Aquatic Toxicity and Analytical Chemistry from Leviathan Mine and Associated Tributaries

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CERCLA Provides for:

1. Response (Clean-up)

2. Natural Resource Damage Assessment (NRDA) and Restoration

    - Primary
    - Compensatory

3. Statute requires coordinating assessments, investigations and planning (42 Section 9604(b)(2)).

NRDA Studies:

- Various studies completed for use in NRD assessments
- Toxicological studies useful for response
- Results of toxicity studies
  - Show toxicity of stream temporally and spatially
  - May provide info on drivers of toxicity

Toxicity and Chemistry Sampling Events

Date of Event	Site Conditions
April 1999	Evaporation system overflow
February 2001	Spring flow conditions
July 2011	Treatment system discharge
November 2011	Fall flow conditions

Sample Sites Across All Years

Summary

Aquatic Toxicity Tests

- Acute Lethality (96 hr) – *Oncorhynchus mykiss* (Rainbow Trout)
- Acute Lethality (48 hr) – *Ceriodaphnia dubia* (C. Dubia)
- Chronic Lethality and Reproductive Effects – C. Dubia
- Standard test organisms
  - Estimate the safe or "no effect" concentration - concentration which permits normal propagation of aquatic life.
  - Results used to assess injury to aquatic resources caused by releases.

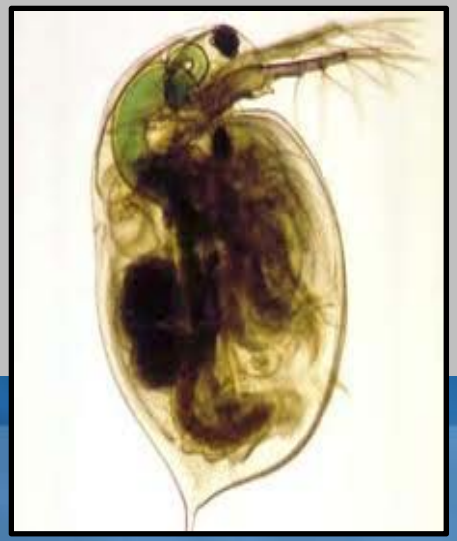
Analytical Chemistry and Water Quality Parameters

- pH, DO, Specific Conductivity, DOC, TOC, Alkalinity, Chloride, Sulfate
- Al, As, B, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Hg, Pb, Ni, K, Se, Na, Sr, Tl, Zn

Test Organisms

<u>C. Dubia</u> adopted for use in standard toxicity testing because:

- Ubiquitous in freshwater bodies and wide range of habitats
- Critical component in aquatic food chains.
- Short life cycle.
- Sensitive to broad range of contaminants.
- Widely used as test organism for evaluating toxicity of chemicals.



Test Organisms

<u>Trout</u> adopted for use in standard toxicity testing because:

- Extensive toxicological database.
- Ubiquitous in montaine stream ecosystems
- Proven sensitivity to aquatic toxicants.
- Relevant due to commercial and recreational value.
- Widespread availability.

METHODS – TOX STUDIES AND CHEMISTRY

Acute survival test with rainbow trout (96 hr) and C. Dubia (48 hr)

- Organisms were exposed to series of dilutions.
- Number of live organisms determined.
- The resulting survival data analyzed to evaluate impairment due to the surface water samples.

Chronic (three brood) survival & reproduction test with C. Dubia

- Short-term chronic test - Expose females to dilutions for the length of time to produce 3 broods (typically 6-8 days).
- Survival of female monitored during chronic exposure.
- Mean # of offspring born during test duration determined.

RESULTS

1999 Sampling Effort –

- Evaporation Ponds at Leviathan Mine began to overflow into Leviathan Creek – January 1999.
- Est. 8 million gallons of AMD were released from the ponds.
- Field collections on April 5, 1999.

99 Winter

Acute Toxicity Test – Rainbow Trout Survival

Station	Station Description	NOEC	LOEC	LC50
1	Aspen Creek, upstream of Leviathan Mine	100 %	NA	NA
17	**Leviathan Creek below confluence with Aspen**	**25 %**	**50 %**	**35%**
5	**Leviathan Creek above confluence with Mountaineer**	**25 %**	**50 %**	**35%**
6	Mountaineer Creek above confluence with Leviathan	100 %	NA	NA
7	**Bryant Creek below confluence with Mountaineer**	**50 %**	**100 %**	**75 %**
9	Bryant Creek above Doud Springs	100 %	NA	NA
10	Bryant Creek upstream of confluence with East Carson	100 %	NA	NA
11	East Fork Carson upstream of Bryant Creek	100 %	NA	NA
12	East Fork Carson downstream of Bryant	100 %	NA	NA
13	East Fork Carson upstream of Ruhenstroth Dam	100 %	NA	NA

Acute Toxicity Test – Daphnia Survival

Station	Station Description	NOEC	LOEC	LC50
1	Aspen Creek, upstream of Leviathan Mine	100 %	NA	NA
17	**Leviathan Creek below confluence with Aspen**	**12.5 %**	**25 %**	**14 %**
5	**Leviathan Creek above confluence with Mountaineer**	**12.5 %**	**25 %**	**16 %**
6	Mountaineer Creek above confluence with Leviathan	100 %	NA	NA
7	**Bryant Creek below confluence with Mountaineer**	**50 %**	**100 %**	**68 %**
9	Bryant Creek above Doud Springs	100 %	NA	NA
10	Bryant Creek upstream of confluence with East Carson	100 %	NA	NA
11	East Fork Carson upstream of Bryant Creek	100 %	NA	NA
12	East Fork Carson downstream of Bryant	100 %	NA	NA
13	East Fork Carson upstream of Ruhenstroth Dam	100 %	NA	NA

99 Winter

Chronic Toxicity Test – Daphnia Survival

Station	Station Description	NOEC	LOEC	IC25
1	Aspen Creek, upstream of Leviathan Mine	100 %	NA	NA
17	**Leviathan Creek below confluence with Aspen**	**<6.25 %**	**6.25 %**	**7 %**
5	**Leviathan Creek above confluence with Mountaineer**	**<6.25 %**	**6.25 %**	**5 %**
6	Mountaineer Creek above confluence with Leviathan	100 %	NA	NA
7	**Bryant Creek below confluence with Mountaineer**	**25 %**	**50 %**	**11 %**
9	**Bryant Creek above Doud Springs**	**25 %**	**50 %**	**36 %**
10	**Bryant Creek upstream of confluence with East Carson**	**25 %**	**50 %**	**24 %**
11	East Fork Carson upstream of Bryant Creek	100 %	NA	NA
12	East Fork Carson downstream of Bryant			
13	East Fork Carson upstream of Ruhenstroth Dam	100 %	NA	NA

99 Winter

Trout and C. Dubia Acute Toxicity Observed at:

