# An Integrated Approach to LNAPL Remediation in Support of a Large-Scale Brownfield Redevelopment

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# Presentation Agenda

- General Methodology;
- Case Study:
  - Background;
  - Strategic Approaches;
  - Area 3 LNAPL Remediation;
  - Areas 1, 2 and 4 LNAPL Mobility;
  - Area 2 LNAPL Remediation;
  - Regulatory Feedback;
  - Redevelopment Status.

# General Methodology

## When to Remediate?

- Remedial drivers present (risk-based or non-risk-based).

## How to Remediate?

- Risk: type/degree of risk (imminent/immediate or long term);
- Non-Risk:
  - Existing/proposed use of property;
  - Development/redevelopment plans, schedules and timelines.

# General Methodology

## How Long to Remediate?

- Remedial objectives and goals;
- Ongoing review and evaluation of remediation metrics.

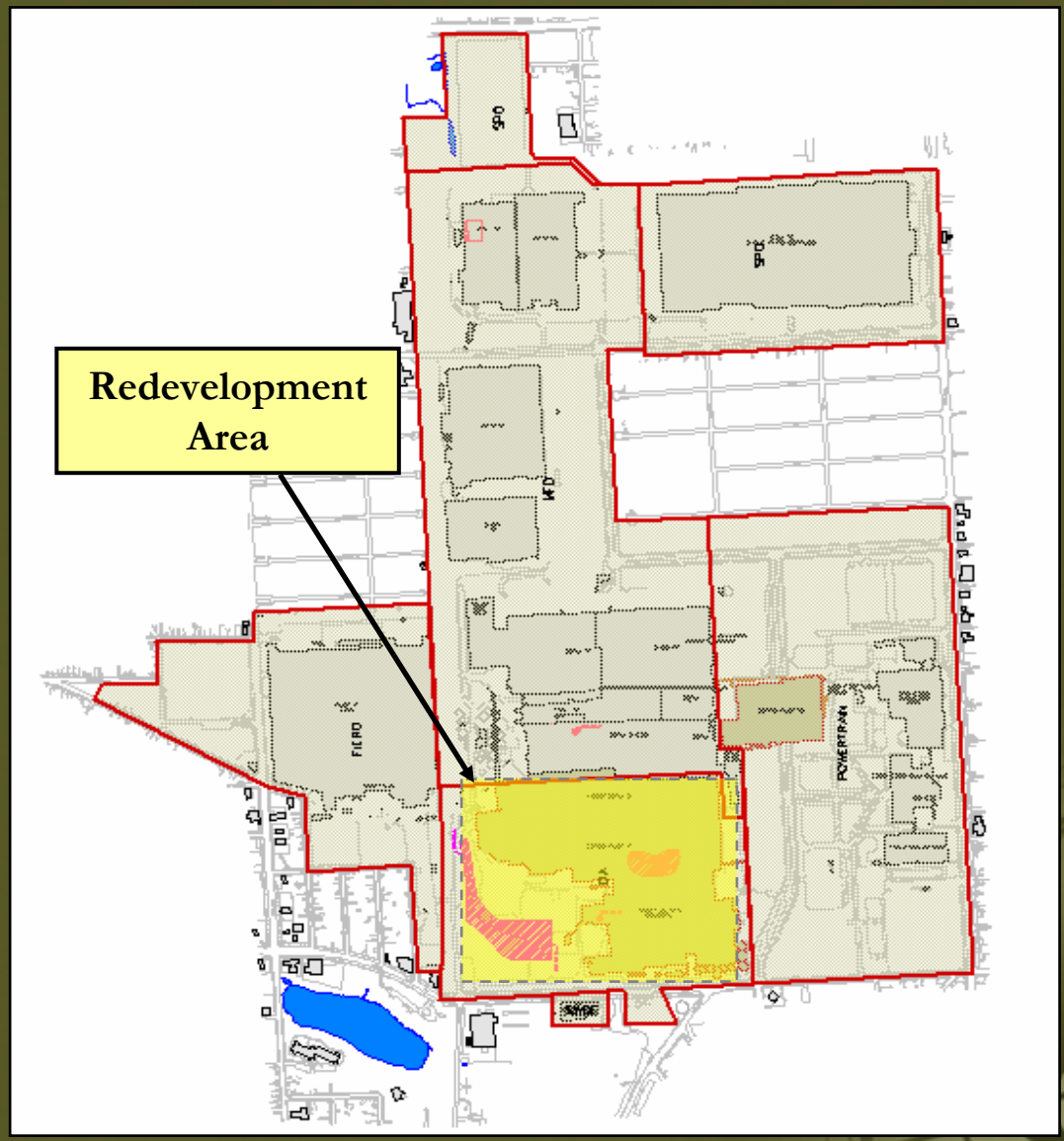
## Note:

- If remediation is required and no feasible remediation options exist, then implement necessary controls (engineering, institutional, and/or administrative) to mitigate risks or address concerns.

# Case Study - Background

- Subject Site – 600 acre industrial manufacturing facility in mid-western U.S.;
- 100 acres of unused portion of Site targeted for property redevelopment, including construction of 800,000 square foot slab-on-grade building;
- LNAPL discovered on various parts of redevelopment area;
- LNAPL remediation deemed necessary to meet requirements for property redevelopment.

