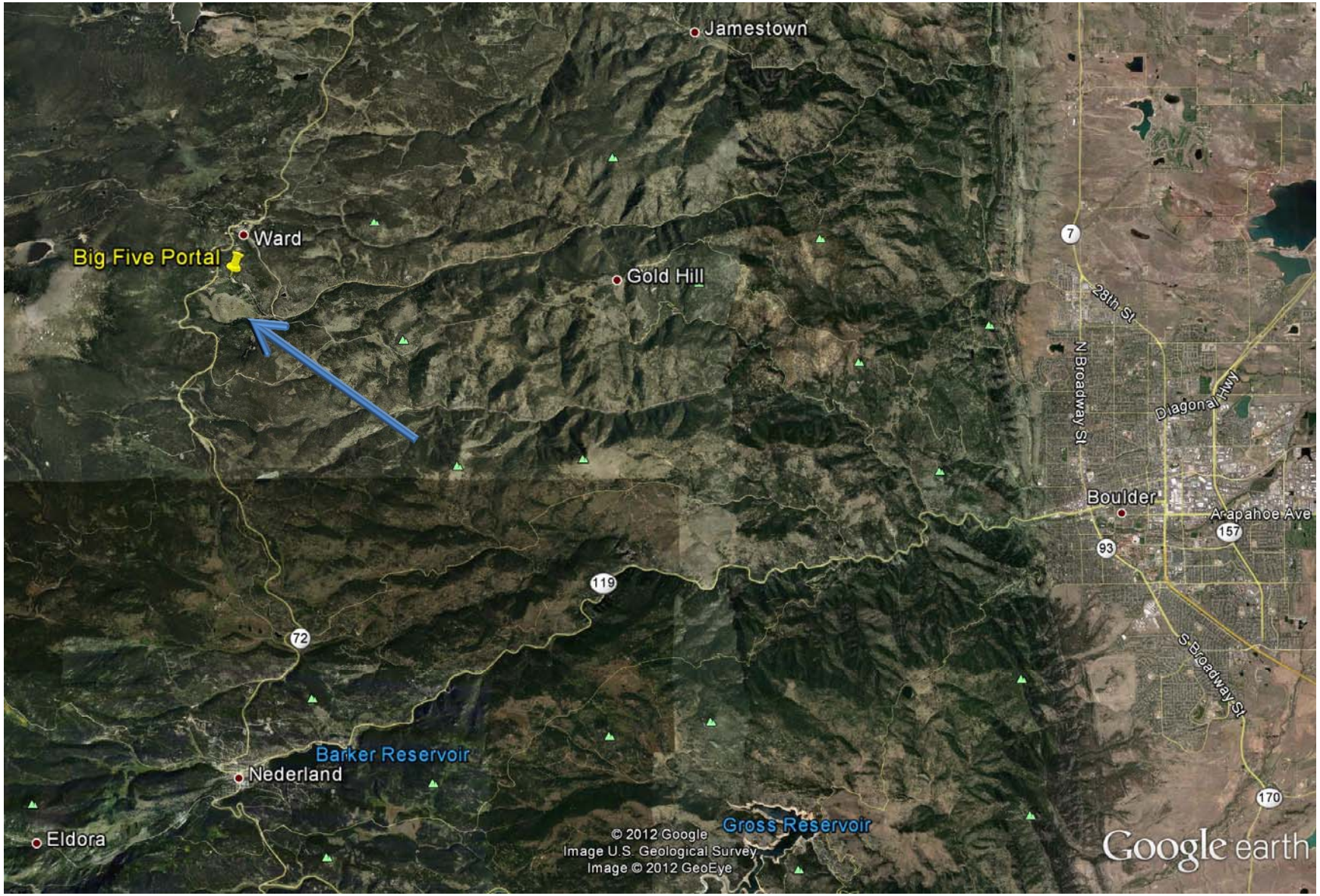
Acknowledgements

- **Colorado Department of Public Health and Environment – Mary Boardman**
- **U.S. Environmental Protection Agency, Region 8 – Joy Jenkins**
- **Key Partners**
  - Zonge International
  - RAS, Inc.
  - Multi-Phase Technologies, LLC
  - James Drilling
  - Flatirons Surveying, Inc.
  - Agapito Associates, Inc.
  - McCollum Excavating

Presentation Overview

- **Technical and Regulatory Background for Captain Jack Site**
- **Pre-Design Activities and Findings**
- **Subsurface Remedy Schematic Design**
  - Flow-through Bulkhead
  - Mine Pool Treatment
  - Long-term Monitoring

Presentation Overview



Concern is…. Acid Mine Drainage

Video shows flow emerging from a “spring” at 850 feet within mine at base of large collapse.

- 30 – 150 gpm (seasonal)
- pH – 2.5 to 4.5
- Discharge to Left Hand Creek
- Elevated Metals: Fe, Al, Cu, Mg, Mn, Zn

Regulatory Summary

- Mining and Milling Operations from 1890's to 1992
- Listed on National Priority List (NPL) by USEPA in September 2003 due to Heavy Metals Loading to Left Hand Creek Watershed
- Colorado State Lead
- ROD Signed in September 2008 by EPA and CDPHE
- Remedial Effort Divided into Two Actions:
  1) Surface Cleanup
  2) Subsurface Remedy
- AMEC E&I Selected for Subsurface Remedy Remedial Design in February 2011

Selected Remedy in the ROD

Alternative 3B from the RI/FS

- **A bulkhead** with stainless steel through-piping and valves
- **Mine-pool mitigation** anticipated to include a neutralization loop with an injection and extraction well drilled into the tunnel reservoir
- **Operational monitoring**

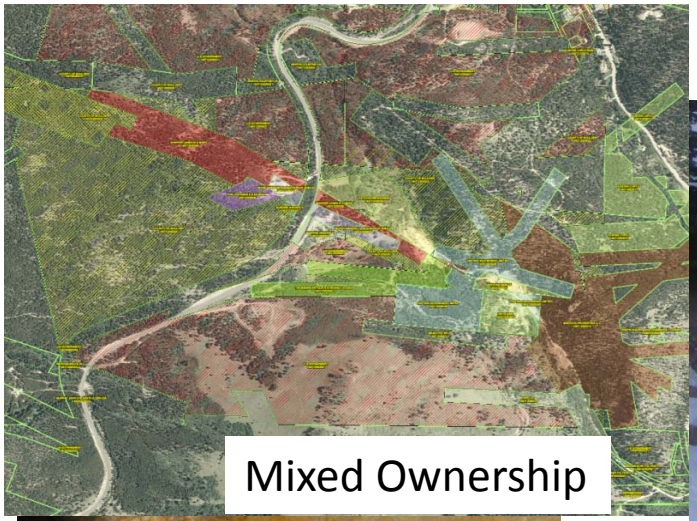
Treatment Concept

- Treats mine water "**in-situ**"
- **Submerges source materials** (to the extent safely practicable) in order to minimize contact with oxygen
- Implement **active neutralization** of impounded mine-pool waters
- If needed, a second phase of remedial operations will include an ex-situ bioreactor

