



Sullivan Mine: Water Collection Closure Plan vs. 10 yrs Post-Closure experience

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Introduction



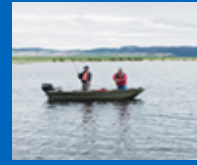
Description of Site Reclamation and Seepage Collection Systems

Post Closure Projections and Current Experience:

- Underground Mine filling, dewatering flows, water quality and metal loading
- Mine Area Seepage flows, water quality and metal loading
- Tailings Area Seepage flows, water quality and metal loading

Summary of Results

Sullivan Mine Location



Sullivan Mine History and Layout



Mine and Mill areas

Lead, Zinc and Silver

Operated 1909 –2001

Primarily underground, some open pit
150 million tonnes ore

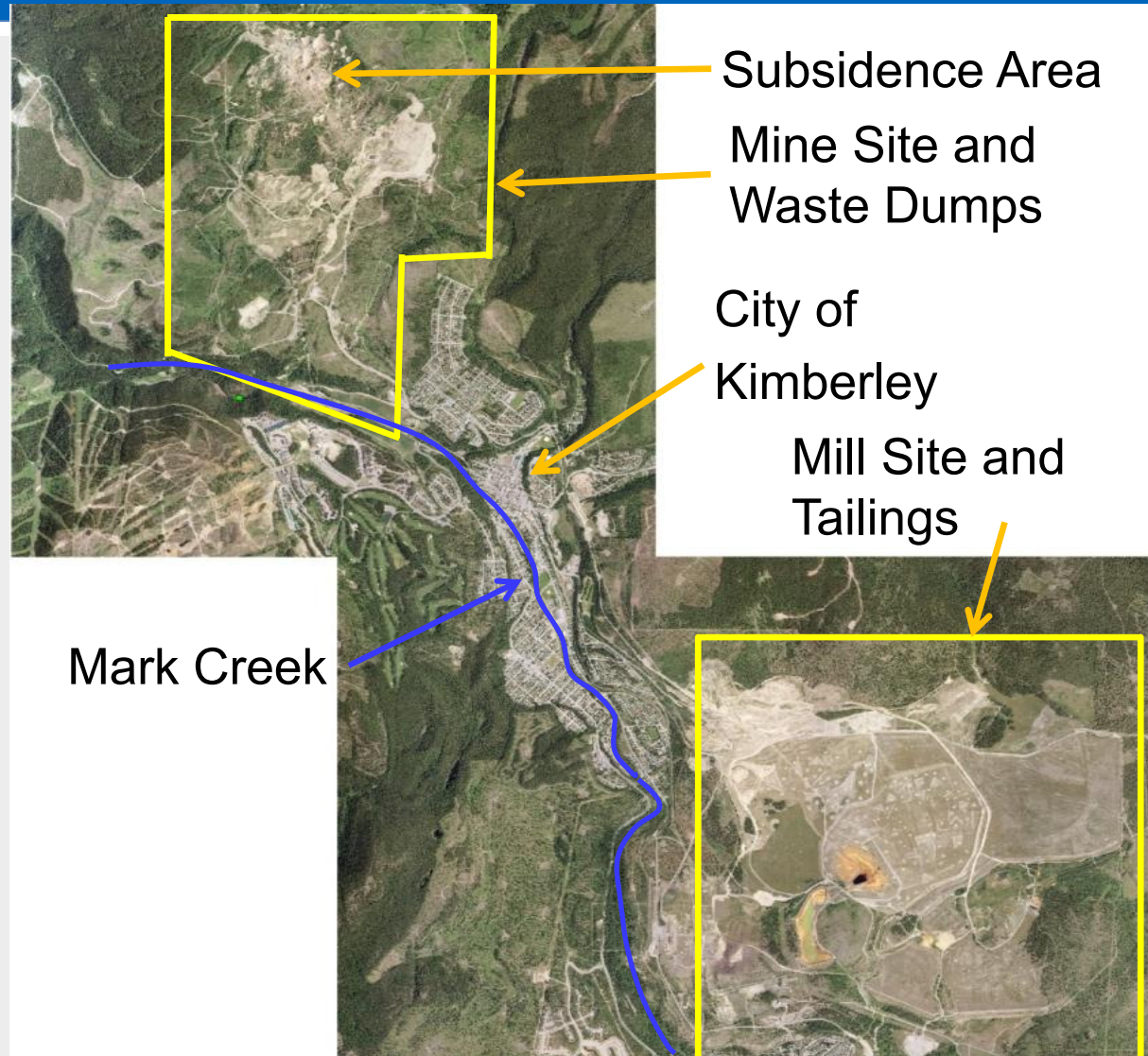
Production (tonnes):

Concentrate: 25.8 million

Waste rock: 9.8 million

Tailings: 122 million

**Total area of disturbance:
1100 ha**



Environmental Concerns: Acid Rock Drainage (ARD)



Sulphide oxidation:

Pyrrhotite and pyrite

Principal Ore:

- Galena and sphalerite

ARD impacts to surface water and groundwater :

- mine workings;
- waste dumps;

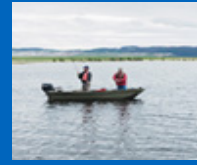


Historic Photo of
No. 1 Shaft Waste Dump



Historic Photo of North and
South Waste Dumps adjacent
to Mark Creek

Environmental Concerns: Acid Rock Drainage (ARD)



Sulphide oxidation:

Pyrrhotite and pyrite

Principal Ore:

- Galena and sphalerite

ARD impacts to surface water and groundwater:

- mine workings;
- waste dumps; and
- tailings impoundments



Historic Photo of Tailings produced by
Concentrator

Review Reclamation Plan



Revised Decommissioning and Closure Plan 2000

Main Objectives:

- Wildlife habitat

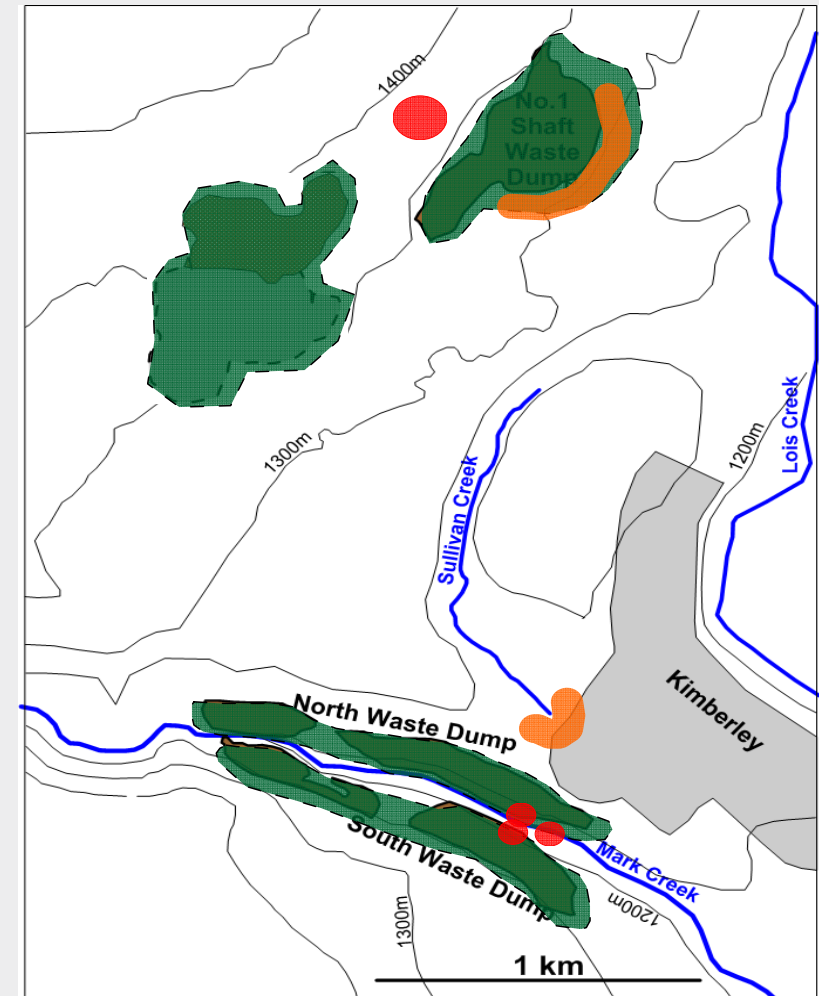
- ARD collection and treatment for *perpetuity*

Reclamation progressive from 1990 to 2010

Review Reclamation Plan: Mine Site



- **Source Control:**
 - Rock from the Open Pit Waste Dump was placed in the Open Pit.
 - Waste dumps were capped with till and re-vegetated with grasses and legumes.
- **Seepage collection:**
 - Underground Mine reservoir
 - No.1 Shaft Waste Dump groundwater collection
 - Sullivan Creek surface and groundwater collection
 - Lower Mine Yard groundwater interception wells



Mark Creek: Before and After



North and South Waste dumps adjacent to Mark Creek Valley

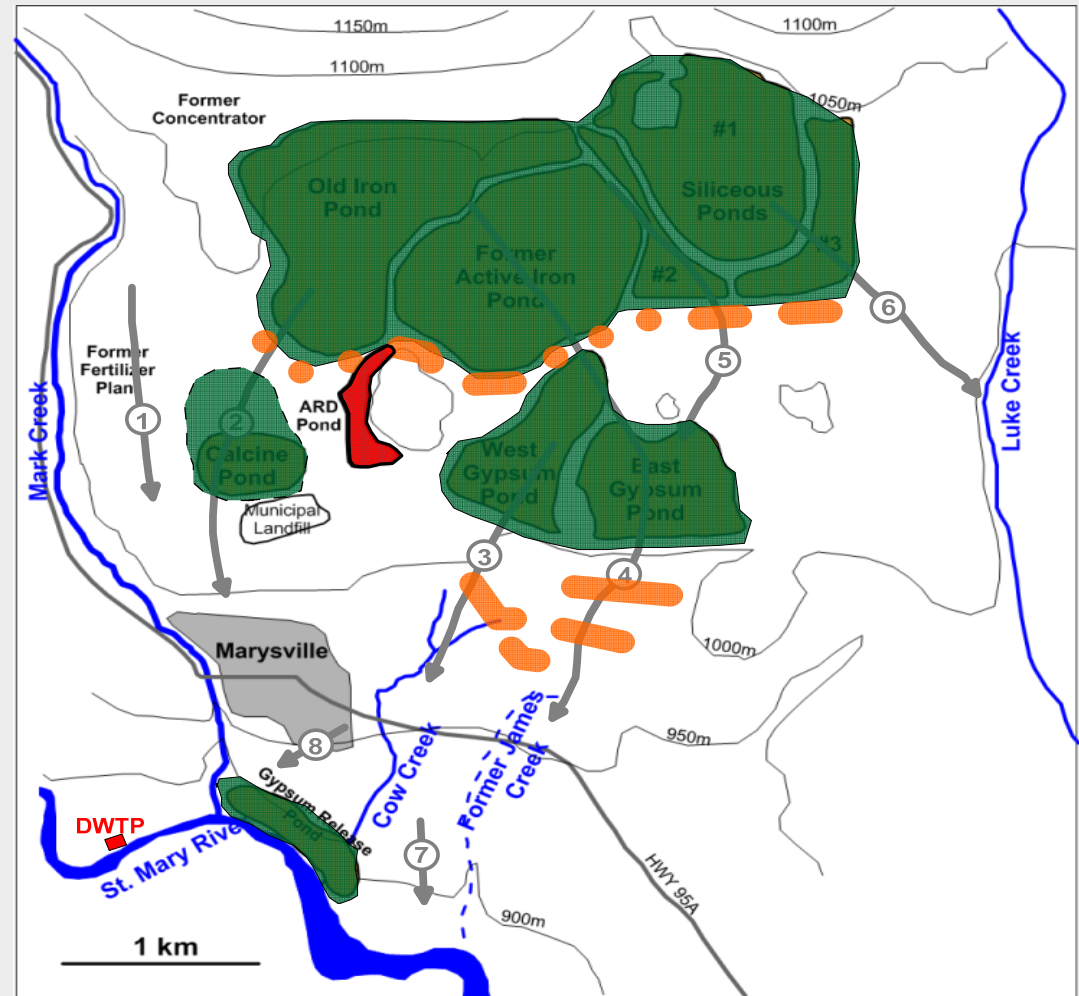
Reclaimed Mark Creek Valley



Review Reclamation Plan: Mill Site



- Source Control – Mill Area
 - Engineered cover systems placed on waste impoundments
 - Re-vegetated with grasses and legumes.
- Seepage Collection
 - Groundwater interception ditches keyed into bedrock/till surface
 - Shallow seeps and runoff collected in ditches
 - Water collected from all collection systems is stored in the ARD Pond, and treated in Teck's Drainage Water Treatment Plant (DWTP)



