Bioremediation of Weathered Crude Oil in Complex Soils: Introduction

Thank you to IPEC and Canadian Pacific for the opportunity to present!

Outline:

1. Brief Site History
2. Summary of Bioremediation Activities
3. Summary of Results from Field test and Site Status

Incident Overview

- Crude oil train left transloading facility on Feb 4, 2014
- Crew change stop near Weaver, Minnesota, adjacent to Weaver Bottoms National Wildlife Refuge (45 minutes)
- Leaking bottom outlet valve due to the car being improperly secured at loading facility caused a release of an unknown quantity of oil along route and at Weaver Bottoms
- Initial investigation along ~70 miles of track resulted in removal of oil impacted snow
- Oil was not detected above ground until March 10th when seeps observed on both sides of main line
- Bioremediation and absorbents used during response efforts
- Site weathered 3 separate flooding events which submerged portions of impacted areas throughout the growing season
- Soil/groundwater investigations and vegetative monitoring confirmed cleanup via bioremediation and absorbent methods
- MPCA closure received Fall 2015

Bioremediation of Weathered Crude Oil in Complex Soils: A Southern Minnesota Field Study

22nd IPEC Conference

Denver, Colorado

November 17-19, 2015

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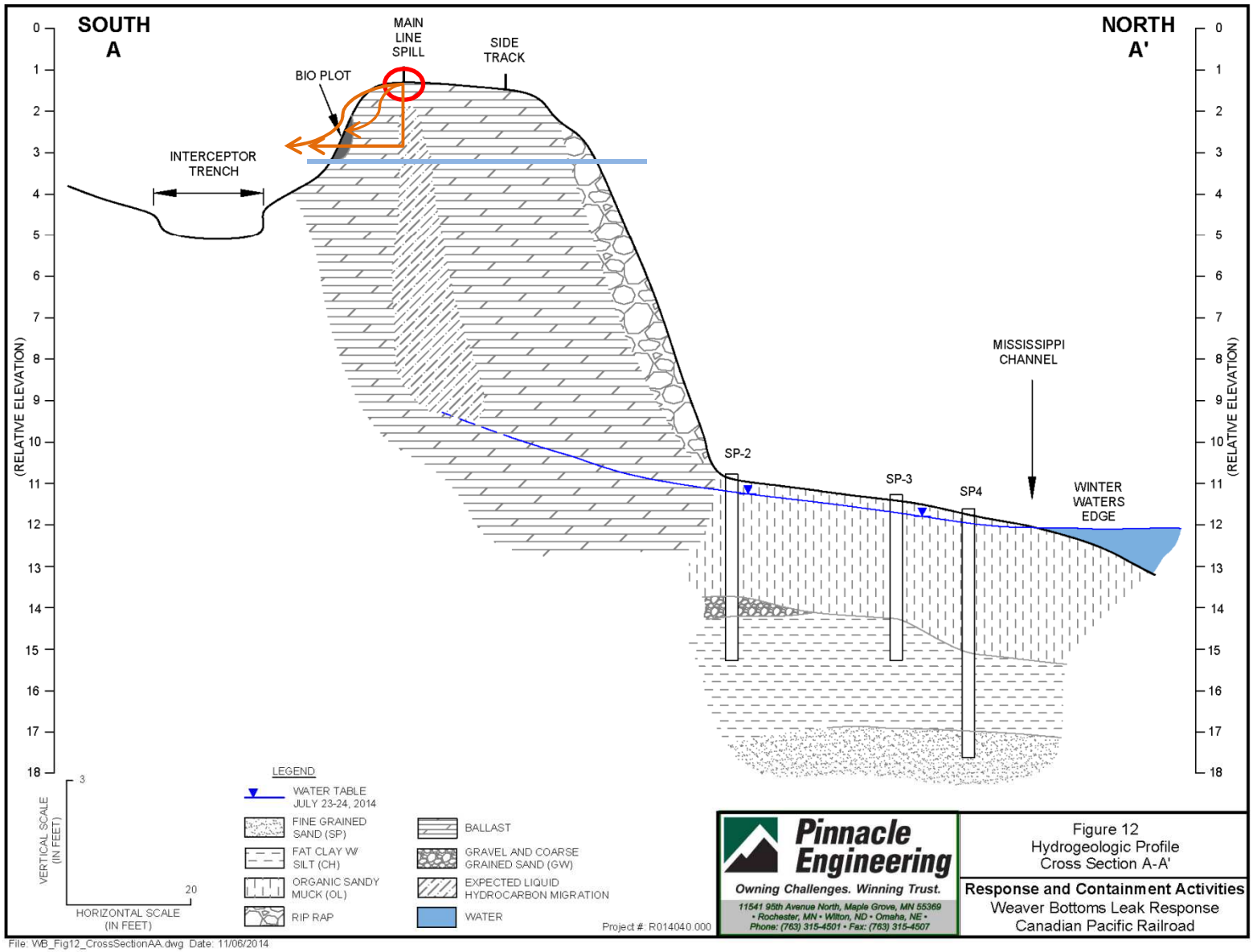
SOUTH
A
NORTH
A'
MAIN LINE SPILL
SIDE TRACK
BIO PLOT
INTERCEPTOR TRENCH
MISSISSIPPI CHANNEL
SP-2
SP-3
SP4
WINTER WATERS EDGE
(RELATIVE ELEVATION)
LEGEND
WATER TABLE JULY 23-24, 2014
FINE GRAINED SAND (SP)
FAT CLAY W/ SILT (CH)
ORGANIC SANDY MUCK (OL)
RIP RAP
BALLAST
GRAVEL AND COARSE GRAINED SAND (GW)
EXPECTED LIQUID HYDROCARBON MIGRATION
WATER
VERTICAL SCALE (IN FEET)
HORIZONTAL SCALE (IN FEET)
Project #: R014040.000
Pinnacle Engineering
Owning Challenges. Winning Trust.
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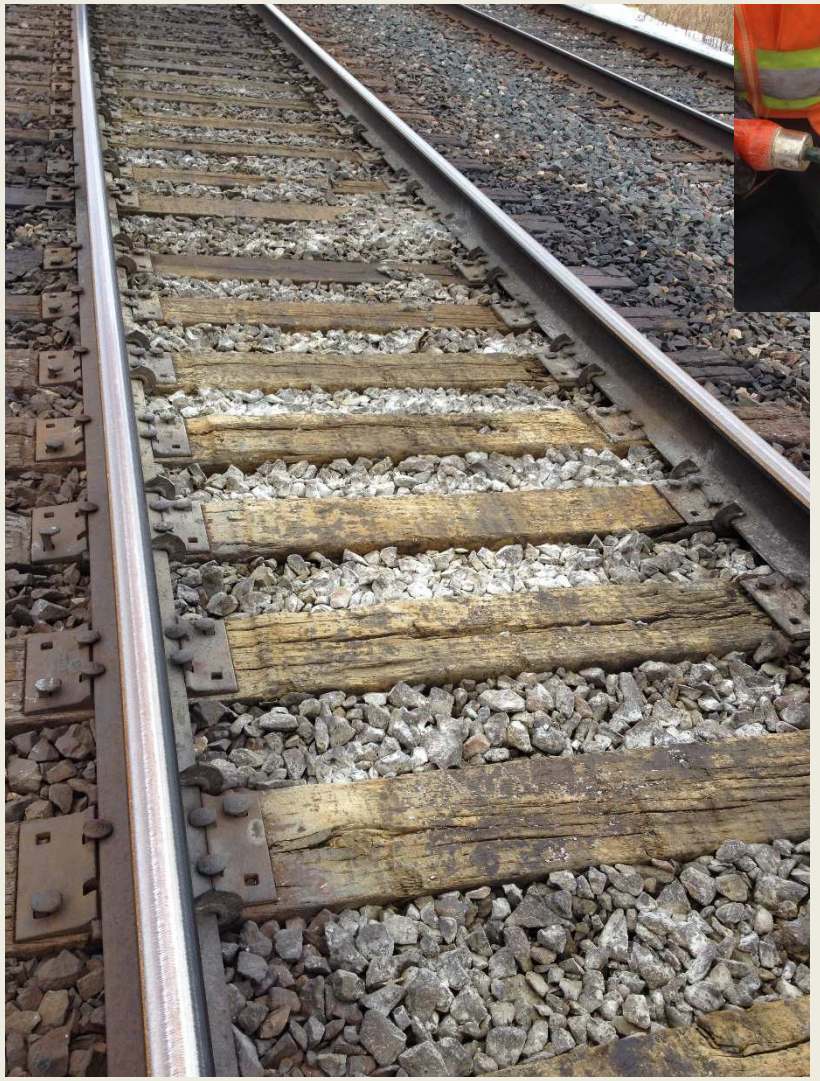
Figure 12
Hydrogeologic Profile
Cross Section A-A'
Response and Containment Activities
Weaver Bottoms Leak Response
Canadian Pacific Railroad
File: WB_Fig12_CrossSectionAA.dwg Date: 11/06/2014