Stations 17, 5, 7

C. Dubia Chronic Toxicity Observed at:

Stations 17, 5, 7 9,10

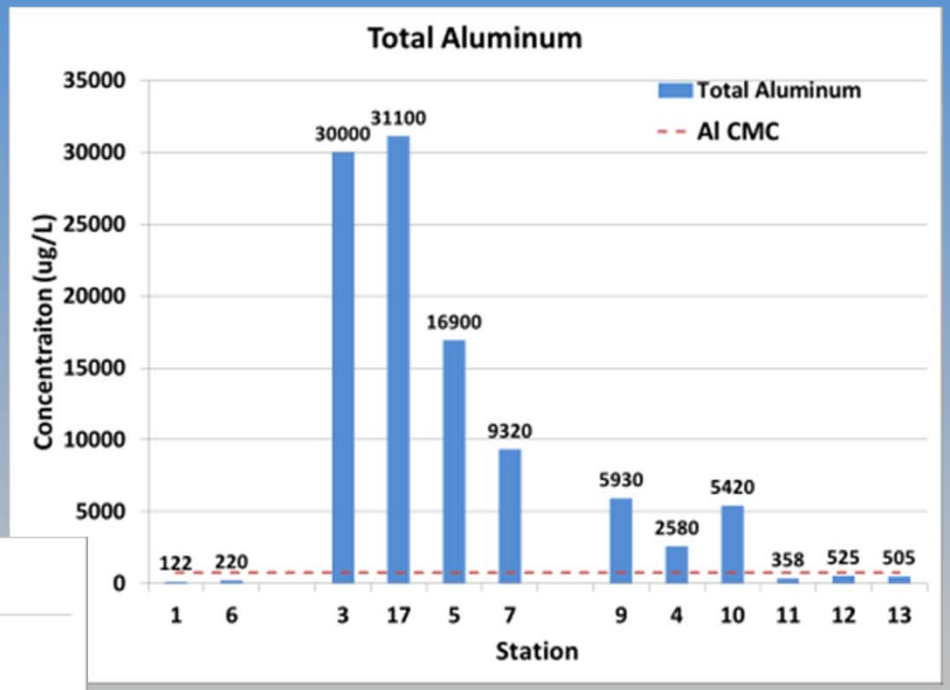
99 Winter

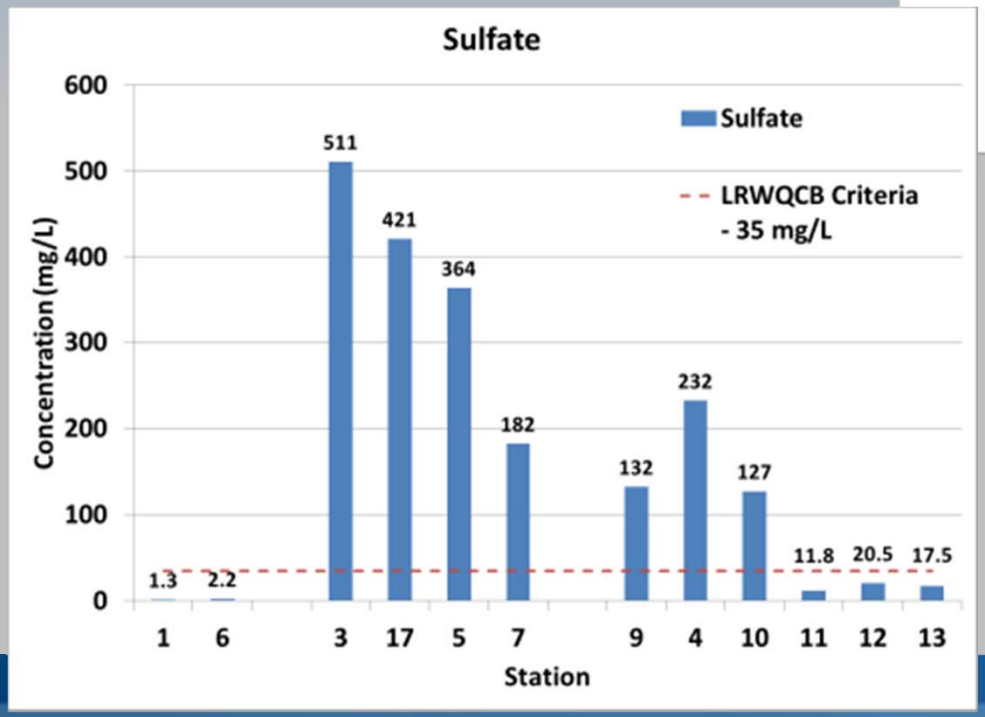
East Fork Carson River
Station 10
Station 9
Doud Springs
Chronic Toxicity Observed
Acute Toxicity Observed – Trout and Daphnia
Station 17
Station 5
Station 7
Bryant Creek
Aspen Creek
Mountaineer Creek
©2012 Google
Google earth
Imagery Date: 7/29/2012
38°45'43.60" N 119°40'03.02" W elev 5984 ft
Eye alt 44932 ft

99 Winter

Suite of 20 constituents analyzed

Al $_{tot}$ and Sulfate selected as representative of trends observed across years and sites





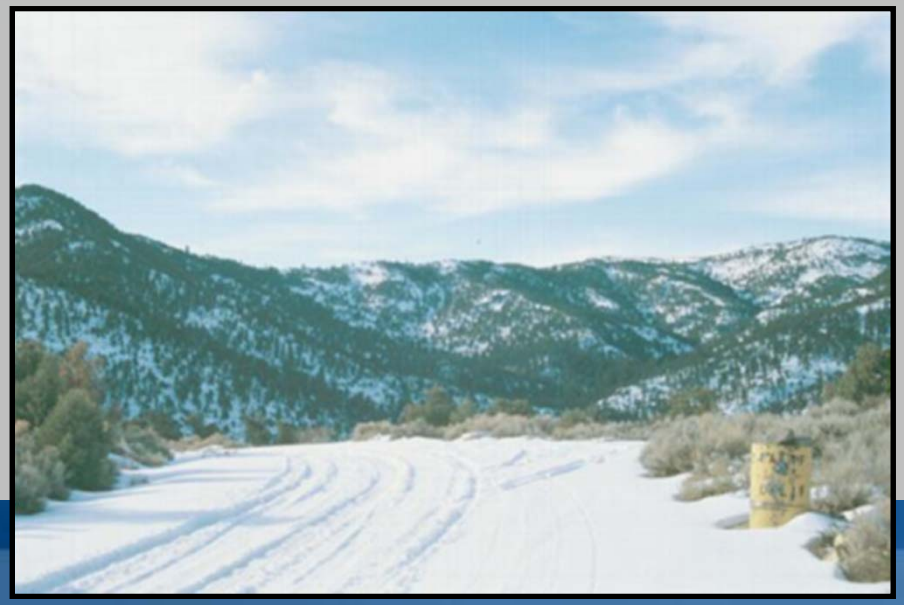
99 Winter

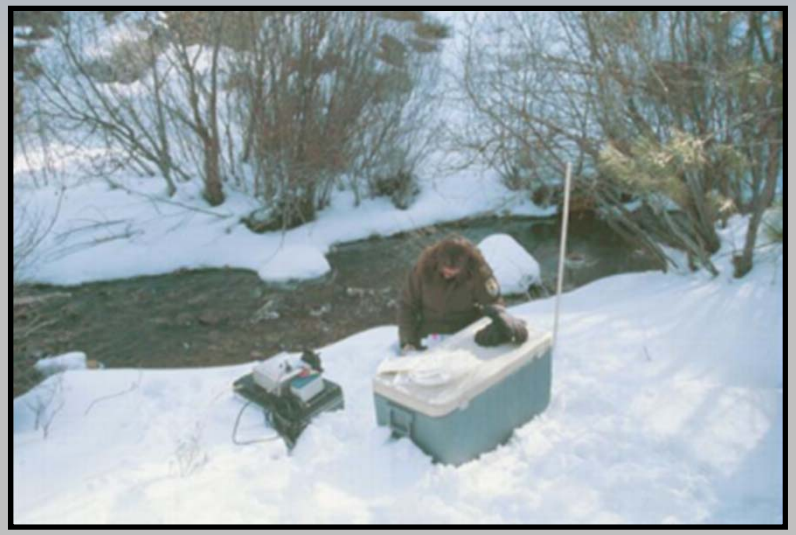
Water Quality Exceedances Observed

Analyte	Stations		
Al_t,	1,6,11	3,4,17,5,7	9,10,12,13
Cd		3,17, 5,7	9,10
Cu		3,17, 5,7	
Fe_d		3,17,5, 7	
Mn		3,4,17,5,7	9,10
Ni		3,17,5,7	9,10
Se		4	
SO_4		3,17, 5, 7	

2001 Sampling Effort –

- Field collections on Feb. 28, 2001
- Treatment ponds not overflowing
- Only AMD entering watershed from runoff and seeps associated with Leviathan Mine.