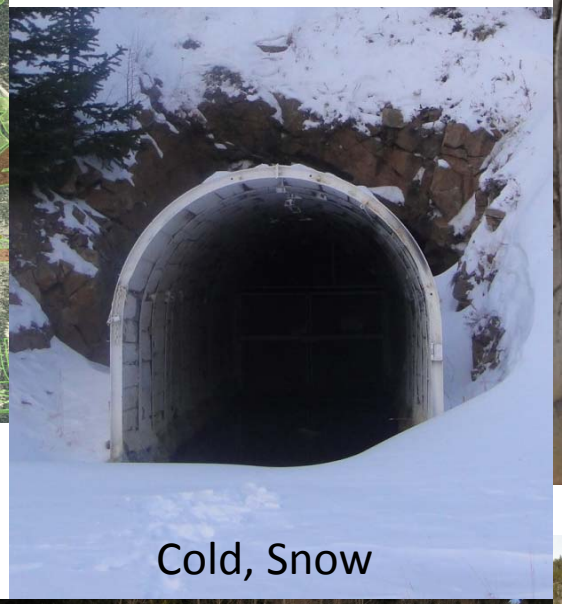
Site Characteristics

8,800 feet amsl

Site Characteristics

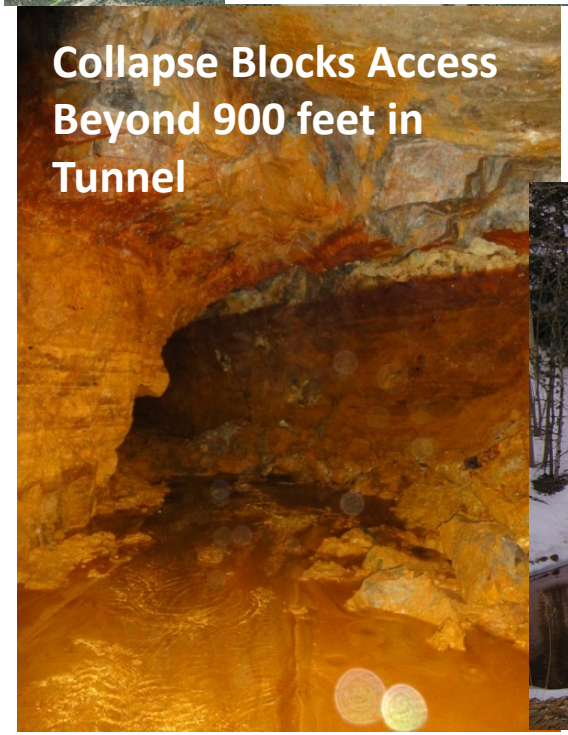


Mixed Ownership



Cold, Snow

Limited Site Security

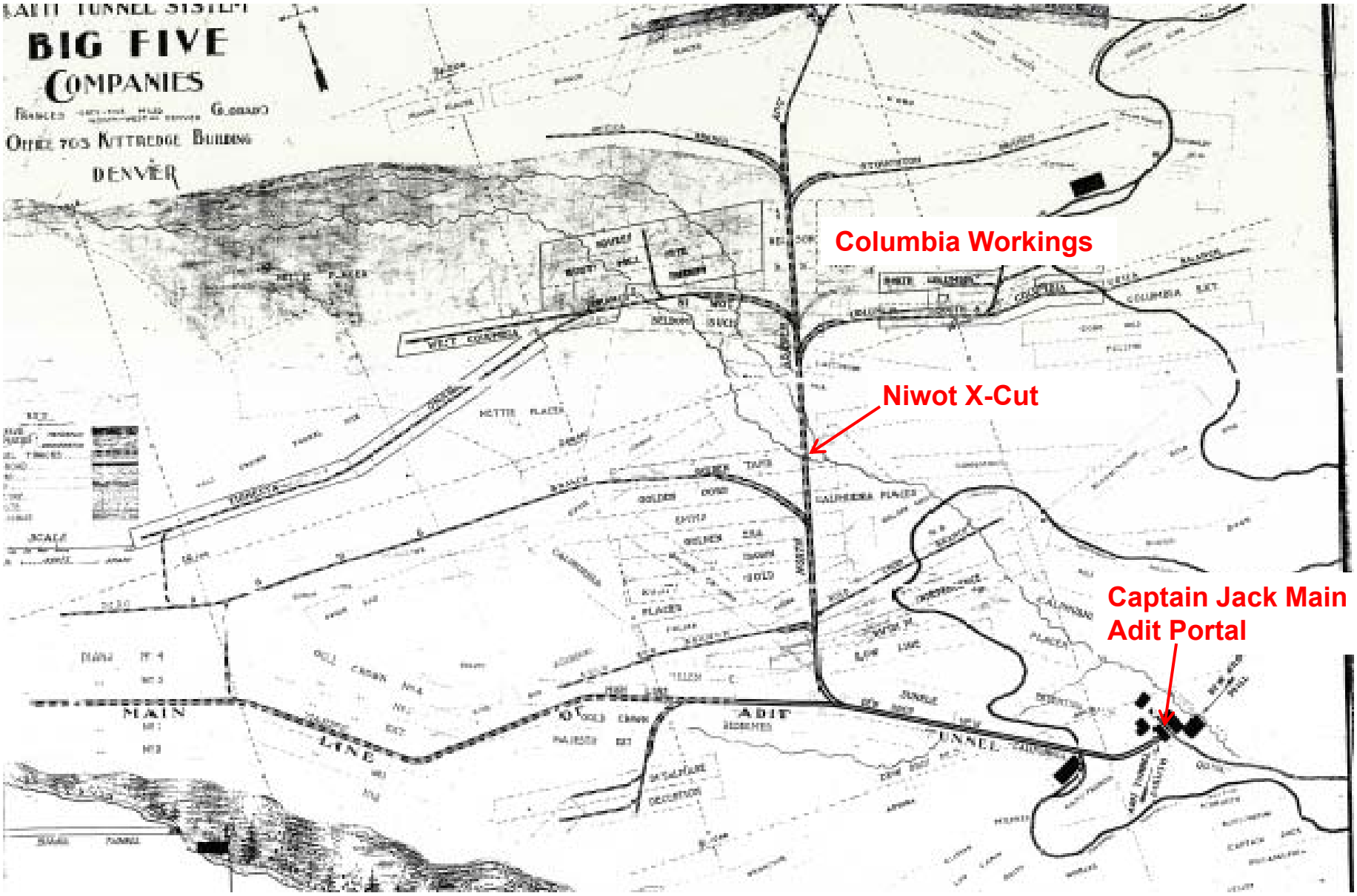


Collapse Blocks Access Beyond 900 feet in Tunnel

Lack of Utilities

Steep Terrain

Historical Mine Workings



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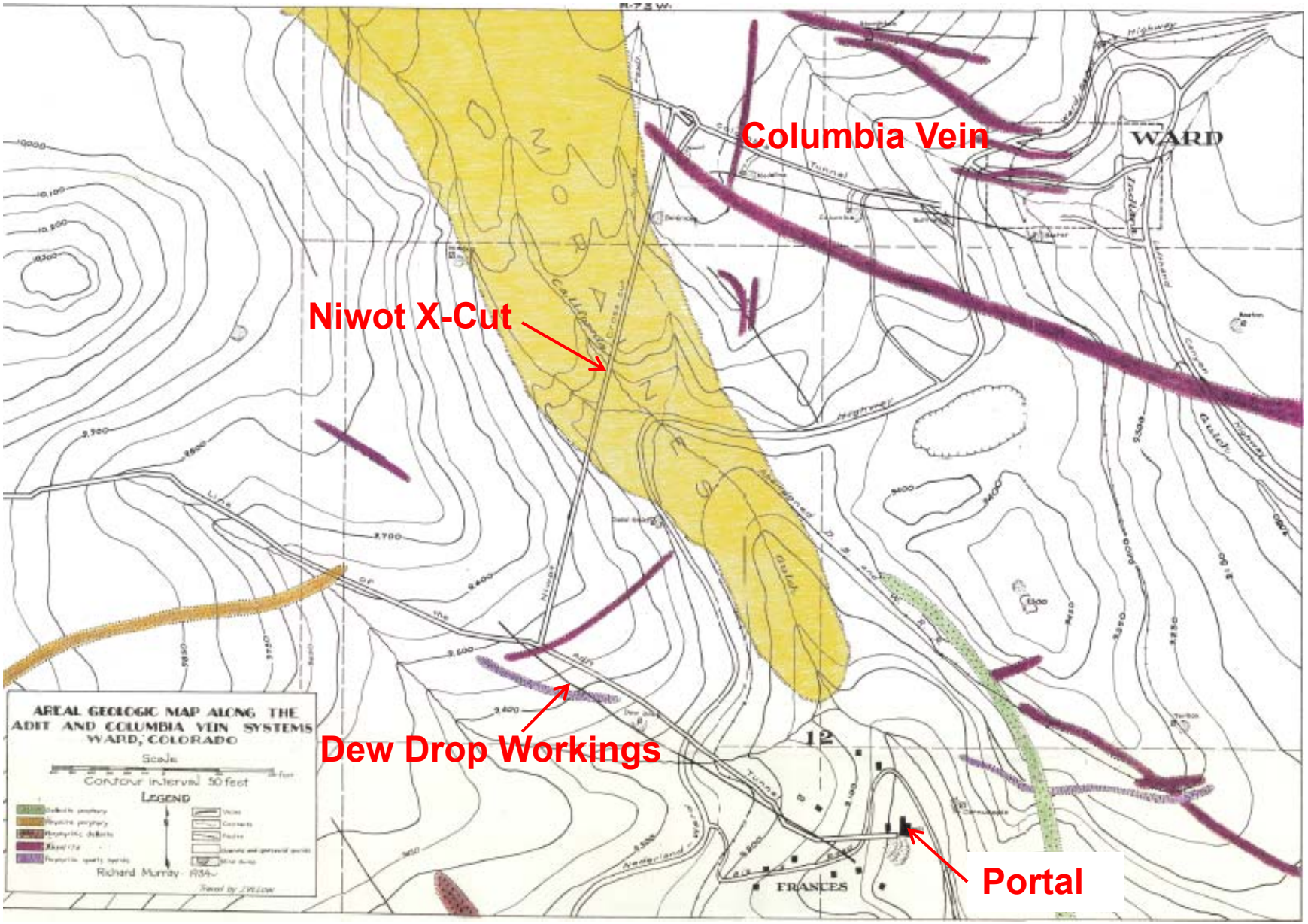
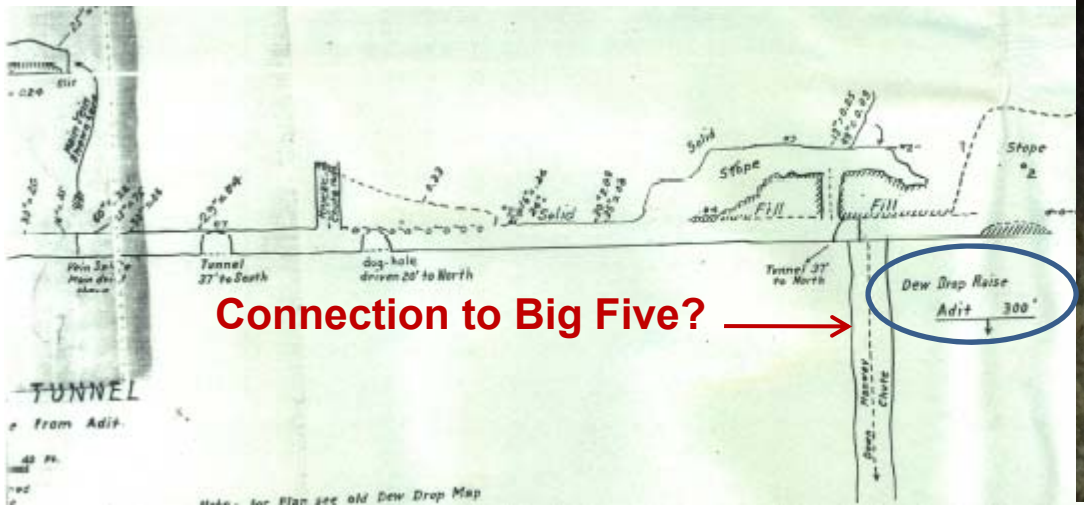
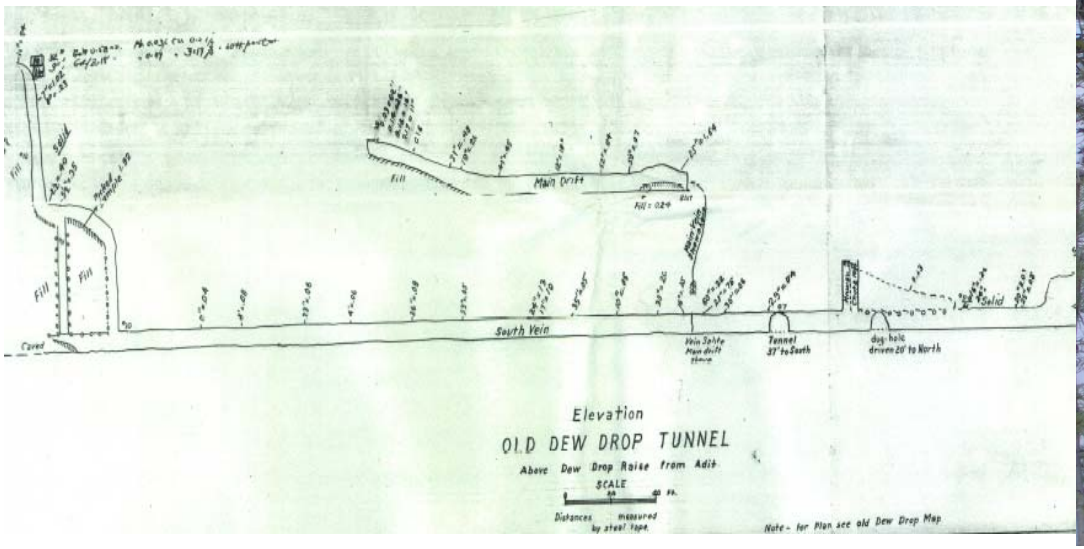


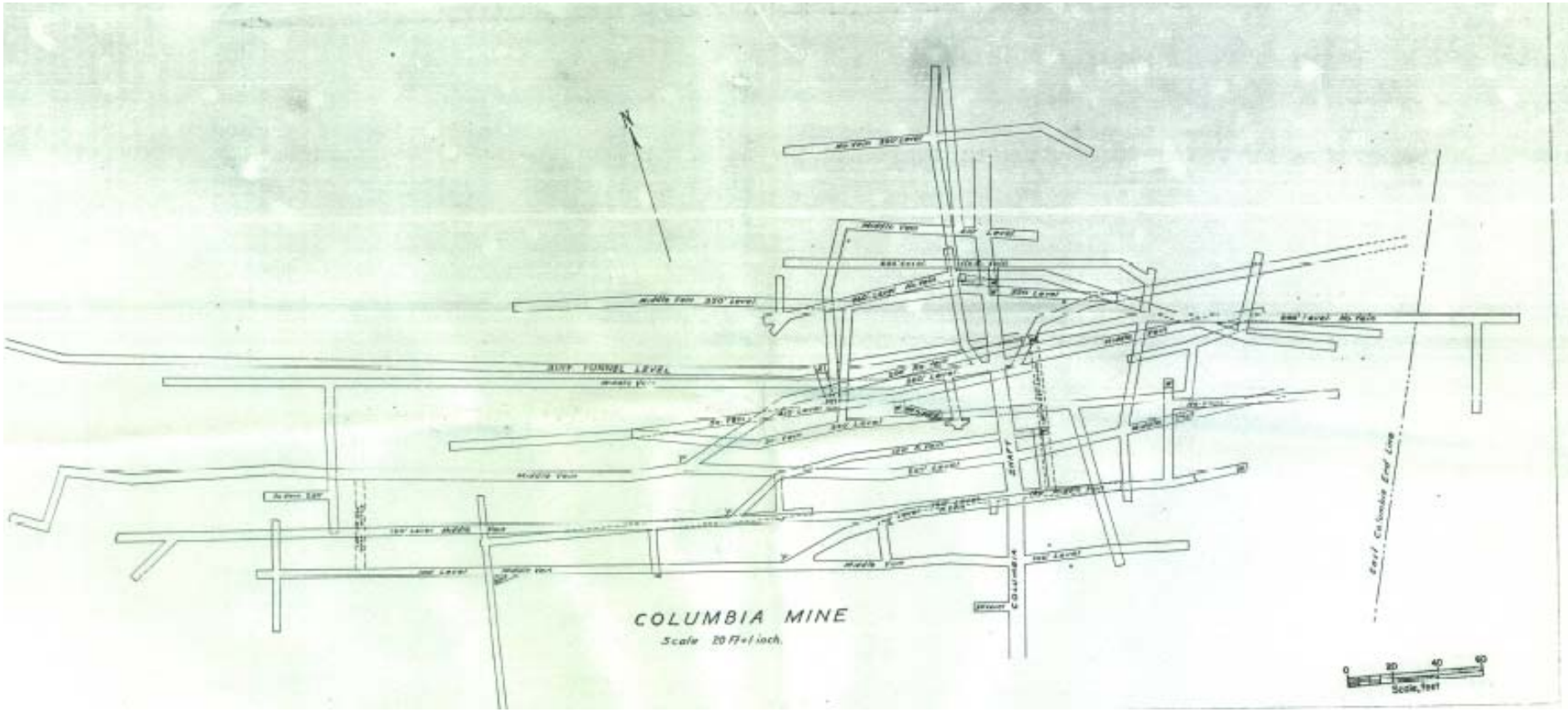
Dew Drop Workings

250 feet above Big Five and parallel





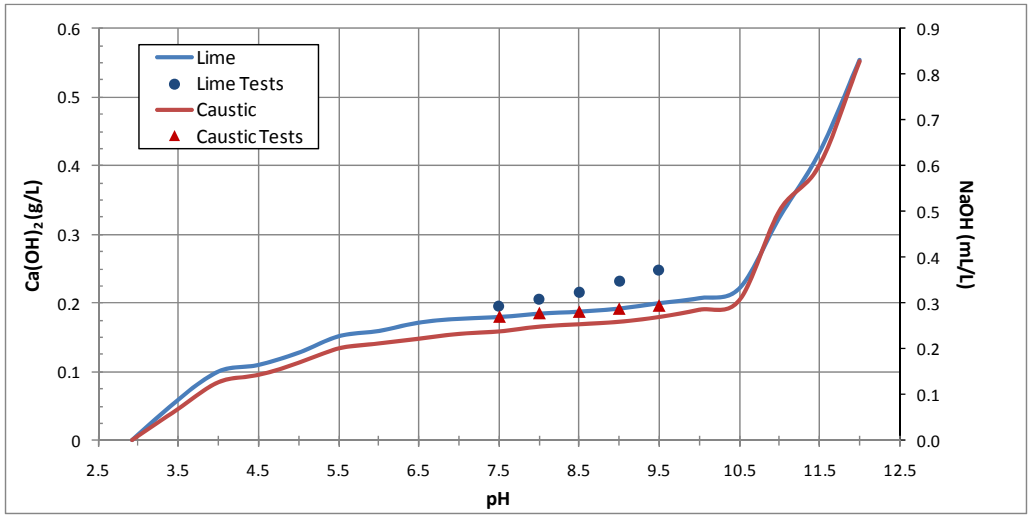
Columbia Vein Workings – Near Ward, CO



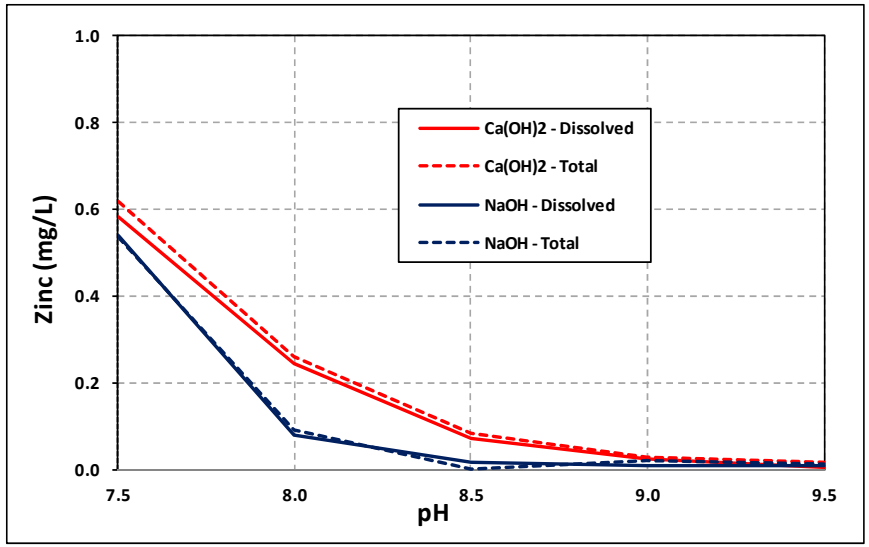
Pre-Design Investigation Summary May 2011 – January 2012

- **Treatability Evaluation**
  - Laboratory Neutralization Testing / Modeling
  - Sampling and Analytical Tests (mine flows)
  - Installation of Flow Meter
  - Dye Tracer
- **Geophysical Survey**
  - Dipole-Dipole/Zeta Elecrical Resistivity and Induce Polarization
  - In-tunnel Mise-a-la-Masse (MALM) Resistivity
- **Tunnel Geotechnical Testing**
  - Visual Mapping
  - Coring
- **Drilling Program**
  - Access Road Construction
  - Air Rotary Investigative Borings
  - Borehole Geophysics (video, deviation, acoustic televiewer, electrical logs, optical televiewer, packer pressure testing)
  - Well Completions
  - Groundwater Monitoring/Sampling
- **Borehole to Borehole Electrical Resistivity Tomography (ERT)**

Treatability Data



Test Conditions	Alkali Consumption		Solids Production	
	$Ca(OH)_2$ (g/L)	NaOH (ml/L)	$Ca(OH)_2$ (g/L)	NaOH
pH 7.5	0.195	0.271	0.196	0.196
pH 8.0	0.205	0.279	0.174	0.200
pH 8.5	0.215	0.282	0.173	0.220
pH 9.0	0.233	0.289	0.215	0.215
pH 9.5	0.247	0.296	0.204	0.220



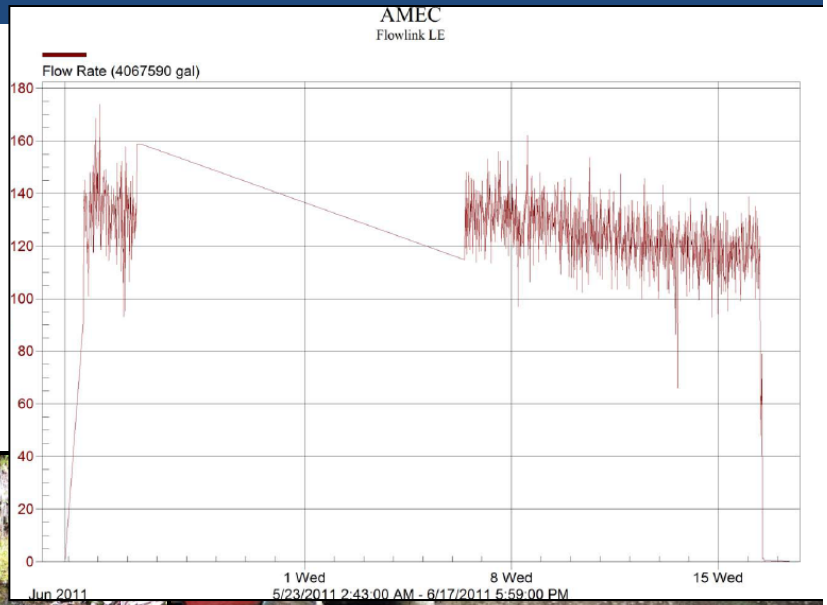
Captain Jack AMD as Collected				
Metals scan	***Analysis by AGAT Laboratories***		***Analysis by TestAmerica***	
	Dissolved mg/L	Total mg/L	Dissolved mg/L	Total mg/L
Aluminum (Al)	13	13	13	13
Cadmium (Cd)	0.015	0.015	0.015	0.016
Calcium (Ca)	161	162	-	150
Cobalt (Co)	0.13	0.13	-	-
Copper (Cu)	8	8.4	7.8	8.0
Iron (Fe)	23	48	40	51
Magnesium (Mg)	81	81	-	86
Manganese (Mn)	9.7	9.8	9.2	9.5
Nickel (Ni)	0.14	0.14	0.14	0.14
Sodium (Na)	7	7	-	-
Sulfur (S)	335	338	-	-
Zinc (Zn)	3.3	3.4	2.6	2.9
Sulfates (SO_4)	1005[1]	1014[1]	-	1400[2]

Note [1] Sulfate concentration reported was calculated based on S analysis (ICP) by AGAT Laboratory

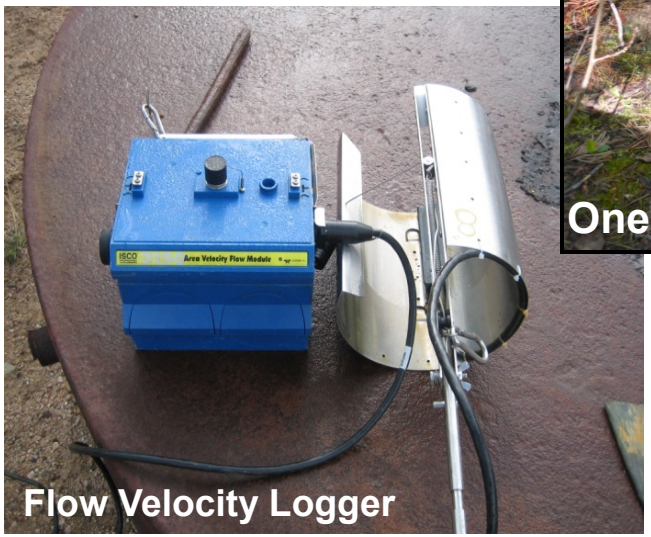
Note [2] Sulfate concentration reported was analyzed by ion chromatography at TestAmerica Laboratory

