MULTIPLE LINES OF EVIDENCE TO SUPPORT EFFECTIVE NAPL MANAGEMENT PLANS

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PASTOR, BEHLING & WHEELER, LLC

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Brian Thomas, P.E.
Pastor, Behling & Wheeler, LLC

PRESENTATION OVERVIEW

- Typical Challenges - Managing NAPL Sites
- Effective NAPL Management Plans
- NAPL Response Objectives and Endpoints
- Use of Multiple Lines of Evidence to Support NAPL Management Plans
- Case Studies
  - Active NAPL Management Approach
  - Passive NAPL Management Approach
- Q&A

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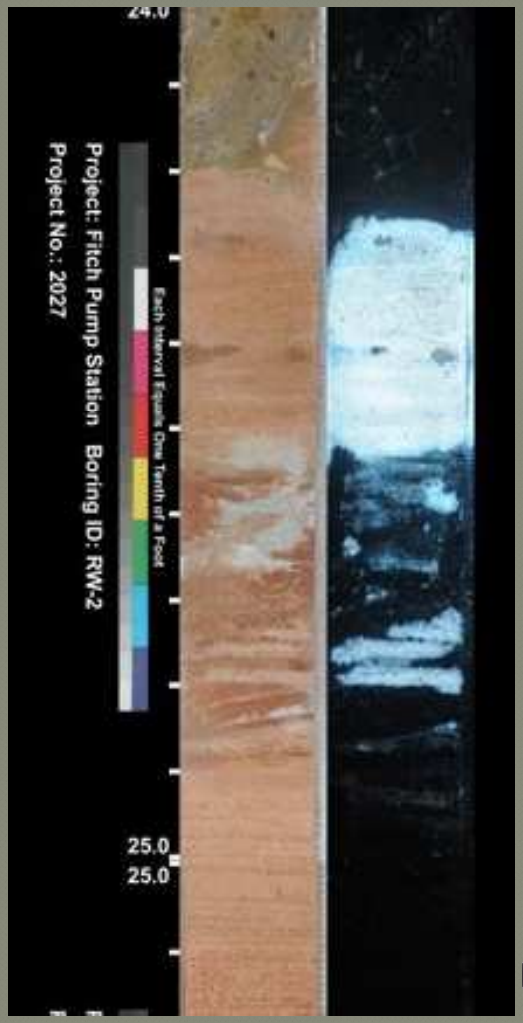
TYPICAL CHALLENGES – MANAGING NAPL SITES

- Heterogeneous Hydrogeologic Conditions
- Regulatory Drivers
- Third Party Issues
- Future Land Use
- Transient Conditions
- Managing the Unknown
- Lack of a Plan
  - Reactionary spending
  - $ wasted in "interim"



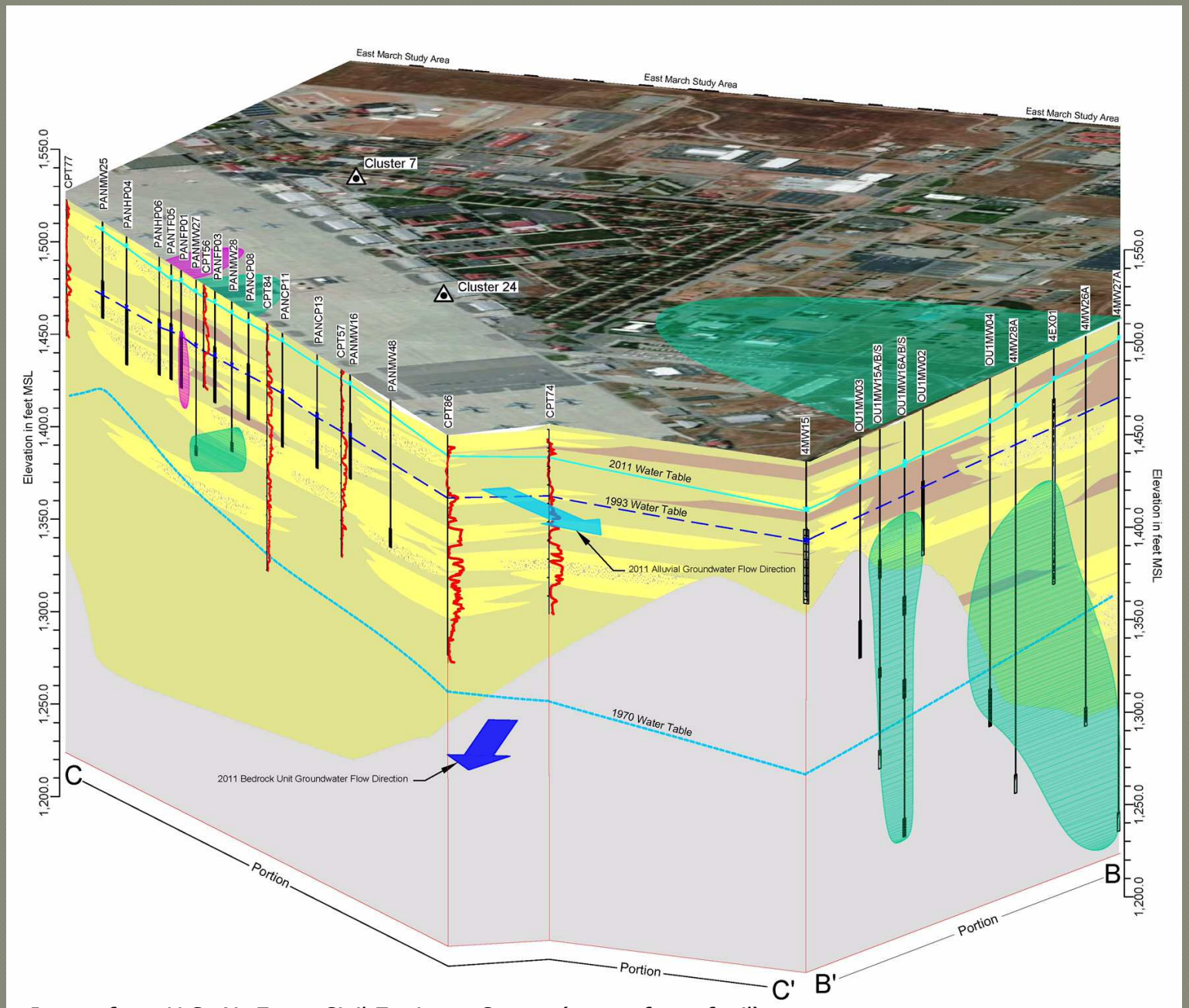


Image from U.S. Air Force Civil Engineer Center (www.afcec.af.mil)

