USE OF CEMENT BASED BINDERS FOR CHEMICAL STABILIZATION OF METALS-IMPACTED RAILBED MATERIALS

Golder Associates

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INTRODUCTION

- Background
- Historical Remediation
- Principles of Stabilization & Bench Scale Testing
- 2015 Field Trial
- Post – Treatment Monitoring
- Lessons Learned / Next Steps

BACKGROUND

- Slurried nickel ore concentrate was transported by rail between 1924 to 1978.

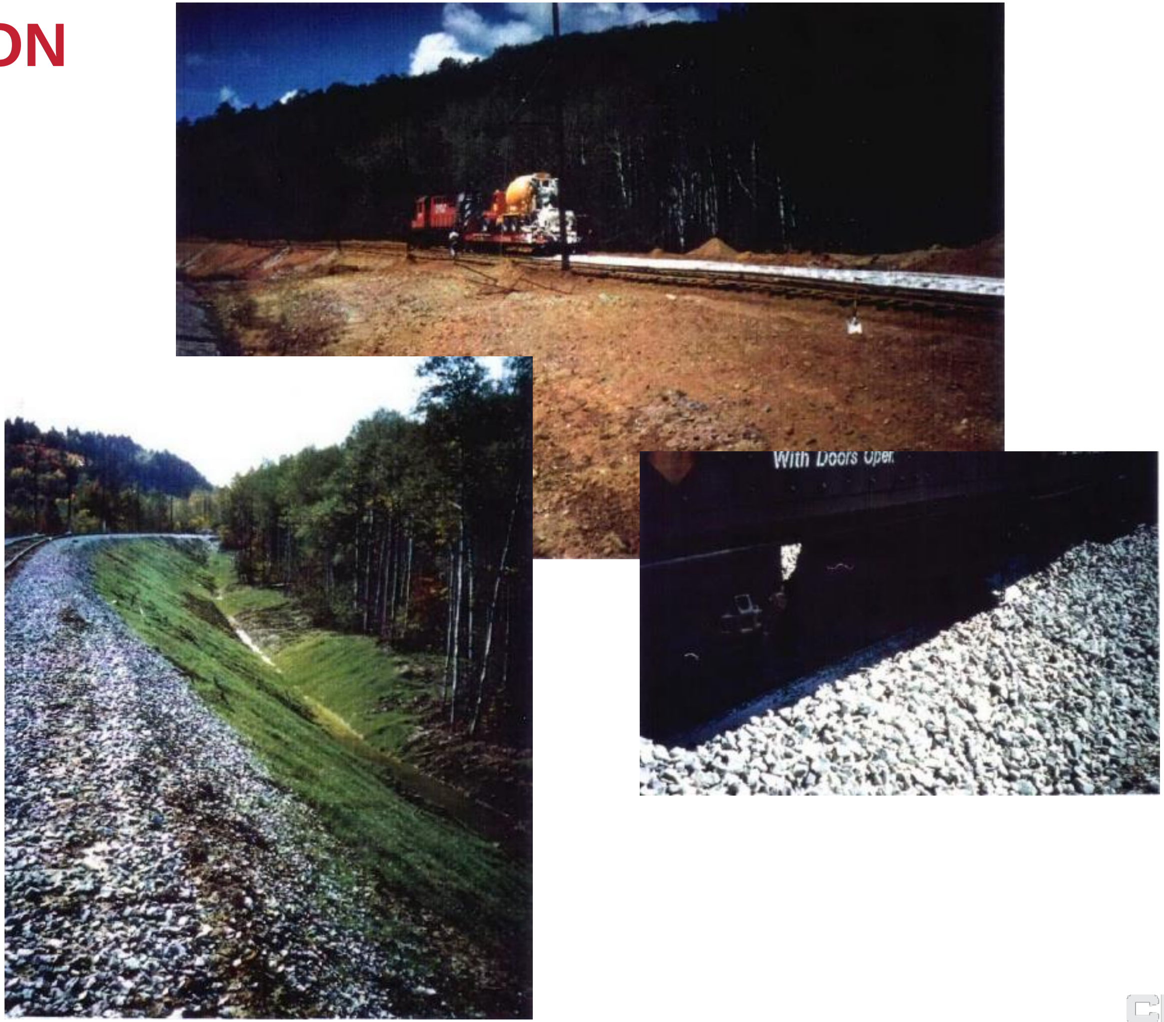
- Dry ore transported since 1978.