01 Winter

No Trout Acute Toxicity was observed at any Station

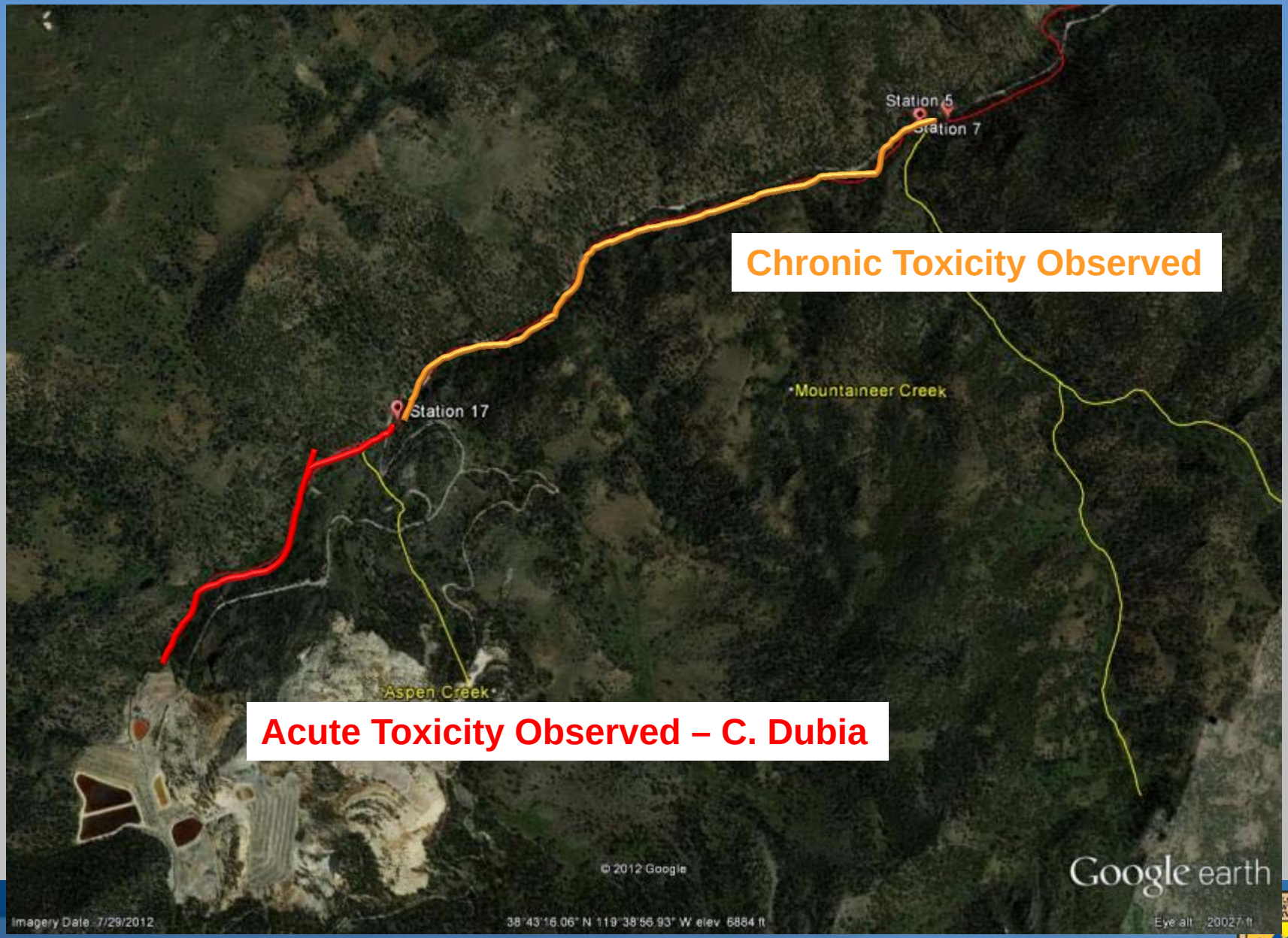
C. Dubia Acute Toxicity Observed at:

Station 17

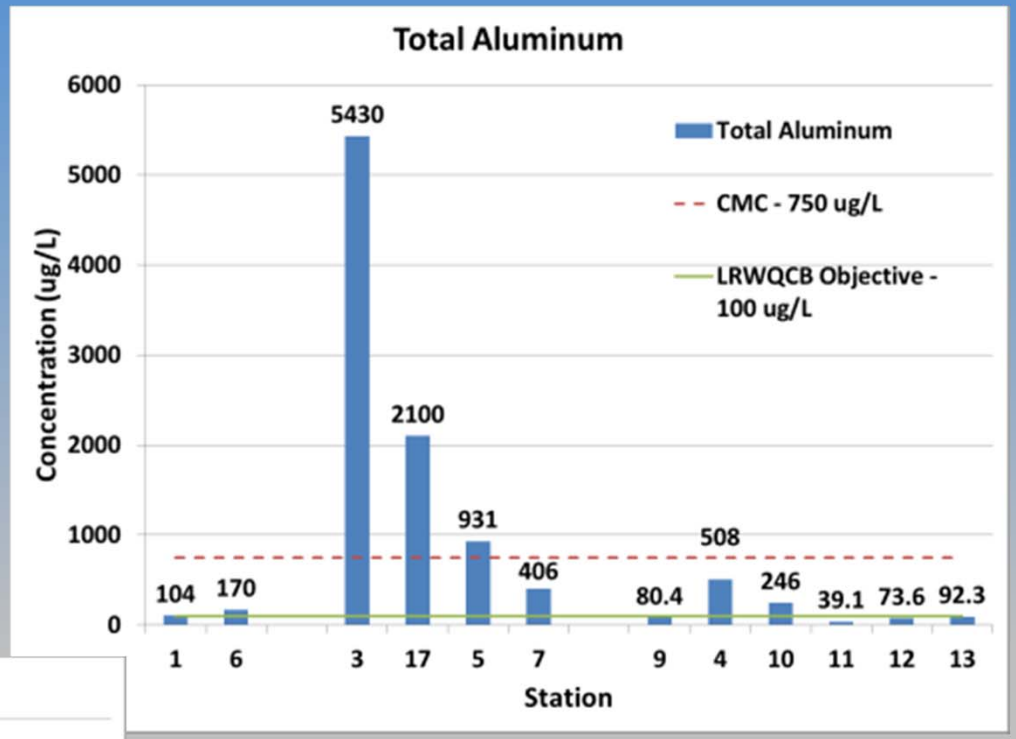
C. Dubia Chronic Toxicity Observed at:

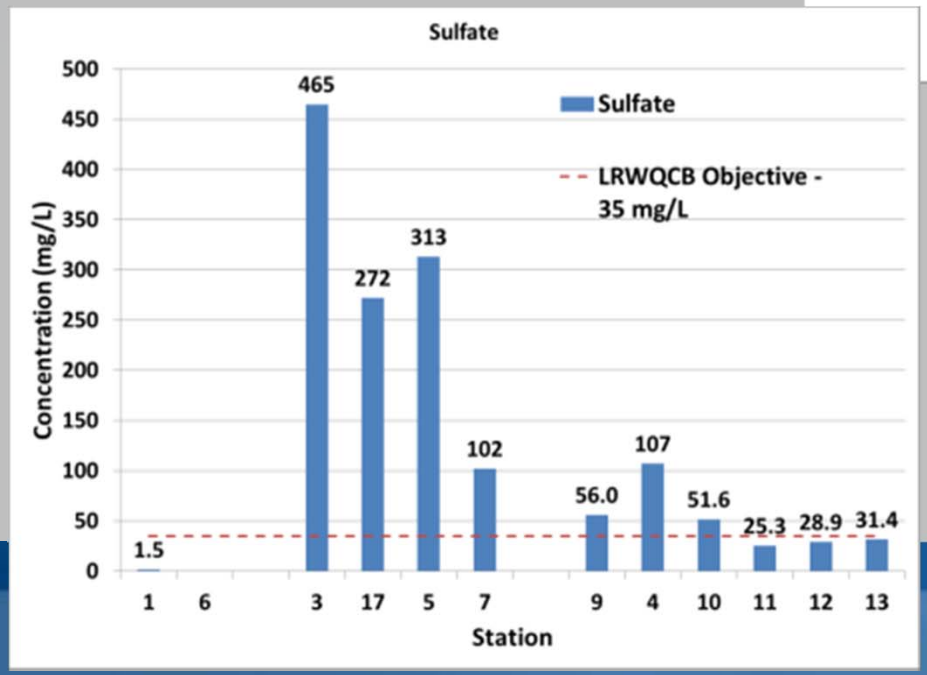
Station 17, 5, 7

01 Winter


Station 5
Station 7
Chronic Toxicity Observed
Mountaineer Creek
Station 17
Aspen Creek
Acute Toxicity Observed – C. Dubia
© 2012 Google
Google earth
Imagery Date: 7/29/2012
38°43'16.06" N 119°38'56.93" W elev 6884 ft
Eye alt 20027 ft

01 Winter


Total Aluminum
Concentration (ug/L)
6000
5000
4000
3000
2000
1000
0
Total Aluminum
CMC - 750 ug/L
LRWQCB Objective - 100 ug/L
104
170
5430
2100
931
406
80.4
508
246
39.1
73.6
92.3
1
6
3
17
5
7
9
4
10
11
12
13
Station


Sulfate
Concentration (mg/L)
500
450
400
350
300
250
200
150
100
50
0
Sulfate
LRWQCB Objective - 35 mg/L
1.5
465
272
313
102
56.0
107
51.6
25.3
28.9
31.4
1
6
3
17
5
7
9
4
10
11
12
13
Station

01 Winter

Water Quality Exceedances Observed

Analyte	Stations		
Al_t,	1,6	3,17,4,5,7	10,13
Fe_d		3,17,5	
Mn		3,17,5,7	
Ni		3	
Se		4	
SO_4		3,17, 4, 5, 7	

2011 Summer Sampling Effort

- Field collections on July 27, 2011.
- AMD being treated and released.
- Water collected directly from output streams from each treatment process – Biphasic Treatment, HDS, Aspen Bioreactor.