EFFECTIVE NAPL MANAGEMENT PLANS

- Starts with NAPL CSM (Living Model)
  - 3 Keys: contaminant/jurisdiction/setting
  - Site characterization pays off (many available tools)
  - Consider technical/non-technical drivers
- Comprehensive Data Set as Foundation
  - Support theoretical data w/ site-specific
  - ID transient conditions affecting recoverability
  - Stepwise process to identify response actions (ITRC)
- Use Creativity for Regulatory Buy-in
- Account for the Unknown
  - Incorporate response action triggers

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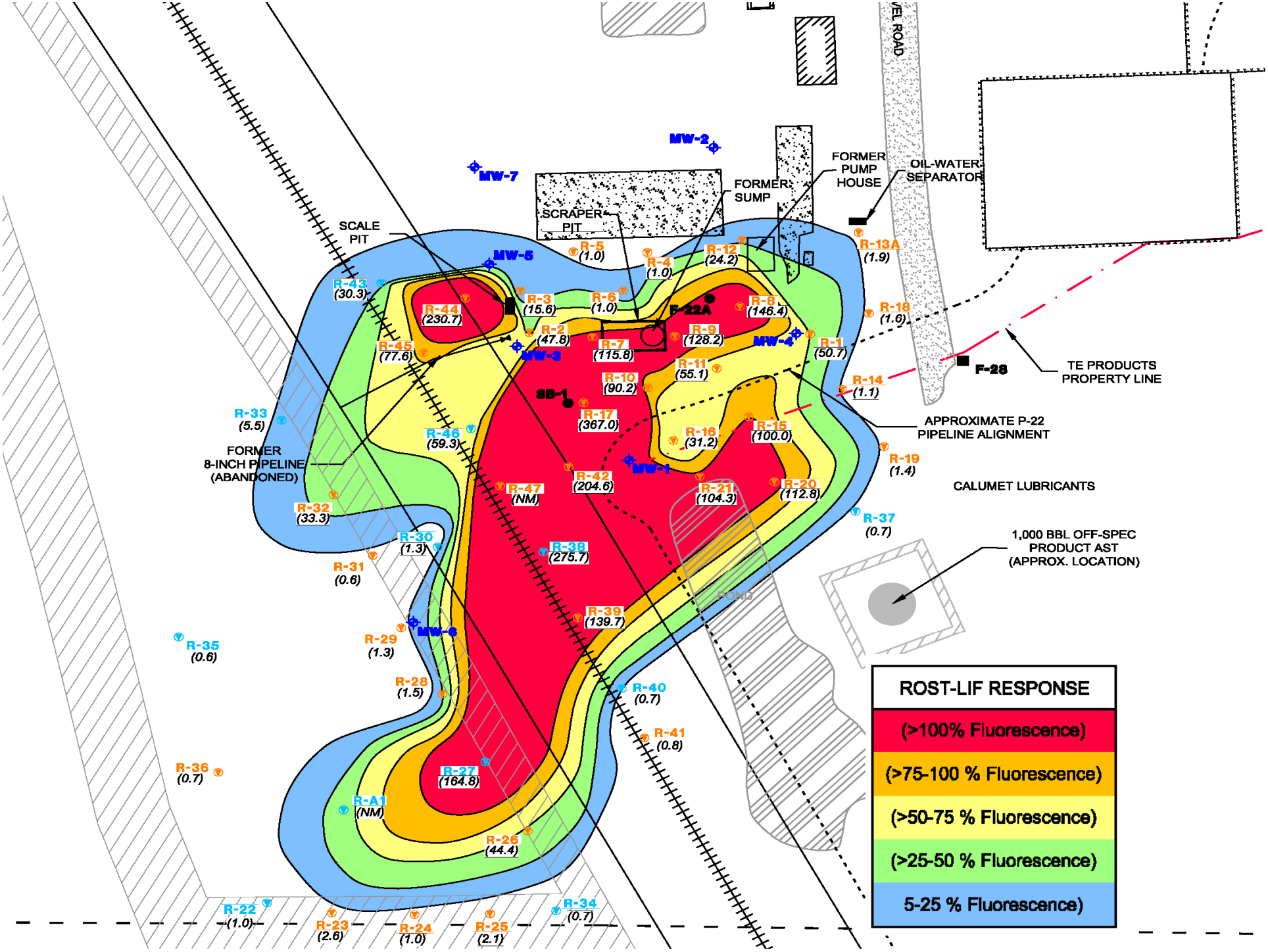
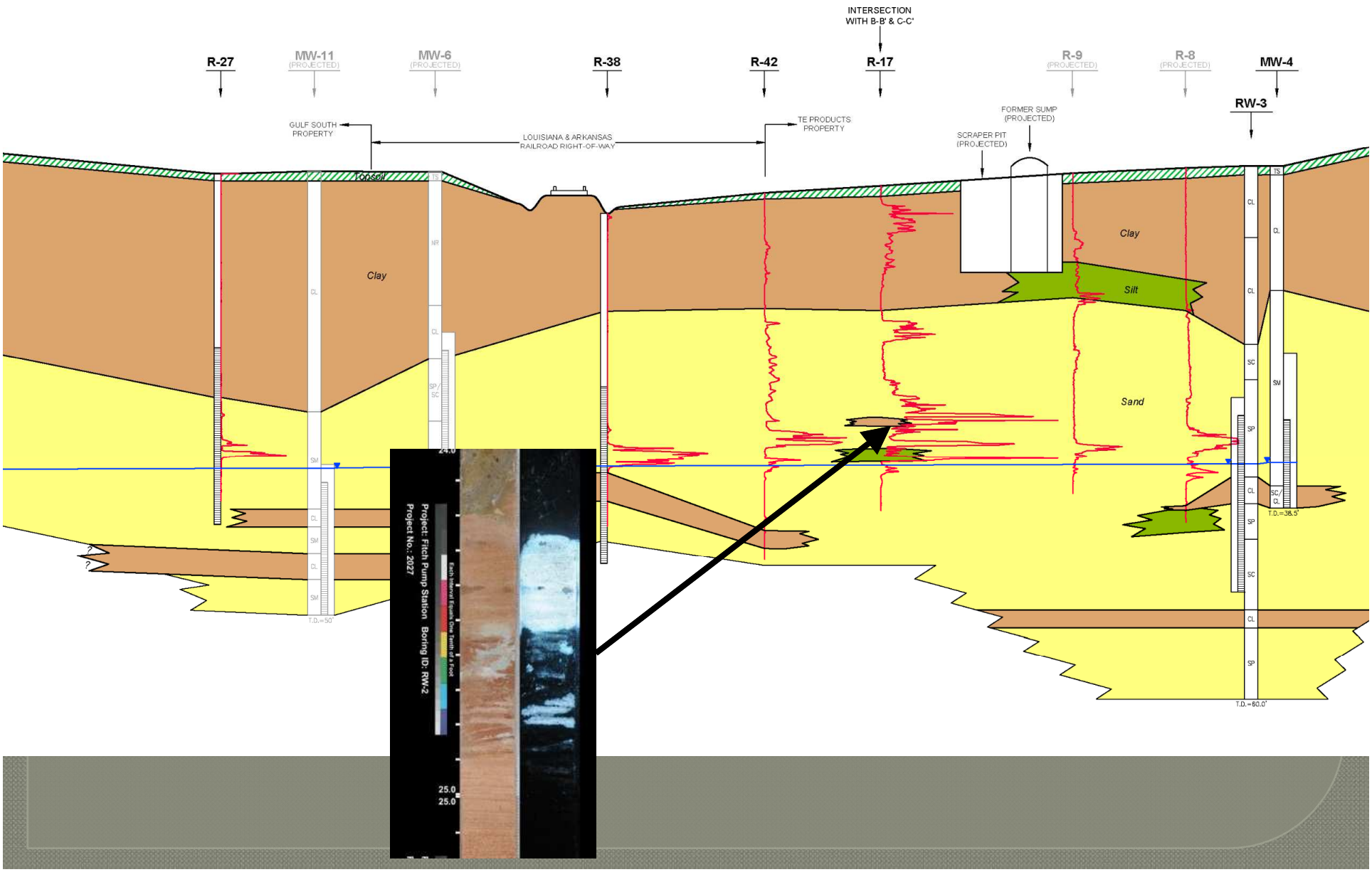
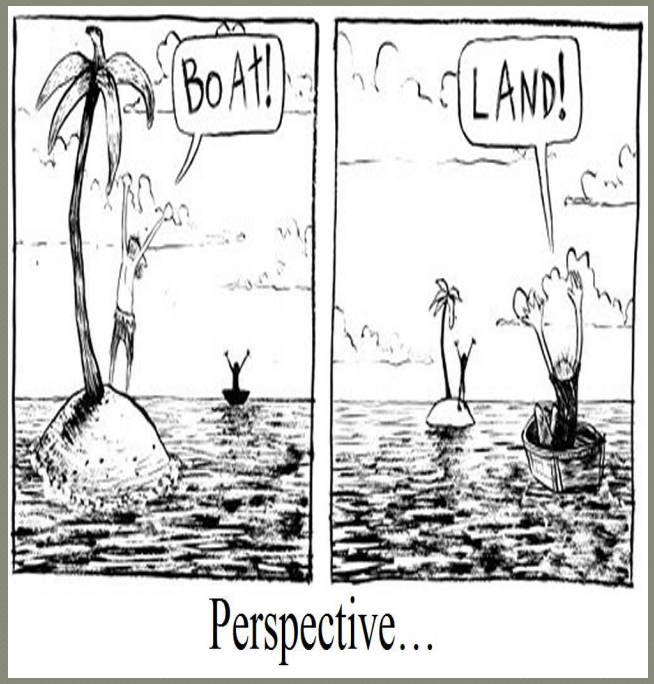

