SURFACTANT ENHANCED PUSH-PULL METHOD FOR IN-SITU REMEDIATION OF PETROLEUM CONTAMINATED SOIL AND GROUNDWATER

Presenter

George (Bud) Ivey
Ivey International Inc.

22nd International Petroleum Environmental Conference
November 17 to 19, 2015
Denver, CO
Grand Hyatt Downtown Denver

www.iveyinternational.com

Chester River Hospital Center

Fuel Oil Spill Release Discovery 1991

vey-sol® Surfactant Pilot Scale Application July 2014

(Evaluation Report January 2015)

Remediation Team Members

Ivey International Inc.

"Today's Environmental Solutions For A Better Tomorrow"

HESTER RIVER
OSPITAL CENTER

HB SOLUTIONS

EBA

BrightFields, Inc.
Environmental Services

IVEY-SOL
Surfactant Technology
www.iveyinternational.com

Public Domain Presentation

CHESTER RIVER HOSPITAL CENTER

GROUNDWATER REMEDIATION

2013/2014 ACTION PLAN MODIFICATIONS

CASE NO. 1987-2534-KE

PILOT TEST EVALUATION REPORT AND PROPOSED 2015 ACTION PLAN

JANUARY 19, 2015

Ivey International Inc.

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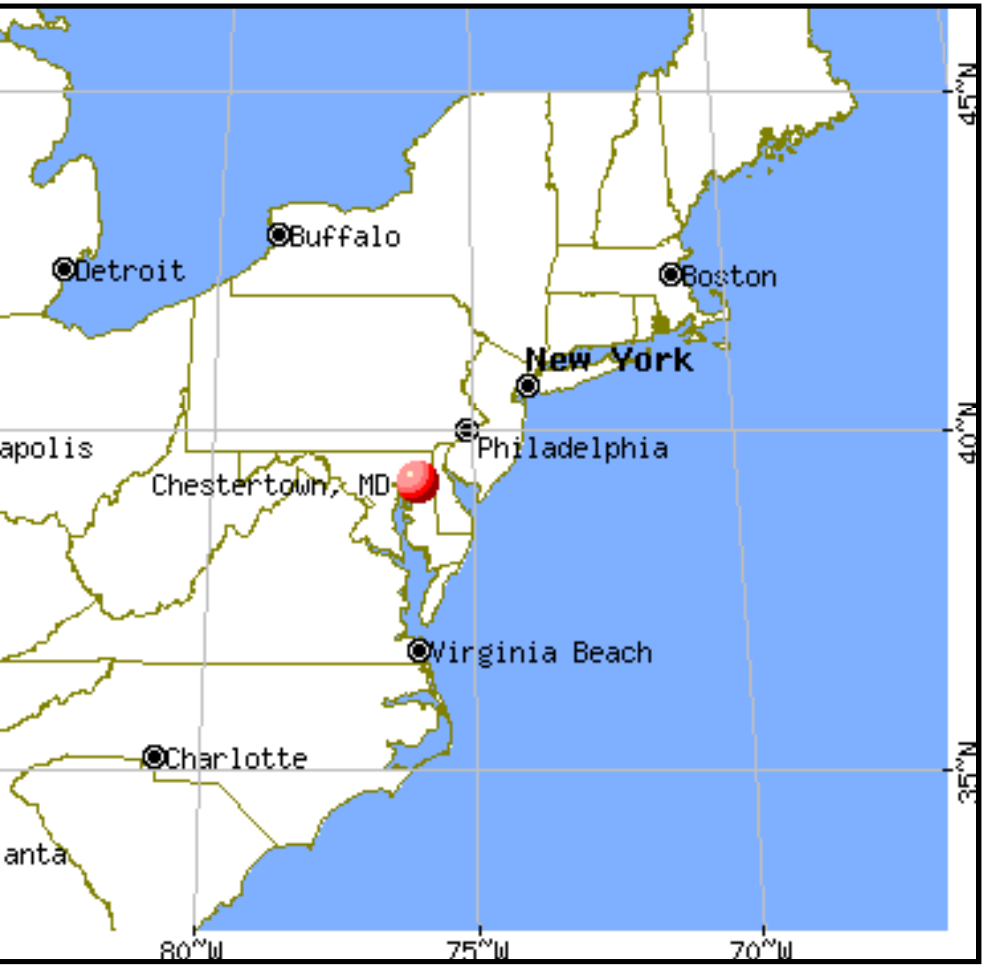
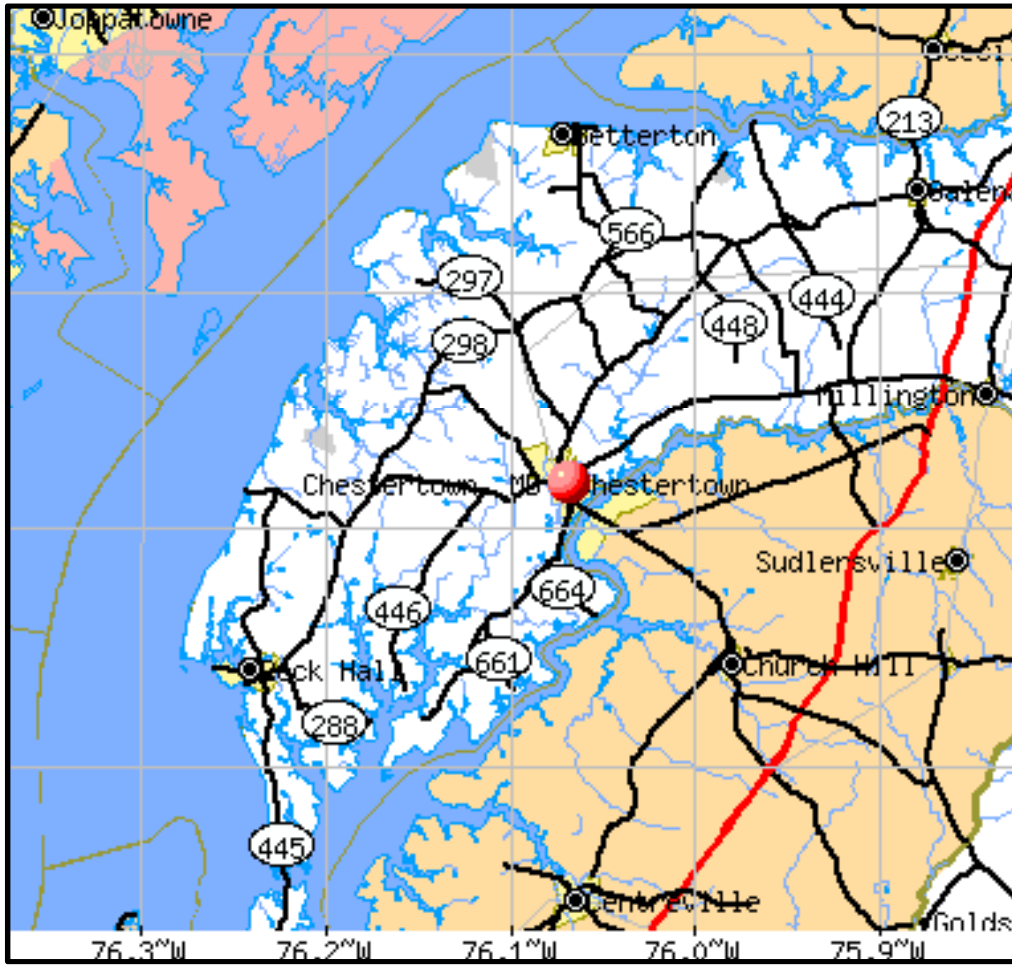
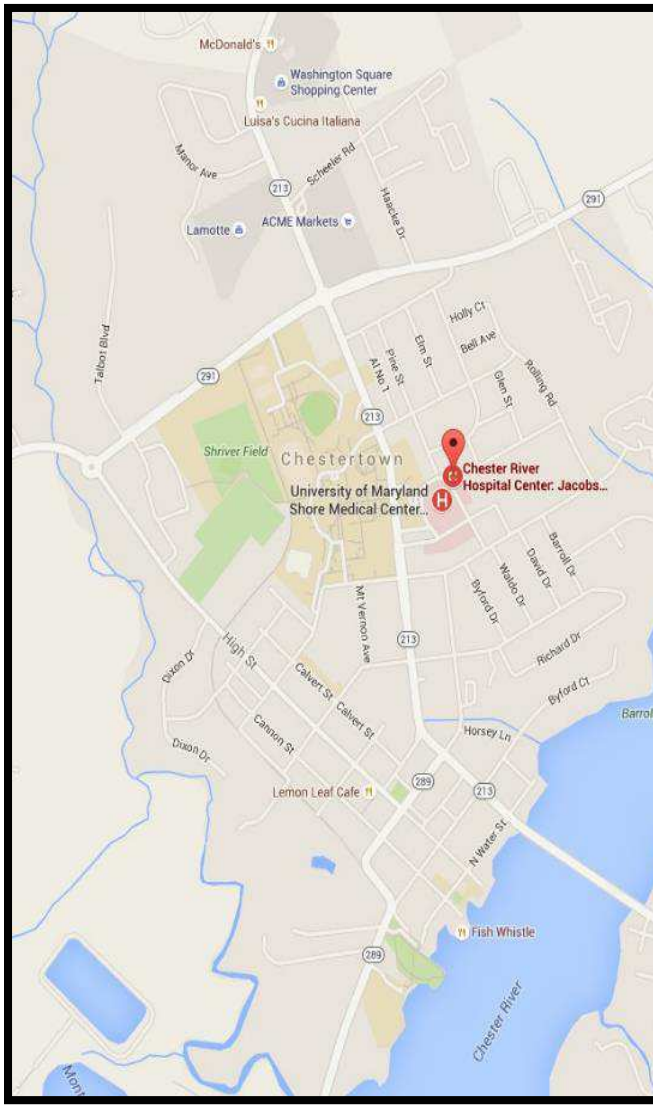
Site Location
Chestertown MD USA