11 Summer

No Trout Acute Toxicity was observed at any Station

C. Dubia Acute Toxicity Observed at:

Station 19 (HDS Trt),
Stations 21, 17

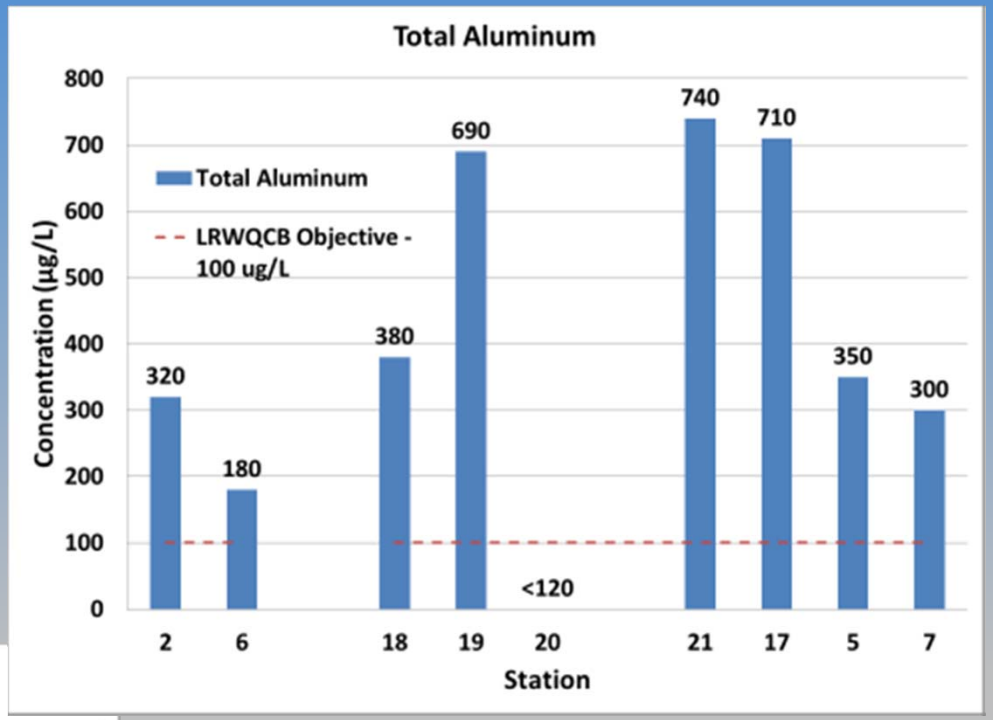
C. Dubia Chronic Toxicity Observed at:

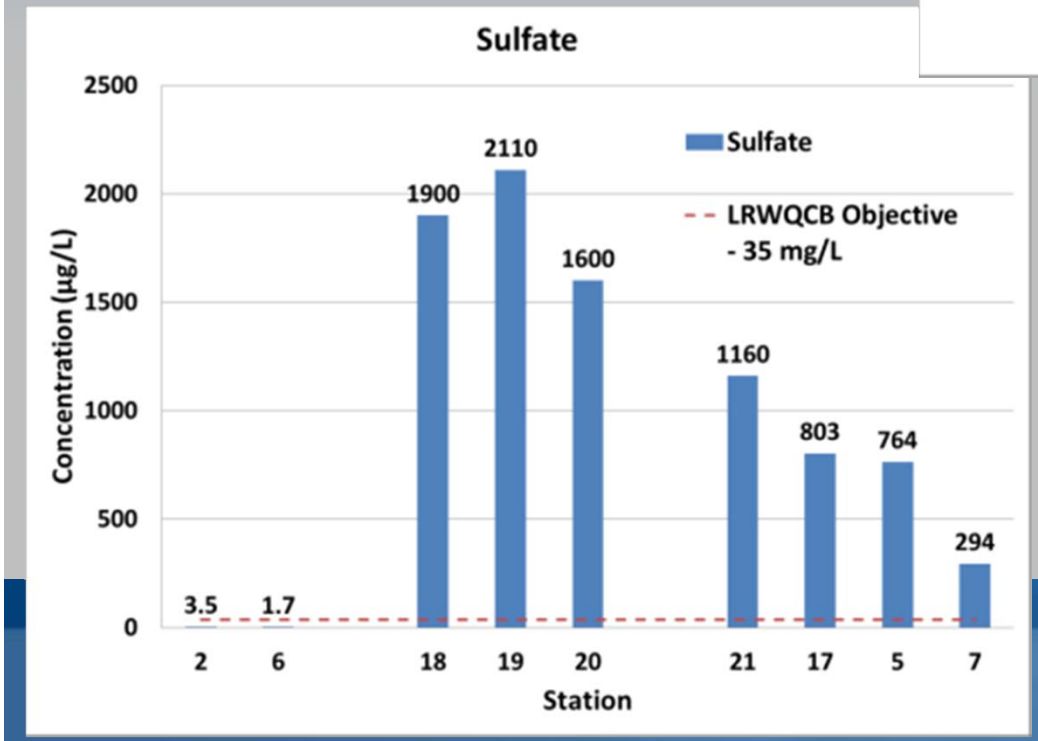
Station 18 (Biphasic), 19 (HDS), 20 (Bioreactor),
Station 21

11 Summer

Station 17
Station 21
Acute Toxicity Observed - Daphnia
tation 20
Station 19
Chronic Toxicity Observed
Aspen Creek
Station 18
Leviathan Mine
© 2012 Google
Google earth
Imagery Date: 6/14/2011
38°42'40.33" N 119°39'22.00" W elev 7096 ft
Eye alt 14931 ft

11 Summer


Total Aluminum
Concentration (µg/L)
800
700
600
500
400
300
200
100
0
Total Aluminum
LRWQCB Objective - 100 ug/L
320
180
380
690
<120
740
710
350
300
2
6
18
19
20
21
17
5
7
Station


Sulfate
Concentration (µg/L)
2500
2000
1500
1000
500
0
Sulfate
LRWQCB Objective - 35 mg/L
3.5
1.7
1900
2110
1600
1160
803
764
294
2
6
18
19
20
21
17
5
7
Station

11 Summer

Water Quality Exceedances Observed

Analyte	Stations		
Al_t,	18, 19	2, 6	21, 17, 5, 7
Fe_d	19		17
Mn	19, 20		21, 17, 5
Ni			21, 17, 5
SO_4	18, 19, 20		21,17, 5, 7

2011 Fall Sampling Effort

- Field collections on November 30, 2011.
- Conditions similar to Winter 2001.
- Treatment ponds not overflowing
- Only AMD entering watershed from runoff and seeps associated with Leviathan Mine.