MW-2
MW-7
FORMER PUMP HOUSE
OIL-WATER SEPARATOR
FORMER SUMP
SCRAPER PIT
SCALE PIT
MW-5
R-5 (1.0)
R-4 (1.0)
R-12 (24.2)
R-13A (1.9)
R-43 (30.3)
R-3 (15.6)
R-6 (1.0)
F-22A
R-8 (146.4)
R-18 (1.6)
R-44 (230.7)
R-2 (47.8)
R-9 (128.2)
R-45 (77.6)
MW-3
R-7 (115.8)
MW-4
R-1 (50.7)
R-11 (55.1)
F-28
TE PRODUCTS PROPERTY LINE
R-10 (90.2)
R-14 (1.1)
SB-1
R-17 (367.0)
R-33 (5.5)
R-46 (59.3)
R-16 (31.2)
R-15 (100.0)
APPROXIMATE P-22 PIPELINE ALIGNMENT
FORMER 8-INCH PIPELINE (ABANDONED)
MW-1
R-19 (1.4)
R-42 (204.6)
R-47 (NM)
R-21 (104.3)
R-20 (112.8)
CALUMET LUBRICANTS
R-32 (33.3)
R-37 (0.7)
R-30 (1.3)
R-38 (275.7)
1,000 BBL OFF-SPEC PRODUCT AST (APPROX. LOCATION)
R-31 (0.6)
R-39 (139.7)
R-35 (0.6)
R-29 (1.3)
MW-6
R-28 (1.5)
R-40 (0.7)
R-41 (0.8)
R-36 (0.7)
R-27 (164.8)
R-A1 (NM)
R-26 (44.4)
R-22 (1.0)
R-23 (2.6)
R-24 (1.0)
R-25 (2.1)
R-34 (0.7)
ROST-LIF RESPONSE
(>100% Fluorescence)
(>75-100 % Fluorescence)
(>50-75 % Fluorescence)
(>25-50 % Fluorescence)
5-25 % Fluorescence)


INTERSECTION
WITH B-B' & C-C'
R-27
MW-11
(PROJECTED)
MW-6
(PROJECTED)
R-38
R-42
R-17
R-9
(PROJECTED)
R-8
(PROJECTED)
MW-4
RW-3
GULF SOUTH
PROPERTY
LOUISIANA & ARKANSAS
RAILROAD RIGHT-OF-WAY
TE PRODUCTS
PROPERTY
FORMER SUMP
(PROJECTED)
SCRAPER PIT
(PROJECTED)
Topsoil
Clay
Silt
Sand
T.D.=50'
T.D.=36.5'
T.D.=60.0'
Project: Fitch Pump Station Boring ID: RW-2
Project No.: 2027
25.0
25.0

NAPL RESPONSE OBJECTIVES AND ENDPOINTS

- ITRC Guidance 2009
  - Evaluating LNAPL Remedial Technologies for Achieving Project Goals
- Remedy Selection Process
  - Focus effort with long $'s
  - Sequenced remedies often more efficient
- A Good NAPL CSM Always Supports Endpoints
- Use Contingency/Response Triggers



MULTIPLE LINES OF EVIDENCE FOR NAPL MANAGEMENT

- Support the CSM with Defensible Data
- More Complex/More Lines of Evidence
- Characterization Lines of Evidence
  - High-resolution options
  - Real-time plume mapping
  - NSZD/impracticability demonstrations
- Recoverability Lines of Evidence
  - NAPL forensics & NAPL mobility analytical methods
  - In-well transmissivity (ASTM E2856)
  - Recoverability testing
  - Pilot testing of technologies

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CASE STUDY – ACTIVE NAPL MANAGEMENT

- NAPL CSM Overview
  - Non-degradation state for groundwater
  - State/BLM lands (Future Site Restoration)
  - Natural gas condensate
  - Partially cemented vadose zone (sand/siltstone)
  - Suspected primary source from storage tanks
  - Suspected NAPL body up to 1-acre
  - Large dissolved-phase plume
  - Harsh climate