Tailings Reclamation – Before and After



Water Treatment Post Closure



DWTP built in 1979

- high density sludge process
- operates in the spring (~ 12 weeks) and fall (2 ½ weeks)
- Dewater the u/g mine reservoir and ARD Pond in the spring
- Completely empty the ARD Pond in the fall

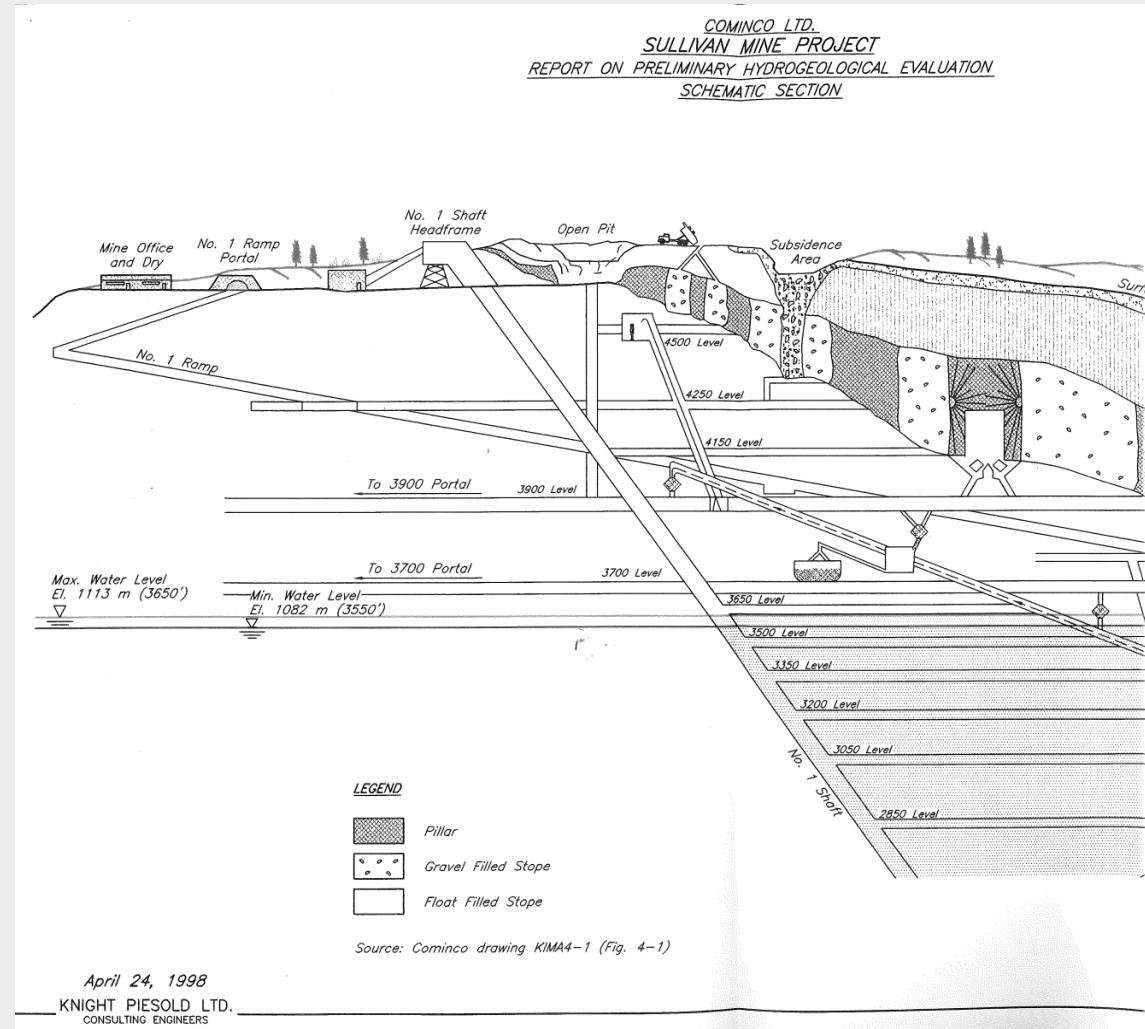


Post Closure Projections



U/G Mine filling projections

- Estimated void space between mine elevations from bottom of mine 2450 ft and max. operating elevation 3650 ft (initial filling)
- Operating range of reservoir is from 3550 ft and 3650 ft with a capacity of 625,000 m³
- Allowance of a 50 ft contingency freeboard



Post Closure Projections



U/G Mine filling projections

Water introduced into the mine 2 ways:

1. Surface infiltration from subsidence area
2. Groundwater inflow

Infiltration rate 1.4M m³/yr assuming average precipitation

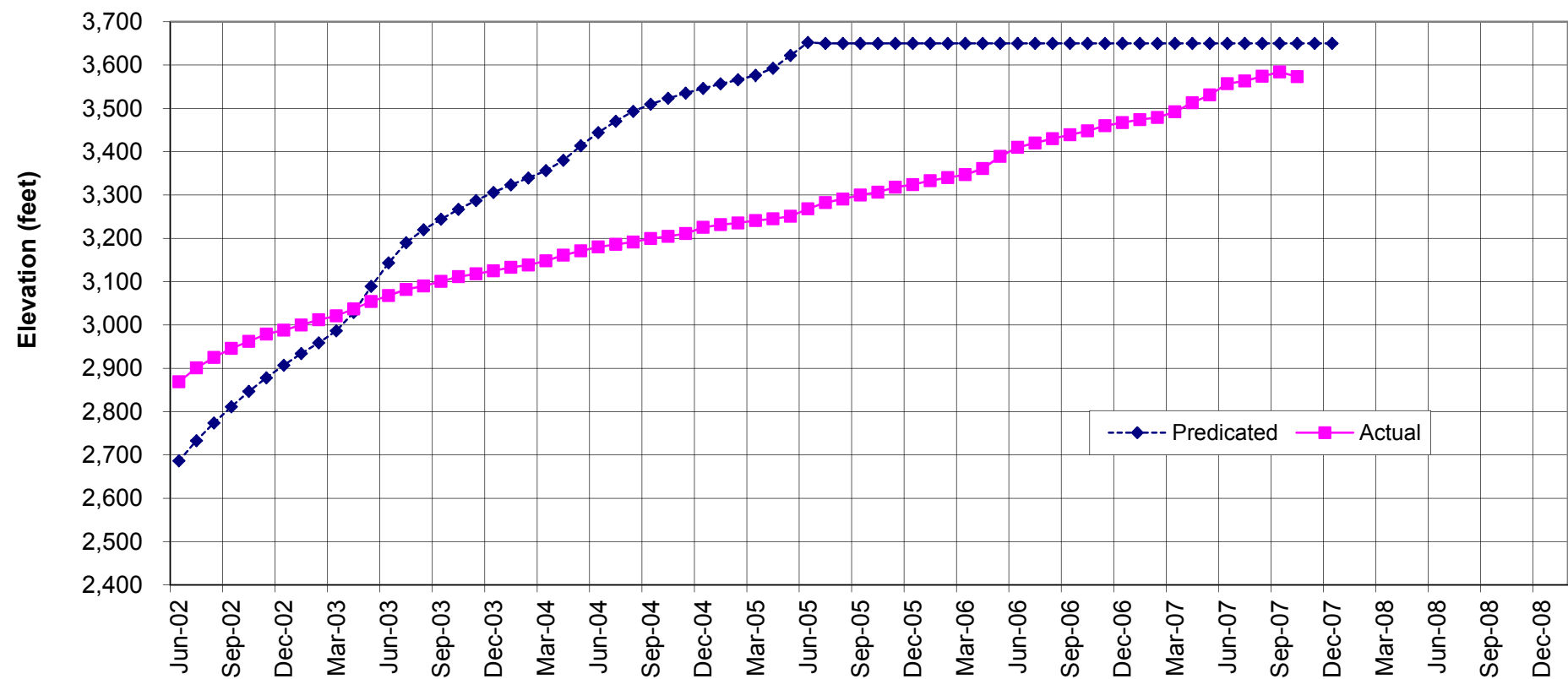


Subsidence area

Mine Filling Graph



Sullivan Mine Water Level



Underground Mine Dewatering



U/G Mine Dewatering in subsequent years

Year	Volume m ³ /yr
2011	667,377
2010	382,312
2009	588,713
2008	627,926
Projected	1,400,000

Original prediction – dewater spring and fall

Actual volume – dewater spring only

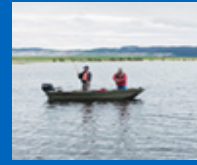
Underground Mine Water Quality



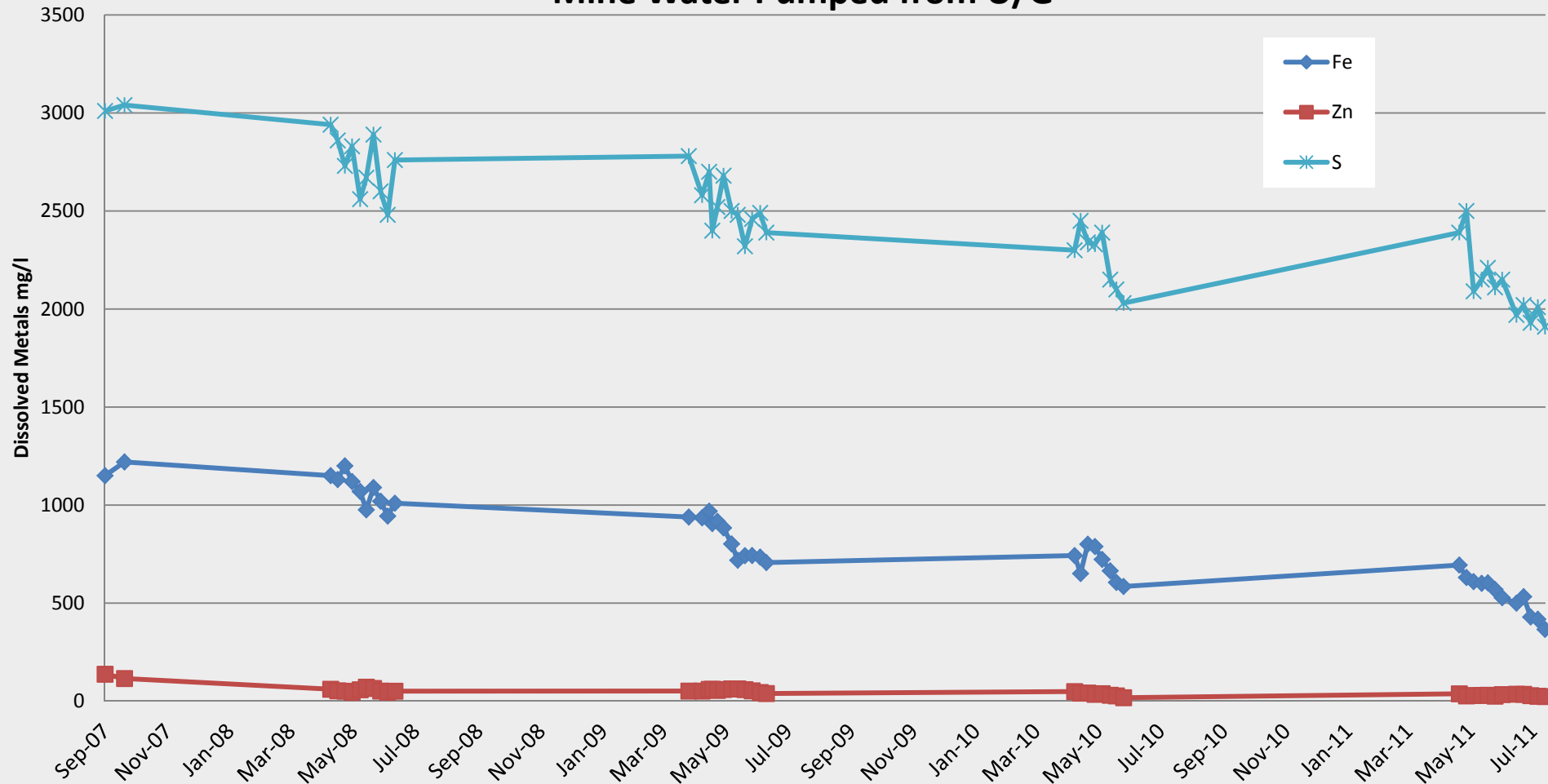
Compound	Predicted	Initial	2011 end
Zn mg/l	130	138	24
Fe mg/l	629	1,150	366
SO4 mg/l	11,115	9,030	5,730