11 Winter

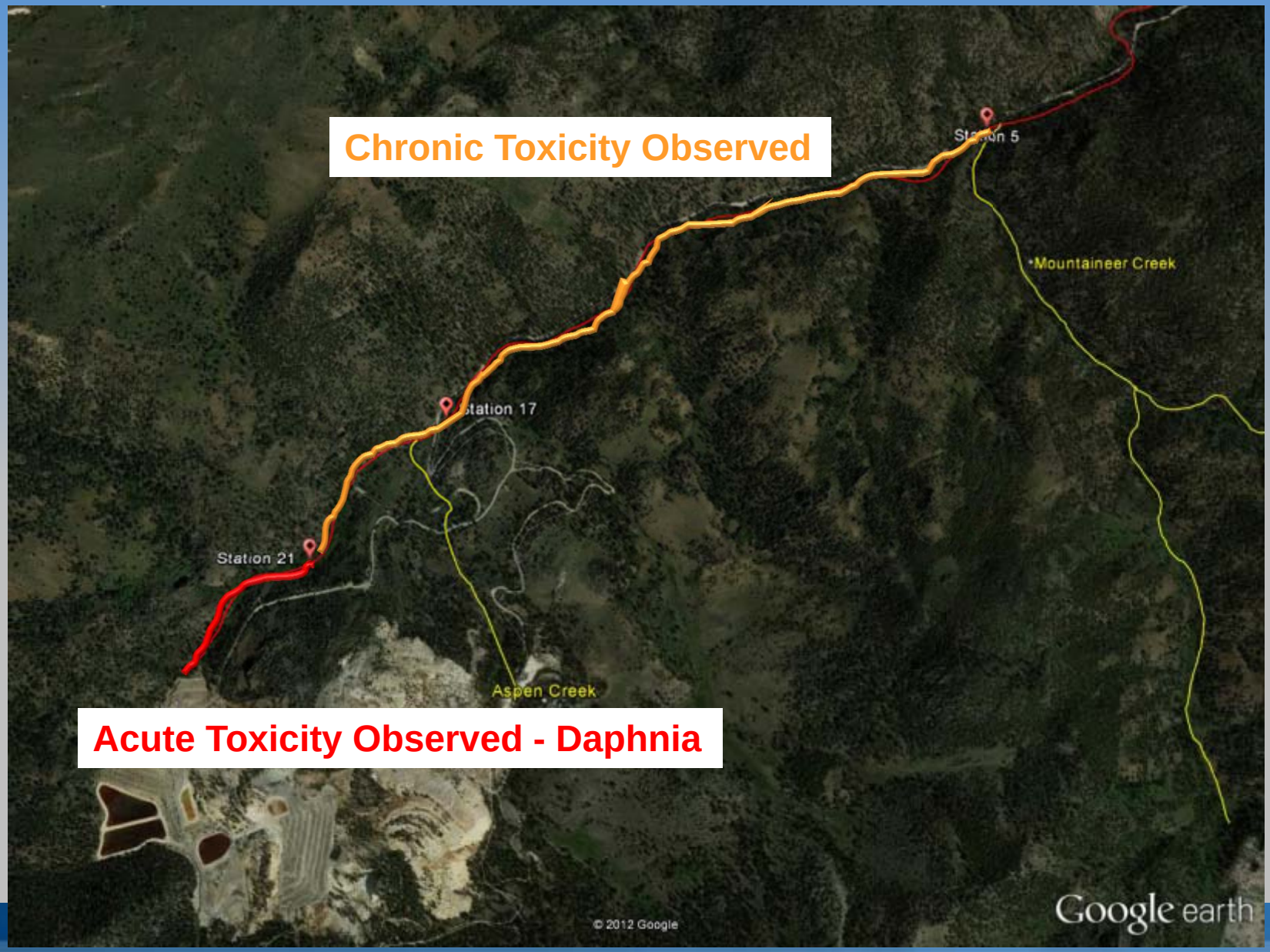
Trout and C. Dubia Acute Toxicity Observed at:

Station 21

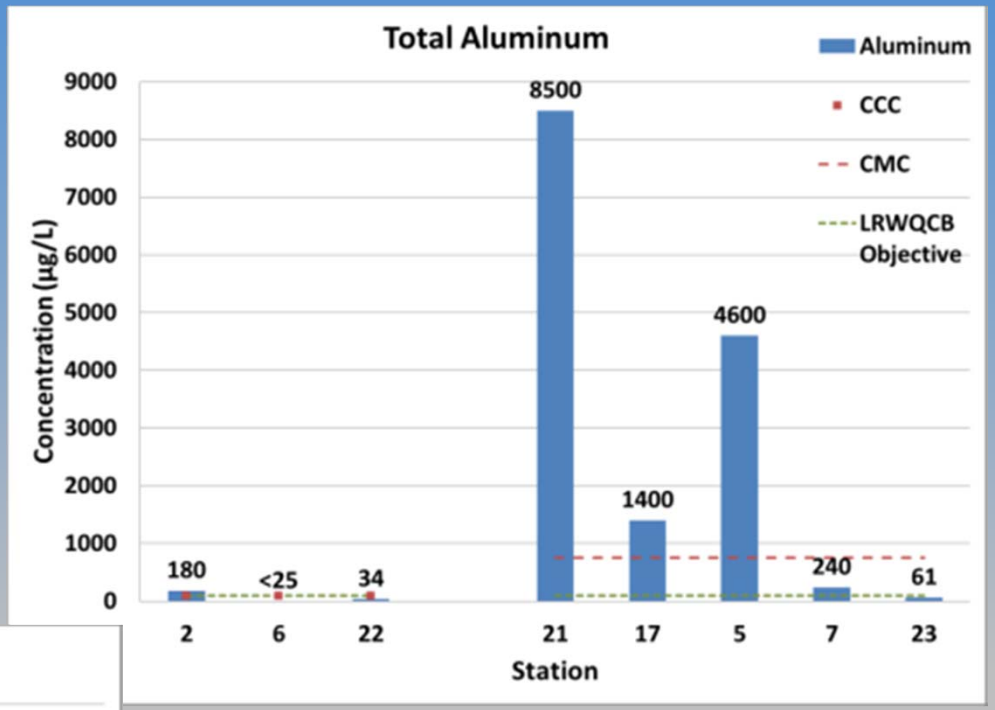
C. Dubia Chronic Toxicity Observed at:

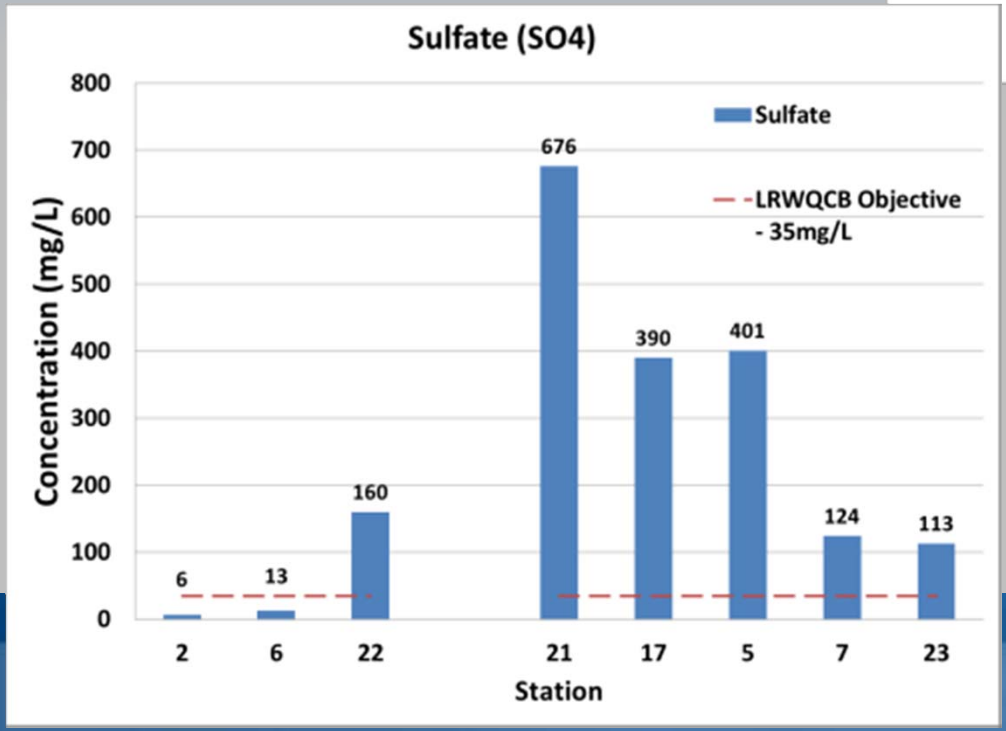
Stations 21, 17, 5

11 Fall


Chronic Toxicity Observed
Station 5
Mountaineer Creek
Station 17
Station 21
Aspen Creek
Acute Toxicity Observed - Daphnia
© 2012 Google
Google earth