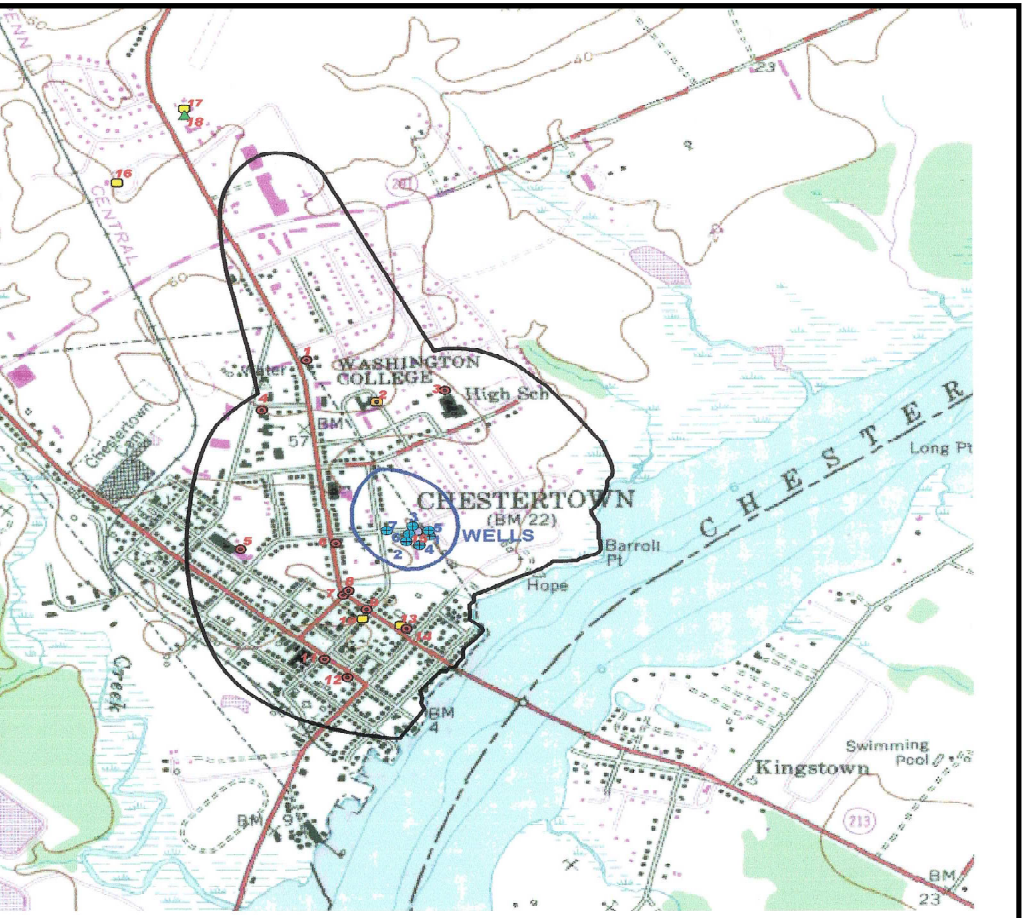


te Background Information

- ter River Hospital Center 7.1 Acres
- development since 1935 as hospital
- Oil release discovered May 1991 (10,000 Gal. tank was y over a weekend)…*likely leaking for years*
- c Water supply well 850 ft. (259 m) down gradient, shut n until remediation system was installed
- ndwater remediation system installed 1991
- Earth Data report indicated ≈ 83,452 Gal. (315,900 L) of PL removed from site between 1991 to July 2012
- tion of MDE 12 month Closeout Monitoring July 2012 to 2013, and the treatment system was shut off;
- evels of TPH (DRO) detected in June 2013 at Eight (8) of nteen (17) downgradient monitoring wells ☹
- *p & Treatment System Turned Back On!*
- *eholder Concerns Started Mounting!*



stertown Wellhead Protection Area (Unconfined Aquifer)



2. Chestertown Wellhead Protection Area with Potential Contaminant Sources

LEGEND

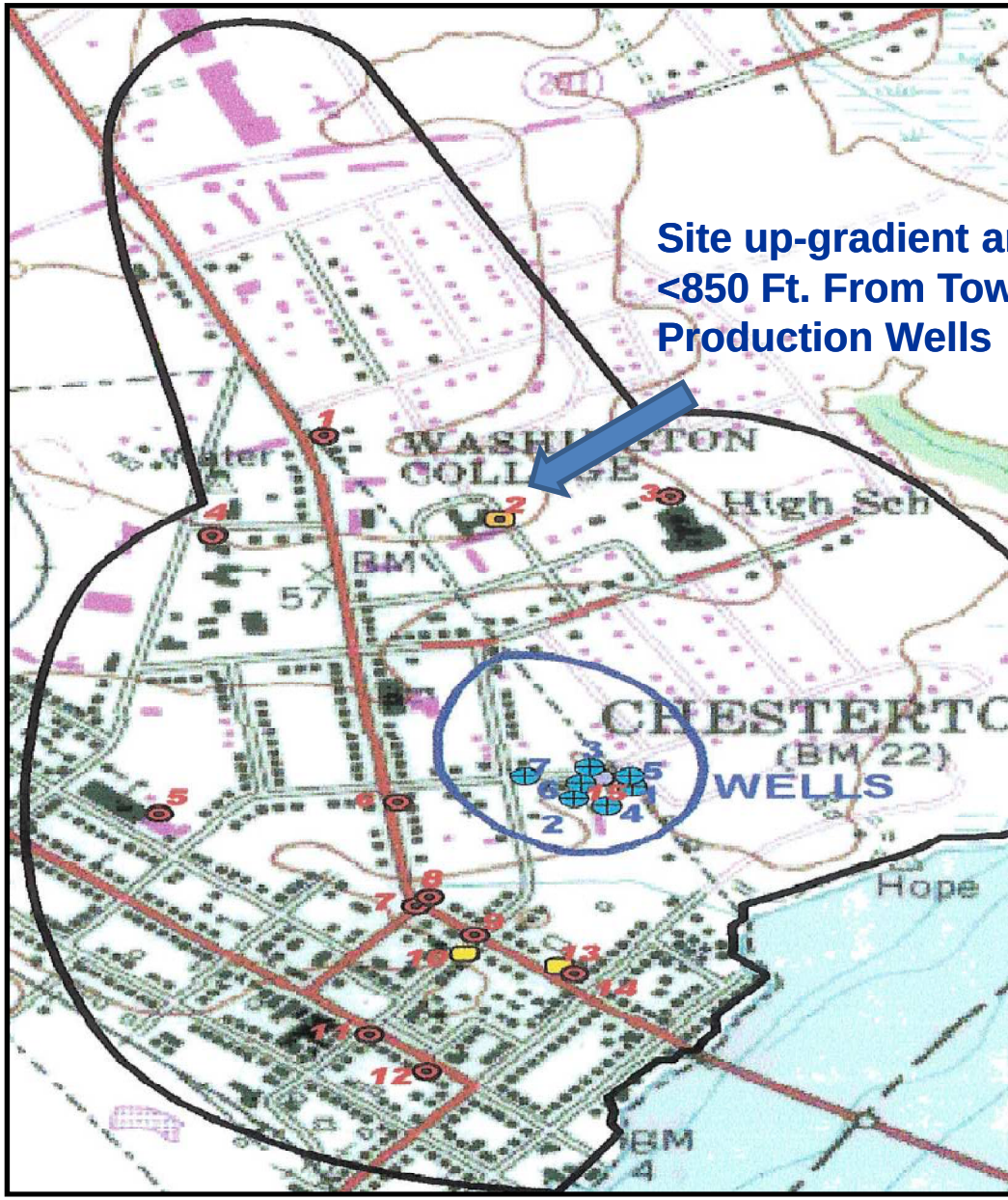
derground Storage Tank
aking UST
ove ground storage tanks
ound Water Discharge
S Generators

Wellhead Protection Area
Zone 1
Zone 2
Supply Well

1500 0 1500 Feet

N

Base Map: USGS 7.5 Minute Chestertown Topgraphic Quadrangle



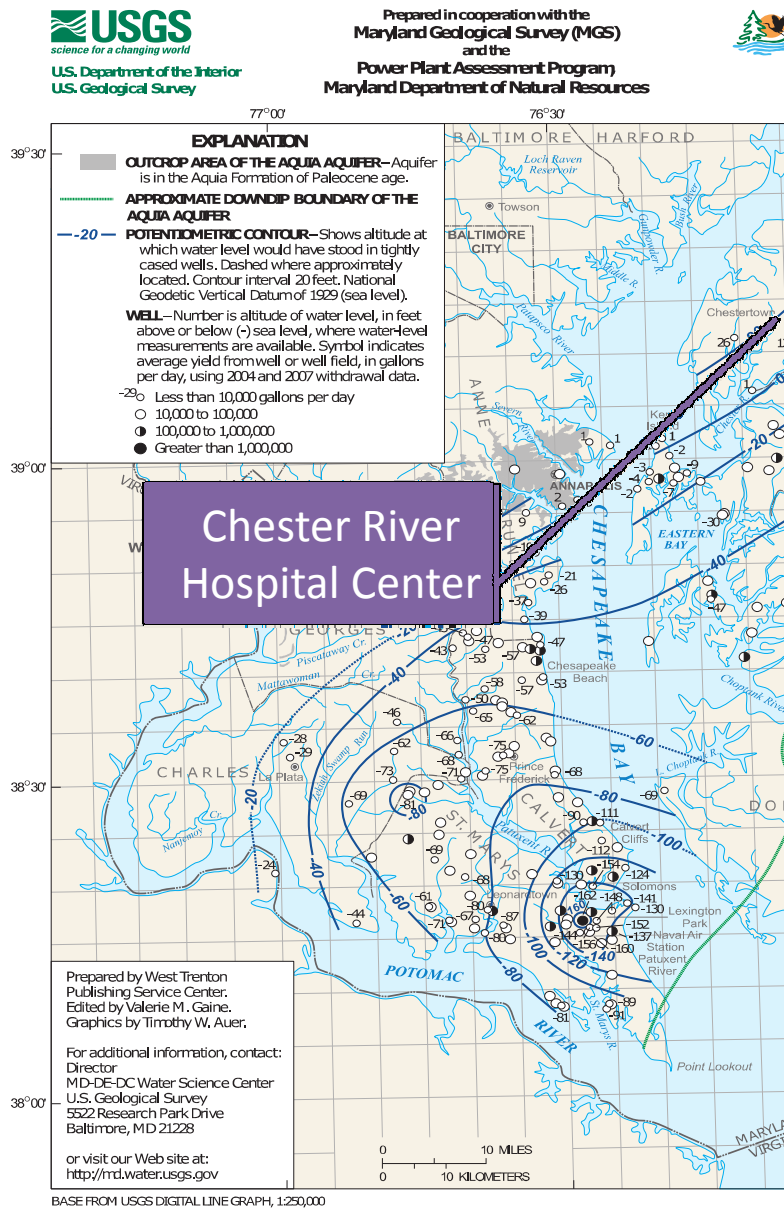
ology & Hydrogeology

ndwater and Surface water drains into the
ter River, a tidal tributary of Chesapeake Bay
h west)

red sand and silty sand to approximately 120 ft.
ia Formation, primary aquifer near site;
sauken Formation, generally absent near site)

er-table elevations fluctuate seasonally between
5 feet [*Smear Zone*] with depth to groundwater
nd 30 - 50 ft. bgs on-site

tertown's water supply from an '*Unconfined*
fer'