Initial water worse than predicted except for SO4
With pumping water quality is better than predicted

Underground Mine Water Quality



Mine Water Pumped from U/G



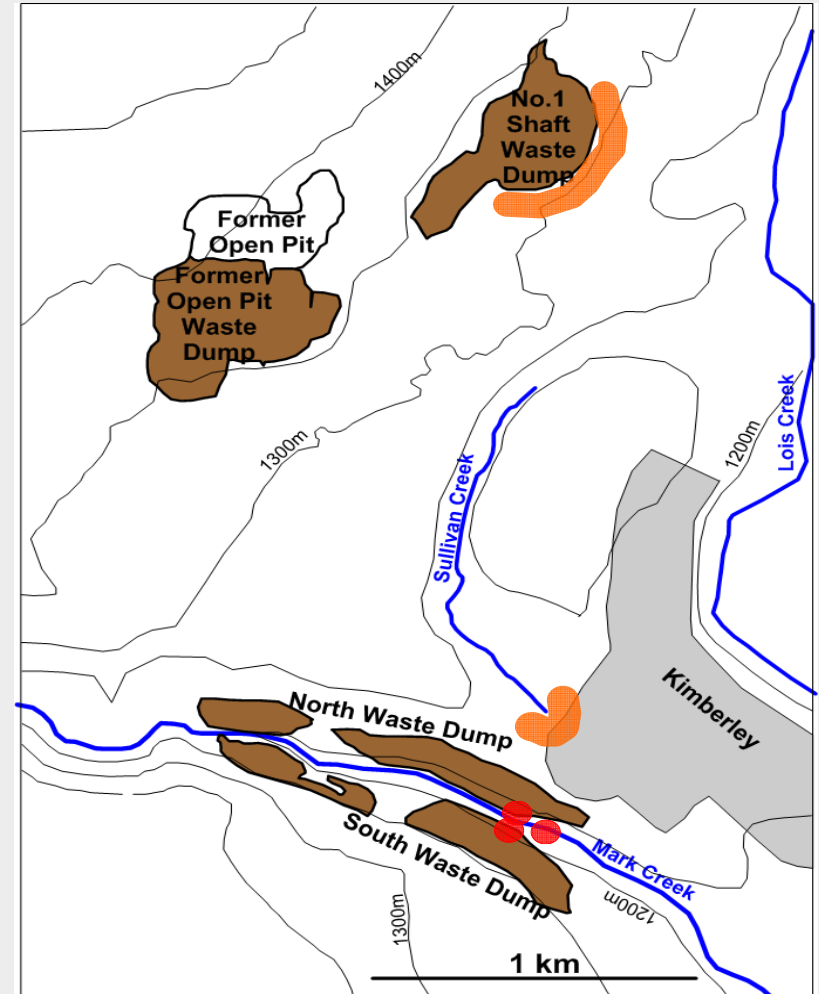
Mine Area Seepage Collection



Mine Area seepage collection –

- No. 1 Shaft waste dump
- Sullivan Creek
- Aquifer pumps in Lower Mine Yard

Predicted volume 940,000 m³/yr



Mine Area Seepage Collection



Mine Area seepage collection –

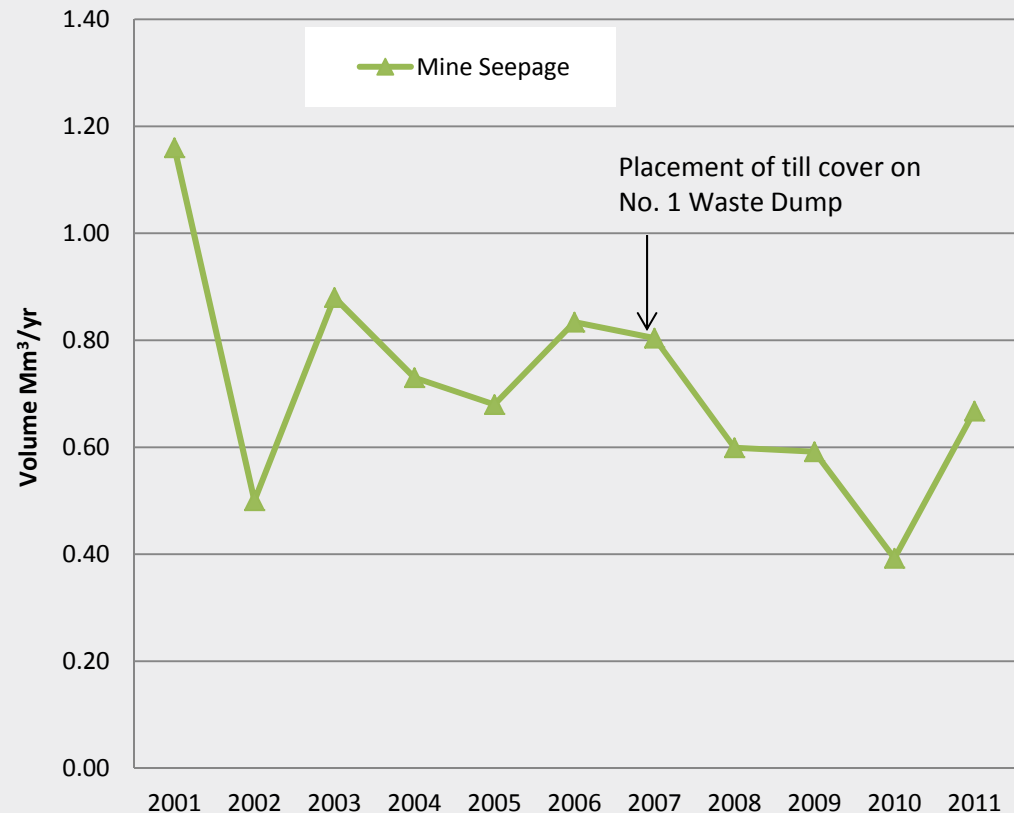
- No. 1 Waste Dump
- Sullivan Creek
- Aquifer pumps in LMY