11 Fall


Total Aluminum
Aluminum
CCC
CMC
LRWQCB Objective
Concentration (µg/L)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
180
<25
34
8500
1400
4600
240
61
2
6
22
21
17
5
7
23
Station

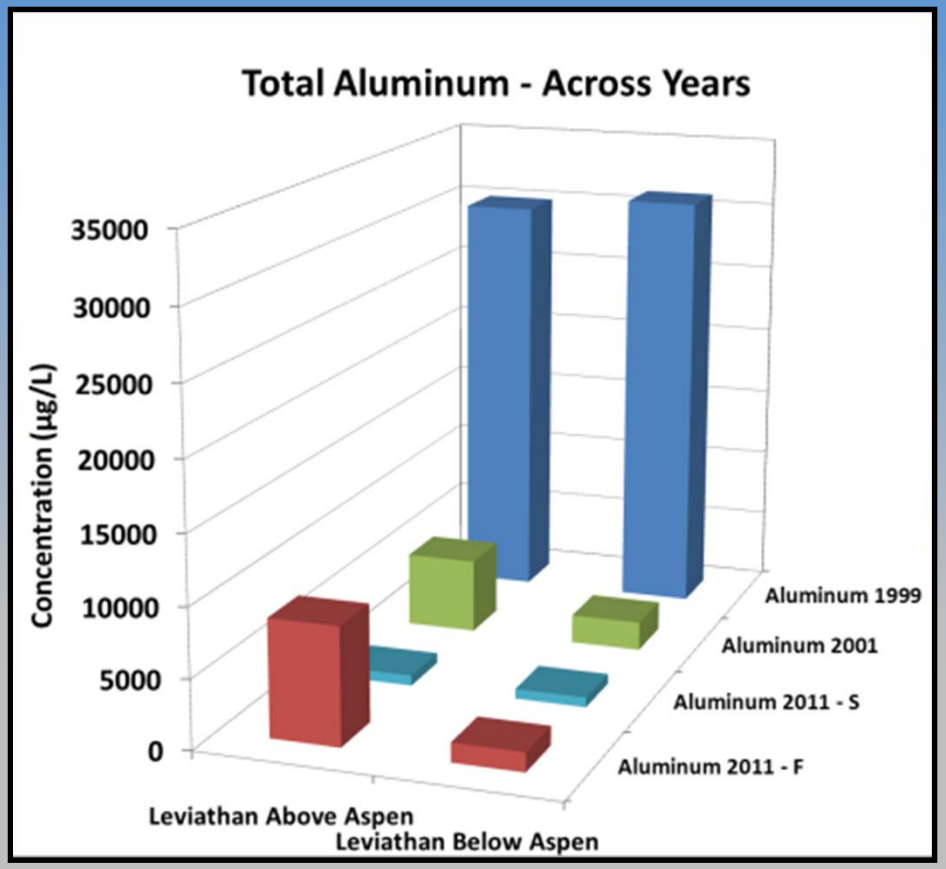

Sulfate (SO4)
Sulfate
LRWQCB Objective - 35mg/L
Concentration (mg/L)
800
700
600
500
400
300
200
100
0
6
13
160
676
390
401
124
113
2
6
22
21
17
5
7
23
Station

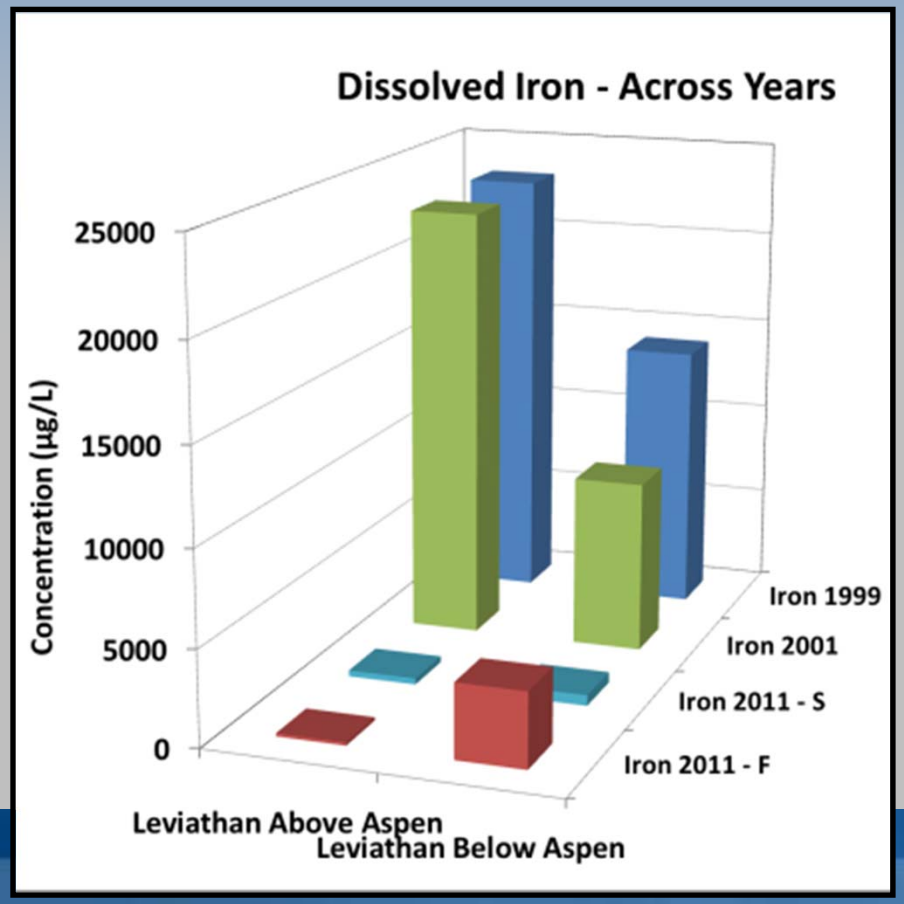
11 Winter

Water Quality Exceedances Observed

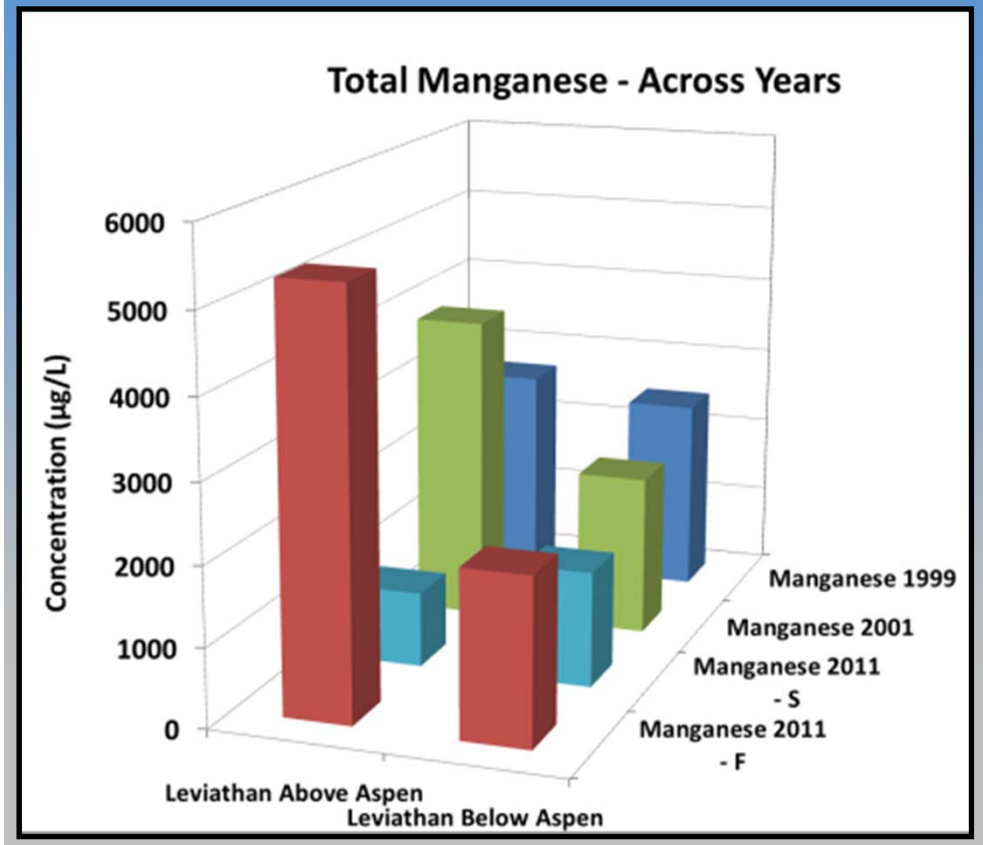
Analyte	Stations	
Al_t,	2	21, 17, 5
Fe_d		17, 5
Mn		21, 17, 5
Ni		21, 17, 5
SO_4	22	21, 17, 5, 7