AMD Evaluations


Sample Collection at 800 feet

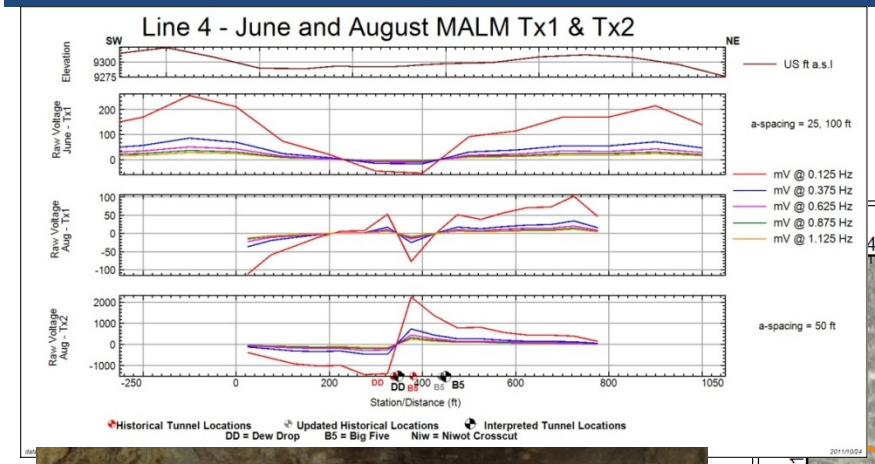



One of Several Seeps

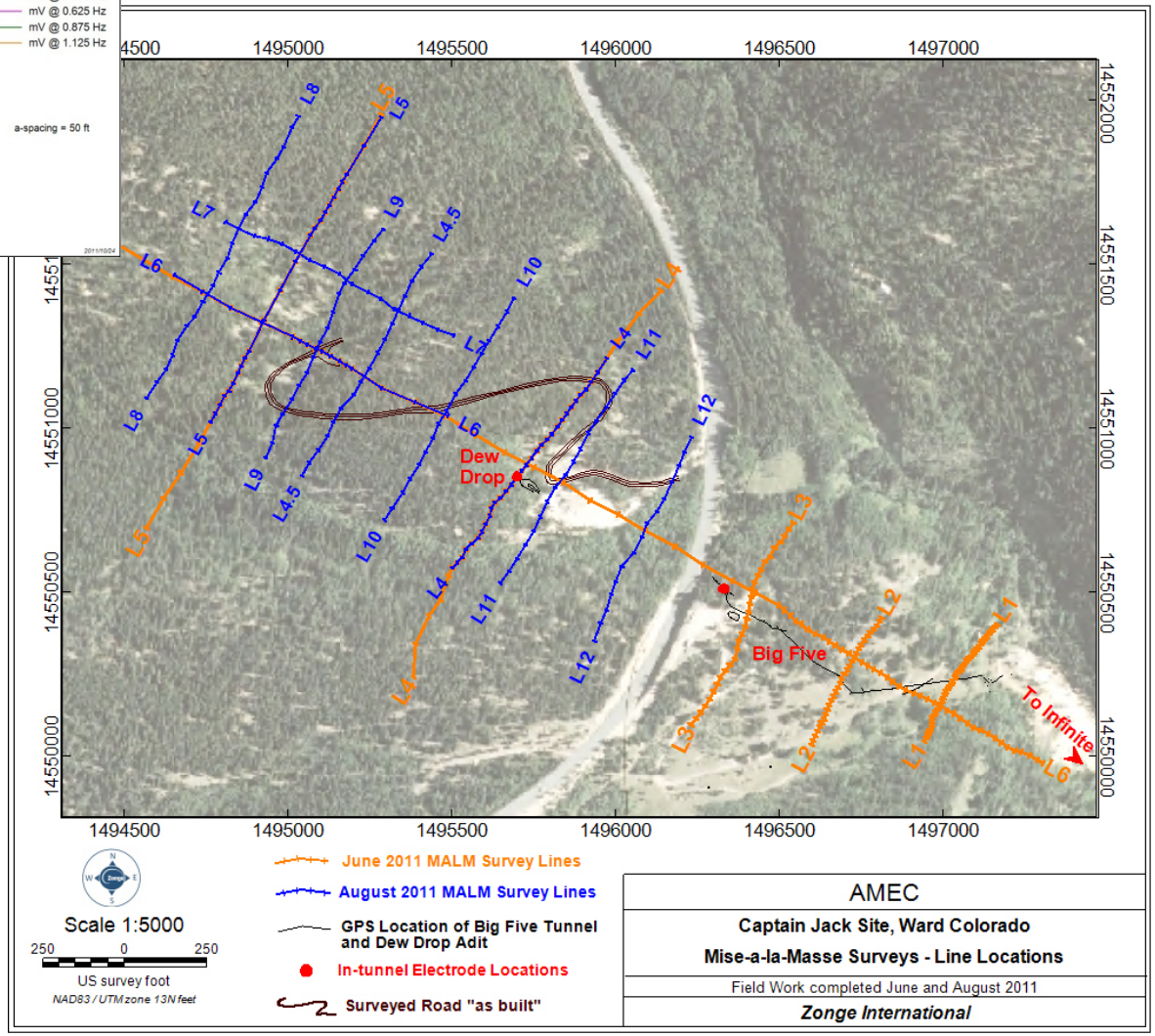

Flow Velocity Logger


Flow Meter Installed

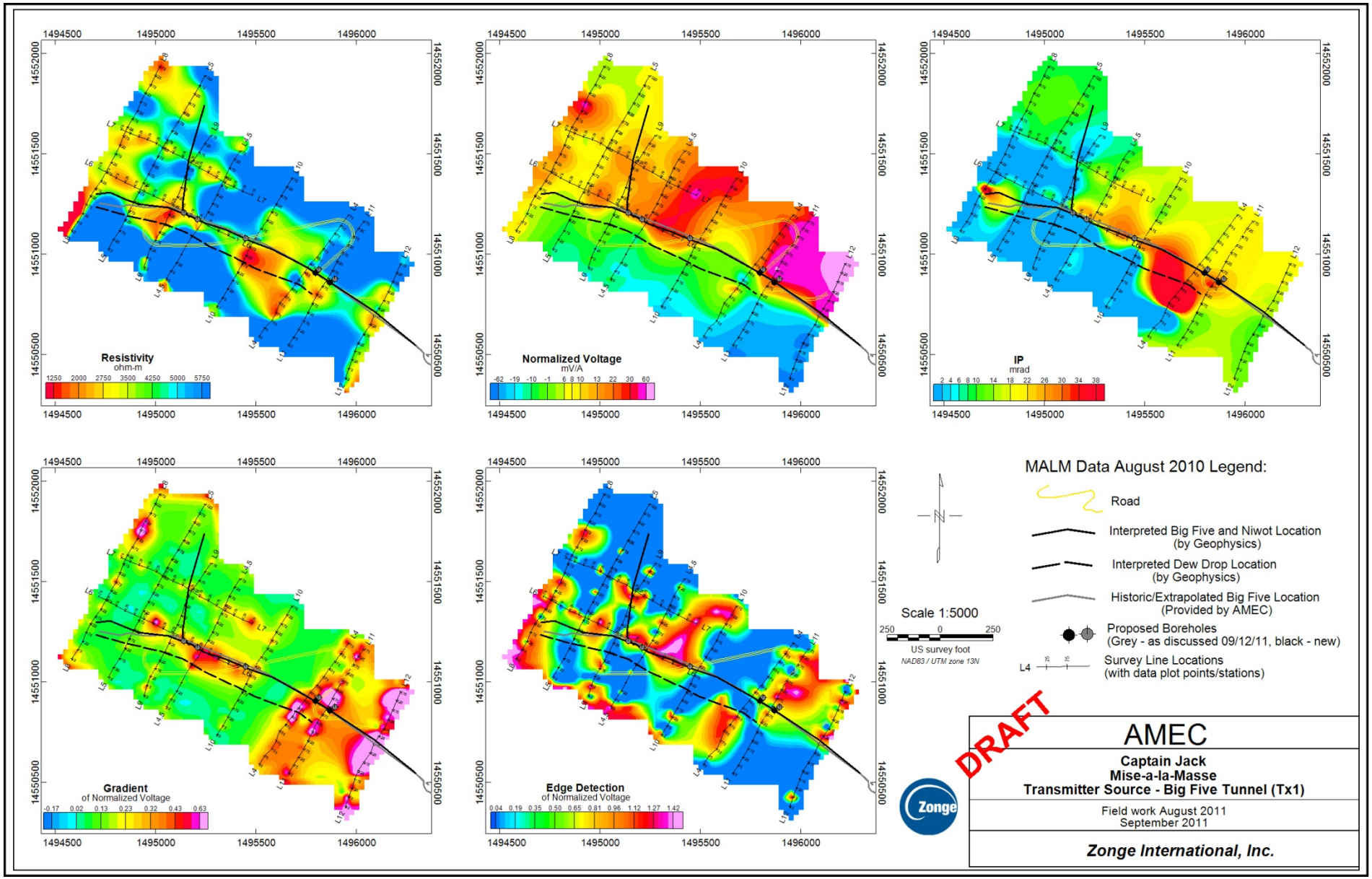
Geophysics – Locate Mine Workings



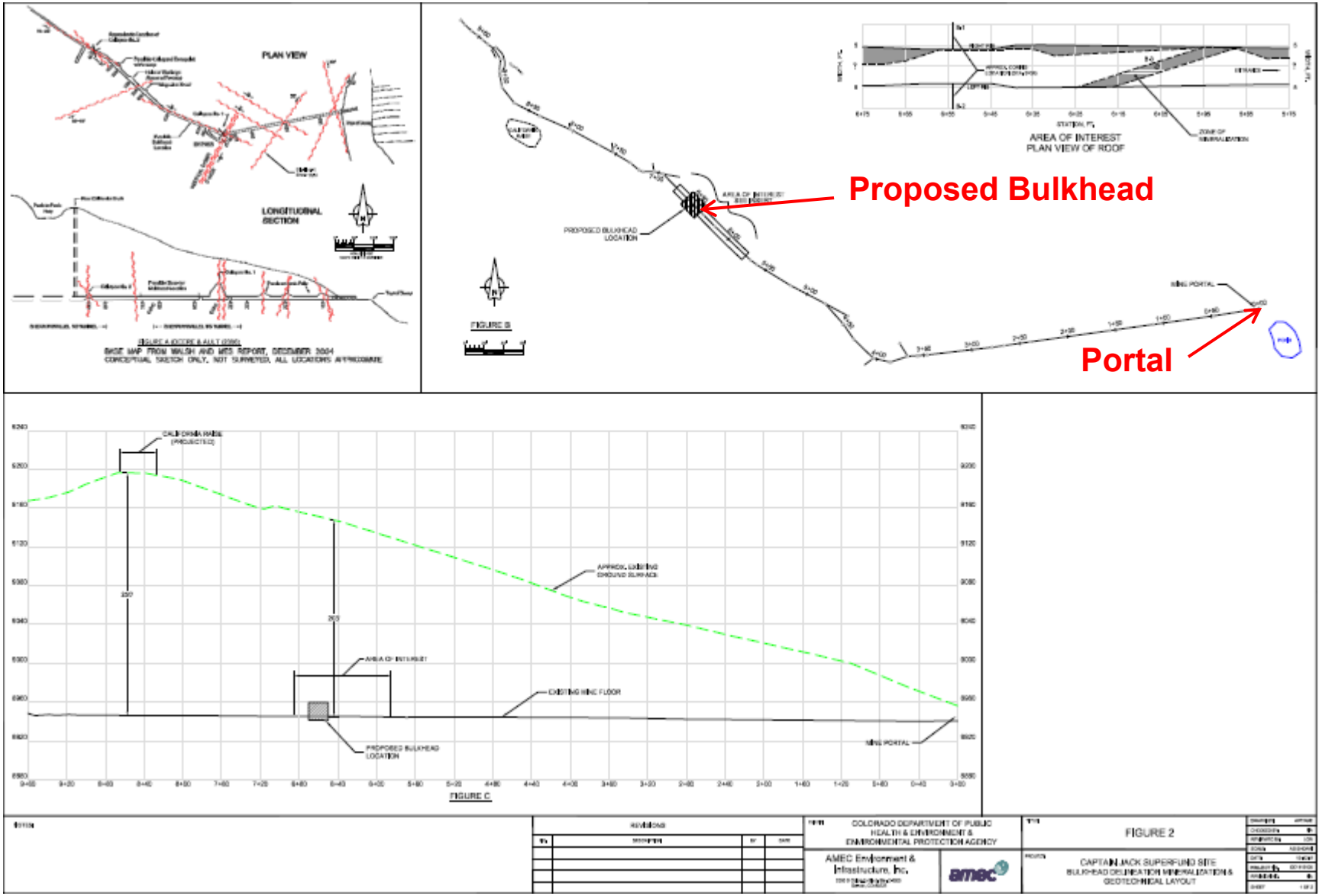
Transmitting Electrode Connected to Rails in Dew Drop Mine