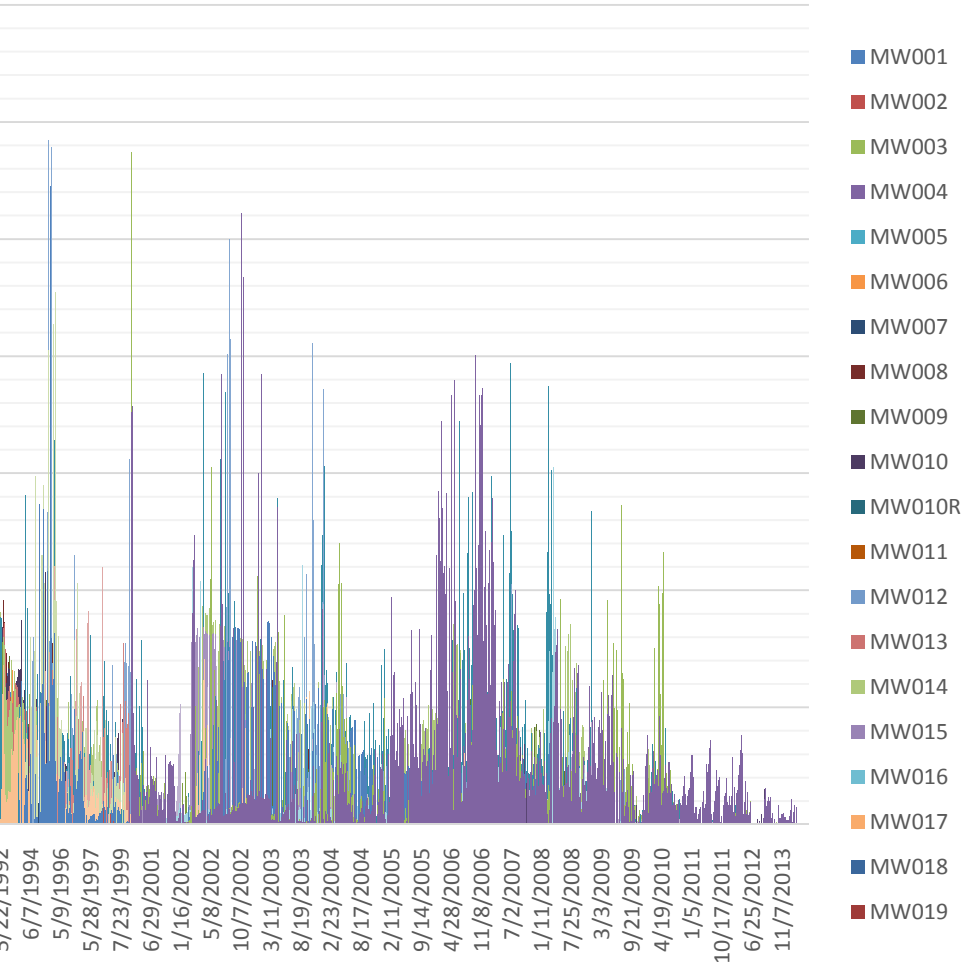


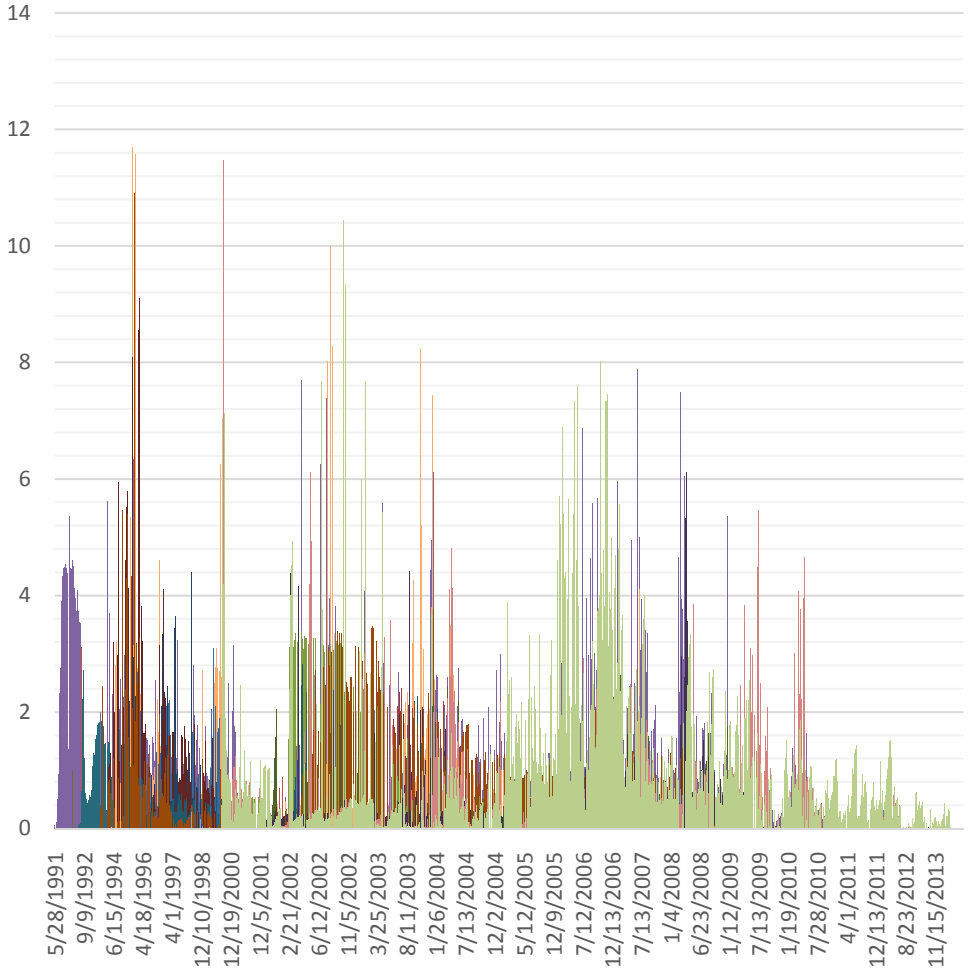
Potentiometric Surface of the Aquia Aquifer in Southern Mar
September 2007

Stephen E. Curtin (USGS), David C. Andreasen (MGS), and Andrew W. Staley (

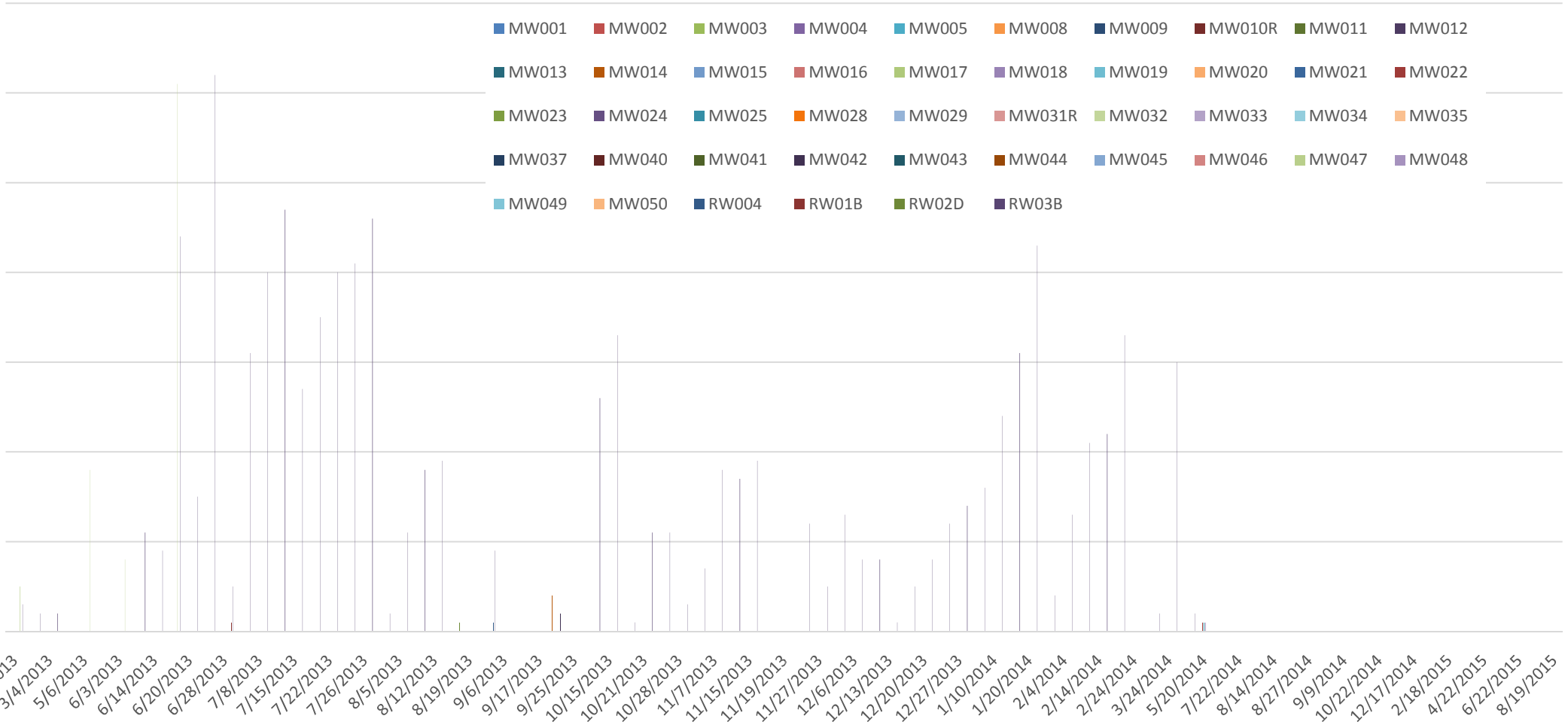
Open-File Report 2009–1080

Historical Product Levels (ft.) 1991 - 2013





Recent Product Levels (ft.) 2013-2015



takeholder Concerns

Chester River
Hospital Center
Time to Closure
>20 Yrs.)
High Costs $$$/yr. O&M
Environmental Risks
Legal Liability
Media Relations
Public Perception

Chestertown
Water Supply

- Hydraulic Control
- Off-site TPH Migration
- Risk to Well Field (Town Aquifer)
- Legal Concerns
- *Communications*
  [Did not know about 2012 closure]
- Public Perception

Maryland Department of Environment (MDE)

- Regulatory Oversight
- Off-site Migration
- Clean-up Standards
- Mediation
- Legal Concerns
- Public Perception

reatment System Background

over twenty (20) years CRHC's focus was:

emove liquid petroleum hydrocarbons (free product)

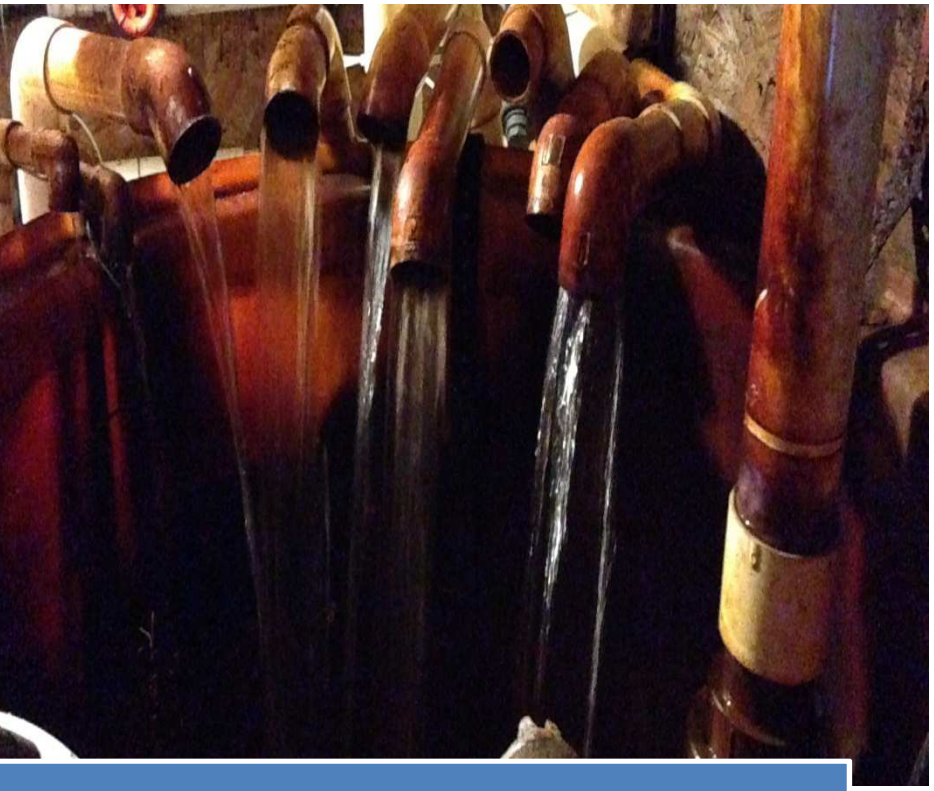
emediate the groundwater using a "Pump and Treat" P&T) system consisting of six (6) recovery wells, four (4) re-filters (sediment and Fe), and two (2) MYCELXCELX® tration units, with discharge to storm sewer