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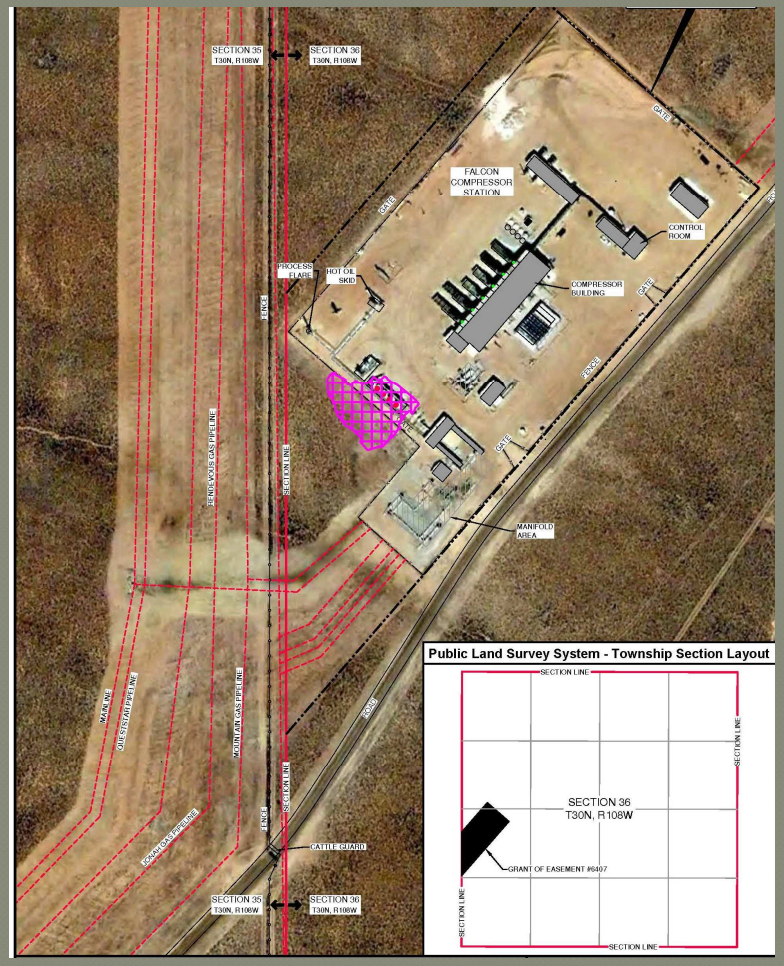
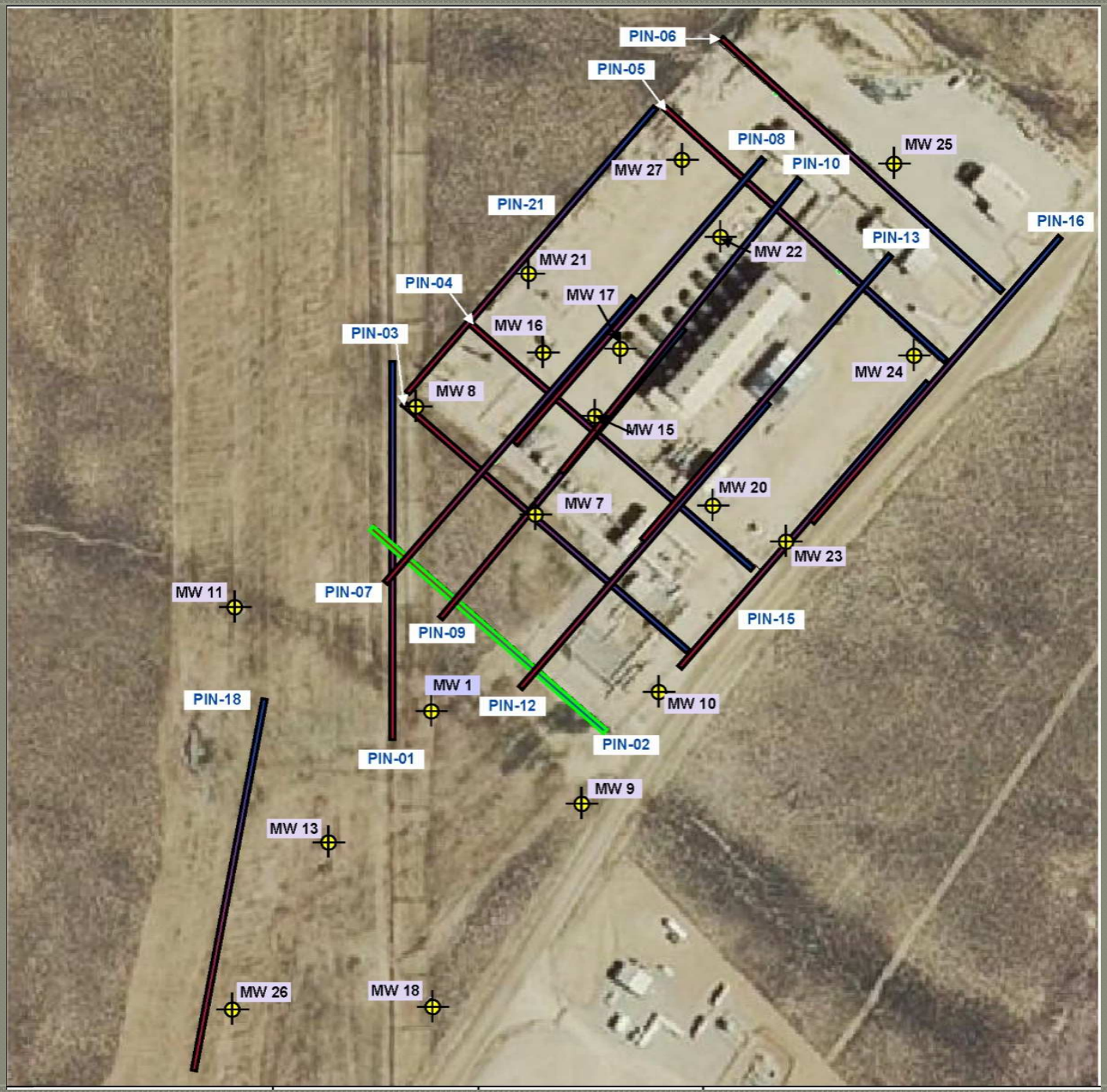
CASE STUDY – ACTIVE NAPL MANAGEMENT