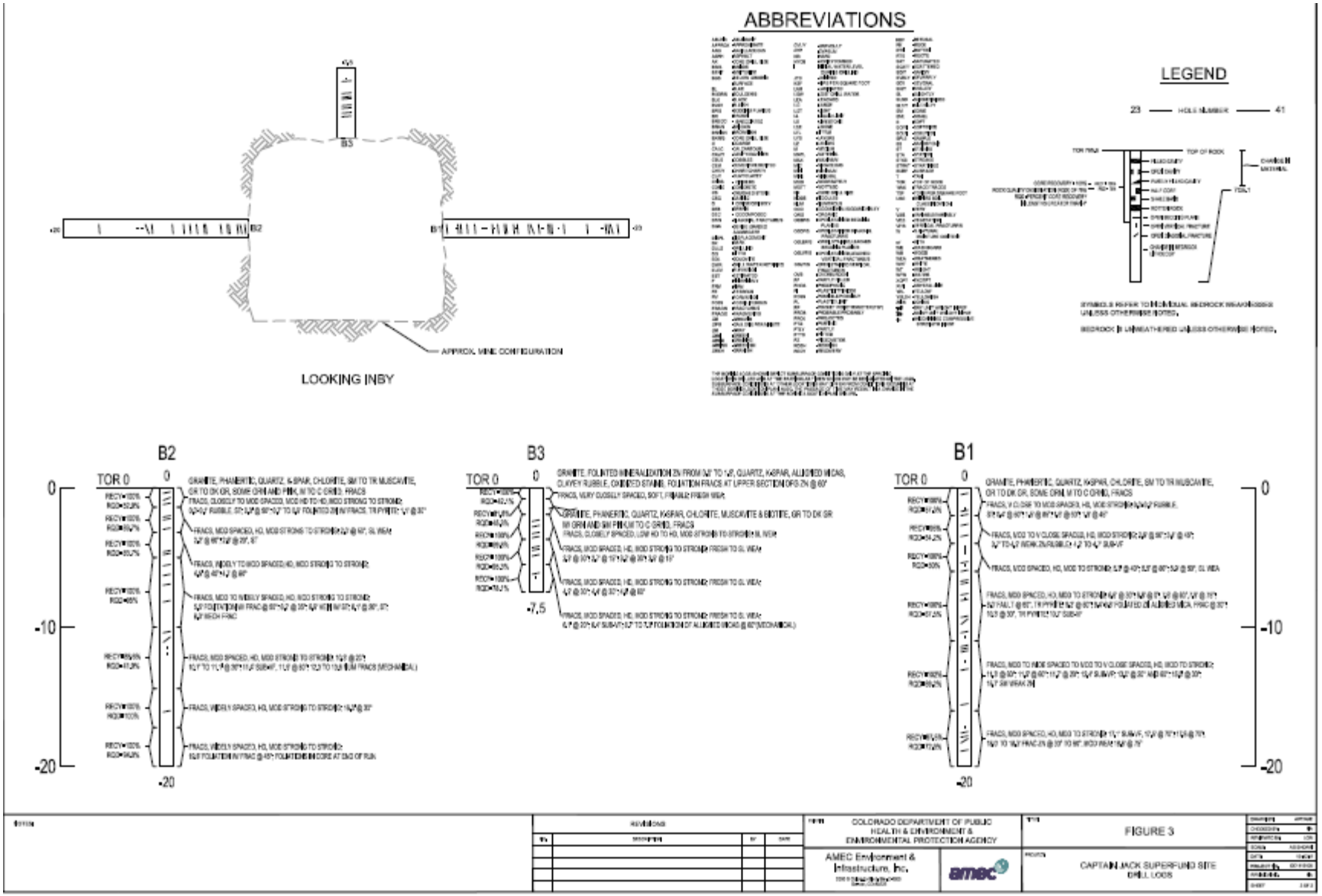
Geophysics – MALM Summary



Mine Tunnel Geotechnical Testing

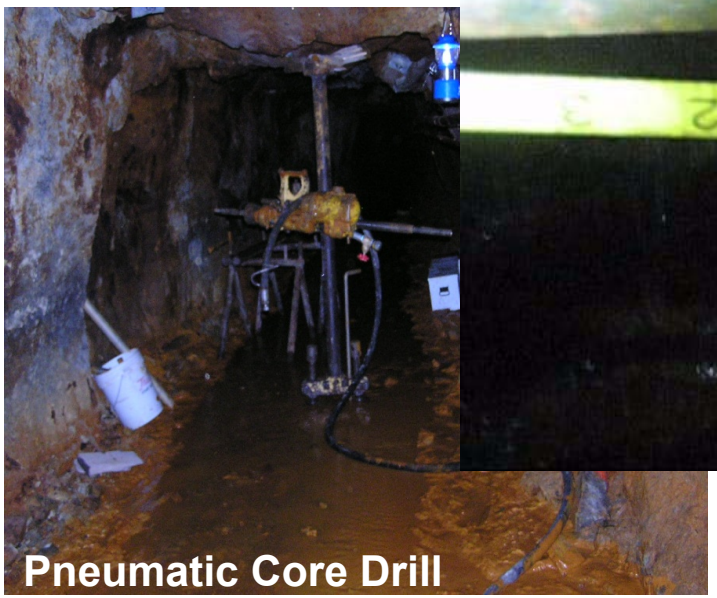


Tunnel Geotechnical Cores

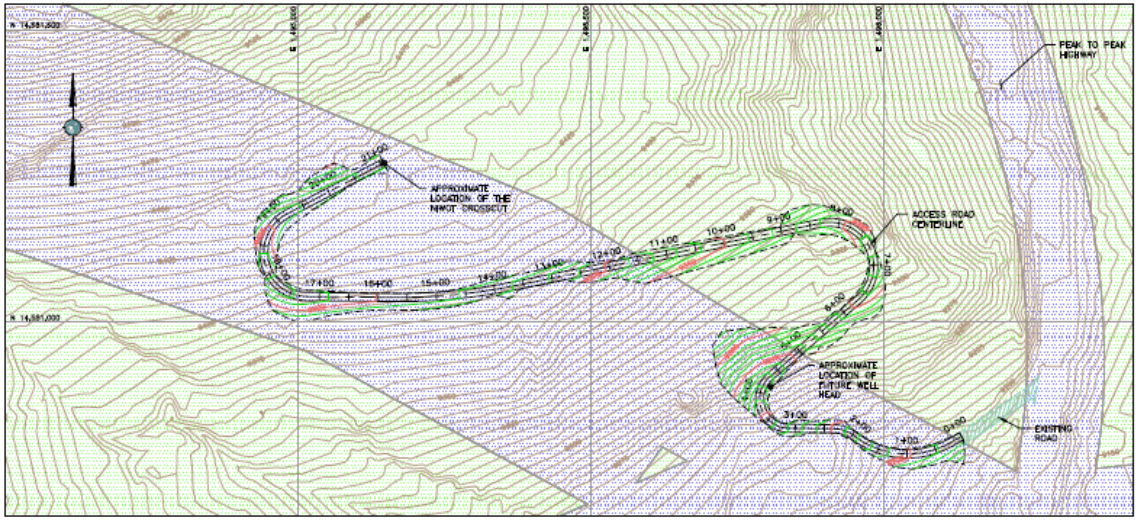


Geotechnical Work


Hydraulic Pressure Test


Pneumatic Core Drill

Borehole Access Road



LEGEND:

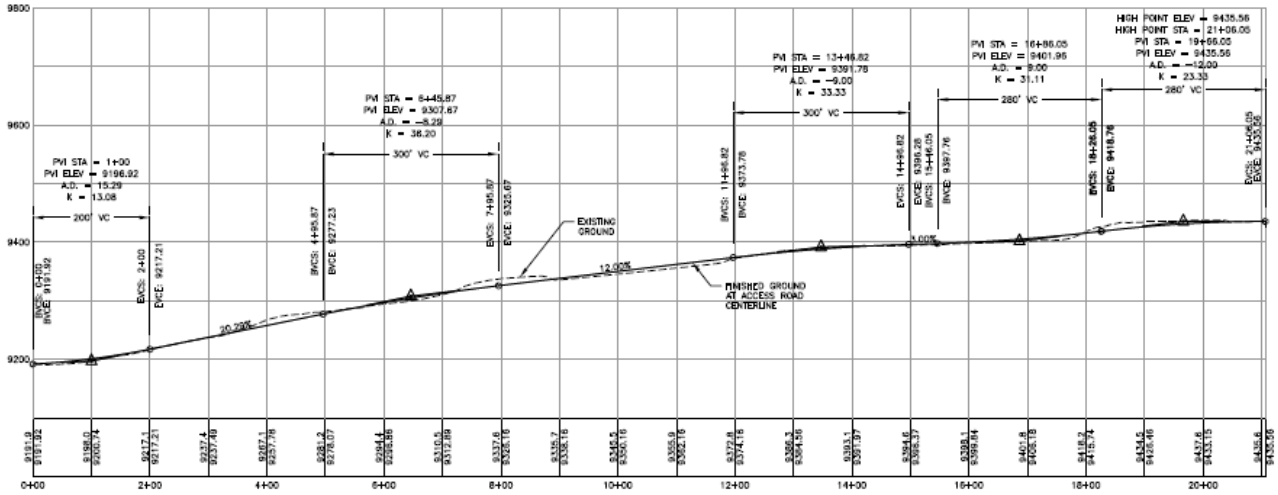
- EXISTING GROUND SURFACE CONTOUR AND EL. FEET
- PROPOSED GROUND SURFACE CONTOUR AND EL. FEET
- DRAINAGE
- COUNTY PROPERTY
- PRIVATE PROPERTY

ESTIMATED EARTHWORKS:

ACCESS ROAD DISTURBANCE: 87,380 ft^2
ACCESS ROAD CUT: 6,500 yd^3
ACCESS ROAD FILL: 4,800 yd^3
(~1,000 yd^3 OF CUT BETWEEN STATIONS 3+00 AND 5+50 THAT ARE DEPENDANT ON EXISTING CONDITIONS UNKNOWN AT TIME OF DESIGN)

PRELIMINARY DRAFT – SUBJECT TO REVISION

ACCESS ROAD PLAN



ACCESS ROAD PROFILE

VERTICAL SCALE: 100 0 100 200 FEET
HORIZONTAL SCALE: 100 0 100 200 FEET
VERTICAL EXAGGERATION = 1X

ACCESS ROAD HORIZONTAL LAYOUT DATA

POINT	STATION	NORTHING	EASTING	DELTA (D–M–S)	RADIUS (FT)	LENGTH (FT)
PI	0+00	14,550,805.27	1,495,133.80			
PC	0+21.33	14,550,794.74	1,495,115.25			
				67–46–21	150.00	177.43
PT	1+98.76	14,550,807.30	1,495,948.46			
PC	1+98.76	14,550,807.30	1,495,948.46			
				37–24–22	50.00	32.64
PT	2+31.40	14,550,818.00	1,495,918.23			
PC	3+11.52	14,550,819.10	1,495,838.12			
				138–08–03	50.00	120.54
PT	4+32.06	14,550,906.79	1,495,805.96			
PC	5+33.82	14,551,039.36	1,495,958.04			
				150–27–29	75.00	196.95
PT	8+30.77	14,551,169.38	1,495,893.76			
PC	13+64.12	14,551,062.71	1,495,371.18			
				12–10–23	1,000.00	212.46
PT	15+76.58	14,551,042.57	1,495,160.06			
PC	17+21.13	14,551,044.17	1,495,015.54			
				151–35–07	75.00	198.45
PT	19+19.57	14,551,185.53	1,494,981.44			
PI	21+06.05	14,551,272.39	1,495,146.45			

C	07/29/11	RE-ISSUED FOR REVIEW	GLD / MED
B	07/20/11	RE-ISSUED FOR REVIEW	FI / MJR
A	05/24/11	ISSUED FOR REVIEW	AB / MJR

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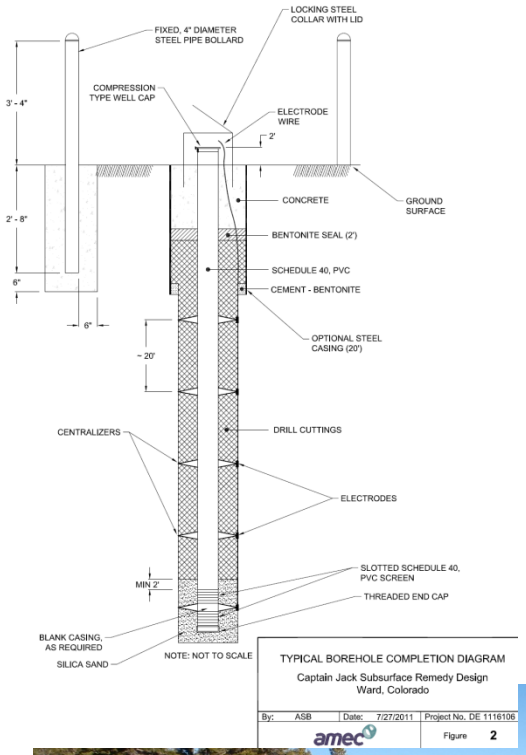
CLIENT: COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT
PROJECT: CAPTAIN JACK SUBSURFACE REMEDY DESIGN
TITLE: NIWOT CROSSCUT ACCESS ROAD ALIGNMENT AND PROFILE

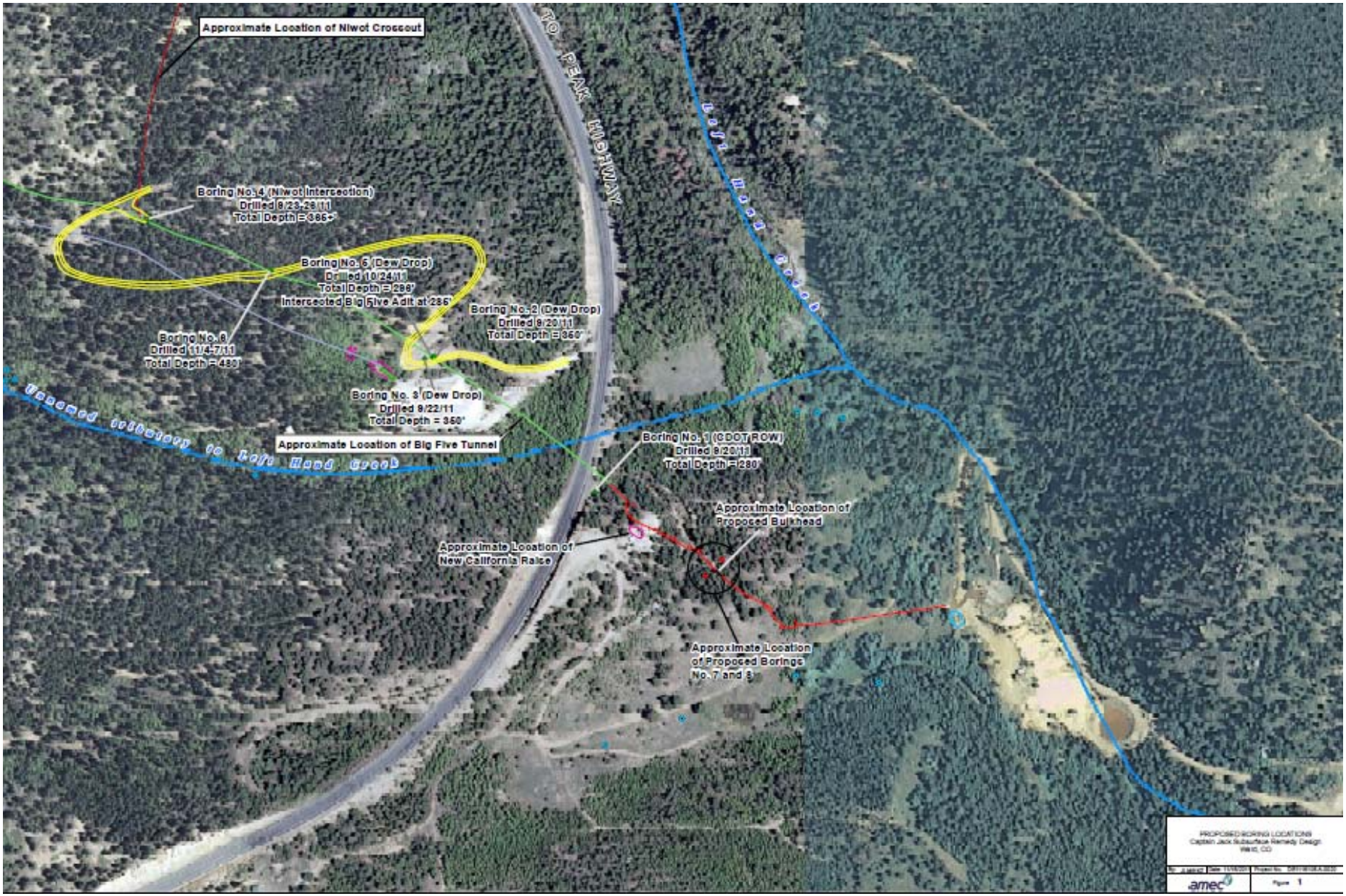
amec

DESIGNED BY	MJR	CHECKED BY	AB
DRAWN BY	MJR	APPROVED BY	AB
FILENAME	DE1116106–P01	DRAWING No.	A100
REV	C		

Drilling Effort



Drilling Summary



Borehole Investigation

Captain Jack Mine, Ward, Colorado
Well – 6
GPL PROCESSING AND NOTES
ALL DEPTHS REFERENCED TO TOP OF STEEL CASING

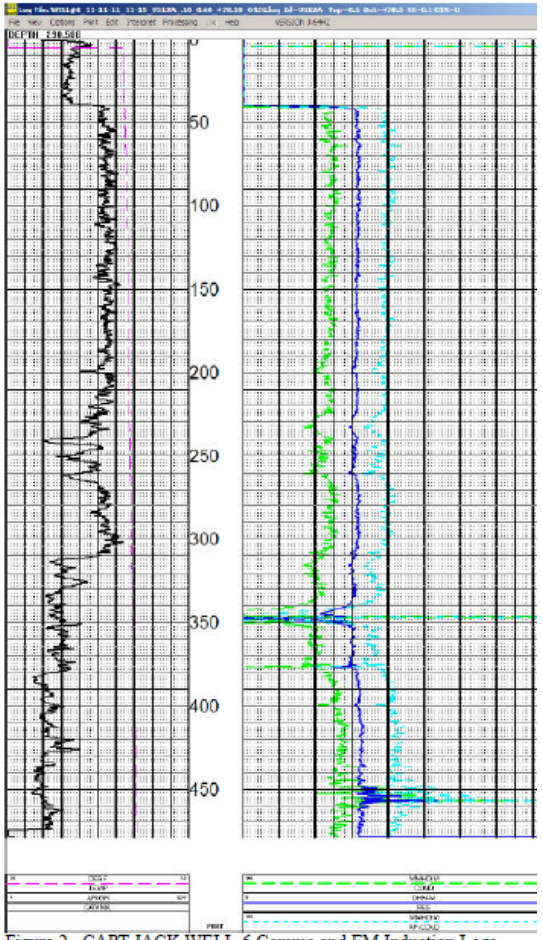


Figure 2. CAPT JACK WELL-6 Gamma and EM Induction Logs

AMEC Caption Jack Project, Ward, Colorado
Dew Drop Well 2 (well-3)
GPL PROCESSING AND NOTES
ALL DEPTHS REFERENCED TO TOP OF STEEL CASING