Emergency Response Phase

Date	BioZorb Applications	Locations of BioZorb Applications	AquaZyme Applications	Location of AquaZyme Applications
March 11, 2014	130 lbs. in 65 gallons water	Point source and 30' linear of surrounding track	#1- 50 lbs. hand spread #2- 1.5 lbs. in 8 gallons of creek water	#1- snow/ice/melt water/oil mixture in ditch #2- directly to seep with backpack sprayer
March 20, 2014	102 lbs. in 205 gallons water	Point source and 30' linear of surrounding track	1 lb. in 4 gallons of creek water	Directly to seep with backpack sprayer
April 7, 2014	50 lbs. in 185 gallons water	Point source	1 lb. in 4 gallons, into injection piezometers	7 separate locations within vegetation
TOTALS	**282 lbs. in 455 gallons of water**	-	**53.5 lbs. in 16 gallons of water**	-

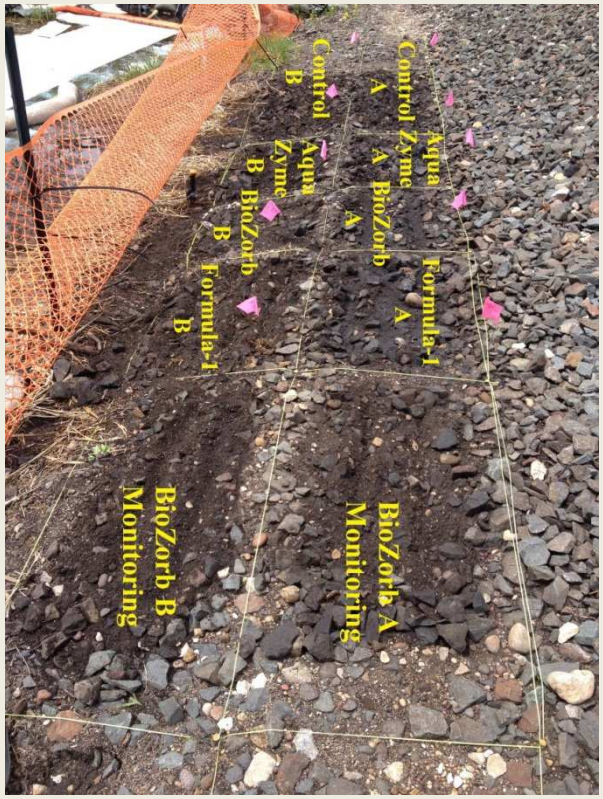


Bioremediation Product in powder form

Study Area Preparation

Visual surface staining

Defining study area by PID screening and baseline sampling



Grid established and bioremediation applied

What contamination is present?

