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



PRESENTERS

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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

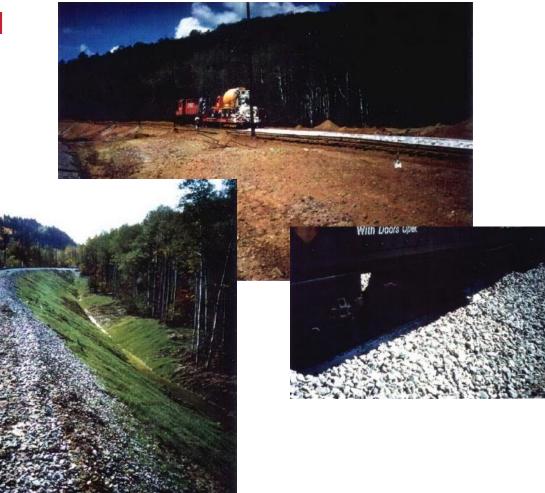
- In the 1980s, elevated metals concentrations were observed in drainage water from the Yard and Spur trackage.
- Track bed remediation was implemented in 1990 to remove metals containing materials.





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.



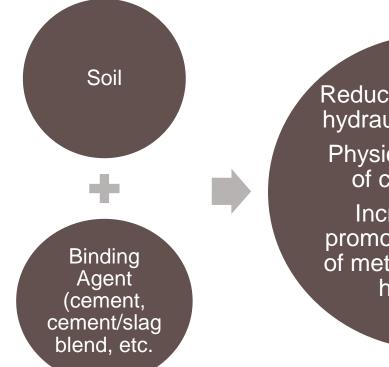


FURTHER MITIGATION REQUIRED

- 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



Reduced porosity and hydraulic conductivity Physical entrapment of contaminants

Increased pH – promotes conversion of metals to insoluble hydroxides



SAMPLE COLLECTION

SAMPLES COLLECTED FROM THREE LOCATIONS

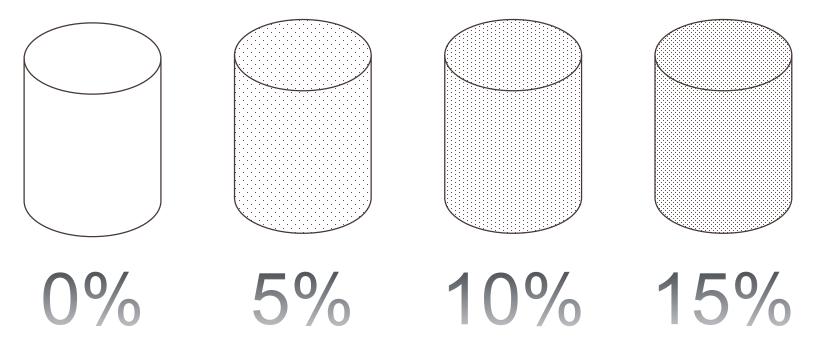




BENCH-SCALE TESTING

MIX DESIGN - SAMPLE MATERIAL COMBINED WITH CEMENT

• Proportions of cement binder by weight was varied between samples



CURING TIME

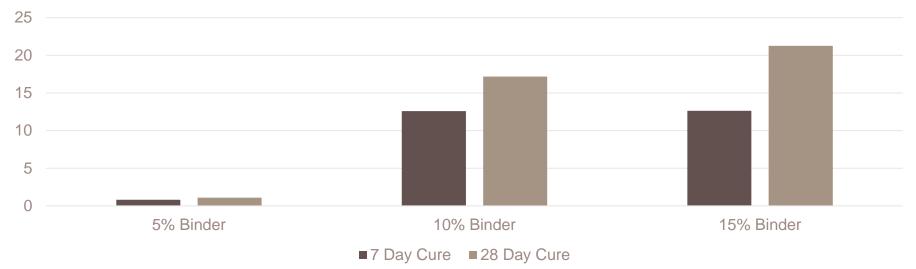
- Samples were cured in a moisture room
- Curing time was varied prior to physical and chemical testing
 - 7 day
 - 28 day



PHYSICAL PROPERTIES TESTING

COMPRESSIVE STRENGTH TESTING – SAMPLING LOCATION 1

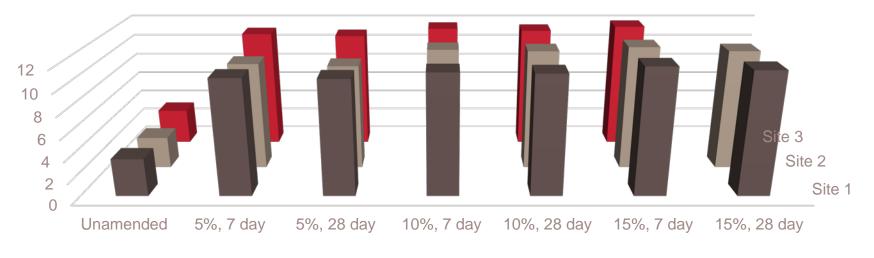
Compressive Strength (MPa) as a function of binder content and cure time







Soil pH vs Binder Content



■ Site 1 ■ Site 2 ■ Site 3



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													
		59	%	1()%	15%								
	Unamended	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													
		59	%	10)%	15%								
	Unamended	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													
		5'	%	10	%	15%								
	Unamended	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





STRIPPING SOIL FROM THE REMEDIATION AREA





DISPENSING BINDING AGENT ONTO STOCKPILED SOILS





BINDING AGENT AND SOIL READY FOR MIXING





MIXING BINDER THROUGH THE STOCKPILE





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	P	Z-3	and the second	10 ca	1.0	1000		24 MV		0014770		N	Demonstern	11-11	Pž	Z-2
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Copper (Cu)	µg/L	21	<1.0		STO DO		ALC: N		4. 198	144	ALC: NO.	1999		Copper (Cu)	µg/L	<1.0	<1
Nickel (Ni)	µg/L	160	260	1000		PZ-1		41.31	and the		10					480	
Zinc (Zn)	µg/L	27	5.1		16		P7-2	A Carlos		111	C LOVE	Market Co	10 M 10	Nickel (Ni)	µg/L		8
			8		10 C 10 11	Contraction of the		Sector 1	\$ K.S.S.			date in		Zinc (Zn)	µg/L	23	5.
Parameter	Unit		Z-4		CARL TON		PZ-3	141.002	St. Oak			100	6.0				
		11/13/2015	5/19/2016		353 10	1000			- U - 10		1114		1 -	_		PZ	Z-5
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					A CONTRACTOR	Se 1 2 1	Land	1000	COMPANY IN			1150	10.20	Zinc (Zn)	µg/L	12	5.
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				1	10	The second	- And	Con al	CONTRACTOR OF		ALC: NOTE:	2000 D		Nickel (Ni) Zinc (Zn)	µg/L	120	230 65
		P	Z-8					Tolker P. In.	ATT COM	ALL SK	The second second	1 400			µg/L	120	00
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Chromium (Cr)	µg/L	<5.0	<5.0				Contra State	Image © 2015 Digital	Slobe	ALC: NO.	5 B. S	Coorden	arth				
Copper (Cu)	µg/L	1010	<1.0	100 B				THORE A	10.000	Contract And		GOOQICE					
	µg/L	200	41														
Nickel (Ni)		200															



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)





- 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.



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