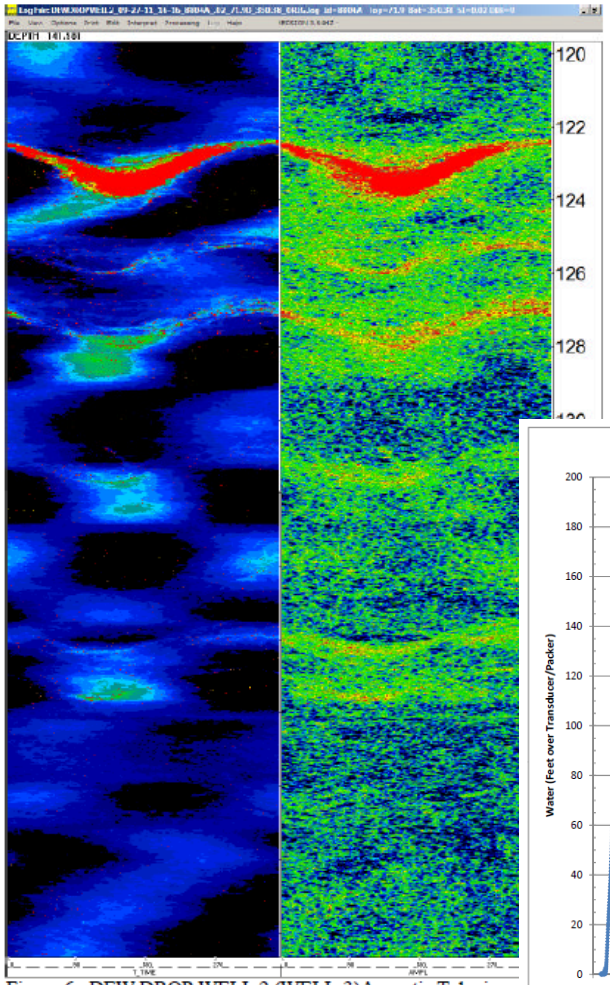
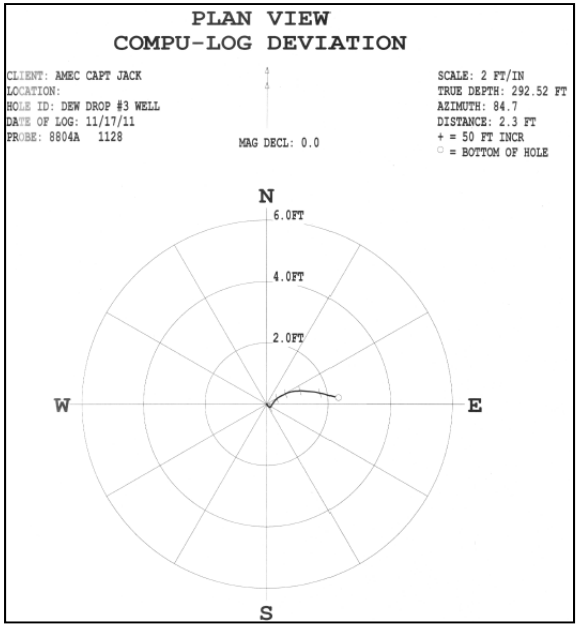
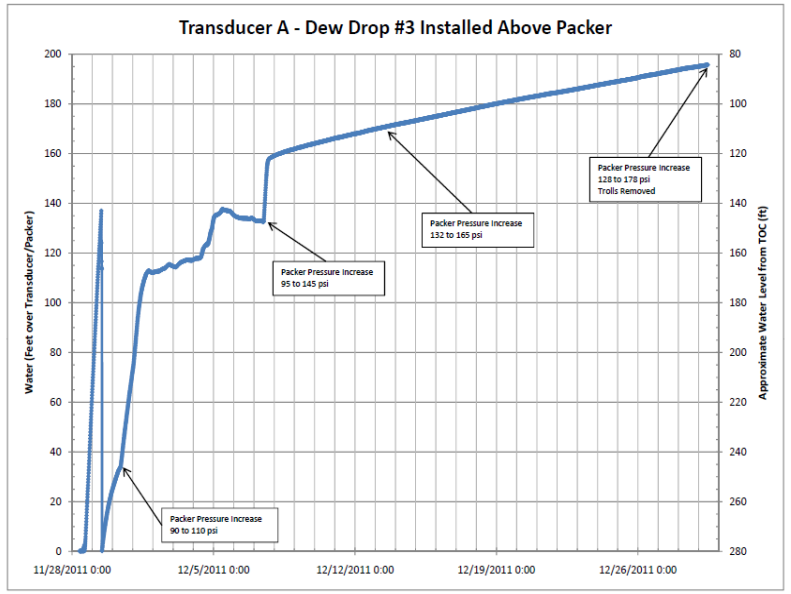
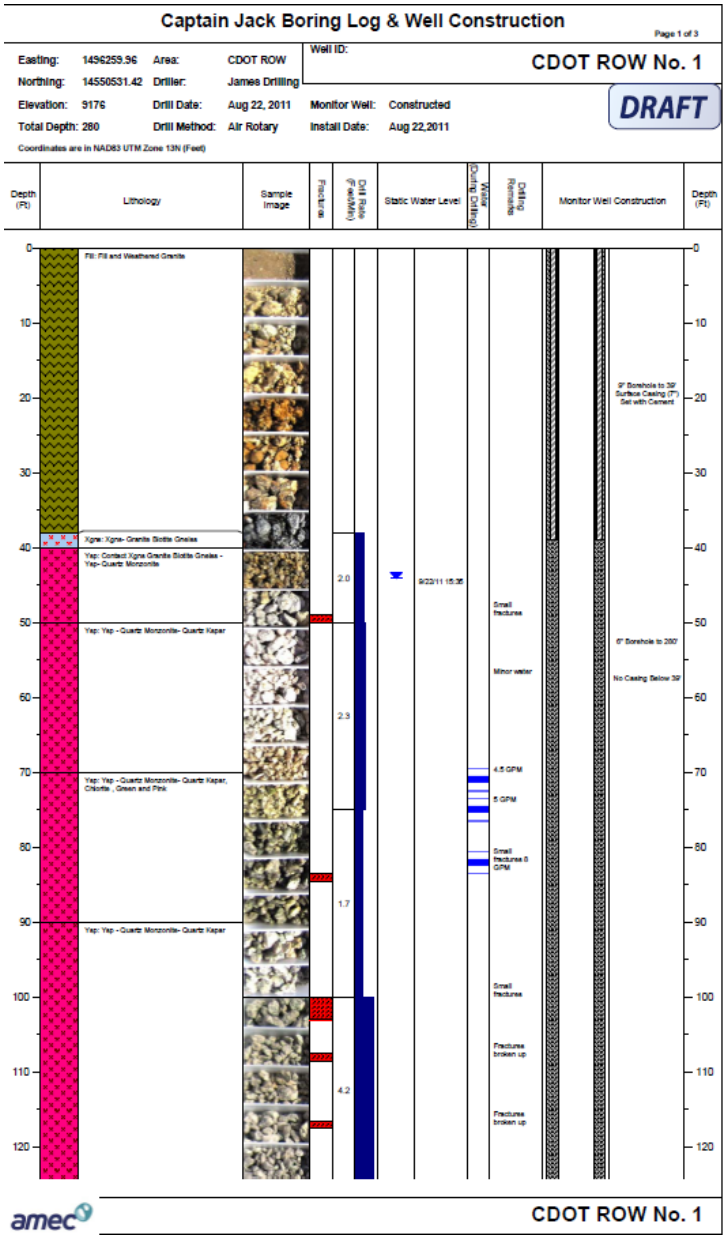


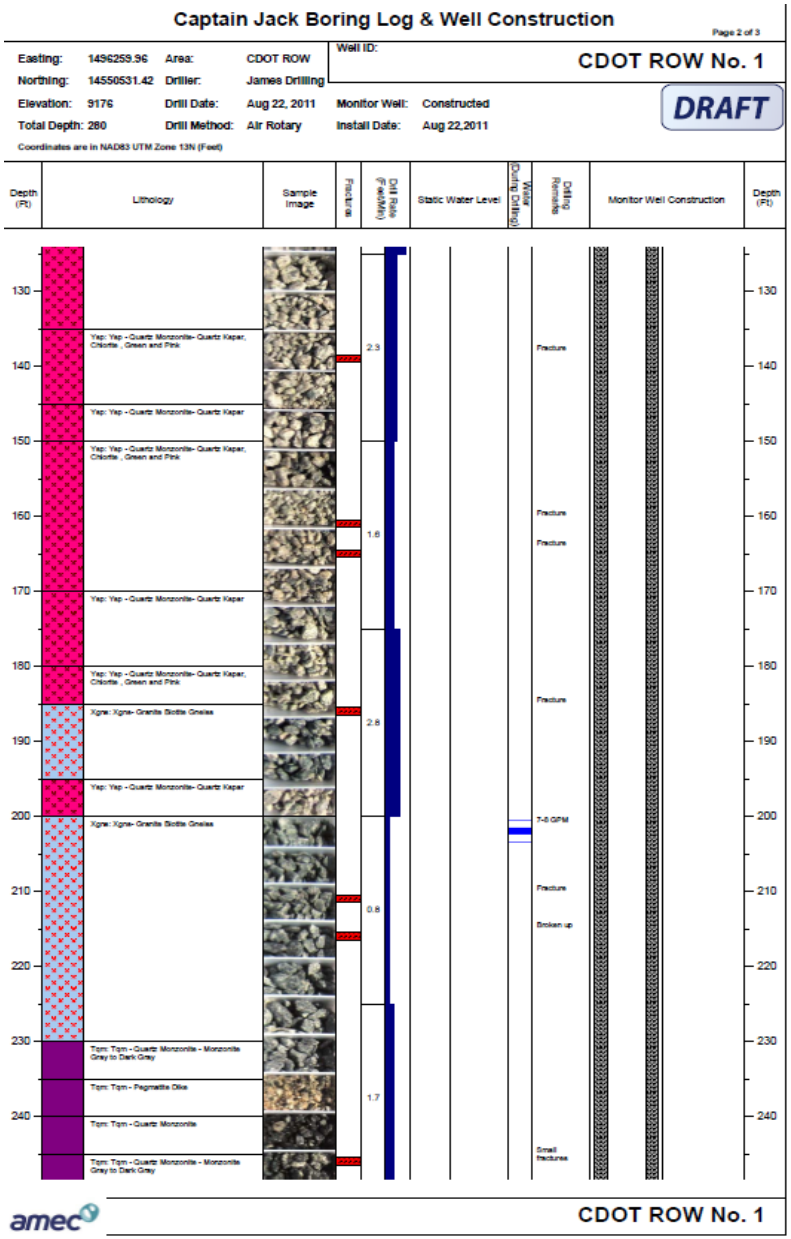
Figure 6. DEW DROP WELL 2 (WELL-3)Acoustic Televiewe
144 feet.





Borehole Logging





Electrical Resistivity Tomography (ERT)

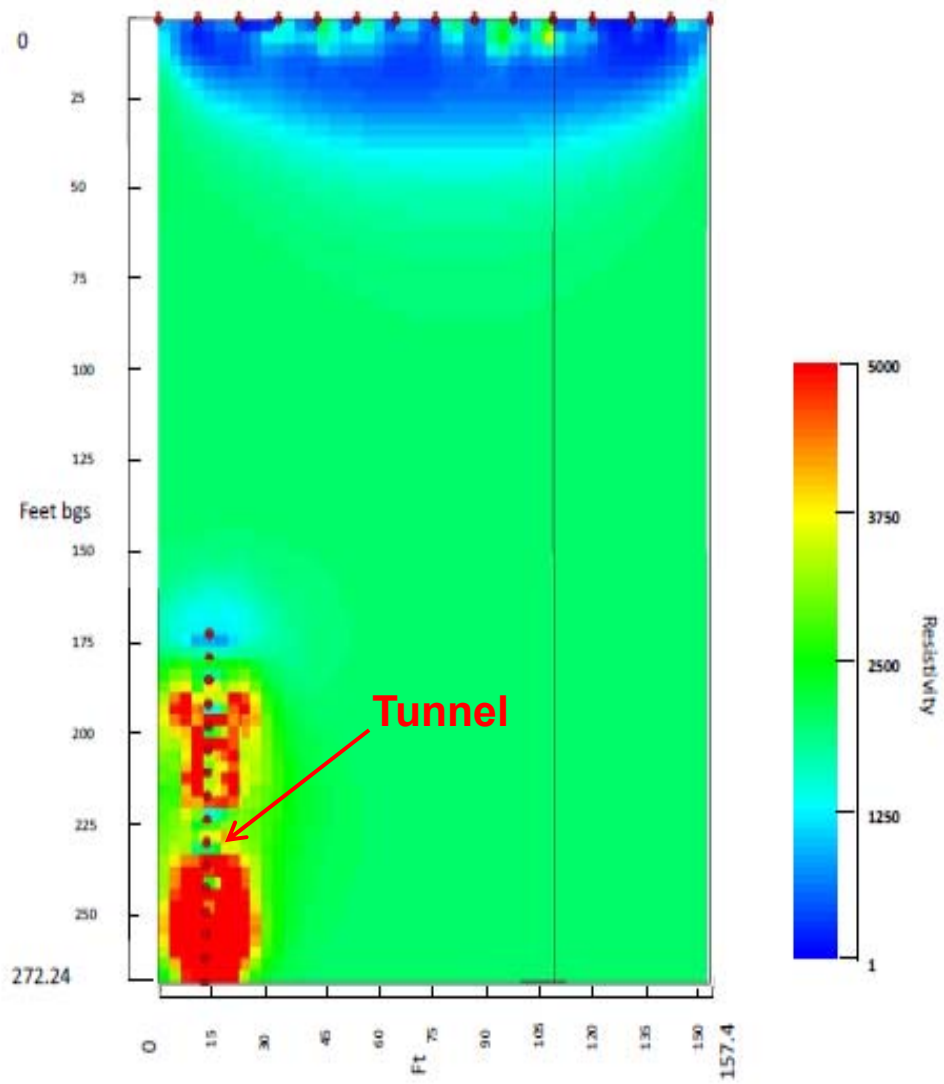
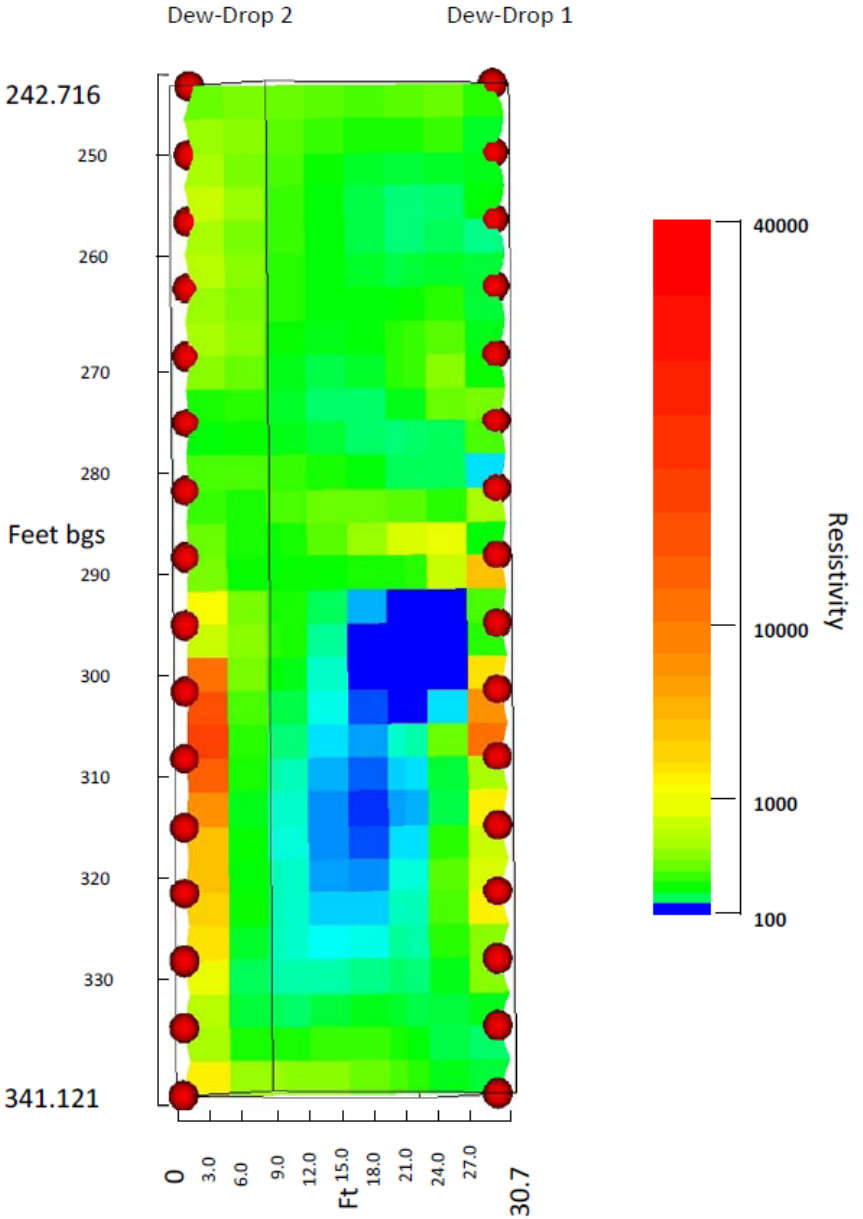
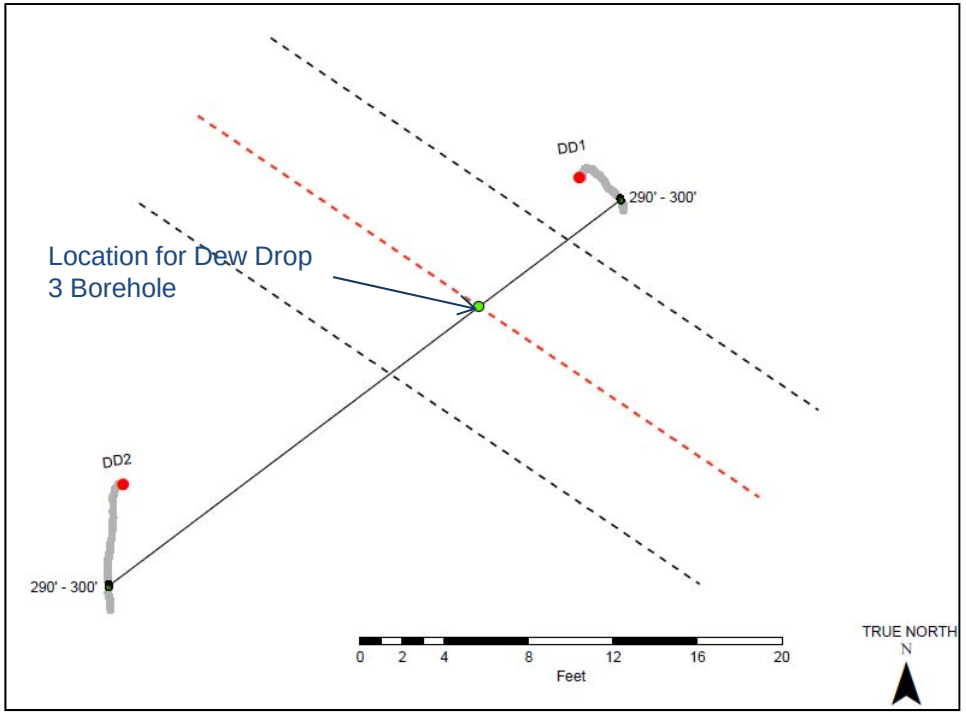