Baseline Sampling at 2-4” bgs

- GC/MS : C_{10} – C_{40} alkane distribution
- BTEX (Benzene, Toluene, Ethylbenzene, total Xylene) | EPA 8260
- TPH – Gasoline Range Organics (C_6 – C_{10}) | EPA 8015/8021
- TPH – Diesel Range Organics (C_{10} – C_{28}) | EPA 8015 Modified
- TPH – Motor Oil Range (C_{24} – C_{36}) | EPA 8015 Modified

Weathering

- Crude oil spent 52 days above ground while seeping
- 78 days total from the release in early February

Site History

- Small amounts of AquaZyme in solution sprayed on seepage face
- Large amounts of BioZorb in slurry applied to railroad tracks up-gradient

Bioremediation Product Selection

3 Oppenheimer Biotechnology Products (Austin, TX)

- **BioZorb** – for land spills requiring absorbent properties
- **AquaZyme** – designed for spills on water
- **Formula 1** – designed for intensity and direct application to pollutants

Compound Name	Microbes per gram of product
BioZorb	10^{8}
AquaZyme	10^{9}
Formula-1	10^{11}

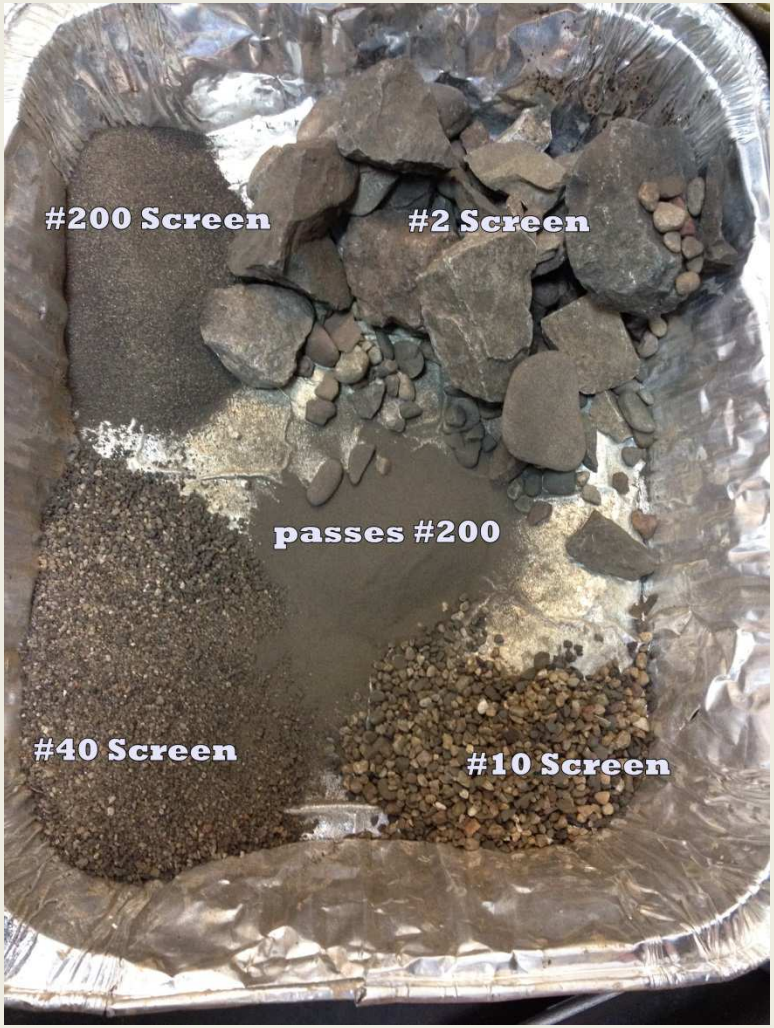
Product Information

- Consortium of naturally occurring aerobic and microaerophilic ***archaea*** selected for hydrocarbon affinity
- Hydrophobic cells only
- 5-year shelf life
- Non-freeze dried
- Activated by fresh or salt water
- Active between 32-120 °F and pH 5.5-10.0

Oppenheimer Biotechnology, Inc. Domain Archaea Fact Sheet. http://www.obio.com/docs/pdf/DA2014.pdf (accessed 8/25/14).