r expanded to Seven (7) Recovery wells and present tion/treatment system

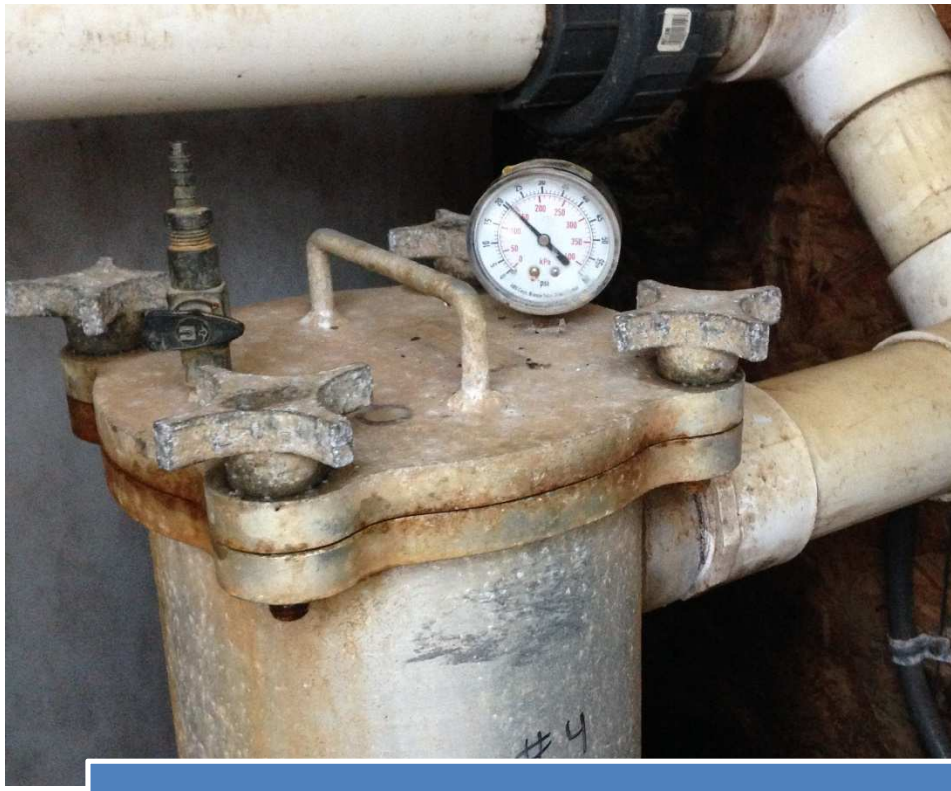
System Designed for 100-120 Gallons of groundwater minute (379 to 455 L/min) extraction rate requiring ment (*They have effective hydraulic control on-site*)

3,452 Gallons (315,900 L) of LNAPL product recovered between 1991 - July 2012

Treatment System



Recovery wells pump into holding tank (wet well)



Pre-treatment Filtration system (sediment)

‘Pump and Treat’ - Treatment System

Wet
Well

Bag
Filters

MYCELX
Treatment

Discharge to Storm Sewer – Under MDE Discharge

‘Pump and Treat’ - Treatment System

DE

Maryland Department of Environment GW Cleanup Standards for Type I and II Aqu

Benzene	Toluene	Ethylbenzene	Xylenes	Total BTEX	MTBE	Naphthalene	TPH-DRO	TP
			ug/L				*mg/L*	
5	1,000	700	10,000	NA	20	NA	0.047	0

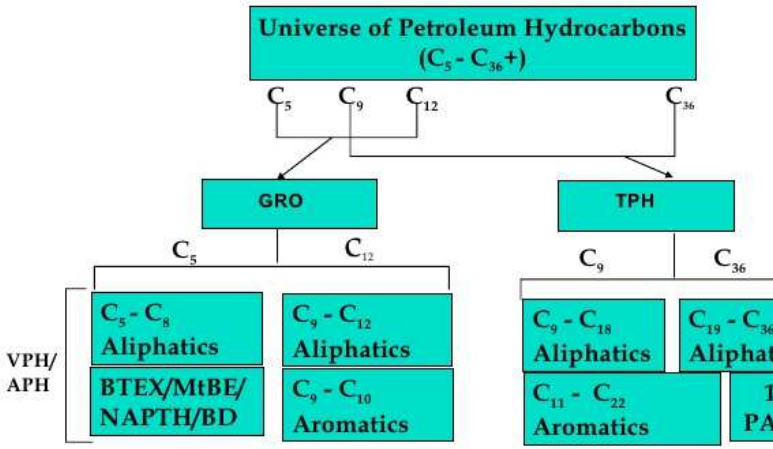
Interim Risk Based Goal: < 0.1

	Agency	n-Alkane Range	Aromatic Range	Boiling Point Range	Sample Preparation	Analysis
ge Organics)	US EPA	C10-C28	n/a	170-430 °C	solvent extraction	GC-FID
	Alaska	C10-C25	n/a	170-400 °C	solvent extraction	GC-FID
	Wisconsin	C10-C28	n/a	170-430 °C	solvent extraction	GC-FID
Petroleum Hydrocarbons)	Massachusetts	C9-C36	C11-C22	150-265 °C	solvent extraction + SPE fractionation	GC-FID
le Total Petroleum Hydrocarbons)	Connecticut	C9-C36	n/a	n/a	solvent extraction	GC-FID
ange Organics)	US EPA	C6-C10	n/a	60-170 °C	purge/trap or direct injection	GC-FID
	Alaska	C6-C10	n/a	60-170 °C	purge/trap	GC-FID
	Wisconsin	C6-C10	n/a	60-220 °C	purge/trap	GC-FID
Range Organics)	Florida	C8-C40	n/a	n/a	solvent extraction	GC-FID
n Volatile Organic Compounds)	Wisconsin	▲	n/a	60-220 °C	purge/trap	GC-PID
nology and Remediation Series)	New York	◆	◆	◆	◆	GC-MS
eum Hydrocarbons)	Texas	C6-C35	n/a	n/a	solvent extraction	GC-FID
	Washington	C7-C30	n/a	n/a	solvent extraction	GC-FID
roleum Hydrocarbons)	Massachusetts	C5-C12	C9-C10	36-220 °C	purge/trap	GC-PID-FID

nes the PVOC analyte list as the Wisconsin GRO list minus naphthalene.
e of New York document that provides guidance on the handling, disposal, and/or reuse of excavated petroleum-contaminated soil, with
-MS per US EPA Methods 8260 and 8270, modified with short, specific analyte lists.

BACKGROUND:
Analytical Methods

RELATIONSHIP OF MADEP VPH/EPH/APH TO TPH AND GRO



MADEP VPH/EPH/APH Guidance Document June 2001.