Figure 13. Borehole to surface data at the CDOT right of way. The adit depth is at approximately 225 feet and resembles the similar pattern as the theoretical model shown in Figure 1.

Dew Drop ERT Tunnel Locate



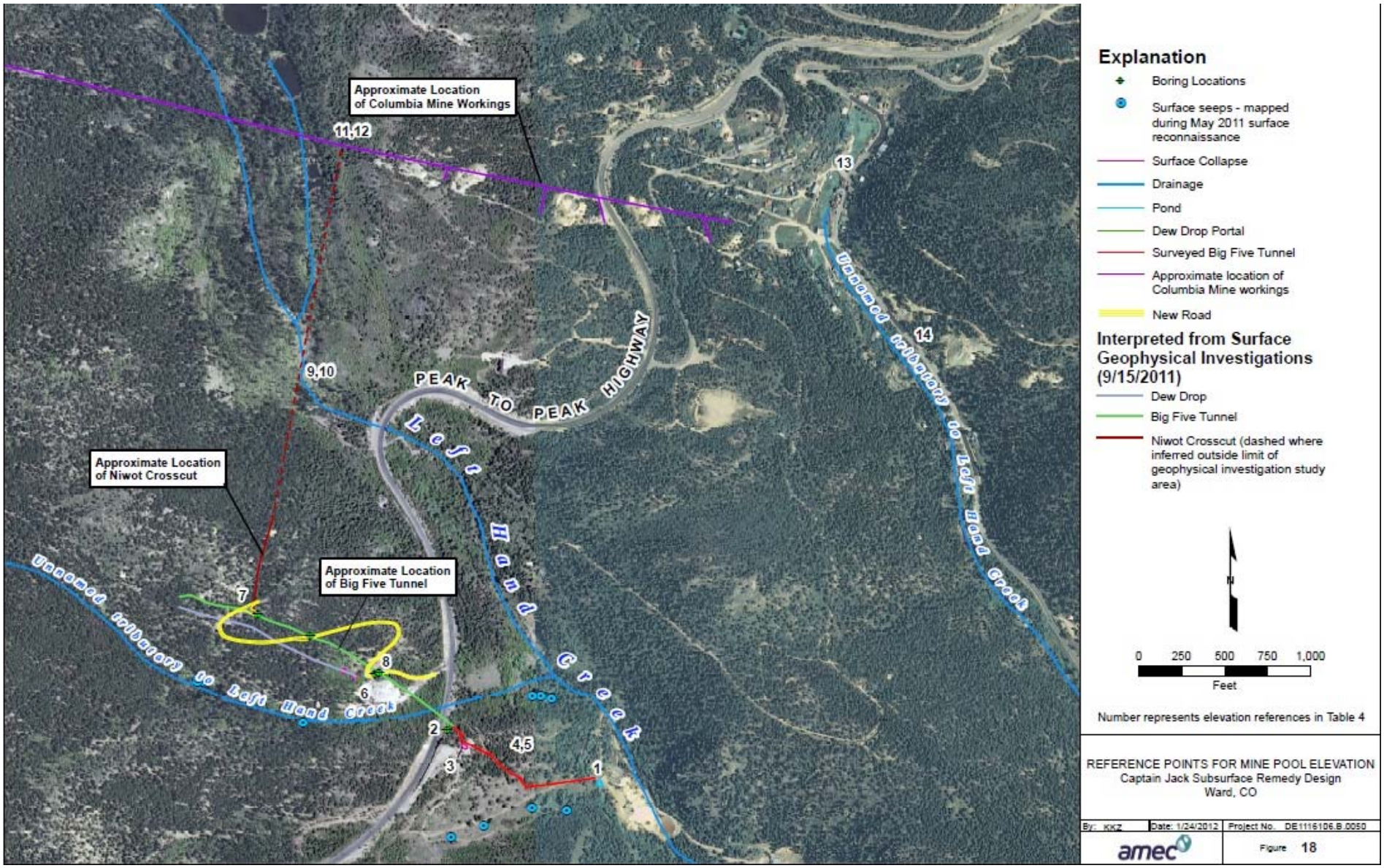


Dew Drop 3 Video in Mine

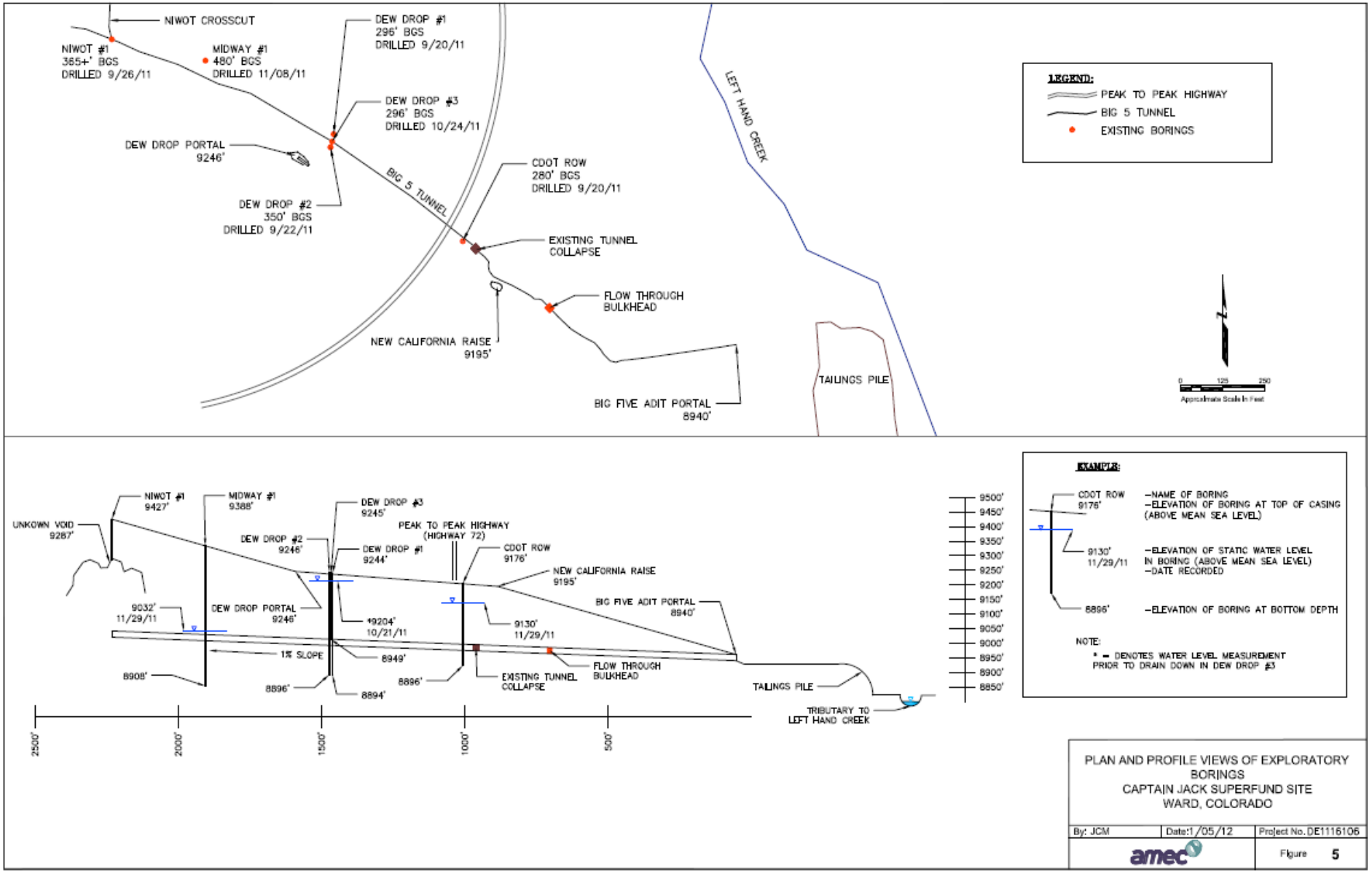
Dew Drop Permanent ERT Installation

- Dew Drop #1 and #2 fitted with ERT Array
- 32 Electrodes per each cable array per boring spaced at 6 or 12 feet
- 12 Type K thermocouples at 25 foot spacing in boreholes
- Installed between 4-inch PVC well casing and borehole wall and backfilled with sand

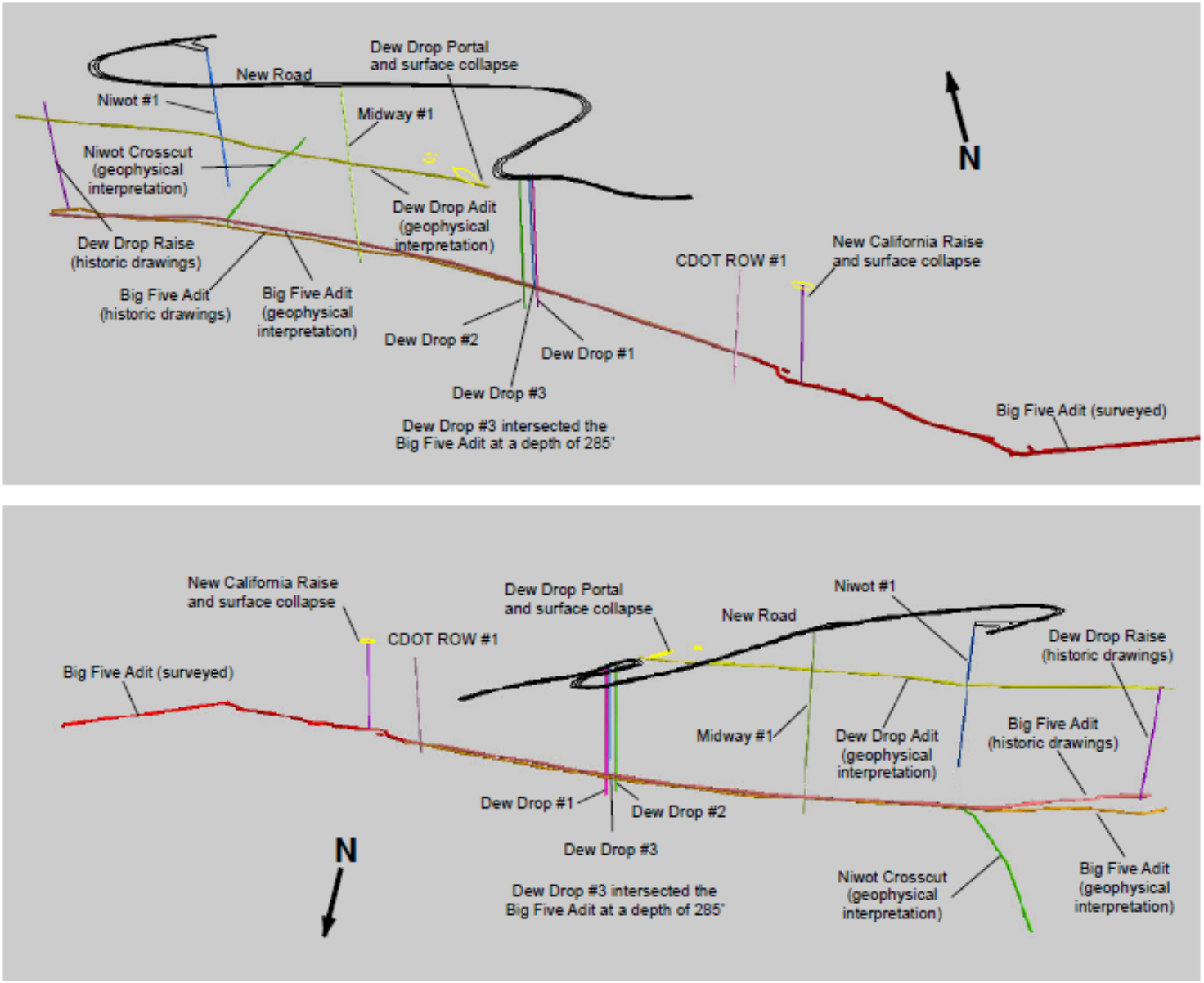
Consolidated Plan View



Plan and Profile



Oblique View



Remedy Concept

Key Engineering Objectives

- Plug Big Five Mine Tunnel to Flood Mine Workings and Eliminate Portal Discharge
- Treat Portion of Resulting Mine Pool In-Situ to Raise pH and Precipitate Metals
- Minimize Long-Term Operating and Maintenance Costs of Treatment
- Monitor Mine Pool Development and Water Quality; and Surrounding Surface and Subsurface Conditions
- Minimize Costs of Long-term Monitoring with Remote Data Acquisition