Portier, R.J. and Basirico, L.M. Laboratory Screening of Commercial Bioremediation Agents for the Deepwater Horizon Spill Response. Louisiana State University Dept. of Env. Sciences. ***2011****, 1-40.*

Study Area Soil Types

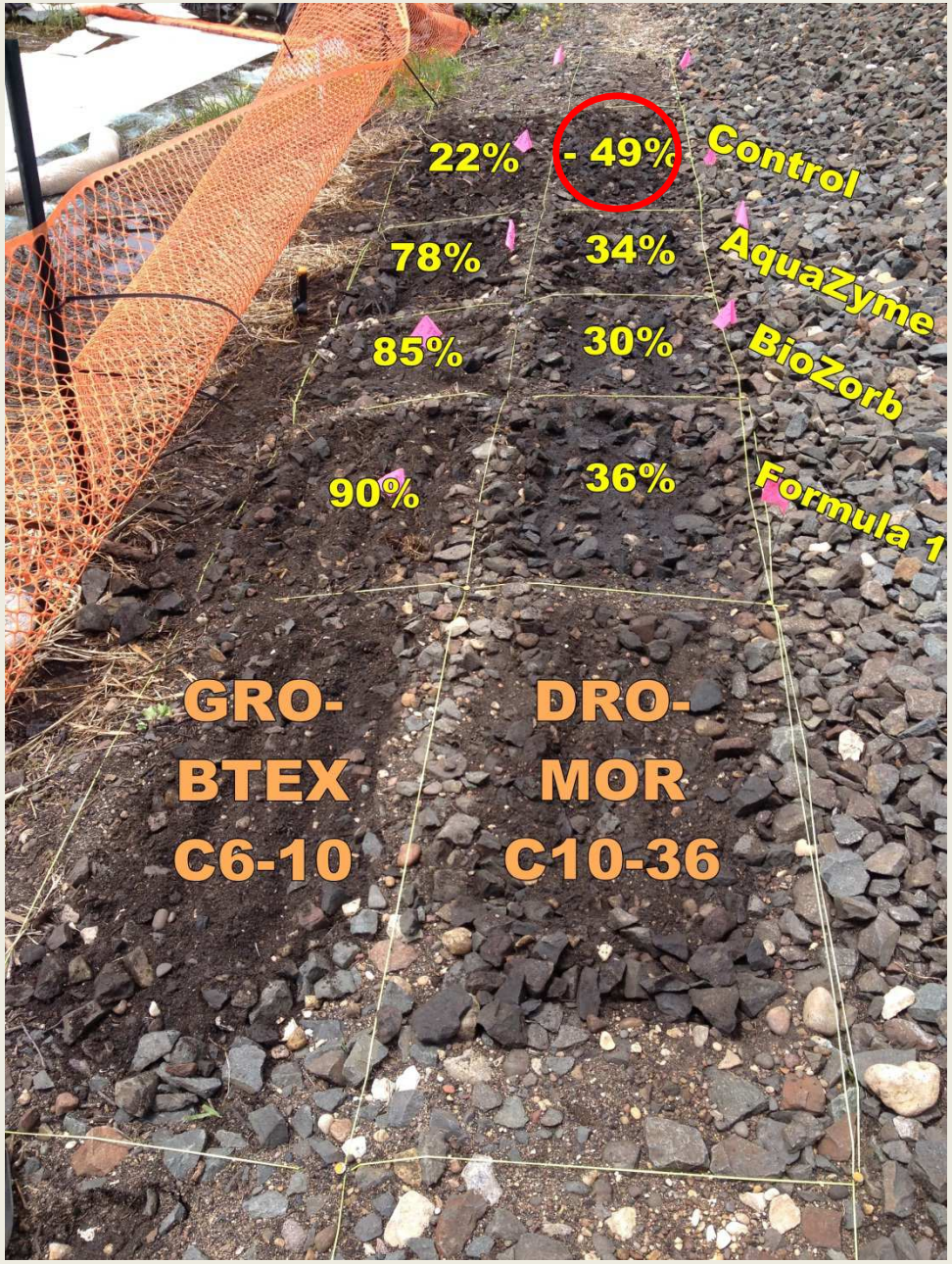


↓ “umbrella effect” from large rock within plot

Bioaugmentation Results

Hydrocarbon Reduction (%) Per Week - Day 0 - 60