How Did We At IVEY Get Involved…

IVEY Surfactant
"TODAY'S ENVIRONMENTAL SOLUTIONS FOR

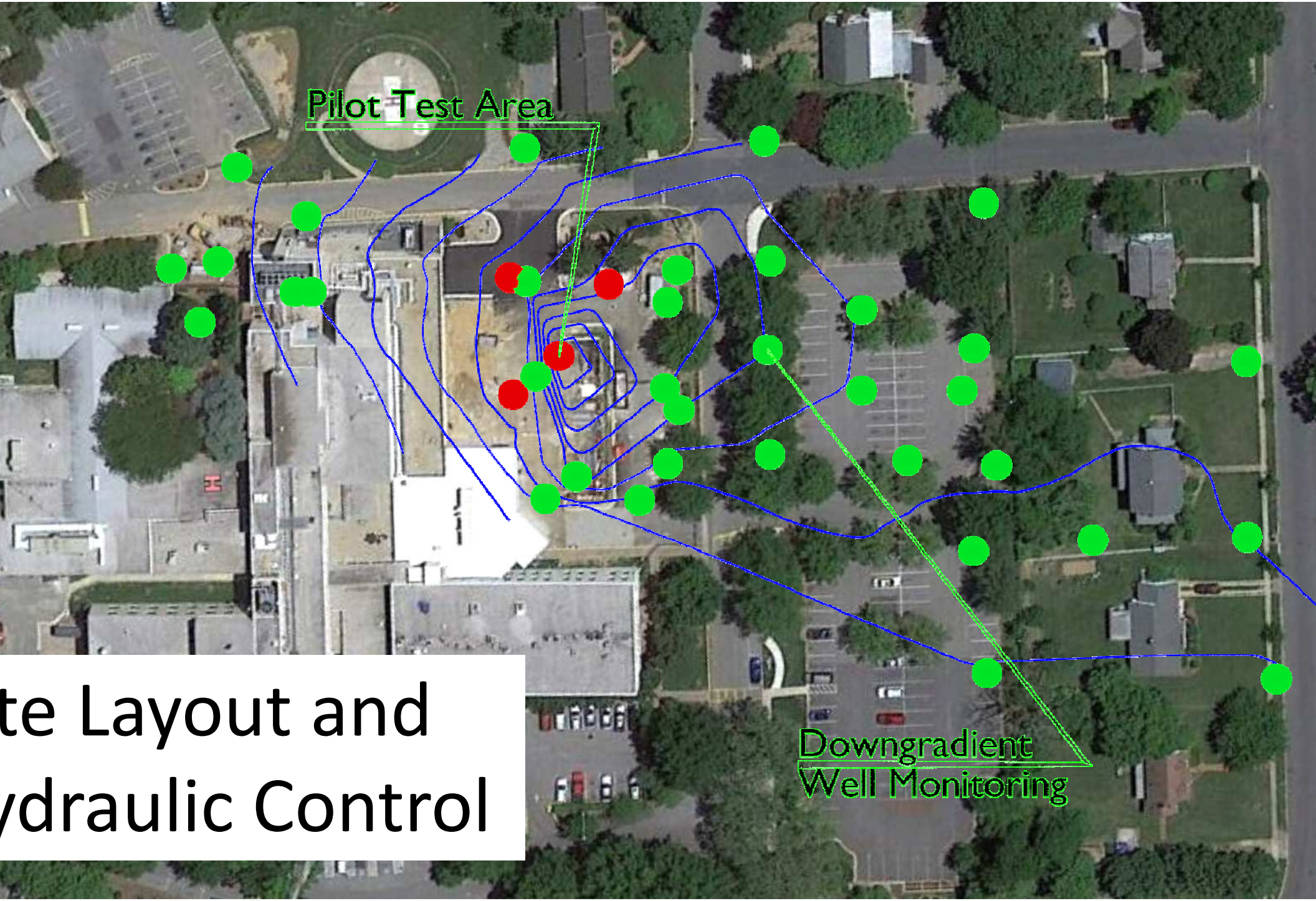
SURFACTANT ENHANCED PUSH-PULL METHOD

Pilot Scale In-situ Application

July – August 2014

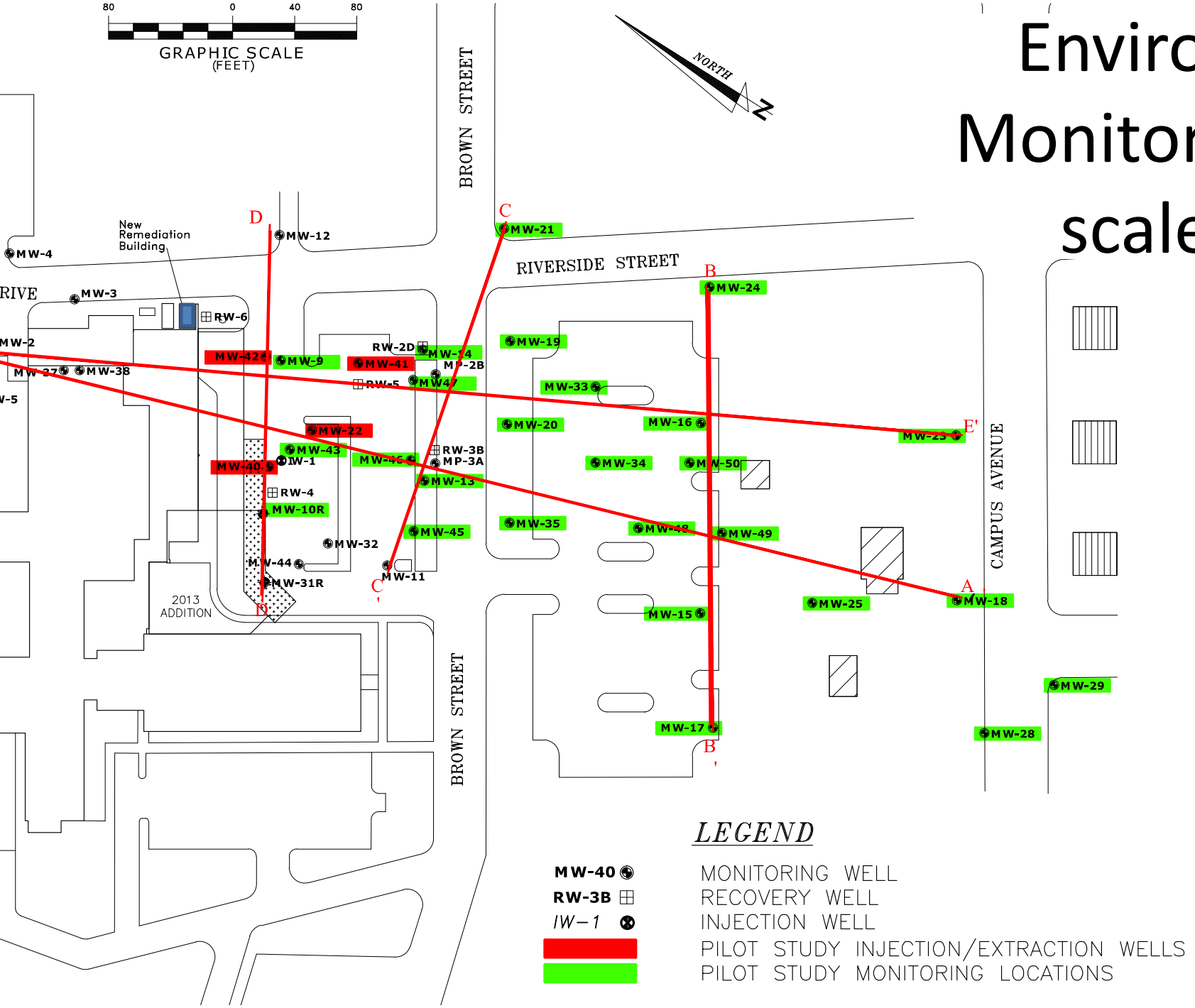
Completion of Three (3) Push-Pull Applications

IVEY-SO
Surfactant Technolo
www.iveyinternational.c

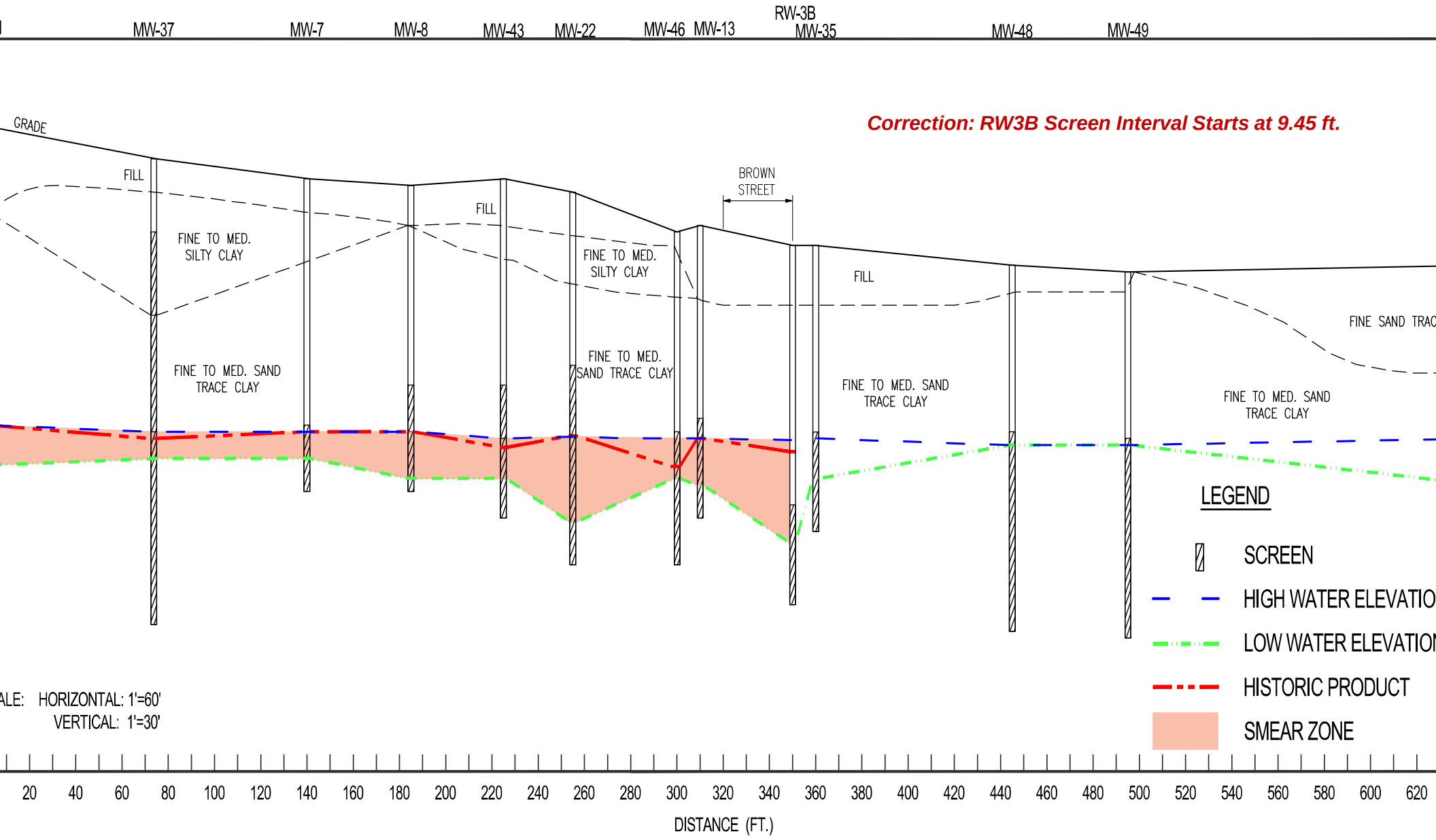


te Layout and
ydraulic Control

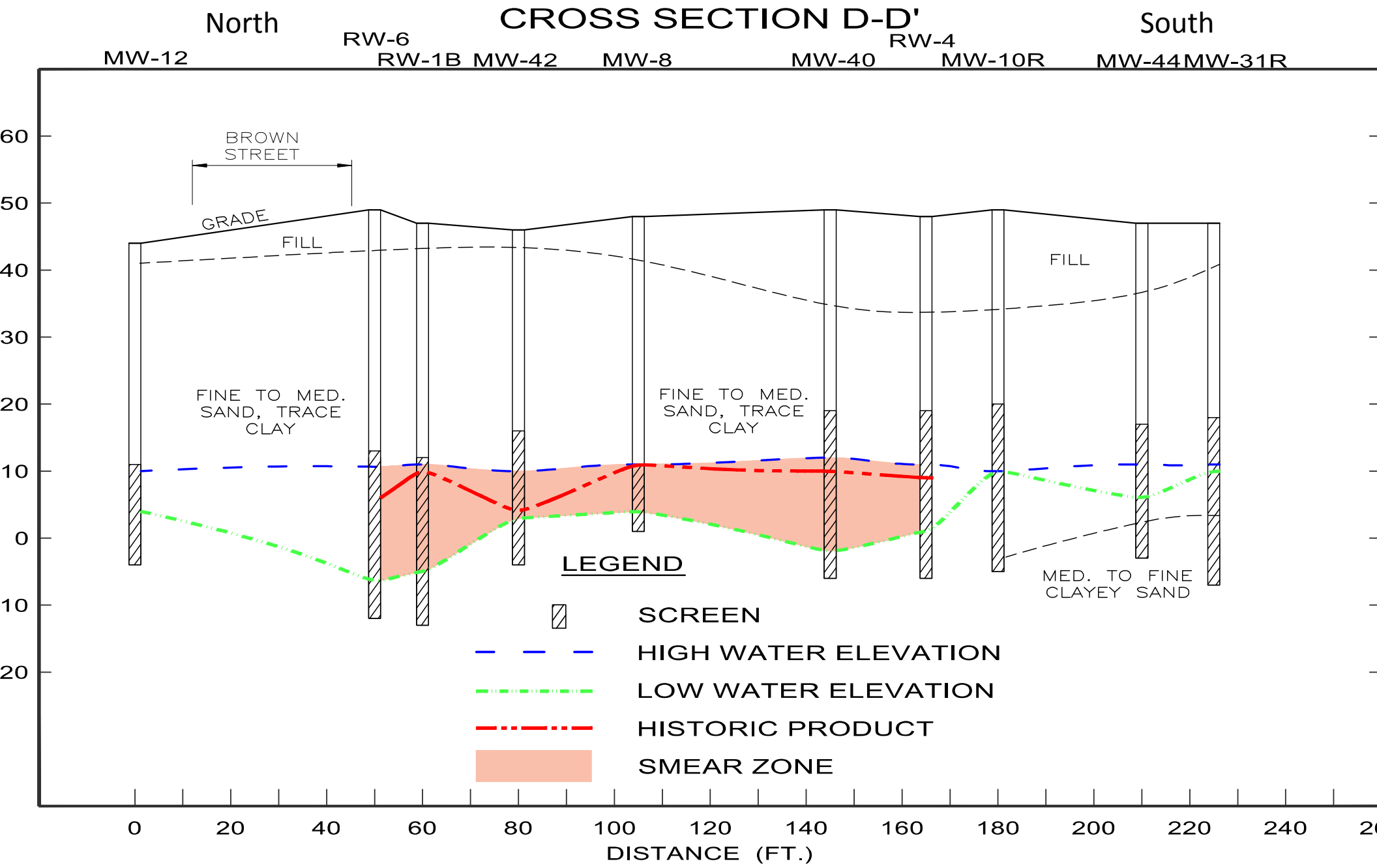
Environmental Monitoring & Pilo scale layout