Data Gaps and Assumptions

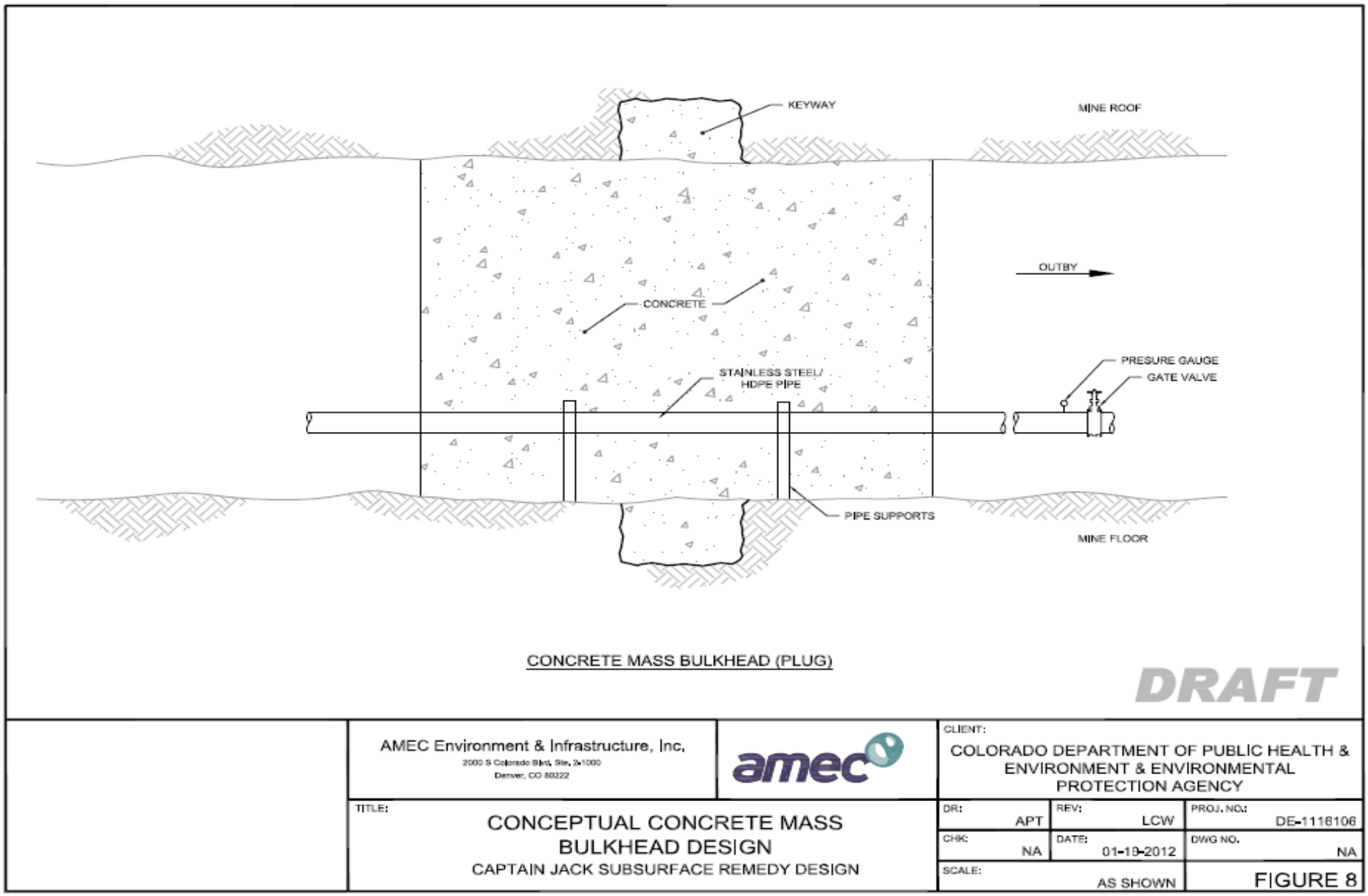
DATA GAPS:

- Condition of Mine Beyond 900 Feet
- Extent of Connected Mine Workings (Volume)
- Main Source of AMD (Columbia vein via Niwot X- cut??)
- Mine Pool Leakage Rate vs. Pressure Increase
- Equilibrium Pressure
- Potential to “flood” workings on Columbia Vein near Ward

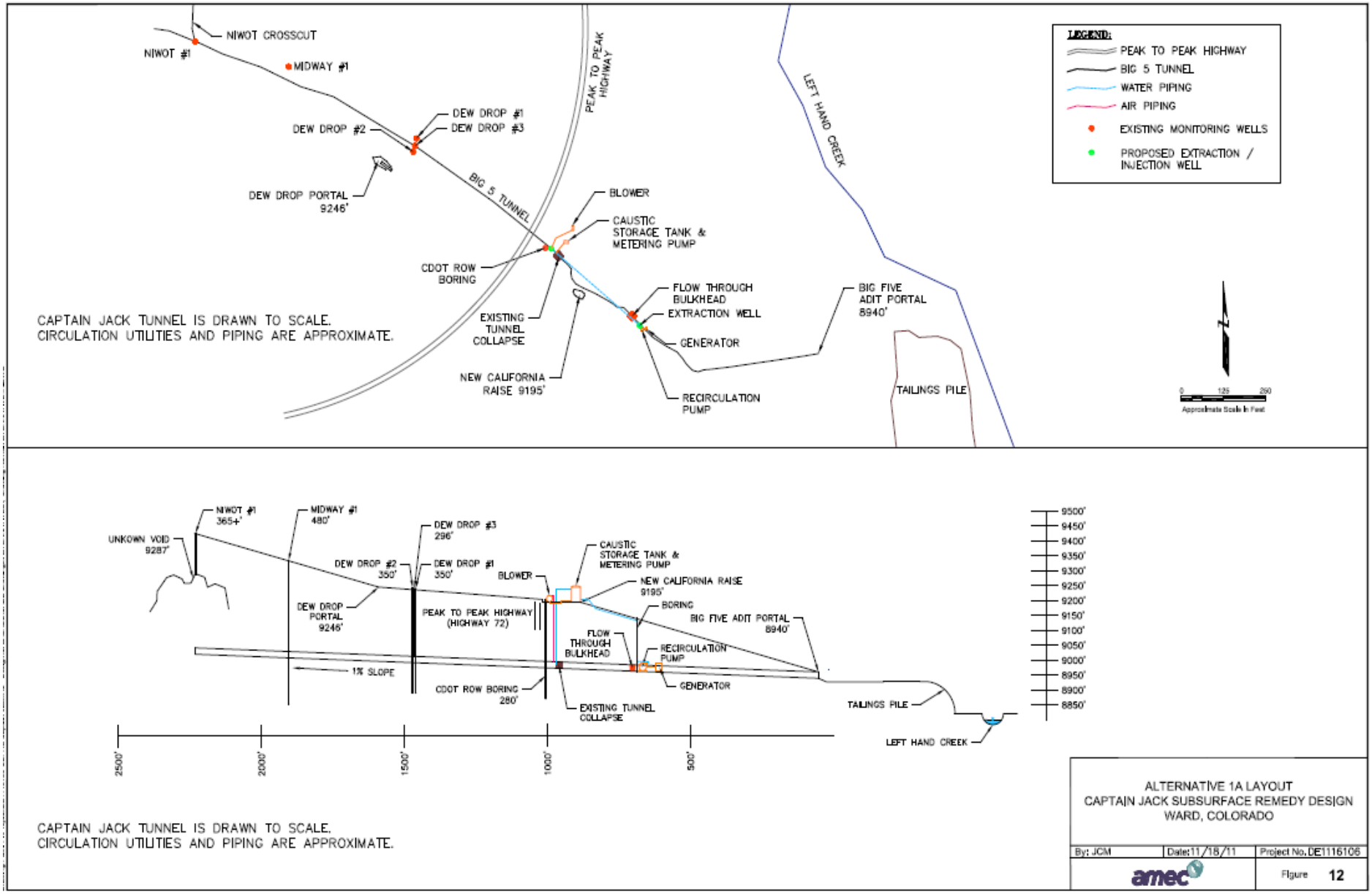
ASSUMPTIONS:

- Current Assumption: 1,000 feet of tunnel = 710,000 gallons
- Bulkhead will leak treated water suitable for discharge to creek
- New pathways for surface leaks (springs) would likely manifest east of Hwy. 72 where pressure is greatest and distance to surface is shortest