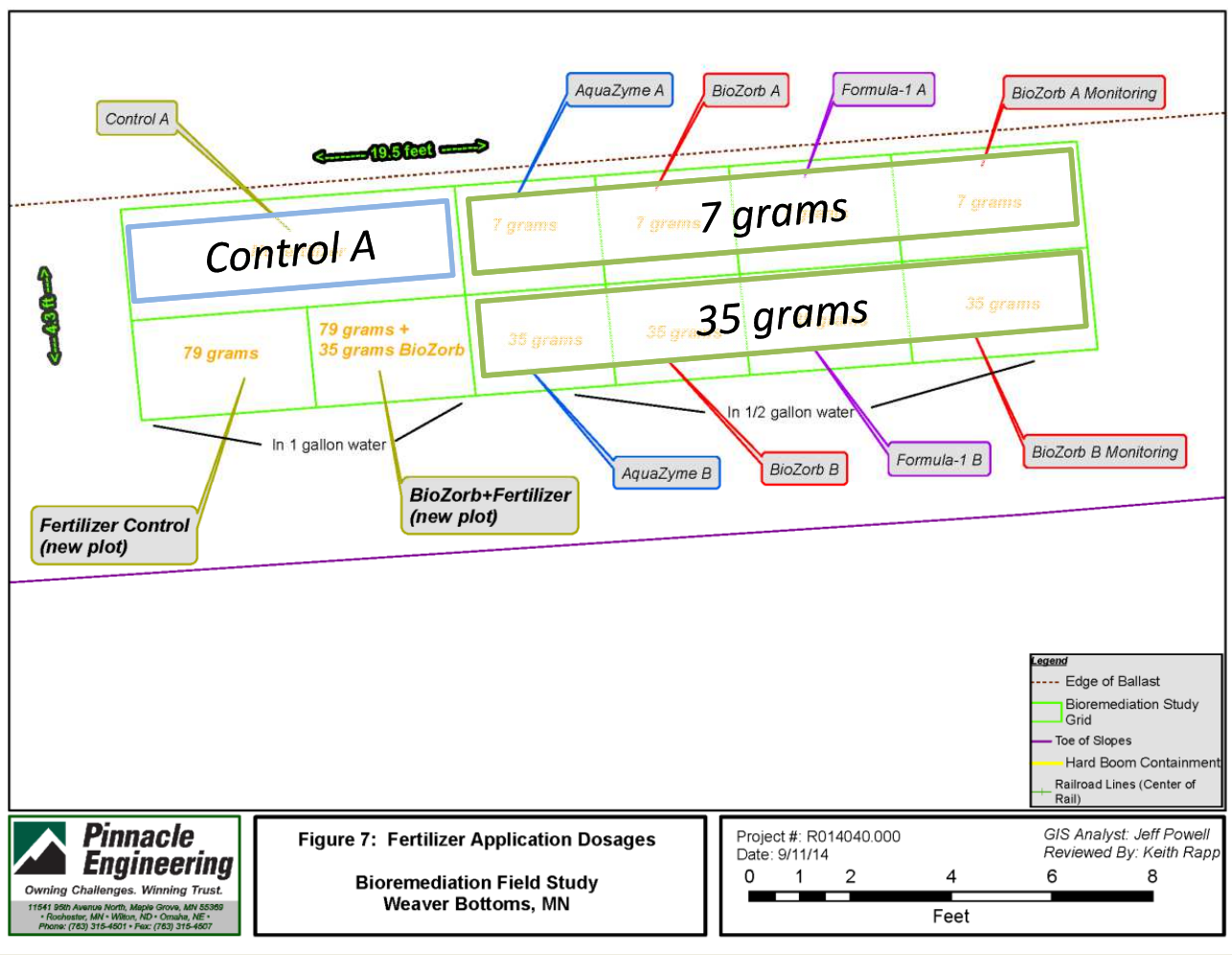
Carbon Chain\BTEX	BioZorb	AquaZyme	Formula I	Control (Natural Attenuation)
TPH-MOR (C24-C36)	2.4%	3.7%	3.9%	-5.2%
TPH-DRO (C10-C28)	1.9%	3.9%	4.2%	-5.7%
TPH-GRO (C6-C10)	6.9%	6.7%	9.2%	0.1%
Benzene	6.5%	8.3%	9.8%	1.9%
Ethylbenzene	9.4%	9.8%	10.6%	5.9%
Toluene	7.5%	8.8%	10.1%	1.2%
Xylene (Total)	9.2%	9.7%	10.6%	3.0%