Predicted volume 940,000 m³/yr

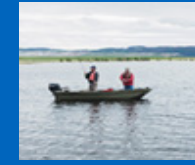
Actual volume currently
~600,000 m³/yr

Volume: down immediately upon
closure and decreased as
reclamation progressed

Seepage Volume vs Time



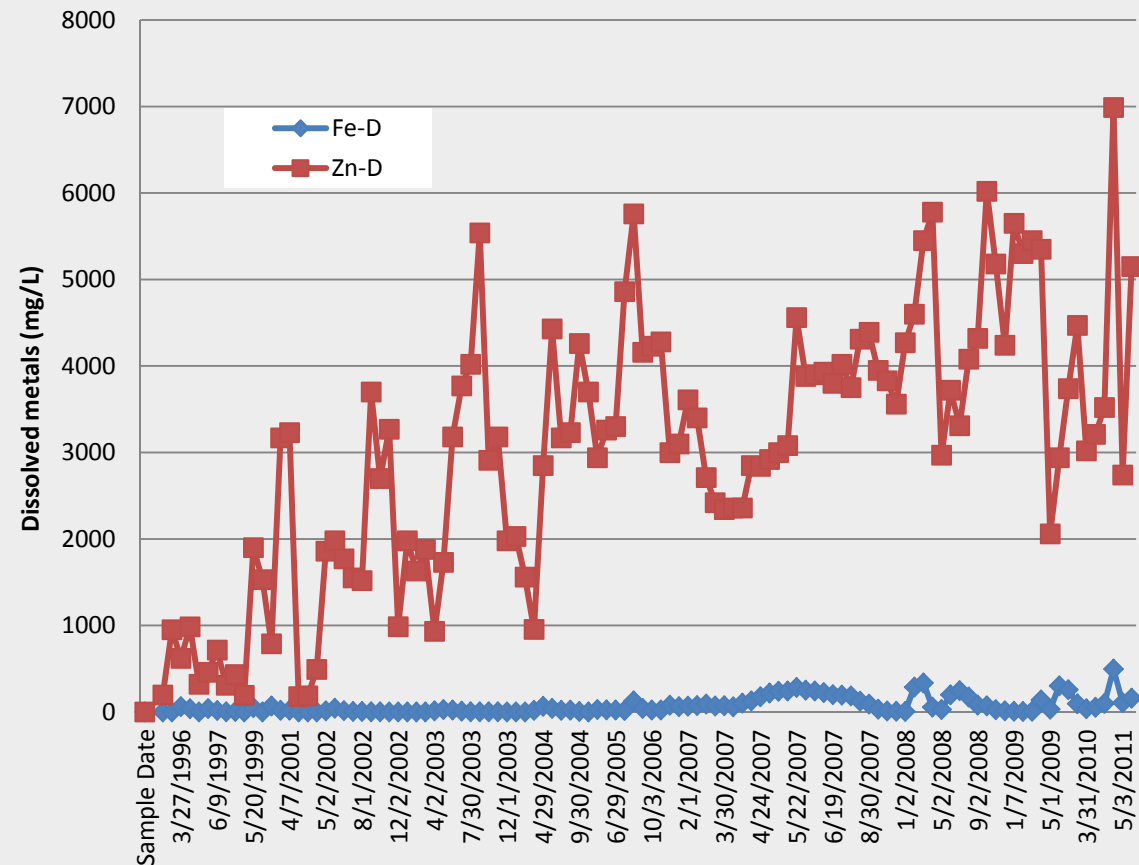
Mine Area Seepage Collection



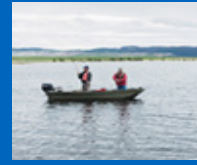
No. 1 Shaft Waste Dump

- Metal concentrations: increasing especially Zn with decreasing volume
- Metal Loading: generally decreasing except when there is a flushing event