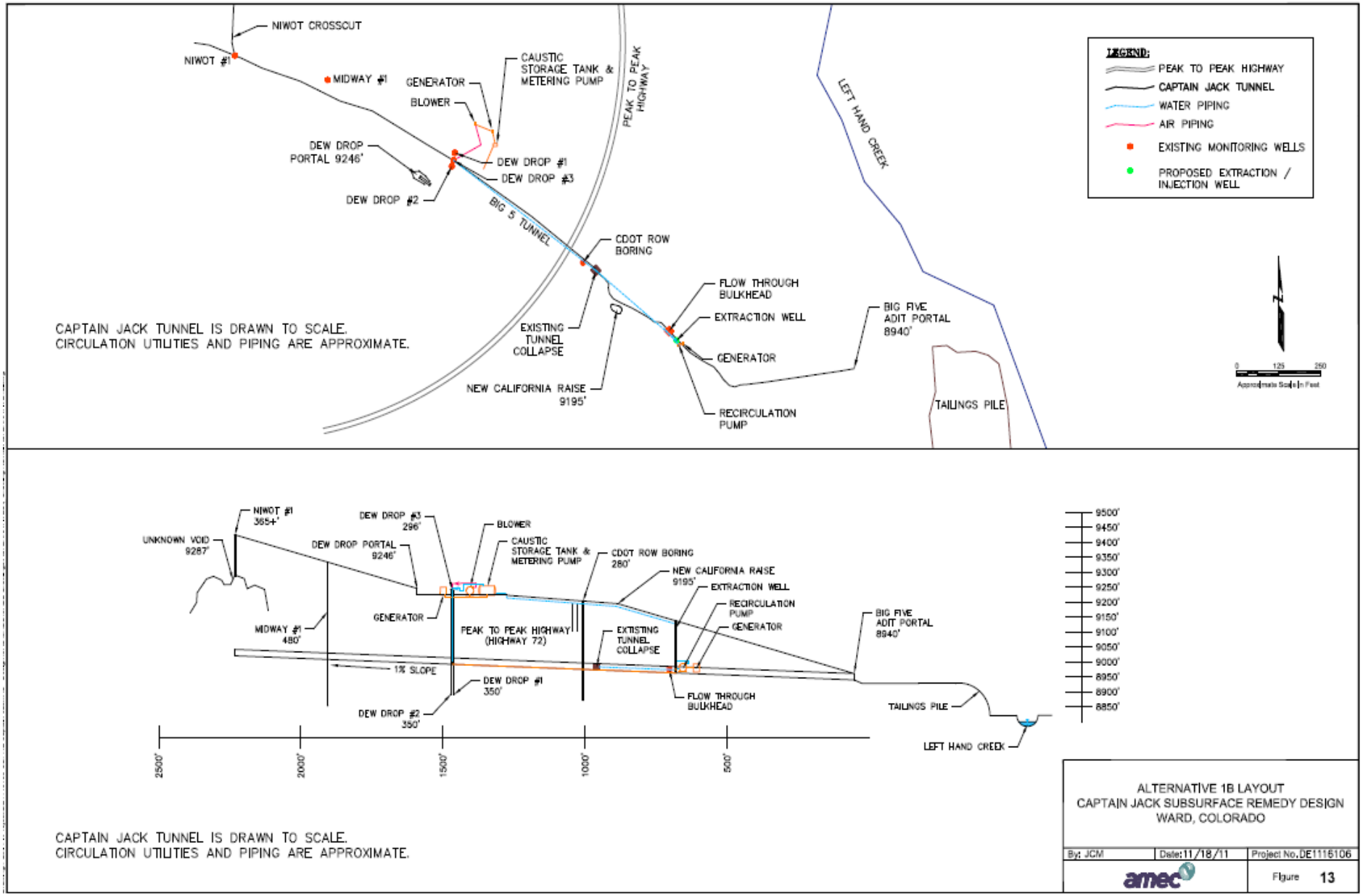
Concrete “Mass” Bulkhead



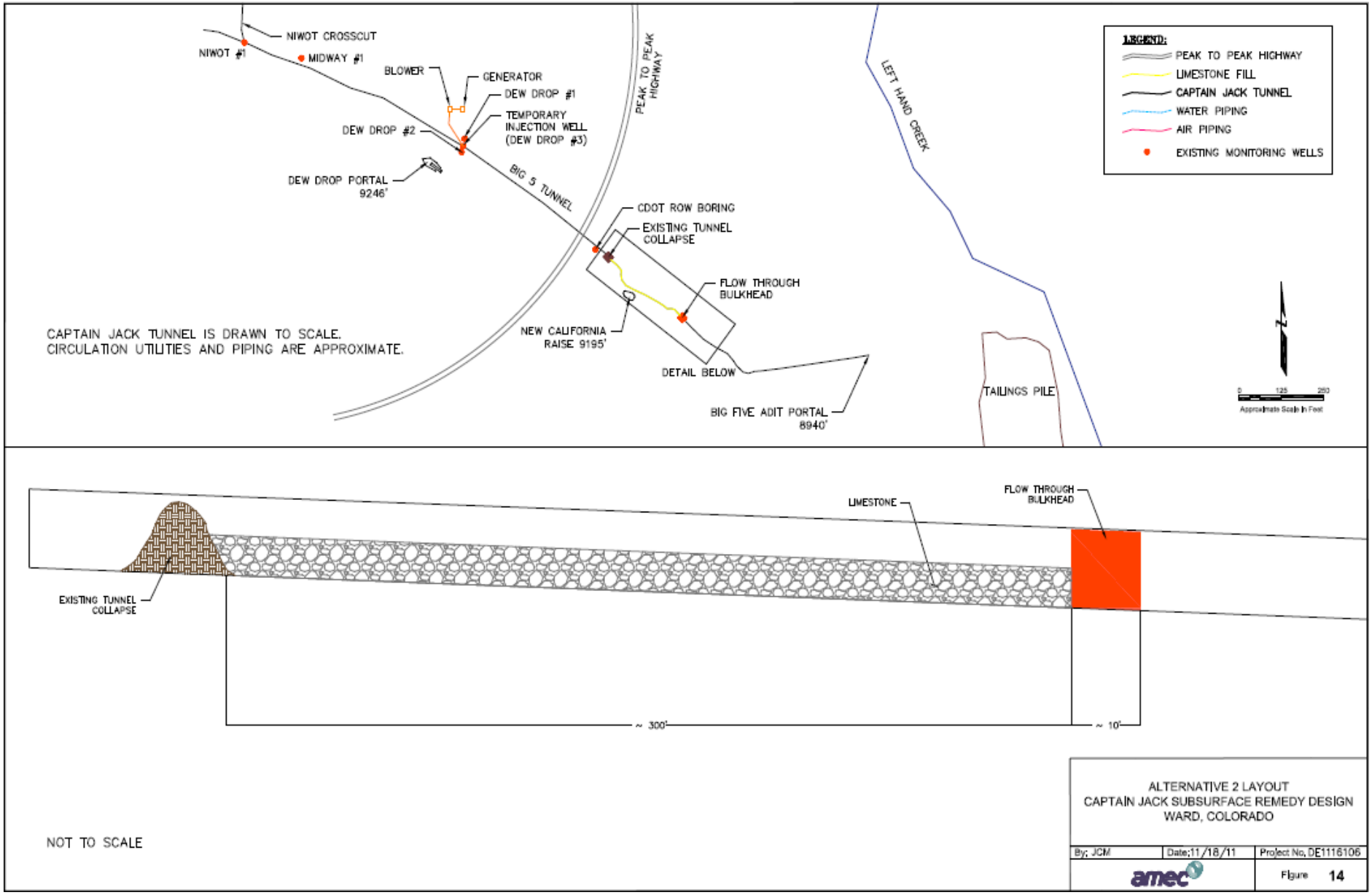
Recirculation Alternative – Short



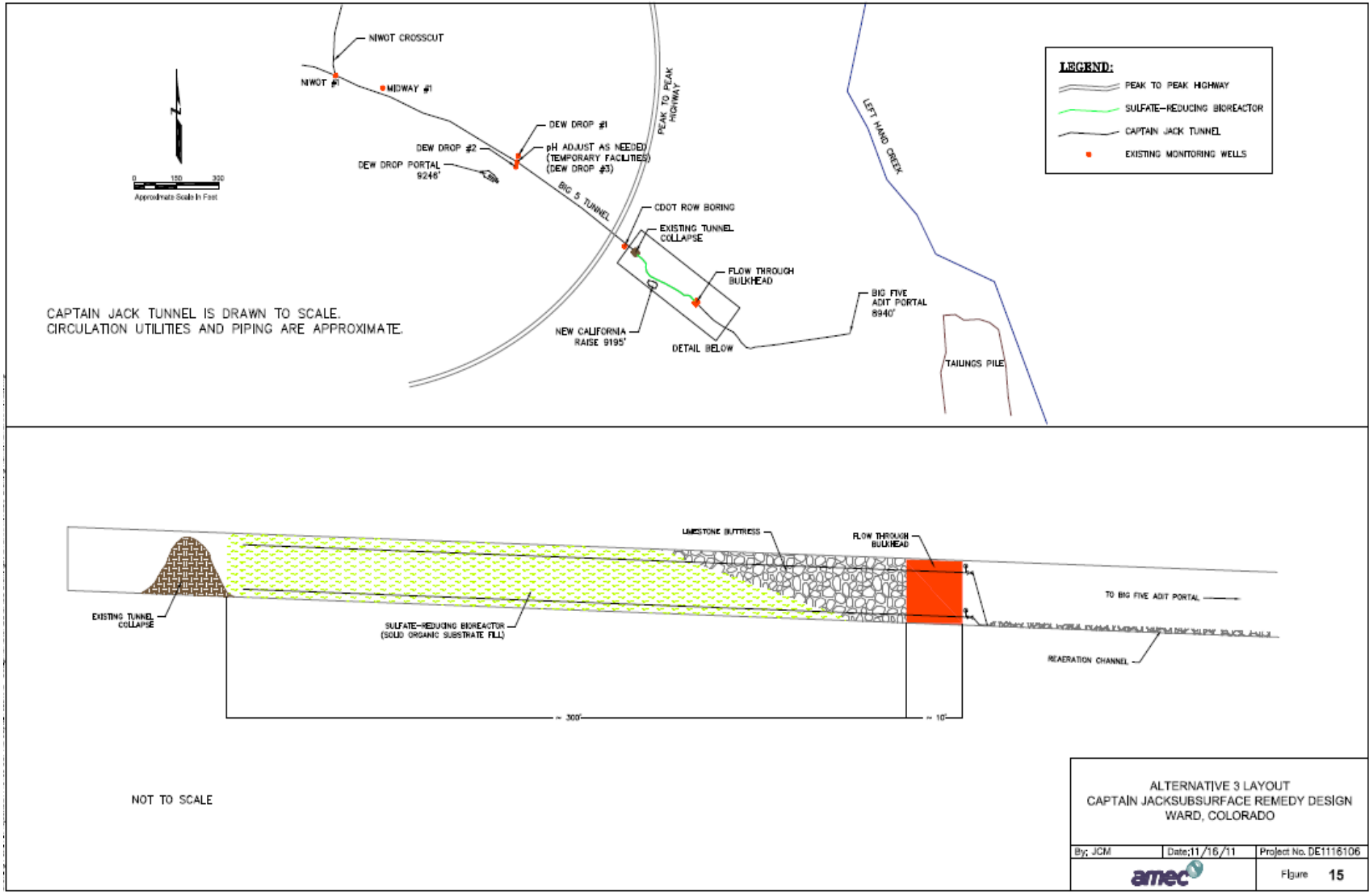
Recirculation Alternative – Long



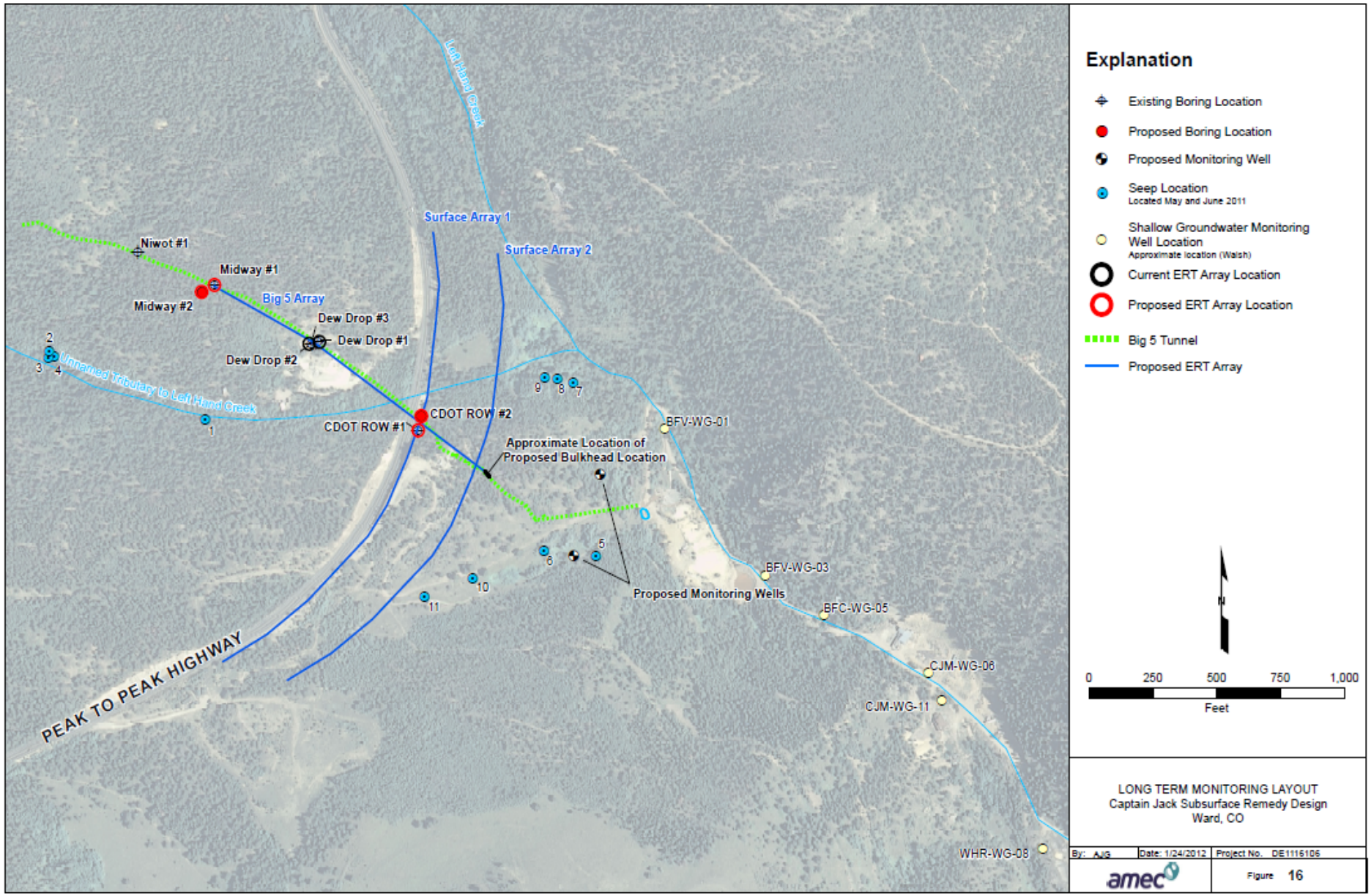
“Passive” Limestone Bed



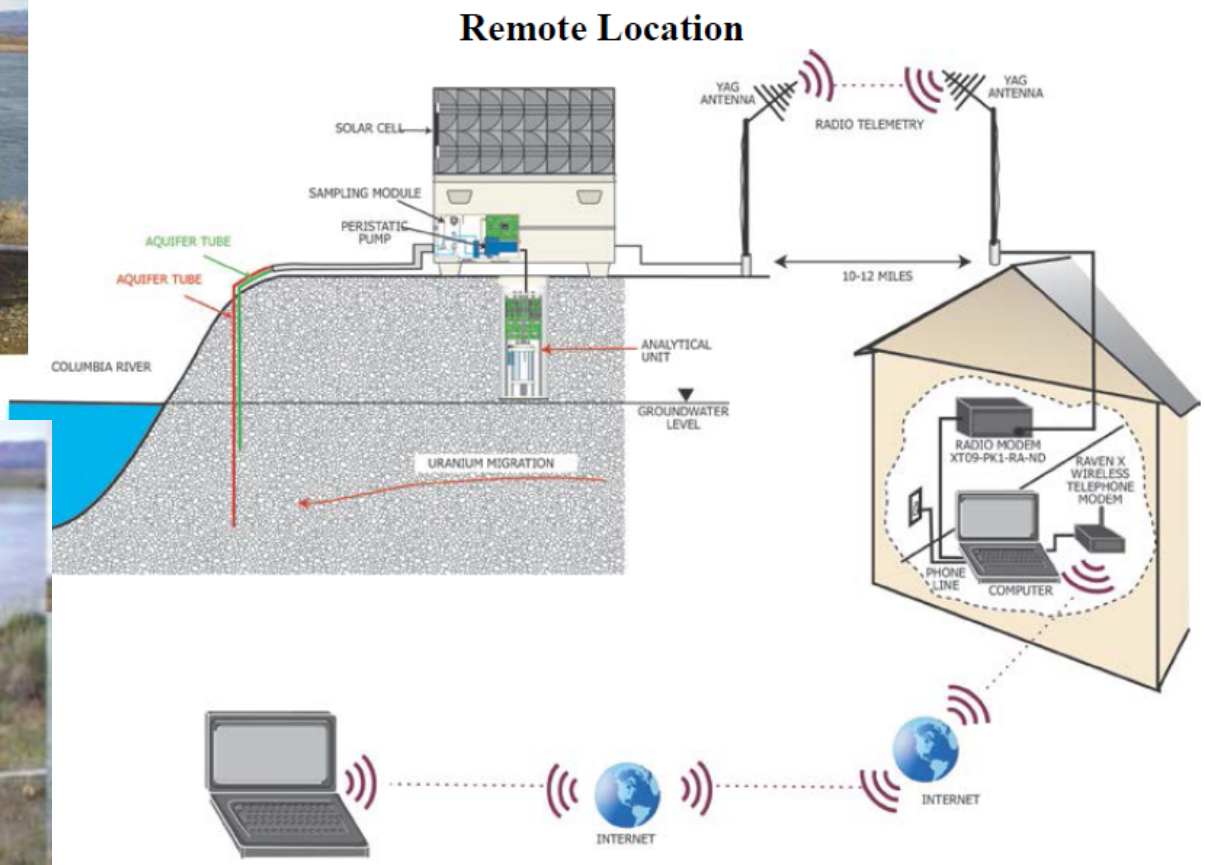
In-Situ Sulfate Reducing Bioreactor



Autonomous Long Term Monitoring - ERT

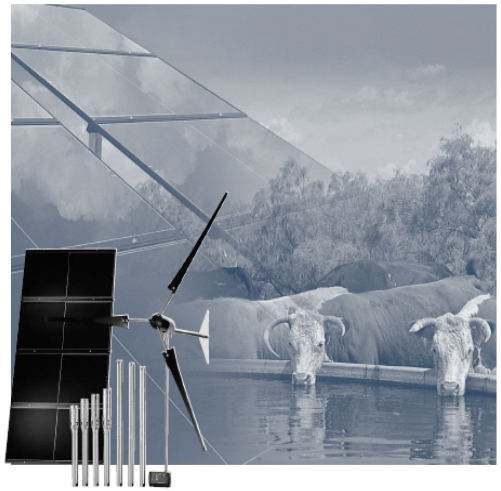


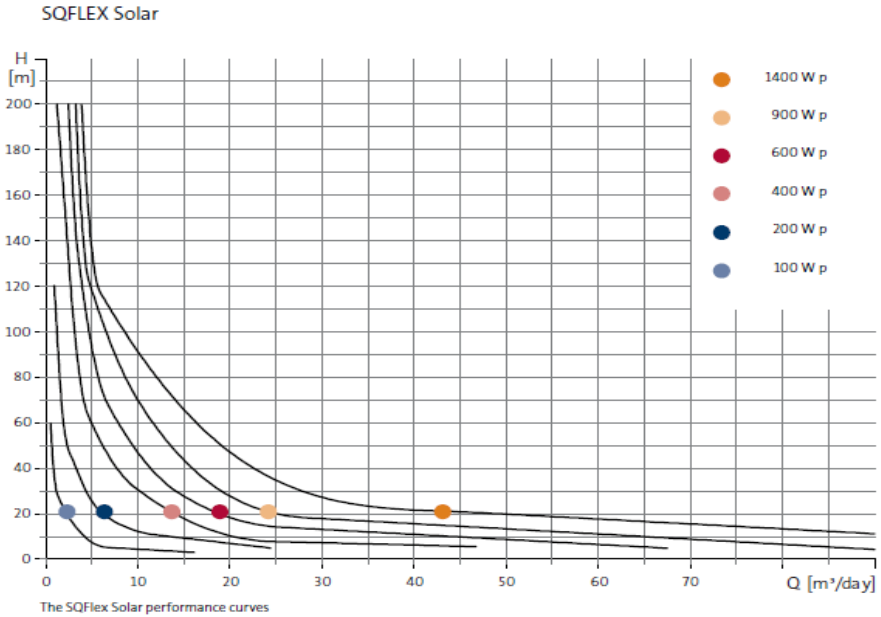
Long-Term Monitoring – Automated Samplers



Power Supply

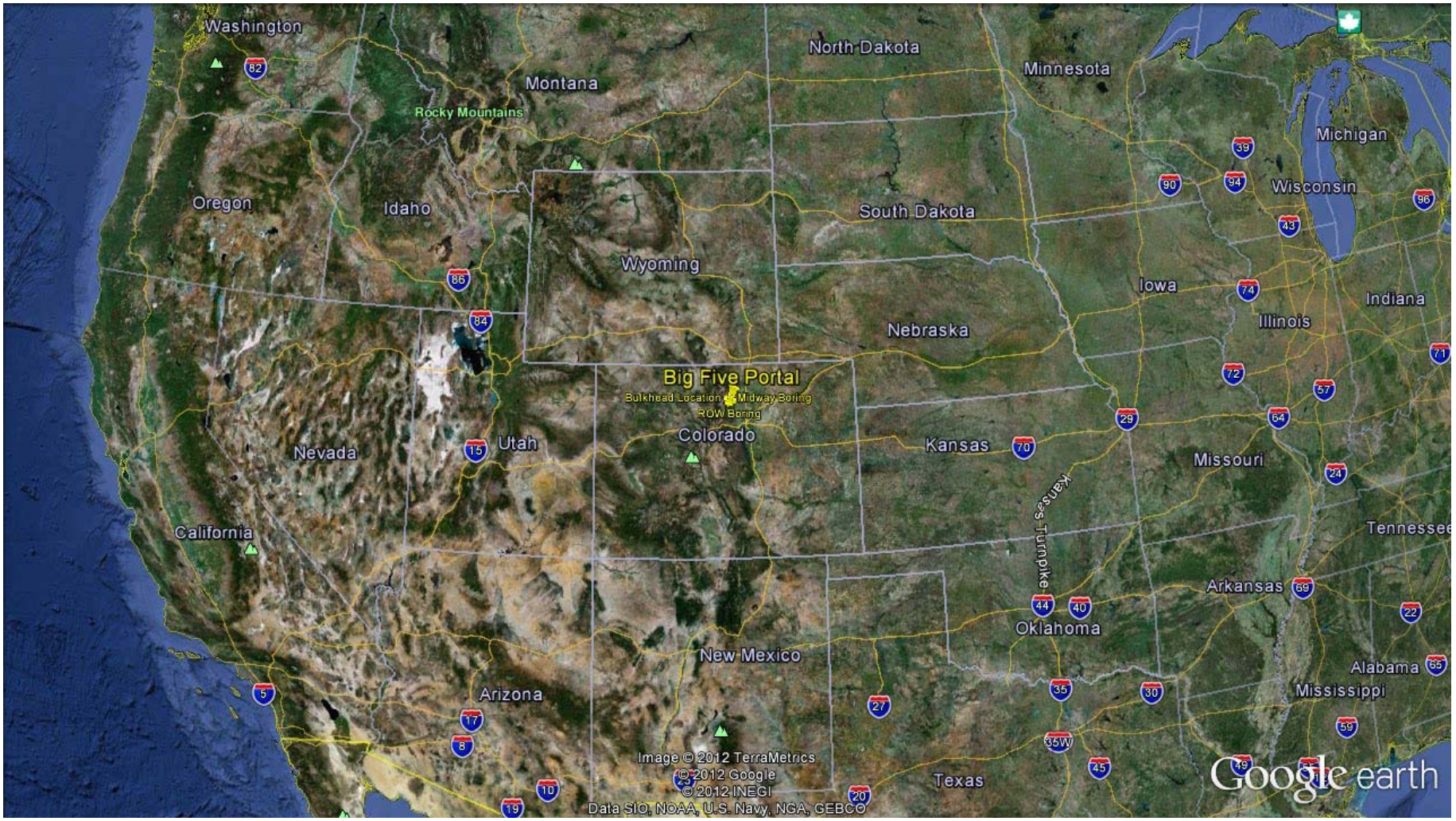
- Line Power – Not available on site; 2,500 feet to nearest potential source
- Generator – Long term maintenance; fuel storage; fuel resupply
- Wind – Erratic in this vicinity
- Solar – Good potential pending power demand
  - Estimate 3 Kw/hr max. (as needed, intermittent)
  - Estimate 500 ft^2 of PV panel – direct connect (no battery storage)





The SQFlex Solar performance curves

Thank You – Questions?



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