Average Temperature Day 0-60:

69.7 °F

Nutrient Amendments – Day 60



Oppenheimer Nutrient Formula

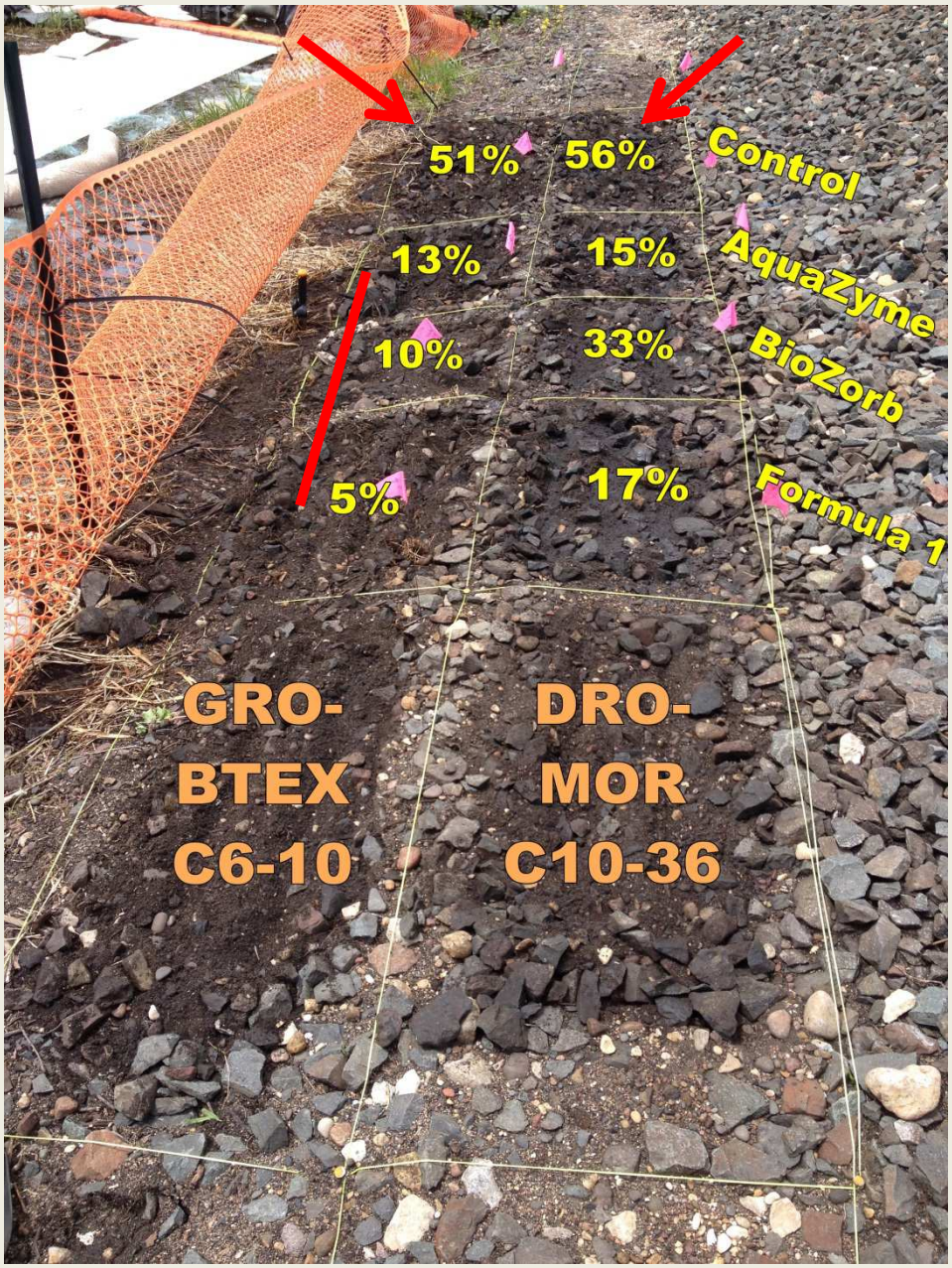
21-10-10 plus trace minerals

- **Ammoniacal N 12.8%**
- **Nitrate 8.2%**
- **$P_2 0_5$ 10%**
- **$K_2 0$ 10%**
- S 7%
- Minerals: B, Cu, chelated Fe, Mn, Mo, Zn

39 Day Nutrient Application Results

Hydrocarbon Reduction (%) Per Week - Day 61-99

Carbon Chain\BTEX	A & B Plots BioZorb	AquaZyme	Formula I	BioZorb + Nutrients	Control (Natural Attenuation)
TPH-MOR (C24-C36)	5.9%	2.3%	2.2%	13.0%	11.8%
TPH-DRO (C10-C28)	9.9%	3.9%	4.6%	15.1%	10.6%
TPH-GRO (C6-C10)	6.2%	5.4%	2.6%	13.8%	13.6%
Benzene	5.5%	2.6%	1.1%	4.7%	9.6%
Ethylbenzene	1.6%	1.2%	0.4%	2.6%	5.7%
Toluene	4.3%	2.5%	0.9%	3.6%	11.6%
Xylene (Total)	2.3%	1.6%	0.4%	7.7%	10.5%



Average Temperature Day 61-99:

73.6 °F

Results Summary

Total Hydrocarbon Reduction (%) - Day 0 - 99

Carbon Chain\BTEX	BioZorb	AquaZyme	Formula I	BioZorb+ Nutrients	Control (Natural Attenuation)	Nutrient Control
TPH-MOR (C24-C36)	50.3%	45.0%	45.6%	64.8%	12%	65%
TPH-DRO (C10-C28)	65.6%	54.2%	61.0%	75.7%	2%	73%
TPH-GRO (C6-C10)	83.7%	87.4%	95.5%	69.2%	69%	93%
Benzene	79.5%	87.8%	94.1%	23.6%	65%	74%
Ethylbenzene	76.5%	94.1%	97.1%	12.9%	82%	42%
Toluene	77.2%	92.0%	95.1%	18.0%	68%	65%
Xylene (Total)	79.6%	95.0%	97.2%	38.3%	79%	64%

Results Summary

Closing Summary

- Demonstrated bioremediation effectiveness
  - In relatively short time
  - In one application event
  - With no active tilling/mixing
  - In cold climate
- Gained approval for emergency response use and pilot study of bioremediation by interfacing with several regulatory agencies

Refuge

Site closure received from MPCA, Fall 2015

Experiment Plot and Interceptor Trench

Refuge


Pinnacle Engineering
Thank You
Untreated
Treated