No. 1 Shaft Waste Dump

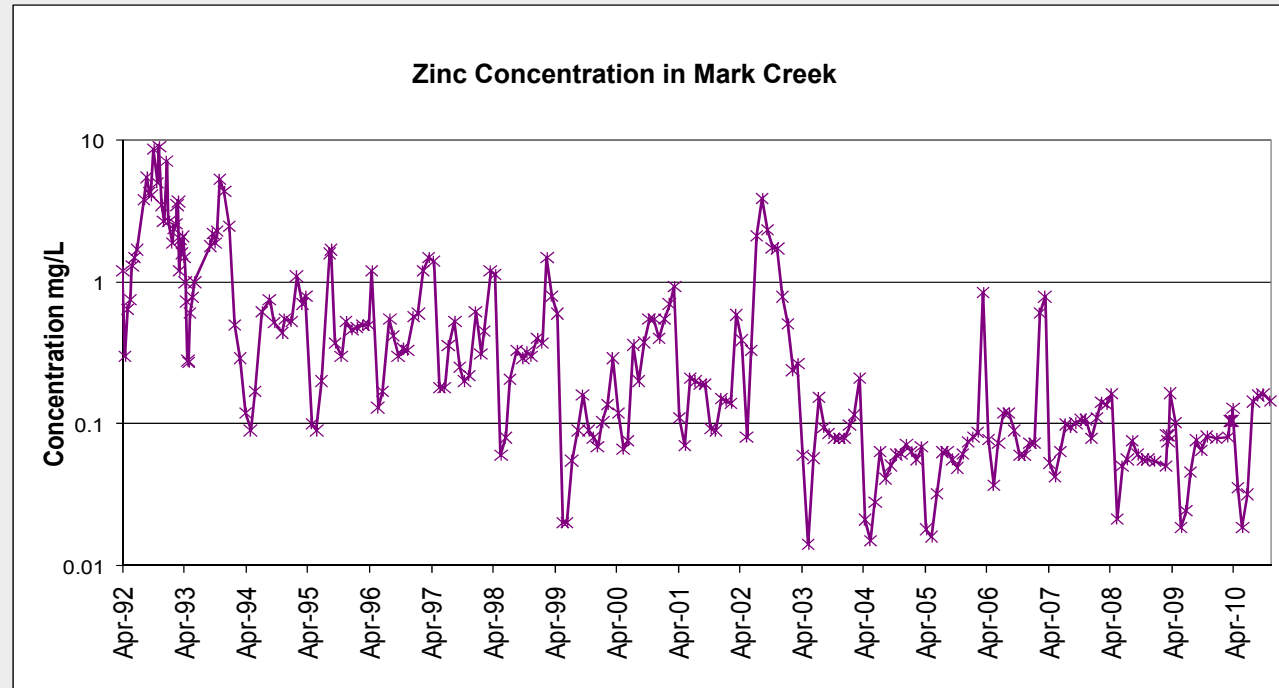


Mine Area Seepage Collection



Lower Mine Yard

- Volume increased with additional aquifer pumps which has reduced impacts on Mark Cr. by 100 times since 1992
- Groundwater metal concentrations: increasing Fe and decreasing Zn from South Dump



Note log scale

Tailings Area Seepage Collection



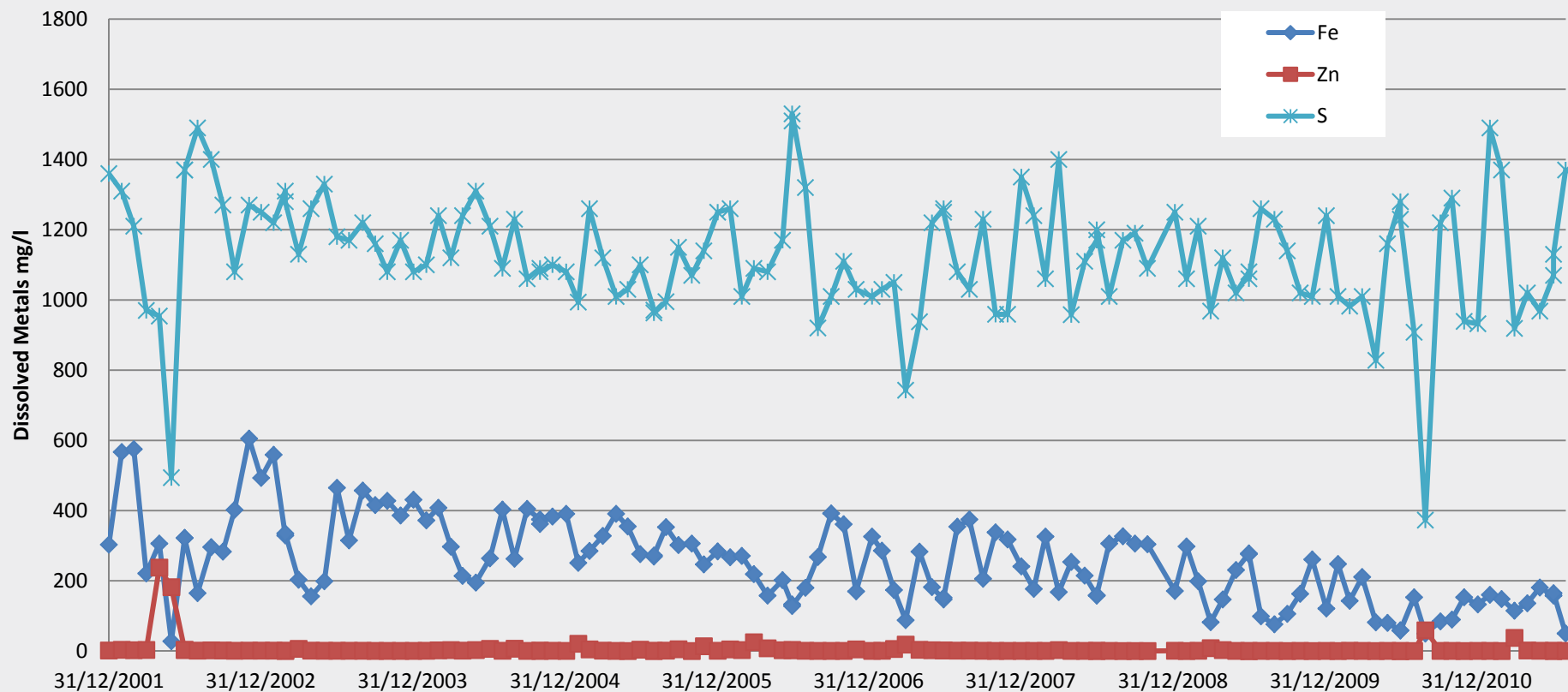
Predicted volume 340,000 m³/yr avg. precipitation
Actual volume average 500,000 m³/yr last 4 years



Tailings Area Water Quality



Tailings Seepage Water



Summary



Predictions and Actuals

- Closure 2001
- Post reclamation conditions since 2007 (3 years of vegetation growth)
- Volumes are approx. 60% less than predicted (primarily u/g)
- Water quality better than predicted, the lime consumption is much lower than predicted