HISTORICAL REMEDIATION

- In the 1980s, elevated metals concentrations were observed in drainage water from the Yard and Spur trackage.
- Track bed remediation was implemented in 1990 to remove metals containing materials.

HISTORICAL REMEDIATION

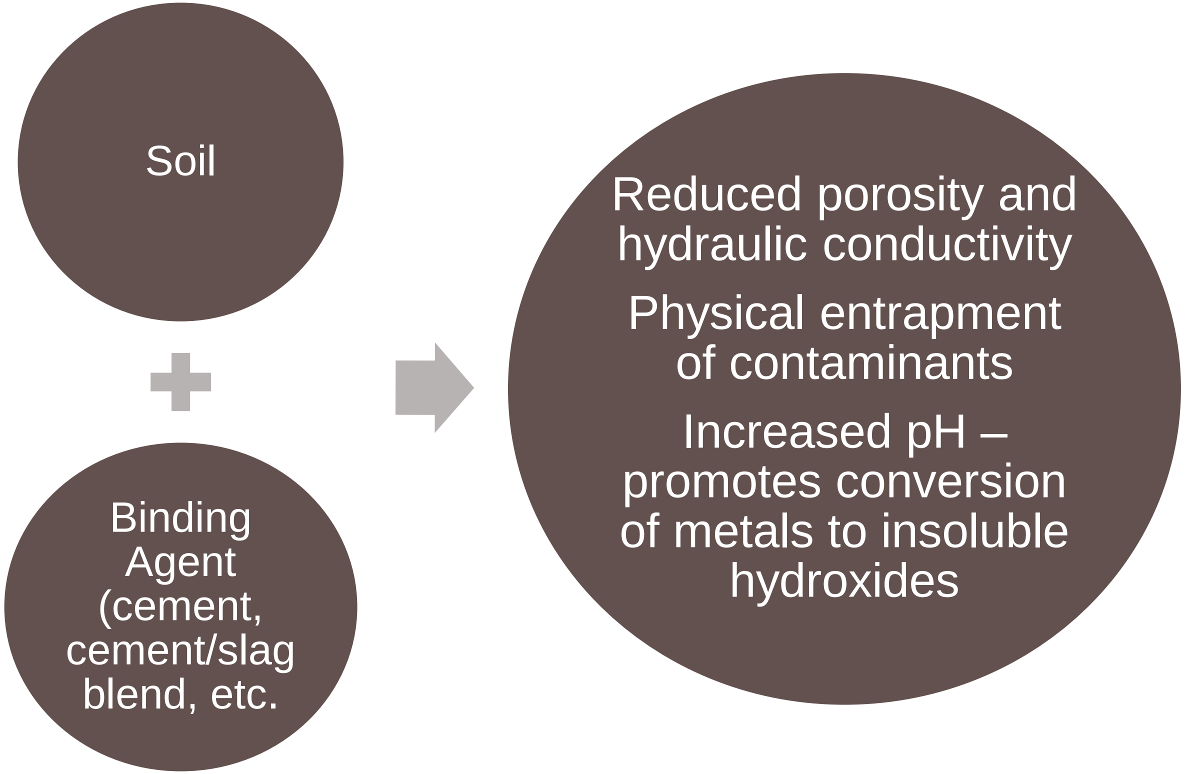
- Remedial Work involved:
  - track bed undercutting,
  - excavation of track side slopes,
  - removal of soils to an industrial landfill,
  - lime application and limestone ballast to the track beds, and
  - revegetation.



FURTHER MITIGATION REQUIRED

- Post – 1990s Remediation water quality monitoring showed some reduction in metals concentrations.
- Site Specific Risk Evaluations provided modified targets for metals concentrations in drainage waters.
- A field trial of Agricultural Lime to a section of railbed proved insufficient to permanently reduce the metals concentrations.
- The evaluation of other options led to selection of Chemical Stabilization as a means to permanently reduce available metals concentrations.