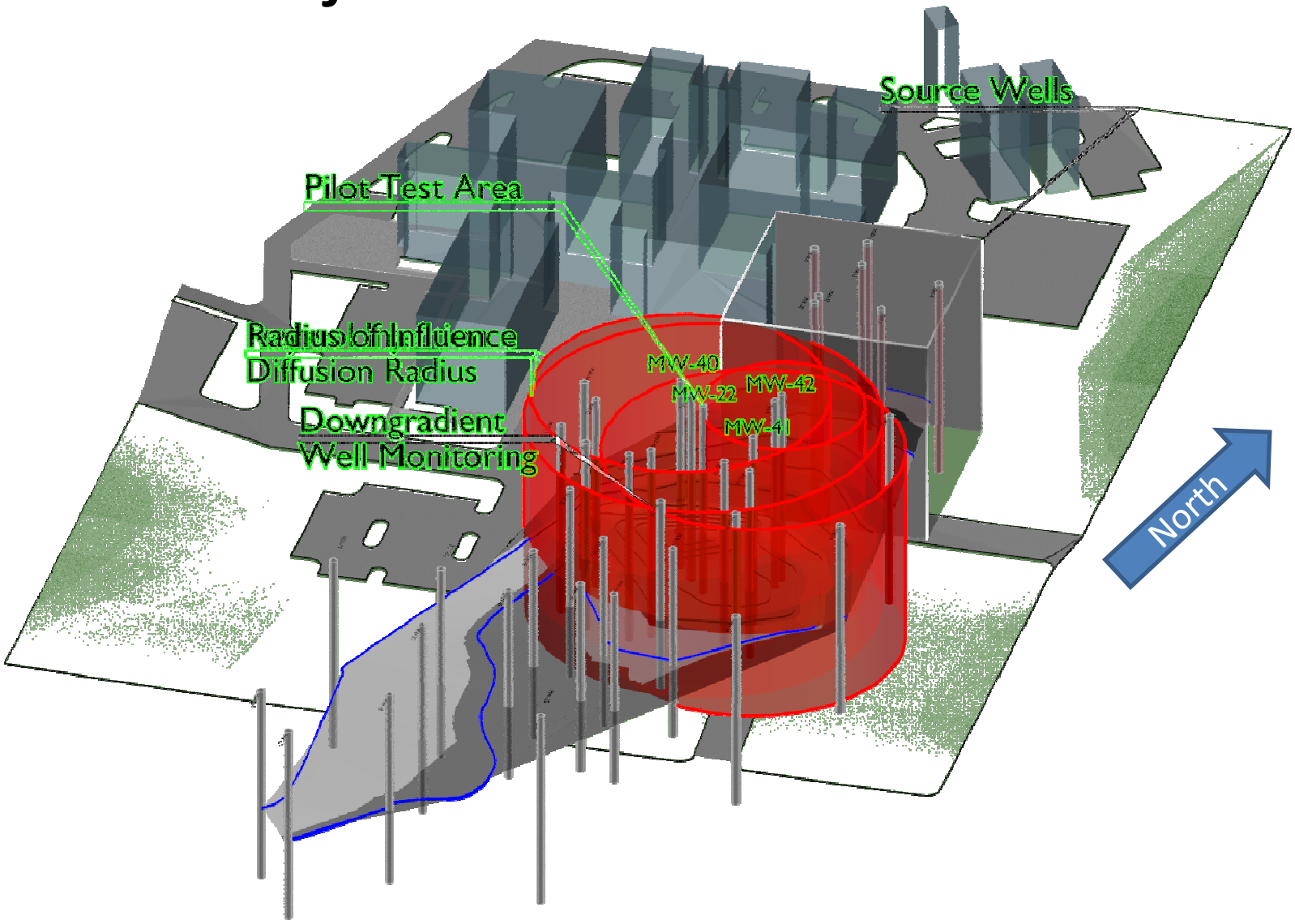
CROSS SECTION A-A'



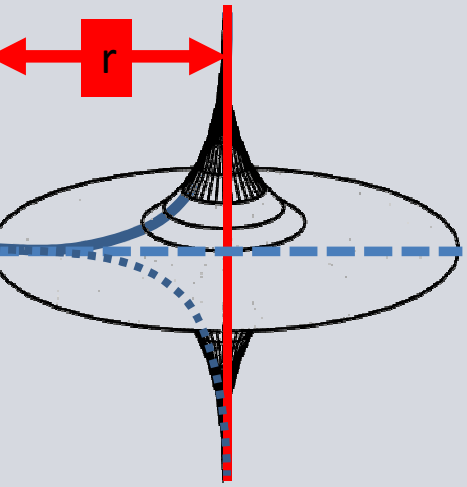
Correction: RW3B Screen Interval Starts at 9.45 ft.

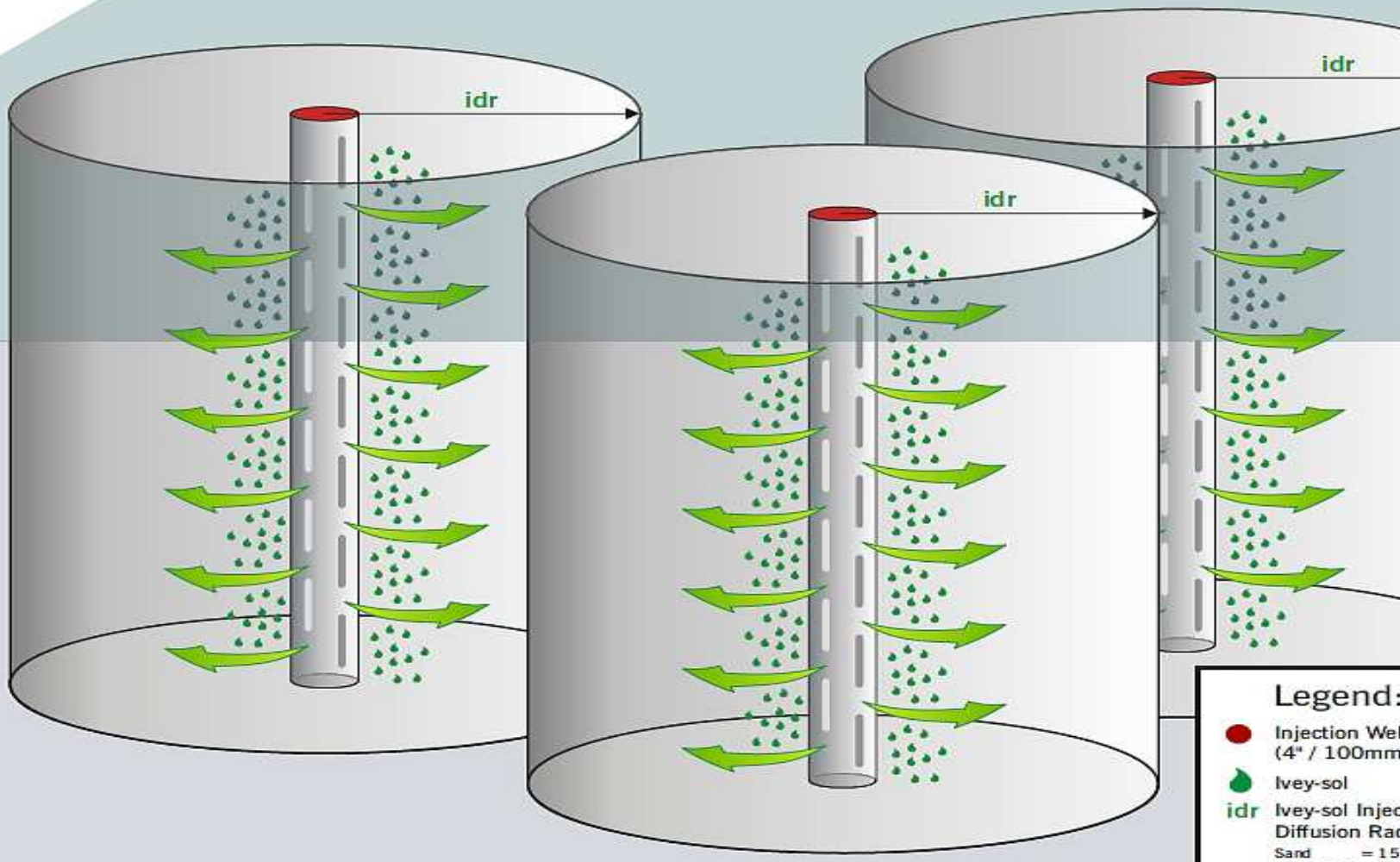

North
CROSS SECTION D-D'
South
MW-12
RW-6
RW-1B
MW-42
MW-8
RW-4
MW-40
MW-10R
MW-44
MW-31R
BROWN STREET
GRADE
FILL
FILL
FINE TO MED. SAND, TRACE CLAY
FINE TO MED. SAND, TRACE CLAY
MED. TO FINE CLAYEY SAND
LEGEND
SCREEN
HIGH WATER ELEVATION
LOW WATER ELEVATION
HISTORIC PRODUCT
SMEAR ZONE
60
50
40
30
20
10
0
10
20
0
20
40
60
80
100
120
140
160
180
200
220
240
DISTANCE (FT.)

Injection and Extraction



ROSS SECTION IVEY-SOL INJECTION DIFFUSION RADI





Legend:

Injection Wel
(4" / 100mm

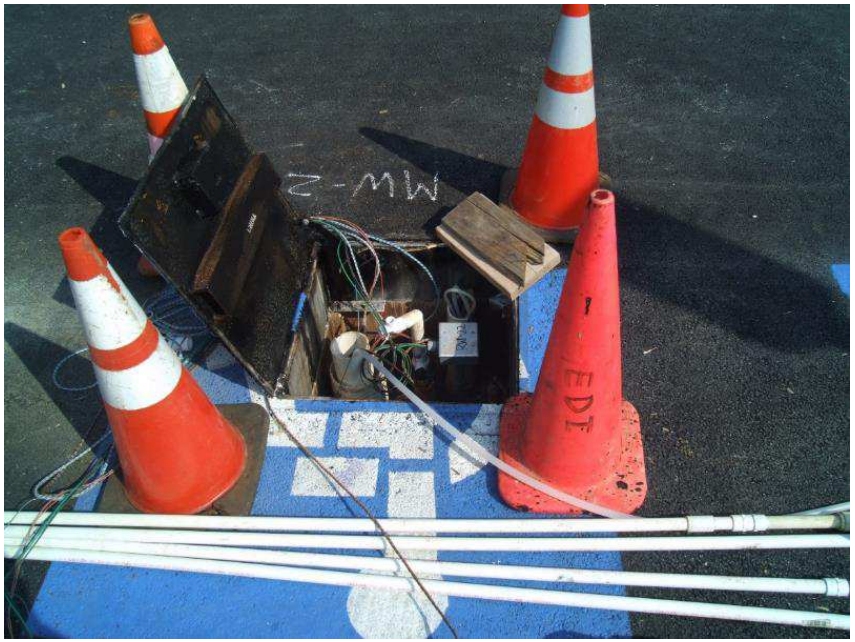
Ivey-sol

idr Ivey-sol Injec
Diffusion Rad

Sand = 15
Silty Sand = 10
Silty = 5-
Silty Clay = 5 ft
Clay = <5

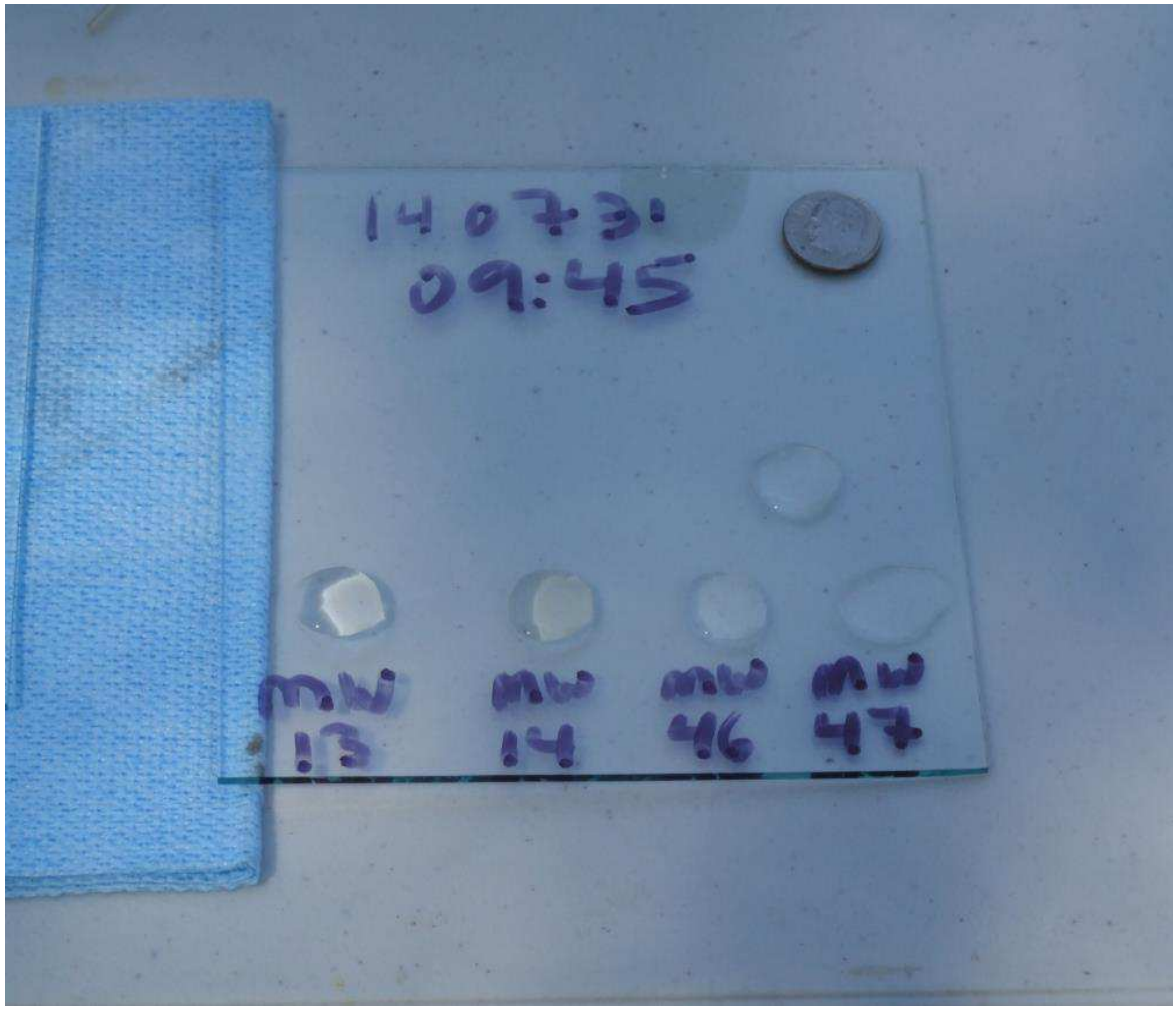
Ivey-sol radius of diffusion
to site as a function of soil
compaction and injection
range from gravity to pres

ot To Scale

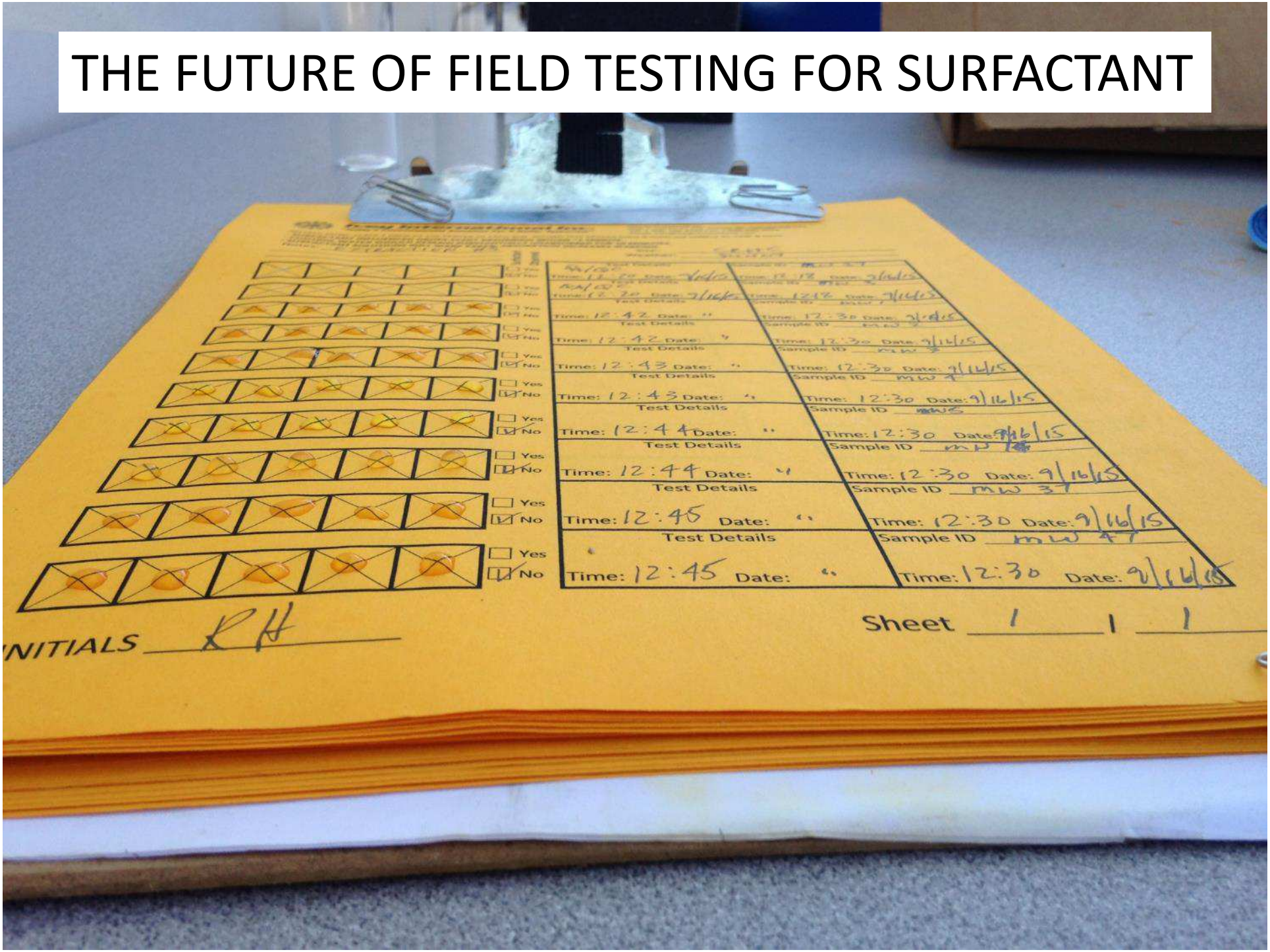


1:50 Ratio of Ivey-sol To Water For The Pilot Scale Application

IVEY Developed Field Testing Method for Surfa
Has >96% correlation with laboratory testin