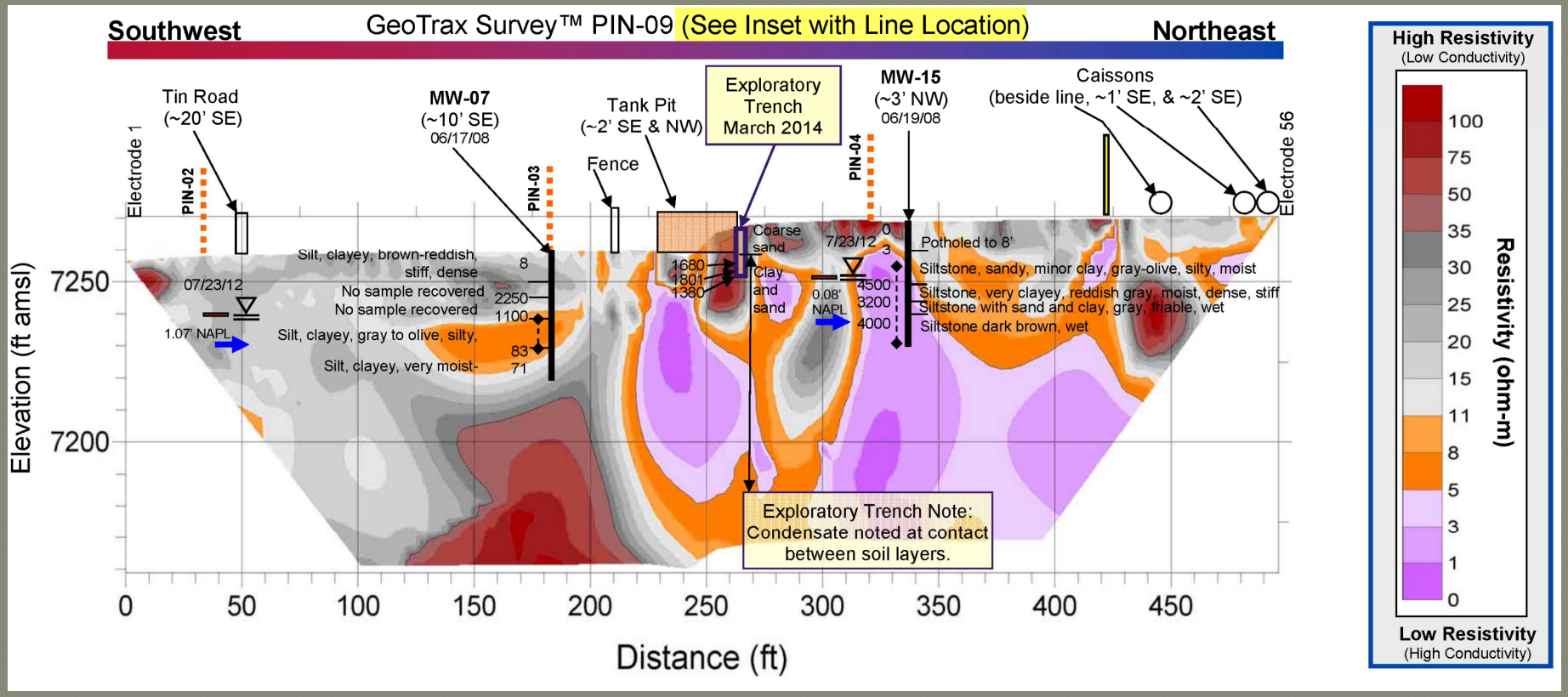
- NAPL CSM Data Gaps
  - Site Delineated to MCLs
  - Stratigraphy
  - Limited source characterization
- NAPL Endpoints
  - Remove NAPL
  - Non-industrial surface soil standards
  - Treat residual NAPL
  - Mitigate sourcing of dissolved-phase plume