PRINCIPLES OF STABILIZATION



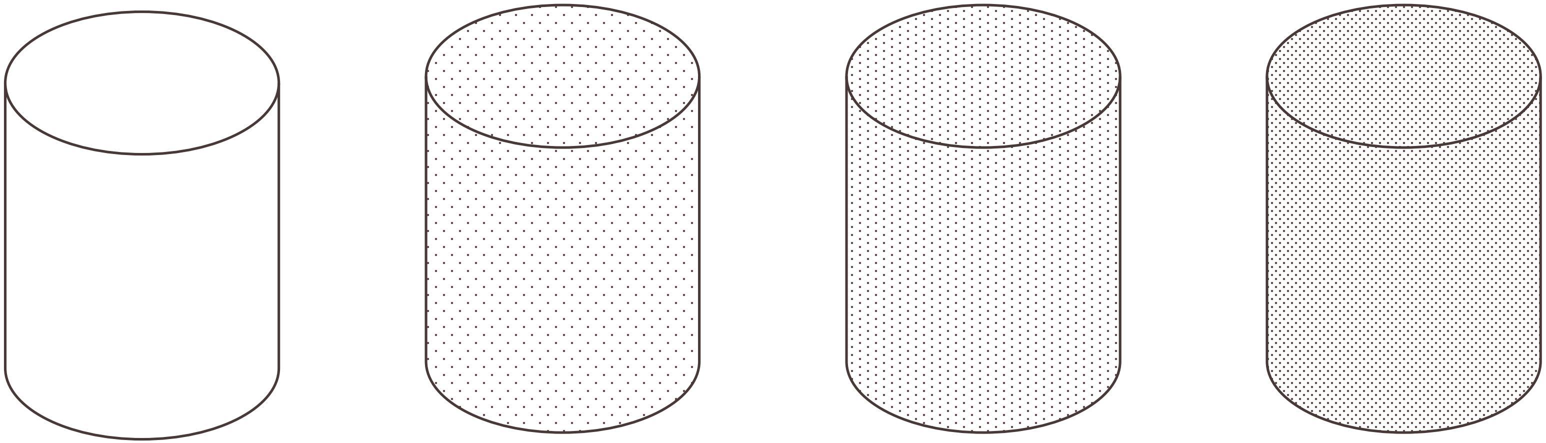
SAMPLE COLLECTION

SAMPLES COLLECTED FROM THREE LOCATIONS

BENCH-SCALE TESTING

MIX DESIGN – SAMPLE MATERIAL COMBINED WITH CEMENT

- Proportions of cement binder by weight was varied between samples