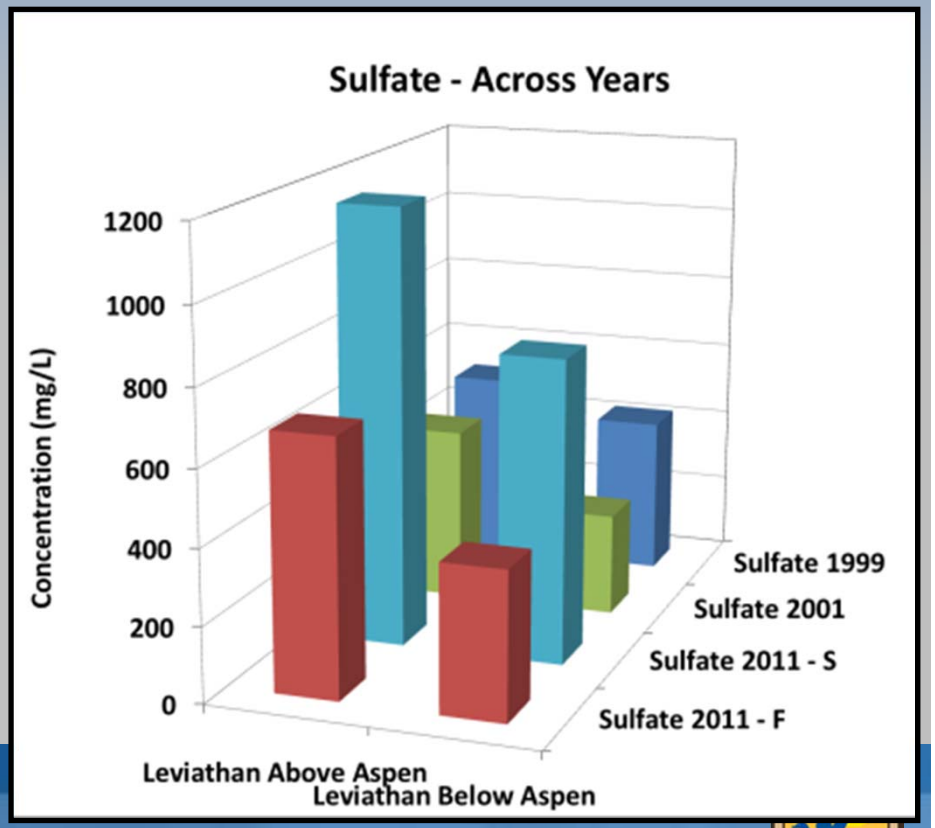
Comparisons between years for critical sites or metals





Comparisons between years for critical sites or metals





Summary of Findings

- **We observed the greatest toxicity at Sites directly downstream to the Mine, with diminishing toxicity with increasing distance from the Site.**

- **We observed no toxicity and metal concentrations were not elevated in reference sites.**

- **All toxicity was associated with sites with increased metal mixtures or altered water quality parameters.**

- **Toxicity observed in Treatment Stream waters is of concern.**

Acknowledgments

USFWS – Larry Thompson, Dan Welsh, Steve Schwarzbach, Cathy Johnson, Kevin Aceituno, Thomas Maurer, Harry Kahler.

CDFG – Randy Imai, Robert Todd, Janna White, Jeff Berliner, Jose Boria.

Pacific Eco-Risk Laboratories

Columbia Analytical Services

TestAmerica

99 Winter

Acute Toxicity Test – Rainbow Trout Survival

Station	Station Description	NOEC	LOEC	LC50
1	Aspen Creek, upstream of Leviathan Mine	100 %	NA	NA
17	**Leviathan Creek below confluence with Aspen**	**25 %**	**50 %**	**35%**
5	**Leviathan Creek above confluence with Mountaineer**	**25 %**	**50 %**	**35%**
6	Mountaineer Creek above confluence with Leviathan	100 %	NA	NA
7	**Bryant Creek below confluence with Mountaineer**	**50 %**	**100 %**	**75 %**
9	Bryant Creek above Doud Springs	100 %	NA	NA
10	Bryant Creek upstream of confluence with East Carson	100 %	NA	NA
11	East Fork Carson upstream of Bryant Creek	100 %	NA	NA
12	East Fork Carson downstream of Bryant	100 %	NA	NA
13	East Fork Carson upstream of Ruhenstroth Dam	100 %	NA	NA

Acute Toxicity Test – *Ceriodaphnia* Survival

Station	Station Description	NOEC	LOEC	LC50
1	Aspen Creek, upstream of Leviathan Mine	100 %	NA	NA
17	**Leviathan Creek below confluence with Aspen**	**12.5 %**	**25 %**	**14 %**
5	**Leviathan Creek above confluence with Mountaineer**	**12.5 %**	**25 %**	**16 %**
6	Mountaineer Creek above confluence with Leviathan	100 %	NA	NA
7	**Bryant Creek below confluence with Mountaineer**	**50 %**	**100 %**	**68 %**
9	Bryant Creek above Doud Springs	100 %	NA	NA
10	Bryant Creek upstream of confluence with East Carson	100 %	NA	NA
11	East Fork Carson upstream of Bryant Creek	100 %	NA	NA
12	East Fork Carson downstream of Bryant	100 %	NA	NA
13	East Fork Carson upstream of Ruhenstroth Dam	100 %	NA	NA

99 Winter

Chronic Toxicity Test – *Ceriodaphnia* Survival

Station	Station Description	NOEC	LOEC	IC25
1	Aspen Creek, upstream of Leviathan Mine	100 %	NA	NA
17	**Leviathan Creek below confluence with Aspen**	**<6.25 %**	**6.25 %**	**7 %**
5	**Leviathan Creek above confluence with Mountaineer**	**<6.25 %**	**6.25 %**	**5 %**
6	Mountaineer Creek above confluence with Leviathan	100 %	NA	NA
7	**Bryant Creek below confluence with Mountaineer**	**25 %**	**50 %**	**11 %**
9	**Bryant Creek above Doud Springs**	**25 %**	**50 %**	**36 %**
10	**Bryant Creek upstream of confluence with East Carson**	**25 %**	**50 %**	**24 %**
11	East Fork Carson upstream of Bryant Creek	100 %	NA	NA
12	East Fork Carson downstream of Bryant			
13	East Fork Carson upstream of Ruhenstroth Dam	100 %	NA	NA

01 Winter

Acute Toxicity Test – Rainbow Trout Survival

Station	Station Description	NOEC	LOEC	LC50
1	Aspen Creek, upstream of Leviathan Mine	100 %	NA	NA
17	Leviathan Creek below confluence with Aspen	100 %	NA	NA
5	Leviathan Creek above confluence with Mountaineer	100 %	NA	NA
6	Mountaineer Creek above confluence with Leviathan	100 %	NA	NA
7	Bryant Creek below confluence with Mountaineer	100 %	NA	NA
9	Bryant Creek above Doud Springs	100 %	NA	NA
10	Bryant Creek upstream of confluence with East Carson	100 %	NA	NA
11	East Fork Carson upstream of Bryant Creek	100 %	NA	NA
12	East Fork Carson downstream of Bryant	100 %	NA	NA
13	East Fork Carson upstream of Ruhenstroth Dam	100 %	NA	NA