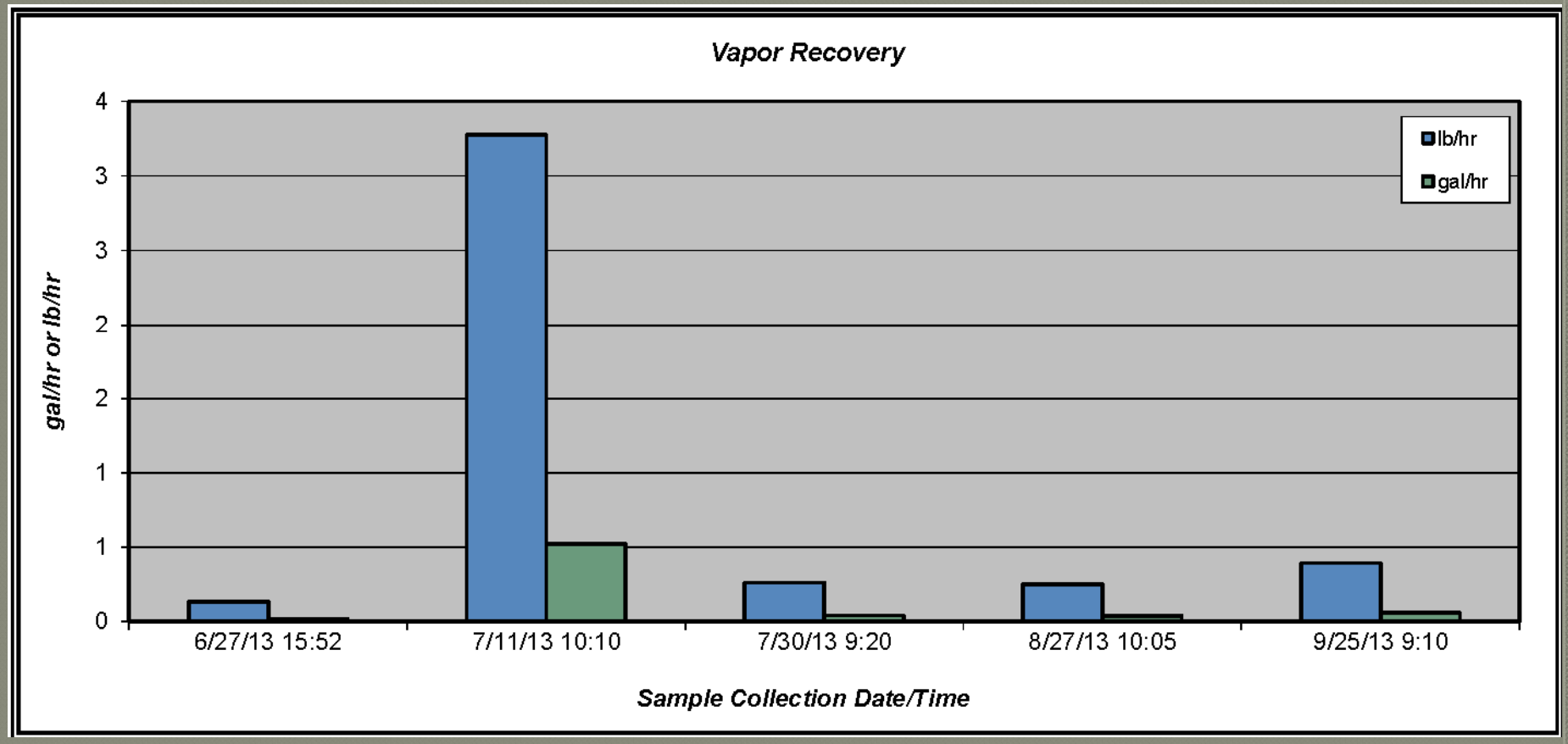


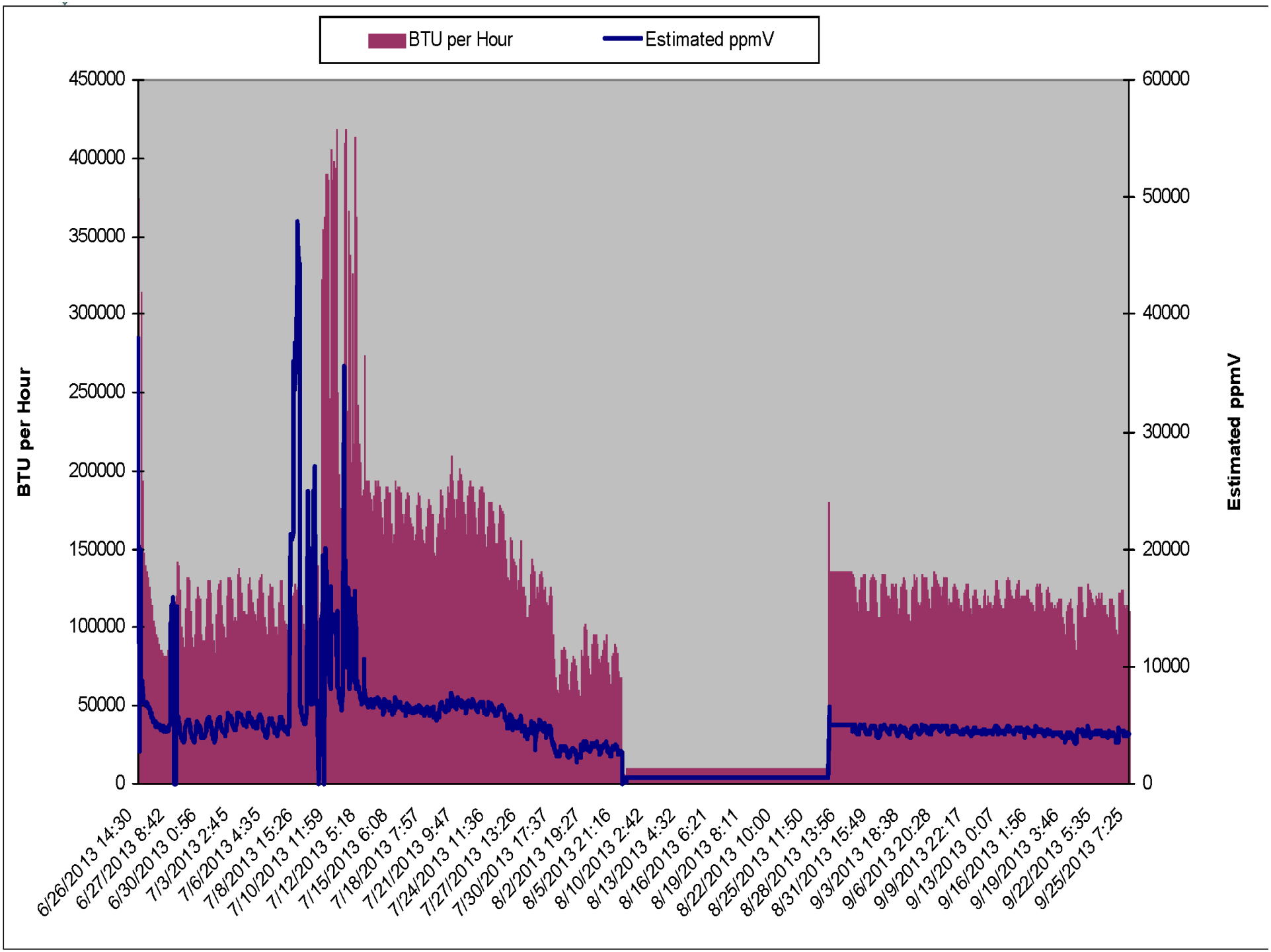
MULTIPLE LINES OF EVIDENCE - NAPL MANAGEMENT PLAN

- Refine Source Characterization
  - High-Res. site characterization (ERI)
  - Confirmation sampling plan (continuous core)
  - Temporary wells/NAPL recoverability
- Evaluate Recoverability
  - In-well NAPL transmissivity
  - Pilot test of multi-phase extraction (MPE)
    - Demonstration of impracticability for residual NAPL


PIN-06
PIN-05
PIN-08
MW 25
MW 27
PIN-10
PIN-21
PIN-16
PIN-13
MW 22
MW 21
PIN-04
MW 17
MW 16
PIN-03
MW 24
MW 8
MW 15
MW 20
MW 7
MW 23
MW 11
PIN-07
PIN-15
PIN-09
MW 1
MW 10
PIN-18
PIN-12
PIN-02
PIN-01
MW 9
MW 13
MW 26
MW 18


Southwest
GeoTrax Survey™ PIN-09 (See Inset with Line Location)
Northeast
Tin Road
(~20' SE)
MW-07
(~10' SE)
06/17/08
Tank Pit
(~2' SE & NW)
Exploratory
Trench
March 2014
MW-15
(~3' NW)
06/19/08
Caissons
(beside line, ~1' SE, & ~2' SE)
Electrode 1
Electrode 56
PIN-02
PIN-03
PIN-04
Fence
Silt, clayey, brown-reddish,
stiff, dense
No sample recovered
No sample recovered
Silt, clayey, gray to olive, silty,
Silt, clayey, very moist-
07/23/12
1.07' NAPL
8
2250
1100
83
71
Coarse
sand
Clay
and
sand
1680
1801
1380
7/23/12
0.08'
NAPL
0
3
4500
3200
4000
Potholed to 8'
Siltstone, sandy, minor clay, gray-olive, silty, moist
Siltstone, very clayey, reddish gray, moist, dense, stiff
Siltstone with sand and clay, gray, friable, wet
Siltstone dark brown, wet
Exploratory Trench Note:
Condensate noted at contact
between soil layers.
Elevation (ft amsl)
7250
7200
0
50
100
150
200
250
300
350
400
450
Distance (ft)
High Resistivity
(Low Conductivity)
100
75
50
35
30
25
20
15
11
8
5
3
1
0
Resistivity (ohm-m)
Low Resistivity
(High Conductivity)


Vapor Recovery
4
3
3
2
2
1
1
0
gal/hr or lb/hr
lb/hr
gal/hr
6/27/13 15:52
7/11/13 10:10
7/30/13 9:20
8/27/13 10:05
9/25/13 9:10
Sample Collection Date/Time