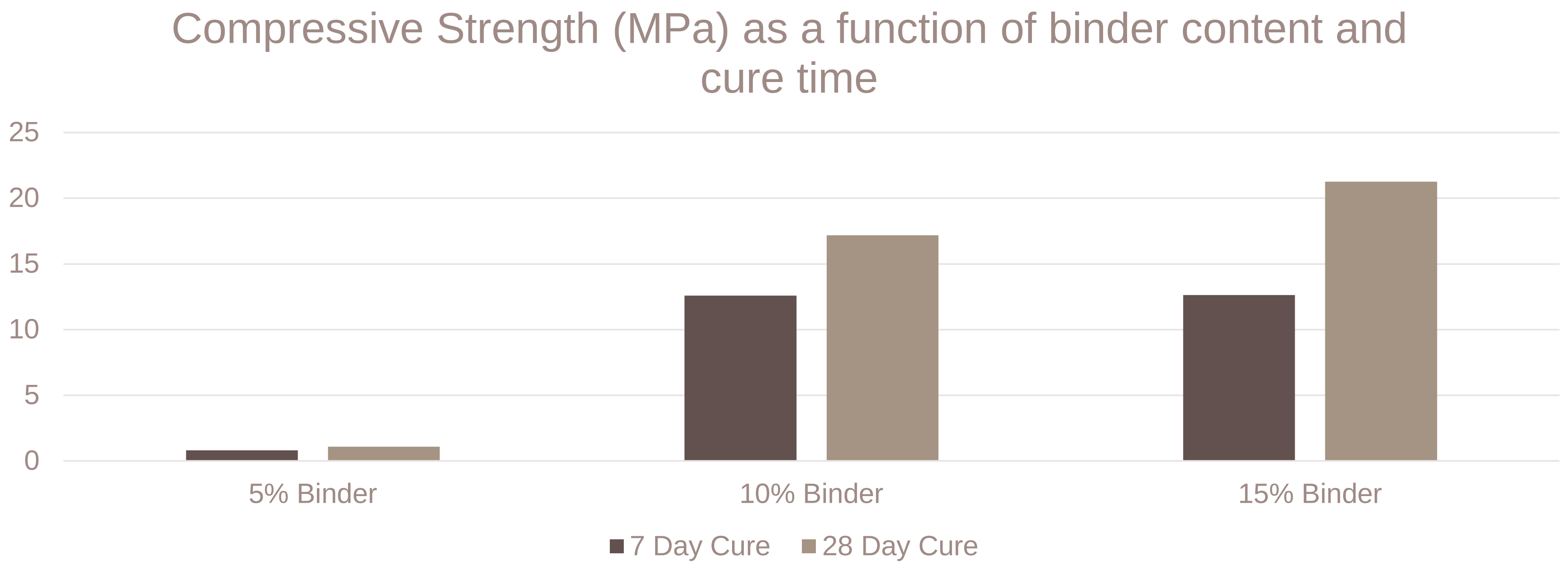
0% 5% 10% 15%

CURING TIME

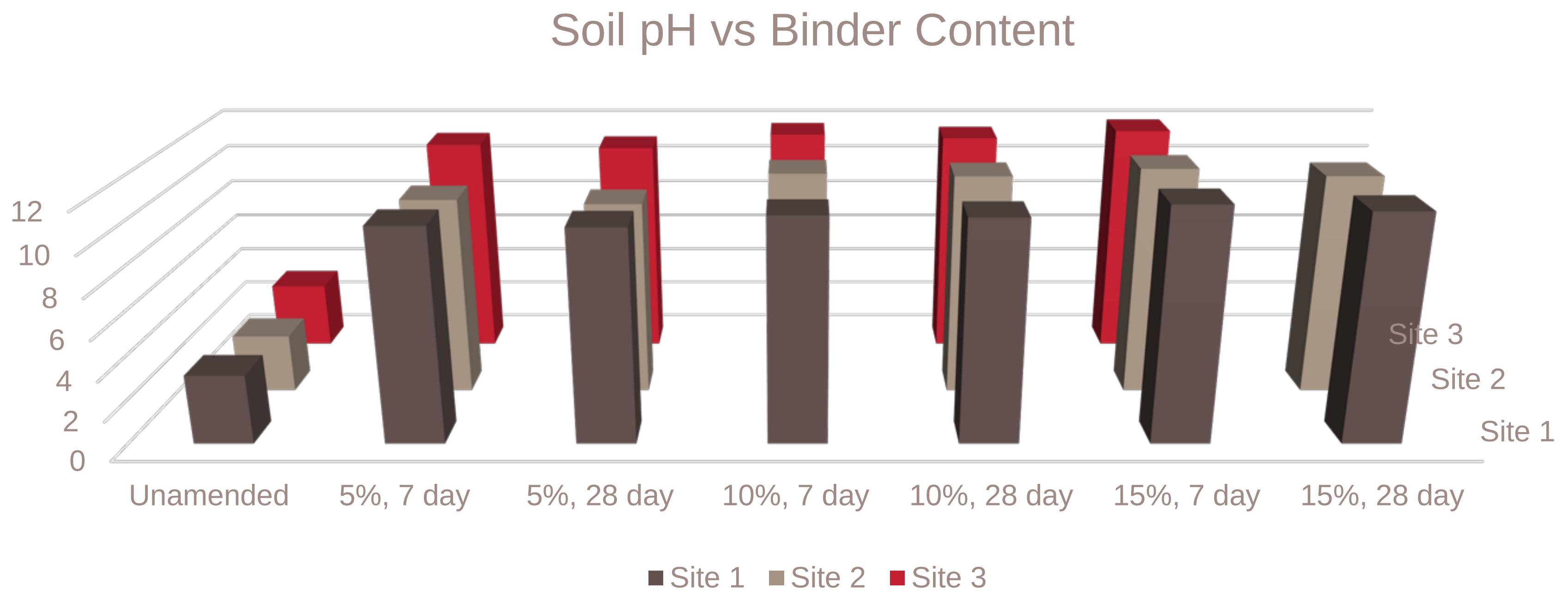
- Samples were cured in a moisture room
- Curing time was varied prior to physical and chemical testing
  - 7 day
  - 28 day