Projected Flow (m ³ /yr)		Actual (m ³ /yr)
U/G	1,400,000	600,000
Mine	940,000	600,000
Tailings	360,000	500,000
Total	2,700,000	1,700,000

Lime consumption	
Projected	6,025 t/yr
Average (2008 – 2011)	2,157 t/yr

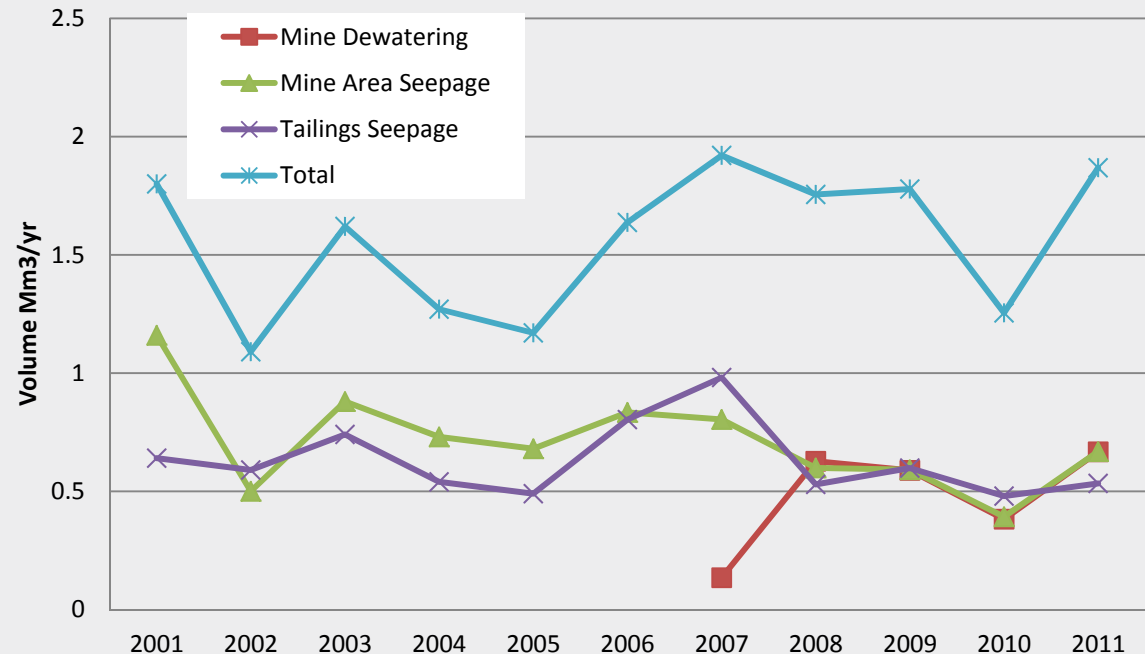
Summary



Volume trends

- Mine area seepage decrease since reclamation of No. 1 Waste Dump
- Tailings area seepage slightly lower than pre reclamation, too early to see a significant difference
- Total seepage volume no significant trend

Seepage Volume vs Time



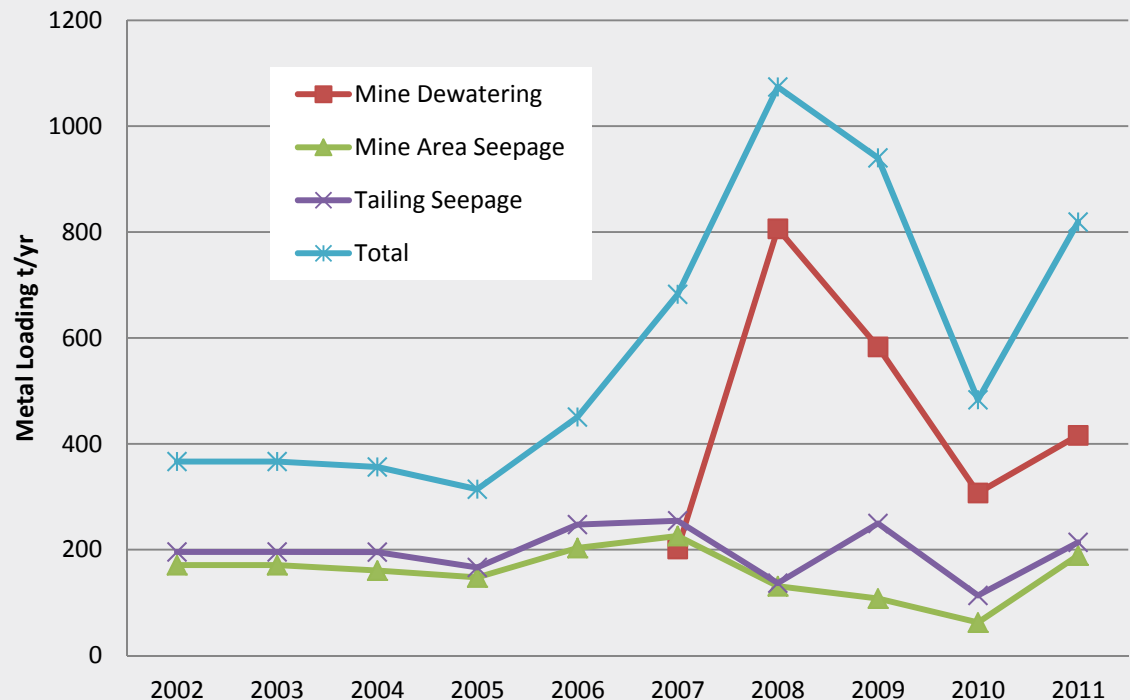
Summary



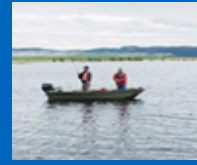
Metal loading

- U/G - Significant decreasing trend, expect to level off
- Mine area seepage – decreasing trend primarily due to reclamation of No. 1 Waste Dump
- Tailings area seepage – no significant trend
- Total loading – no trend at this point

Metal Loading vs Time



Questions??



Elk on Reclaimed Pond