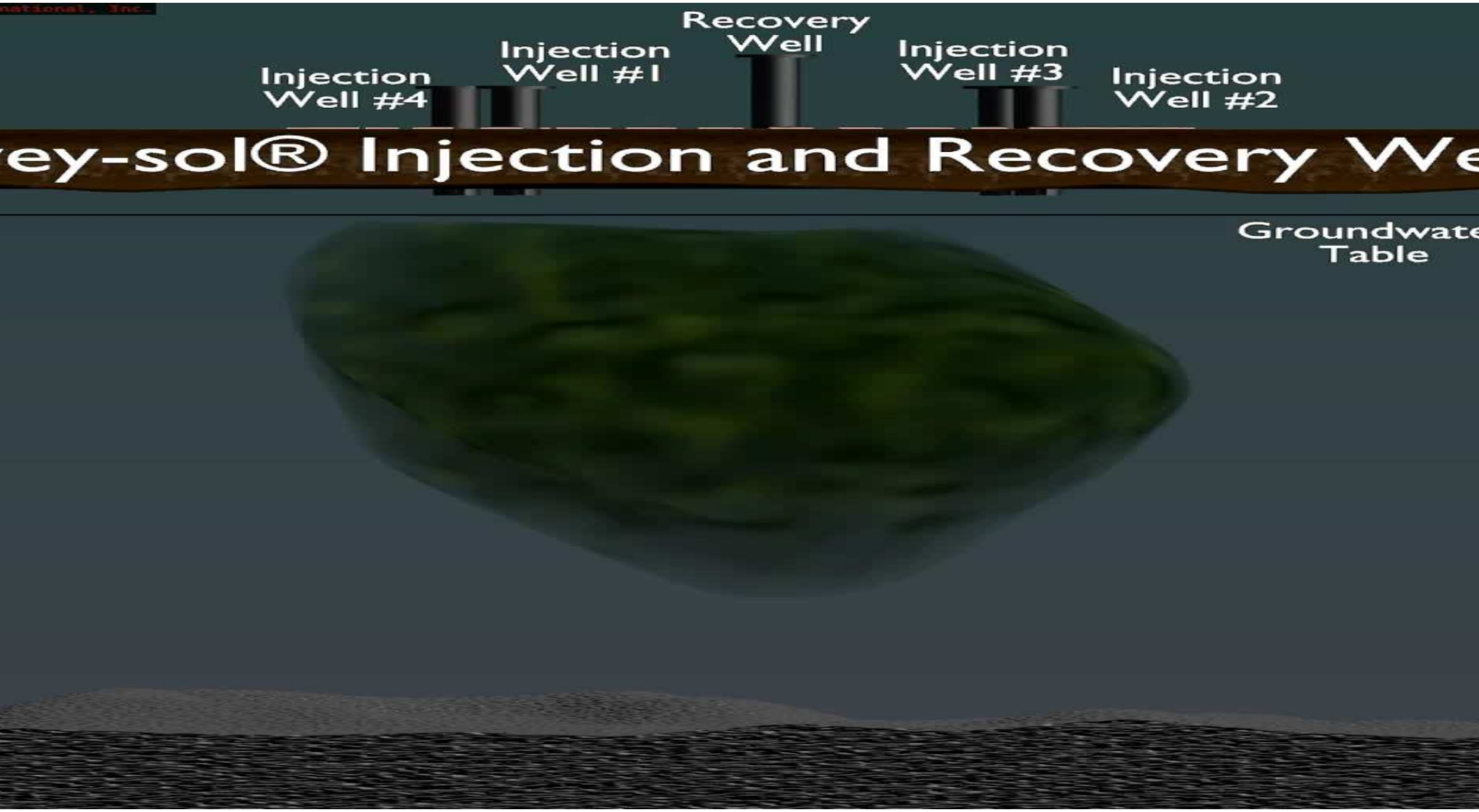


THE FUTURE OF FIELD TESTING FOR SURFACTANT

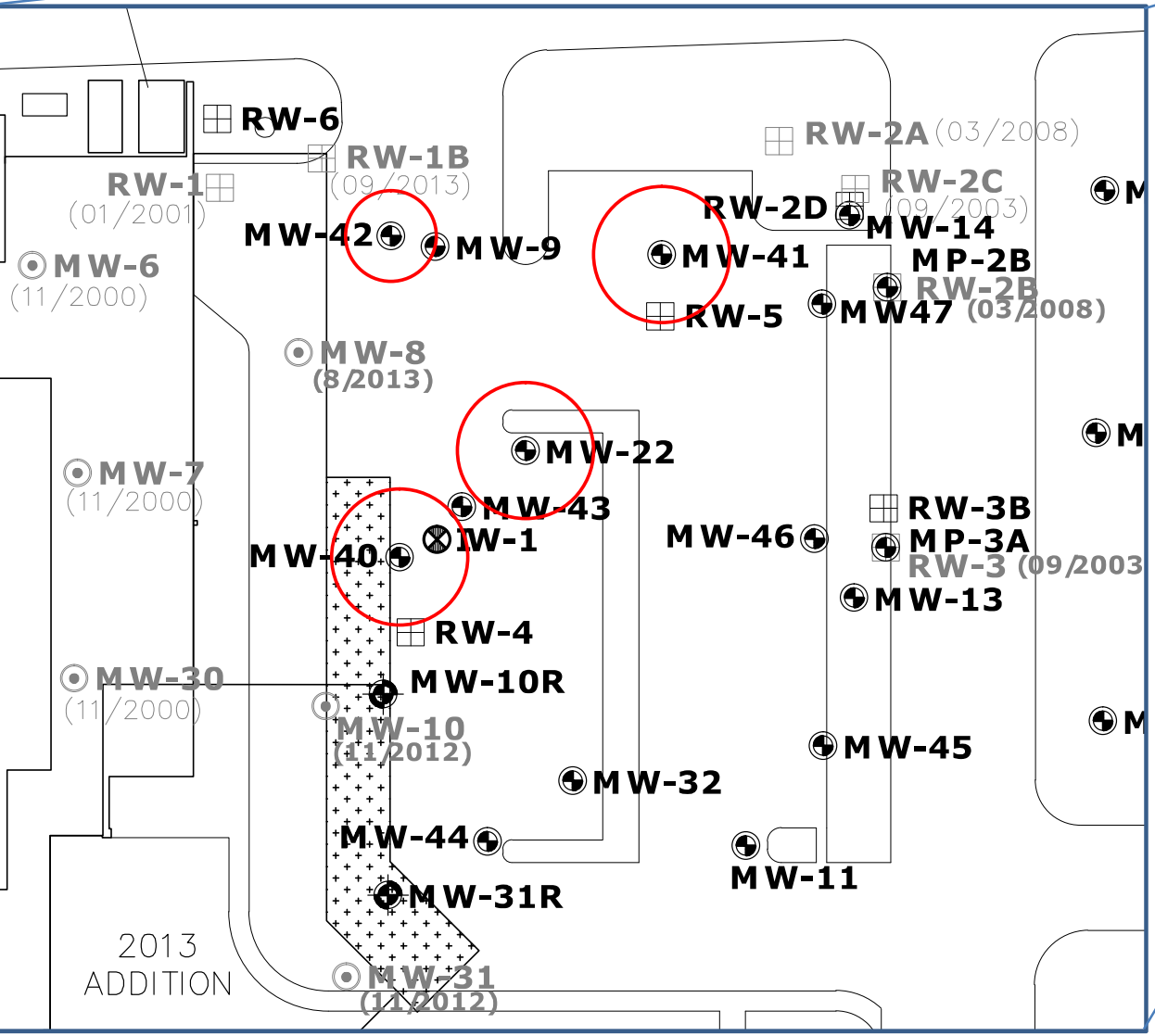


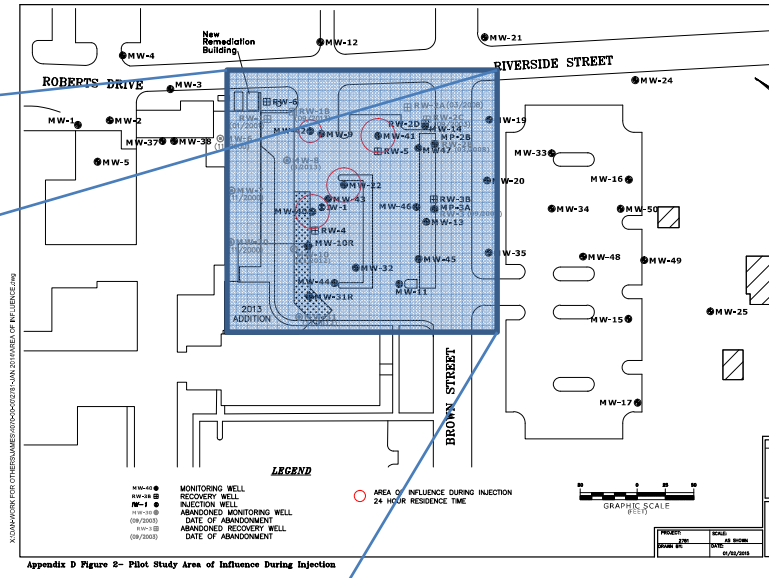
IVEY-SOL

IVEY-SOL


Injection
Well #4
Injection
Well #1
Recovery
Well
Injection
Well #3
Injection
Well #2
ey-sol® Injection and Recovery We
Groundwate
Table

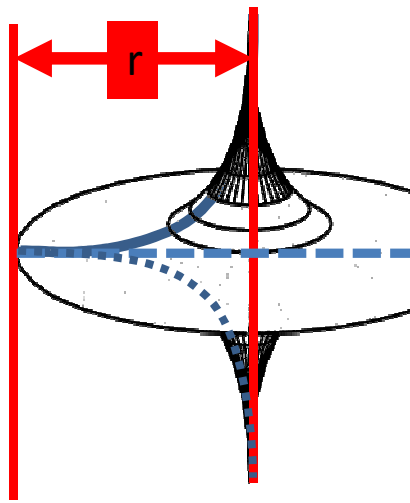
Injection Radius of Influence



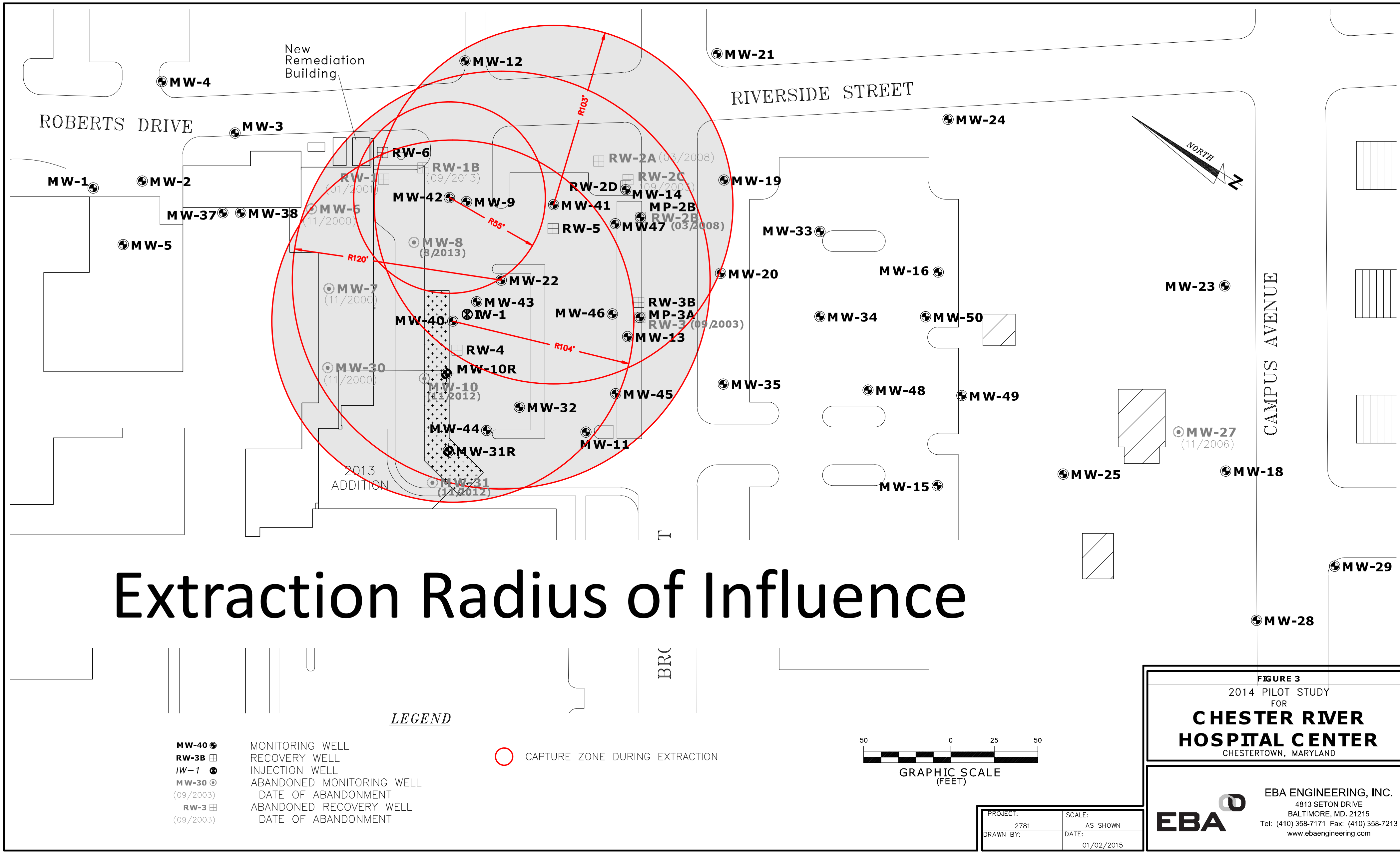


Appendix D Figure 2- Pilot Study Area of Influence During Injection

Area of Influence
r = 10 to 15 feet



Extraction Radius of Influence



Appendix D Figure 3– Pilot Study Capture Zone During Extraction

TPH-DRO Mass Recovery Calculations

y-sol® Injection #1 **426%** Increase in **TPH-DRO**
y-sol® Injection #2 **6,240%** Increase in **TPH-DRO**
y-sol® Injection #3 **6,846%** Increase in **TPH-DRO**

y-sol® Injection #1 **7,333%** Increase in **TPH-DRO**
y-sol® Injection #2 **5,133%** Increase in **TPH-DRO**
y-sol® Injection #3 **5,156%** Increase in **TPH-DRO**

y-sol® Injection #1 *Not Calculated (Missed Sample)*
y-sol® Injection #2 **18,966%** Increase in **TPH-DRO**
y-sol® Injection #3 **3,226%** Increase in **TPH-DRO**

y-sol® Injection #1 **948%** Increase in **TPH-DRO**
y-sol® Injection #2 **824%** Increase in **TPH-DRO**
y-sol® Injection #3 **3,737%** Increase in **TPH-DRO**

Averaged TPH-DRO Concentration Pre Injection Eve
[**Pre** Ivey-sol injection TPH-DRO (ppm) X Concentrations

Averaged TPH-DRO Concentration Post Injection Eve
[**Post** Ivey-sol Injection TPH-DRO (ppm) X Concentrations

Mass Recovery =

[Averaged TPH-DRO Concentration Post Injection Event] X
[Averaged TPH-DRO Concentration Pre Injection Even

= % Mass Recovery Increase For The Ivey-sol® Push-Pull Ev

Mass Recovery Calculations Completed by EBA Engineering

EBA
ENGINEER

SUMMARY

result of the investigations, analysis, and calculations of mass recovery the Tech
n determined that in the Push-Pull wells recovery rates were significantly enhan

ne thousand percent (1,000%) to Eighteen thousand percent (18,000%) TPH

polation:

ubstantial soil and groundwater remediation results can be achieved from usi
ush-Pull' Ivey-sol® process at the original up-gradient source area and the sev
id to down-gradient regions of the TPH plume

ffective for treating sorbed TPH in smear zone

asy to inject 'Push' and does not require pressure using gravity feed

eld surfactant test minimized volume of groundwater extracted during the 'P
hase

cale:

DE approved full scale application in June 2015 (Priority Zone 1, 2, 3, 4 Approach)
arted Full Scale applications on August 31, 2015 (Early results look very promising)

CONTACT INFORMATION

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