PHYSICAL PROPERTIES TESTING

COMPRESSIVE STRENGTH TESTING – SAMPLING LOCATION 1



SOIL pH TESTING



CONTAMINANT LEACHABILITY TESTS

- Tests were conducted using US EPA Method 1312 – Synthetic Precipitation Leaching Procedure (SPLP)
- Extraction Fluid No. 1 was used
  - pH 4.20 ± 0.05
  - Intended to mimic precipitation east of the Mississippi River

METALS CONCENTRATIONS IN LEACHATE (μg/L)

SITE 1

Contaminant	Binder Content						
	Unamended	5%		10%		15%	
		7-day cure	28-day cure	7-day cure	28-day cure	7-day cure	28-day cure
Copper	2430	<50	66	<50	60	87	78
Nickel	1350	<100	<100	<100	<100	<100	<100
Zinc	<150	<150	<150	<150	<150	<150	<150
Chromium	<50			66	54	230	95

Chromium is not a COC - originates from the slag in the binder.

METALS CONCENTRATIONS IN LEACHATE (µg/L)

SITE 2

Contaminant	Binder Content						
	Unamended	5%		10%		15%	
		7-day cure	28-day cure	7-day cure	28-day cure	7-day cure	28-day cure
Copper	2250	434	553	650	699	764	797
Nickel	140	<100	<100	<100	<100	<100	<100
Zinc	<150	<150	<150	<150	<150	<150	<150
Chromium	<50	<50	<50	97	53	113	104

METALS CONCENTRATIONS IN LEACHATE (µg/L)

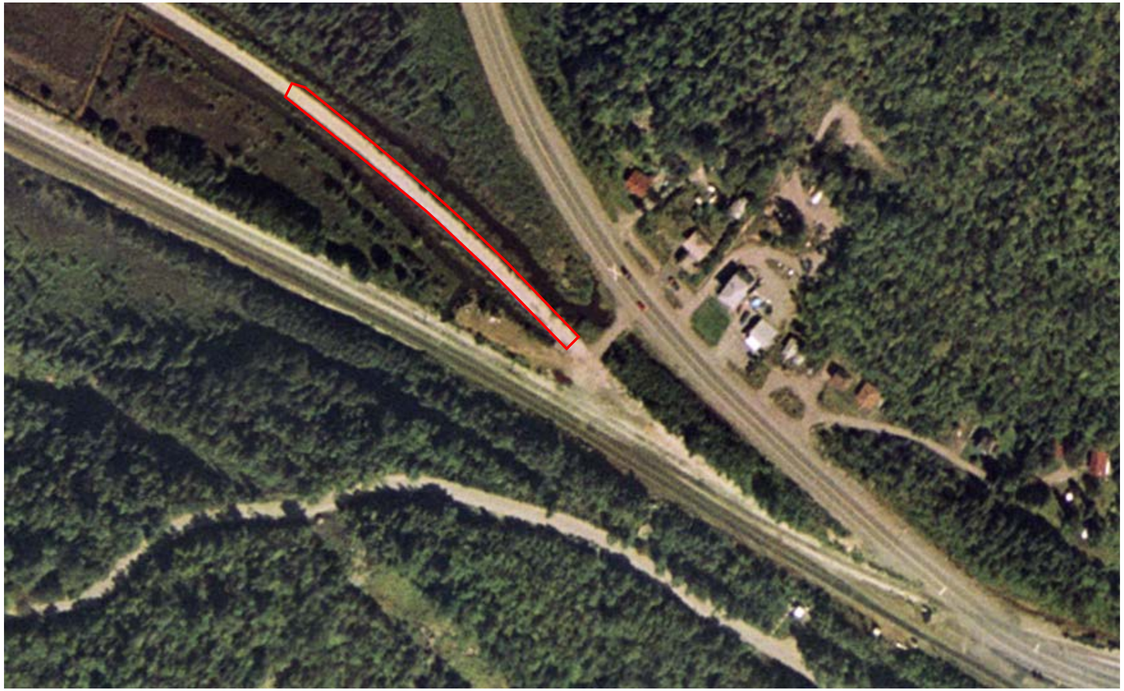
SITE 3

Contaminant	Binder Content						
	Unamended	5%		10%		15%	
		7-day cure	28-day cure	7-day cure	28-day cure	7-day cure	28-day cure
Copper	1940	<50	57	64	58	60	-
Nickel	350	<100	<100	<100	<100	<100	-
Zinc	350	<100	<100	<100	<100	<100	-
Chromium	<50	<50	<50	291	140	215	-