Acute Toxicity Test – *Ceriodaphnia* Survival

Station	Station Description	NOEC	LOEC	LC50
1	Aspen Creek, upstream of Leviathan Mine	100 %	NA	NA
17	**Leviathan Creek below confluence with Aspen**	**25 %**	**50 %**	**35%**
5	Leviathan Creek above confluence with Mountaineer	100 %	NA	NA
6	Mountaineer Creek above confluence with Leviathan	100 %	NA	NA
7	Bryant Creek below confluence with Mountaineer	100 %	NA	NA
9	Bryant Creek above Doud Springs	100 %	NA	NA
10	Bryant Creek upstream of confluence with East Carson	100 %	NA	NA
11	East Fork Carson upstream of Bryant Creek	100 %	NA	NA
12	East Fork Carson downstream of Bryant	100 %	NA	NA
13	East Fork Carson upstream of Ruhenstroth Dam	100 %	NA	NA

01 Winter

Chronic Toxicity Test – *Ceriodaphnia* Survival

Station	Station Description	NOEC	LOEC	IC50
1	Aspen Creek, upstream of Leviathan Mine	100 %	NA	NA
17	**Leviathan Creek below confluence with Aspen**	**<6.25 %**	**6.25 %**	**4.4 %**
5	**Leviathan Creek above confluence with Mountaineer**	**100 %**	**NA**	**11.8 %**
6	Mountaineer Creek above confluence with Leviathan	100 %	NA	NA
7	**Bryant Creek below confluence with Mountaineer**	**50 %**	**100 %**	**12.3 %**
9	Bryant Creek above Doud Springs	100 %	NA	NA
10	Bryant Creek upstream of confluence with East Carson	100 %	NA	NA
11	East Fork Carson upstream of Bryant Creek	100 %	NA	NA
12	East Fork Carson downstream of Bryant	100 %	NA	NA
13	East Fork Carson upstream of Ruhenstroth Dam	100	NA	NA

11 Summer

Acute Toxicity Test – Rainbow Trout Survival

Station	Station Description	NOEC	LOEC	LC50
2	Upper Leviathan Creek above mine and AMD seeps	100 %	NA	NA
6	Mountaineer Creek above confluence with Leviathan	100 %	NA	NA
18	Biphasic Treatment Stream	100 %	NA	NA
19	High-Density Sludge Stream	100 %	NA	NA
20	Aspen Creek Bioreactor Stream	100 %	NA	NA
21	Leviathan Creek above Beaver Pond	100 %	NA	NA
17	Leviathan Creek below confluence with Aspen	100 %	NA	NA
5	Leviathan Creek above confluence with Mountaineer	100 %	NA	NA
7	Bryant Creek below confluence with Mountaineer	100	NA	NA
23	Bryant Creek at CA state line	100	NA	NA

Acute Toxicity Test – *Ceriodaphnia* Survival

Station	Station Description	NOEC	LOEC	LC50
2	Upper Leviathan Creek above mine and AMD seeps	100 %	NA	NA
6	Mountaineer Creek above confluence with Leviathan	100 %	NA	NA
18	Biphasic Treatment Stream	100 %	NA	NA
19	**High-Density Sludge Stream**	**50 %**	**100%**	**>100%**
20	Aspen Creek Bioreactor Stream	100 %	NA	NA
21	**Leviathan Creek above Beaver Pond**	**50 %**	**100%**	**>100%**
17	**Leviathan Creek below confluence with Aspen**	**50 %**	**100%**	**82%**
5	Leviathan Creek above confluence with Mountaineer	100 %	NA	NA
7	Bryant Creek below confluence with Mountaineer	100	NA	NA
23	Bryant Creek at CA state line	100	NA	NA

11 Summer

Chronic Toxicity Test – *Ceriodaphnia* Survival

Station	Station Description	NOEC	LOEC	LC50
2	Upper Leviathan Creek above mine and AMD seeps	100 %	NA	NA
6	Mountaineer Creek above confluence with Leviathan	100 %	NA	NA
18	Biphasic Treatment Stream	100 %	NA	NA
19	High-Density Sludge Stream	100 %	NA	NA
20	Aspen Creek Bioreactor Stream	100 %	NA	NA
21	Leviathan Creek above Beaver Pond	100 %	NA	NA
17	Leviathan Creek below confluence with Aspen	100 %	NA	NA
5	Leviathan Creek above confluence with Mountaineer	100 %	NA	NA
7	Bryant Creek below confluence with Mountaineer	100	NA	NA
23	Bryant Creek at CA state line	100	NA	NA

Chronic Toxicity Test – *Ceriodaphnia* Reproduction

Station	Station Description	NOEC	LOEC	LC50
2	Upper Leviathan Creek above mine and AMD seeps	100 %	NA	NA
6	Mountaineer Creek above confluence with Leviathan	100 %	NA	NA
18	**Biphasic Treatment Stream**	**25%**	**50%**	**49%**
19	**High-Density Sludge Stream**	**>6.25%**	**6.25%**	**25%**
20	**Aspen Creek Bioreactor Stream**	**>6.25%**	**6.25%**	**63%**
21	**Leviathan Creek above Beaver Pond**	**12.5%**	**25%**	**17%**
17	Leviathan Creek below confluence with Aspen	100 %	NA	NA
5	Leviathan Creek above confluence with Mountaineer	100 %	NA	NA
7	Bryant Creek below confluence with Mountaineer	100	NA	NA
23	Bryant Creek at CA state line	100	NA	NA

11 Winter

Acute Toxicity Test – Rainbow Trout Survival

Station	Station Description	NOEC	LOEC	LC50
2	Upper Leviathan Creek above mine and AMD seeps	100 %	NA	NA
6	Mountaineer Creek above confluence with Leviathan	100 %	NA	NA
22	Aspen Creek above confluence with Leviathan	100 %	NA	NA
21	**Leviathan Creek above Beaver Pond**	**25 %**	**50 %**	**35 %**
17	Leviathan Creek below confluence with Aspen	100 %	NA	NA
5	Leviathan Creek above confluence with Mountaineer	100 %	NA	NA
7	Bryant Creek below confluence with Mountaineer	100	NA	NA
23	Bryant Creek at CA state line	100	NA	NA

Acute Toxicity Test – *Ceriodaphnia* Survival

Station	Station Description	NOEC	LOEC	LC50
2	Upper Leviathan Creek above mine and AMD seeps	100 %	NA	NA
6	Mountaineer Creek above confluence with Leviathan	100 %	NA	NA
22	Aspen Creek above confluence with Leviathan	100 %	NA	NA
21	**Leviathan Creek above Beaver Pond**	**50 %**	**100 %**	**68 %**
17	Leviathan Creek below confluence with Aspen	**50 %**	**100 %**	**>100%**
5	Leviathan Creek above confluence with Mountaineer	100 %	NA	NA
7	Bryant Creek below confluence with Mountaineer	100	NA	NA
23	Bryant Creek at CA state line	100	NA	NA

11 Winter

Chronic Toxicity Test – *Ceriodaphnia* Survival

Station	Station Description	NOEC	LOEC	LC50
2	Upper Leviathan Creek above mine and AMD seeps	100 %	NA	NA
6	Mountaineer Creek above confluence with Leviathan	100 %	NA	NA
22	Aspen Creek above confluence with Leviathan	100 %	NA	NA
21	**Leviathan Creek above Beaver Pond**	**12.5 %**	**25 %**	**17 %**
17	Leviathan Creek below confluence with Aspen	100 %	NA	NA
5	Leviathan Creek above confluence with Mountaineer	100 %	NA	NA
7	Bryant Creek below confluence with Mountaineer	100	NA	NA
23	Bryant Creek at CA state line	100	NA	NA

Chronic Toxicity Test – *Ceriodaphnia* Reproduction

Station	Station Description	NOEC	LOEC	LC50
2	Upper Leviathan Creek above mine and AMD seeps	100 %	NA	NA
6	Mountaineer Creek above confluence with Leviathan	100 %	NA	NA
22	Aspen Creek above confluence with Leviathan	100 %	NA	NA
21	**Leviathan Creek above Beaver Pond**	**>6.25 %**	**6.25%**	**5.20 %**
17	**Leviathan Creek below confluence with Aspen**	**50 %**	**100%**	**>100%**
5	**Leviathan Creek above confluence with Mountaineer**	**50 %**	**100%**	**>100%**
7	Bryant Creek below confluence with Mountaineer	100	NA	NA
23	Bryant Creek at CA state line	100	NA	NA