BTU per Hour
Estimated ppmV
BTU per Hour
Estimated ppmV
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
60000
50000
40000
30000
20000
10000
0
6/26/2013 14:30
6/27/2013 8:42
6/30/2013 0:56
7/3/2013 2:45
7/6/2013 4:35
7/8/2013 15:26
7/10/2013 11:59
7/12/2013 5:18
7/15/2013 6:08
7/18/2013 7:57
7/21/2013 9:47
7/24/2013 11:36
7/27/2013 13:26
7/30/2013 17:37
8/2/2013 19:27
8/5/2013 21:16
8/10/2013 2:42
8/13/2013 4:32
8/16/2013 6:21
8/19/2013 8:11
8/22/2013 10:00
8/25/2013 11:50
8/28/2013 13:56
8/31/2013 15:49
9/3/2013 18:38
9/6/2013 20:28
9/9/2013 22:17
9/13/2013 0:07
9/16/2013 1:56
9/19/2013 3:46
9/22/2013 5:35
9/25/2013 7:25

NAPL MANAGEMENT PLAN

- Aggressive Source Removal
  - Excavate majority of NAPL body
  - Mitigate surface soil exposure (future re-use)
- Management of Inaccessible NAPL
  - Recovery trench with controls
  - Total fluids recovery
  - Future actions??
- In-situ Treatment for Residual NAPL
  - In-situ ozone sparge (source treatment)
  - Flexibility for future dissolved-phase plume

CASE STUDY – PASSIVE NAPL MANAGEMENT

- NAPL CSM Overview
  - Recover to extent practicable (No guidance)
  - State provides a challenging regulatory setting
  - Co-mingled refined products (multiple releases)
  - Low permeability groundwater bearing zone
  - Unsaturated zone migration pathway
  - Large NAPL body; periodic "mobility"
  - Large dissolved-phase plume
  - Remote site (limited receptors)
  - Private landowner (prefers forested buffer)

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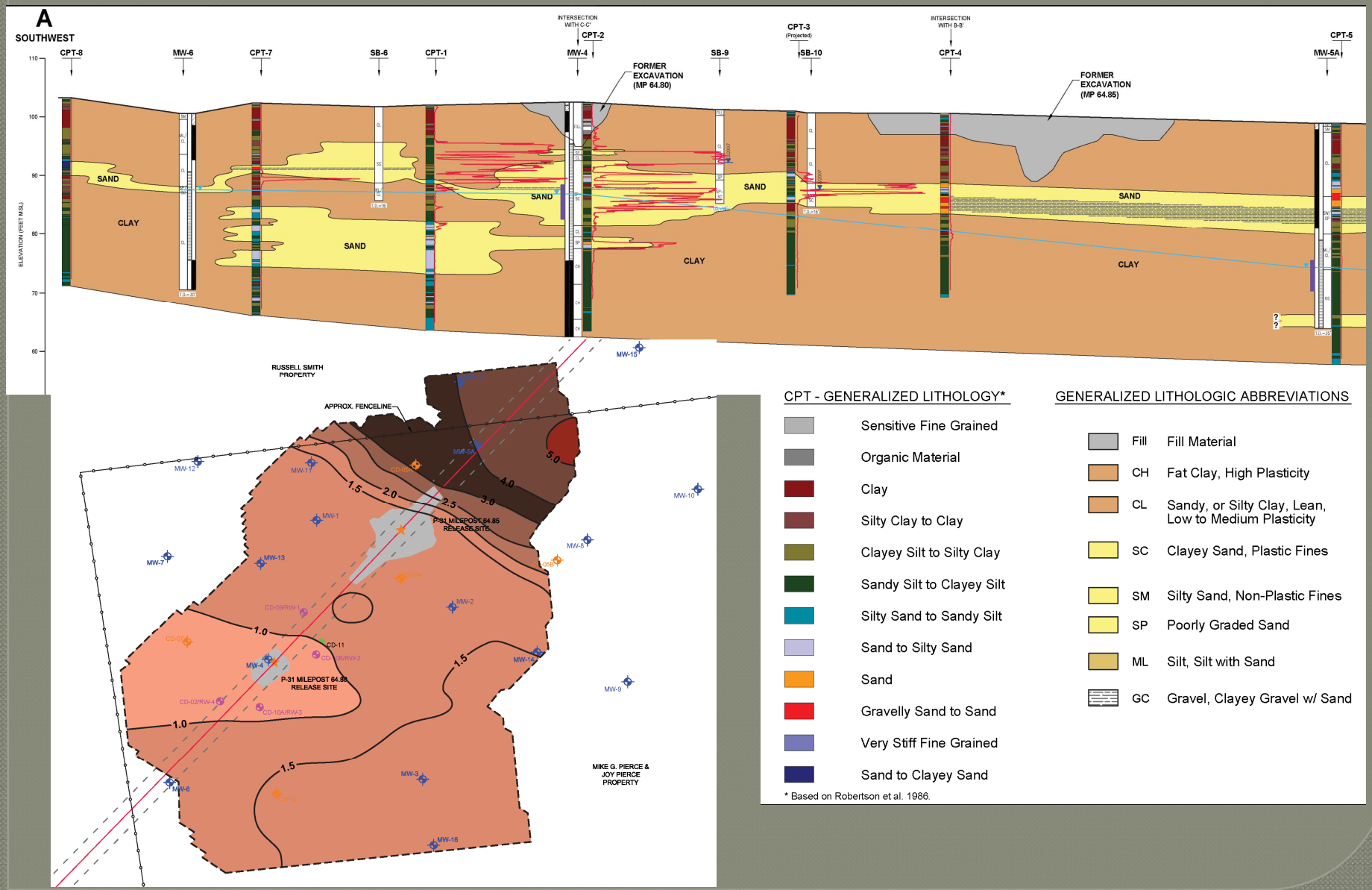
CASE STUDY – PASSIVE NAPL MANAGEMENT

- NAPL CSM Data Gaps
  - Site delineated to MCLs
  - Challenging vadose zone stratigraphy
  - Initial CPT/ROST (access)
  - Limited recoverability data
- NAPL endpoints
  - NAPL management/controls
  - Institutional controls
  - Treat "migrating" NAPL
  - NAPL triggers (IWT)
  - Dissolved-phase triggers

MULTIPLE LINES OF EVIDENCE - NAPL MANAGEMENT PLAN

- Refine Source Characterization
  - High-Res. site characterization (CPT/ROST)
    - Source areas (Limited Access)
    - Absence of LIF-response at key location
  - High-Res site characterization (GeoTrax™)
    - Resolved stratigraphy/site-wide continuity
    - Identified significant microbial activity
    - Confirmed by Microbial Insights "QuantArray"
  - Confirmation sampling plan (continuous core)
  - Temporary wells/NAPL recoverability