2015 FIELD TRIAL

- A section of the Swamp Track railbed was treated in 2015
- 40 mt of Lafarge Maxcem 80:20 (80% Portland Cement, 20% slag) was applied to railbed materials excavated to a depth of approximately 0.5 m from a 124 m long, 7 m wide area
- Binding agent was applied to excavated soils by a loader with a bucket scale and mixed with an excavator bucket before replacement into the excavation

REMEDIATION AREA



STABILIZATION TRIAL

STRIPPING SOIL FROM THE REMEDIATION AREA

STABILIZATION TRIAL

DISPENSING BINDING AGENT ONTO STOCKPILED SOILS

STABILIZATION TRIAL

BINDING AGENT AND SOIL READY FOR MIXING

STABILIZATION TRIAL

MIXING BINDER THROUGH THE STOCKPILE

STABILIZATION TRIAL

REINSTATEMENT OF BLENDED MATERIAL

POST-TREATMENT MONITORING

- Piezometers were installed surrounding the treatment area
- To date, two rounds of groundwater sampling have been conducted
- Samples are analyzed for metals

REMEDIATION AREA AND MONITORING NETWORK

DISSOLVED METALS IN GROUNDWATER

Parameter	Unit	PZ-3	
		11/13/2015	5/19/2016
DISSOLVED METALS			
Chromium (Cr)	µg/L	<5.0	<5.0
Copper (Cu)	µg/L	21	<1.0
Nickel (Ni)	µg/L	160	260
Zinc (Zn)	µg/L	27	5.1

Parameter	Unit	PZ-4	
		11/13/2015	5/19/2016
DISSOLVED METALS			
Chromium (Cr)	µg/L	5.6	5.6
Copper (Cu)	µg/L	39	9.3
Nickel (Ni)	µg/L	630	610
Zinc (Zn)	µg/L	55	16

Parameter	Unit	PZ-6	
		11/13/2015	5/19/2016
DISSOLVED METALS			
Chromium (Cr)	µg/L	<5.0	<5.0
Copper (Cu)	µg/L	21	<1.0
Nickel (Ni)	µg/L	1100	1100
Zinc (Zn)	µg/L	42	<5.0

Parameter	Unit	PZ-8	
		11/13/2015	5/19/2016
DISSOLVED METALS			
Chromium (Cr)	µg/L	<5.0	<5.0
Copper (Cu)	µg/L	100	<1.0
Nickel (Ni)	µg/L	200	41
Zinc (Zn)	µg/L	<5.0	<5.0

Parameter	Unit	PZ-2	
		11/13/2015	5/19/2016
DISSOLVED METALS			
Chromium (Cr)	µg/L	<5.0	<5.0
Copper (Cu)	µg/L	<1.0	<1.0
Nickel (Ni)	µg/L	480	85
Zinc (Zn)	µg/L	23	5.5

Parameter	Unit	PZ-5	
		11/13/2015	5/19/2016
DISSOLVED METALS			
Chromium (Cr)	µg/L	<5.0	<5.0
Copper (Cu)	µg/L	20	<1.0
Nickel (Ni)	µg/L	410	140
Zinc (Zn)	µg/L	12	5.8

Parameter	Unit	PZ-7	
		11/13/2015	5/19/2016
DISSOLVED METALS			
Chromium (Cr)	µg/L	<5.0	<5.0
Copper (Cu)	µg/L	530	220
Nickel (Ni)	µg/L	23000	23000
Zinc (Zn)	µg/L	120	65

LESSONS LEARNED/NEXT STEPS

- Cement-based stabilization appears promising in reducing the leaching of metals from the railbed materials in areas that affect drainage water quality.
- Some areas of persistent metals concentrations may be related to a secondary source – this is being investigated.
- Mixing methods need to be matched to the scope of application. Full-scale approaches could use an Allu mixer or pug mill in place of the methods applied here.
- The treatment area has been expanded in 2016 through the creation of a second test plot – differences:
  - 100% Portland cement binder
  - Pre-dosed application of cement (supersacks vs. bulk transport)

FUTURE WORK

- Further followup water quality monitoring and regulatory reporting.
- Preparation of multi-year plan for expansion of cement-based stabilization to target other key locations at this site.

CONTACT INFORMATION

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