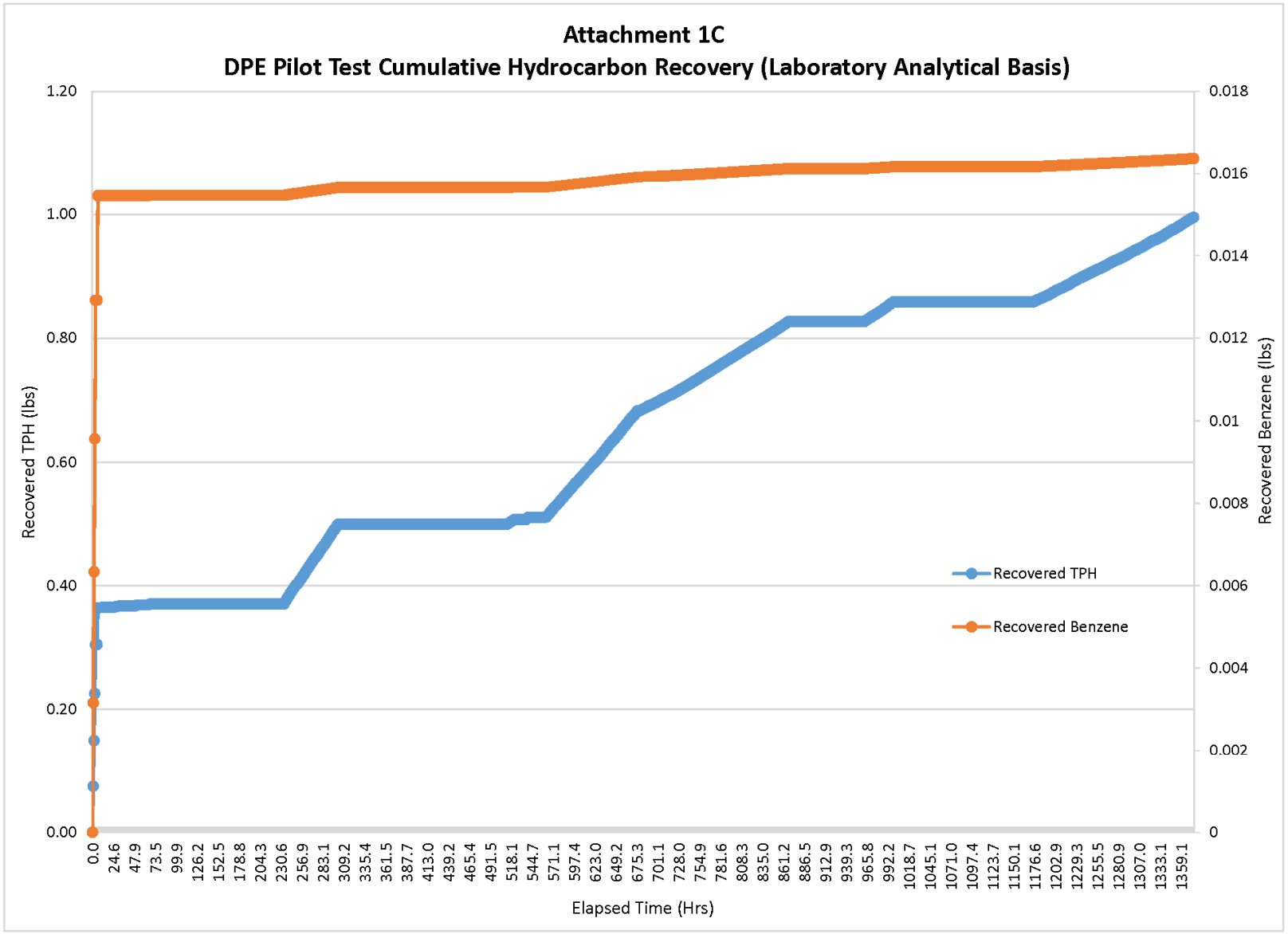

A
SOUTHWEST
CPT-8
MW-6
CPT-7
SB-6
CPT-1
INTERSECTION WITH C-C'
CPT-2
MW-4
SB-9
CPT-3 (Projected)
SB-10
INTERSECTION WITH B-B'
CPT-4
CPT-5
MW-5A
FORMER EXCAVATION (MP 64.80)
FORMER EXCAVATION (MP 64.85)
ELEVATION (FEET MSL)
110
100
90
80
70
60
SAND
CLAY
SAND
SAND
CLAY
SAND
SAND
CLAY
RUSSELL SMITH PROPERTY
APPROX. FENCELINE
MW-15
MW-5A
MW-12
MW-11
MW-10
MW-1
MW-8
MW-7
MW-13
MW-2
MW-14
MW-4
MW-9
MW-3
MW-6
MW-16
CD-08A
CD-08B
CD-10A
CD-09/RW-1
CD-07
CD-11
CD-10B/RW-2
CD-02/RW-4
CD-10A/RW-3
CD-12
1.0
1.5
2.0
2.5
3.0
4.0
5.0
P-34 MILEPOST 64.85 RELEASE SITE
P-31 MILEPOST 64.85 RELEASE SITE
MIKE G. PIERCE & JOY PIERCE PROPERTY
CPT - GENERALIZED LITHOLOGY*
Sensitive Fine Grained
Organic Material
Clay
Silty Clay to Clay
Clayey Silt to Silty Clay
Sandy Silt to Clayey Silt
Silty Sand to Sandy Silt
Sand to Silty Sand
Sand
Gravelly Sand to Sand
Very Stiff Fine Grained
Sand to Clayey Sand
* Based on Robertson et al. 1986.
GENERALIZED LITHOLOGIC ABBREVIATIONS
Fill Fill Material
CH Fat Clay, High Plasticity
CL Sandy, or Silty Clay, Lean, Low to Medium Plasticity
SC Clayey Sand, Plastic Fines
SM Silty Sand, Non-Plastic Fines
SP Poorly Graded Sand
ML Silt, Silt with Sand
GC Gravel, Clayey Gravel w/ Sand

MULTIPLE LINES OF EVIDENCE - NAPL MANAGEMENT PLAN

- Lines of Evidence for Recoverability
  - In-well NAPL transmissivity
  - Pneumatic recovery (1-yr; Solar-Sipper™)
    - 0.5-gallon per day long term average
  - 60-day MPE event
    - 60-day demonstration
    - 20,000-30,000 BTU/Hr (ICE w/ Propane Assist)
    - Diffusion limited recovery
  - MPE served as long-term pump test
    - Confirmed low-yield (<0.1 GPM/Well)
- Ultimately Demonstrated Diffusion Limited Recovery w/ Vigorous Microbial Activity

Attachment 1C

DPE Pilot Test Cumulative Hydrocarbon Recovery (Laboratory Analytical Basis)



NAPL MANAGEMENT PLAN

- Passive Management of NAPL Body
  - Execute institutional controls
    - 2.4-acre soil area (soil restriction)
    - 7.3-acre groundwater restriction
  - 2-year NAPL monitoring program
  - NAPL action triggers
    - "Migrating" NAPL
    - 1.5 times IWT threshold (Annual baildown)
  - Dissolved-phase triggers
    - MCL exceedances at POEs (Confirmed)
    - Revise institutional controls
    - Contingency plan for dissolved-phase (POE based)

QUESTIONS & ANSWERS

"Don't fall victim to what I call the ready-aim-aim-aim-aim syndrome. You must be willing to fire" – T. Boone Pickens

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