# Case Study - Background

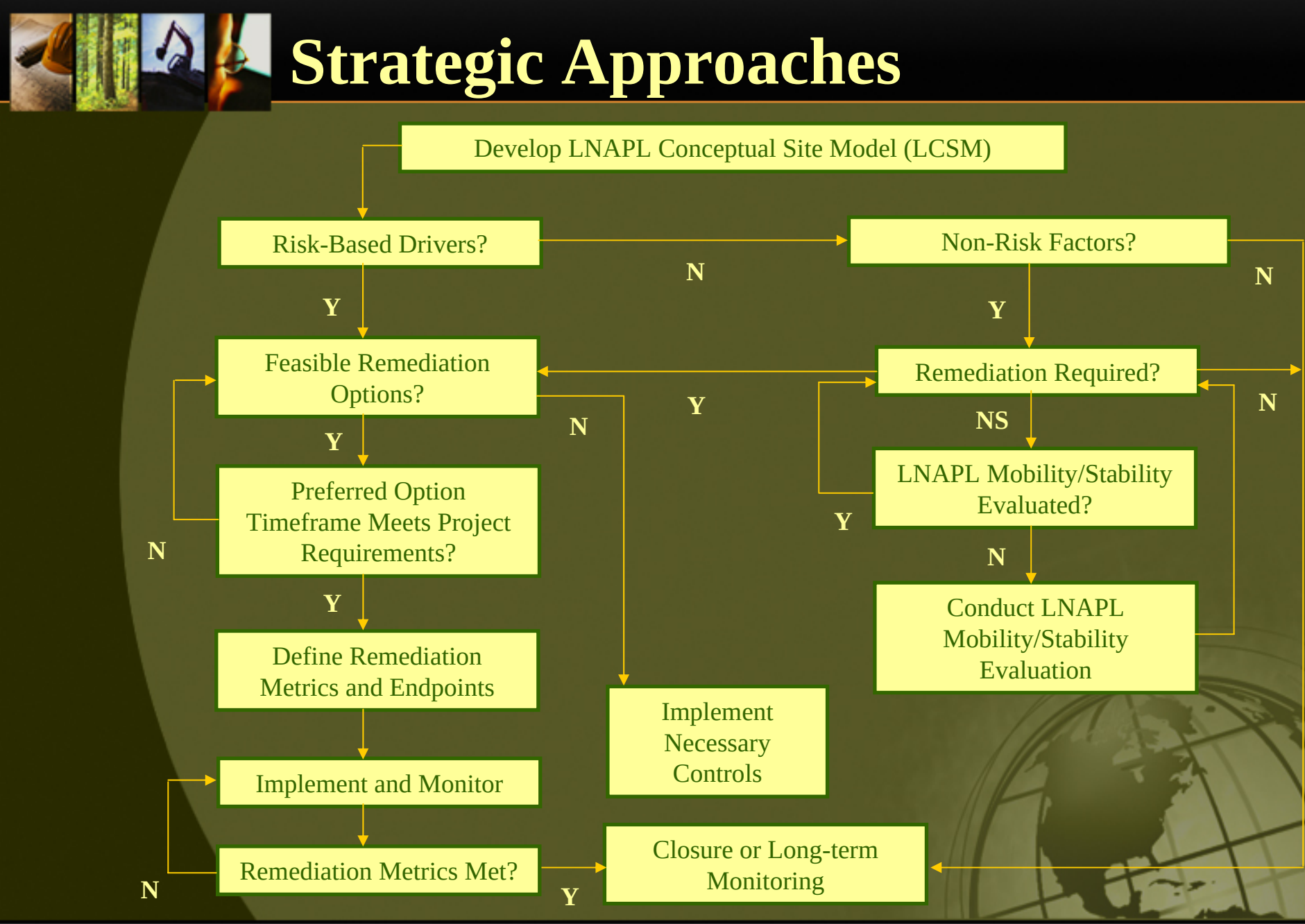


# Case Study - Background

- Geology comprised of low permeability glacial soils (silts and clays with occasional sand seams) with several areas of sand fill material;
- Depth to air/LNAPL interface varies from approximately 15 to 30 feet bgs;
- LNAPL thicknesses vary from a sheen to 12 feet; and
- Majority of LNAPL fingerprinted as a weathered No. 2 fuel oil/diesel with lesser amounts of No. 6 fuel oil. Some LNAPL predominantly No. 6 fuel oil.

# Strategic Approaches





# Strategic Approaches

## Risk-Based Remedial Driver:

- Presence of methane (due to anaerobic degradation of LNAPL) and associated potential risks for future building occupants.

## Non-Risk Remedial Factors:

- Aggressive reduction of LNAPL plume mass in area of proposed building construction to support property redevelopment efforts.

# Strategic Approaches

## Risk-Based Strategy

- No feasible remediation option to remove sufficient LNAPL to prevent future methane issues;
- Implemented necessary controls - engineering control: passive venting system beneath entire floor slab for new building.

## Non-Risk Strategy

- To develop LNAPL remediation/management strategies proportionate to property redevelopment plans and schedules, and in particular, vertical construction of proposed building. Time was of the essence!

# Strategic Approaches

## Non-Risk Strategy

- Redevelopment area divided into smaller LNAPL target areas based on: LNAPL type, soil type, and property redevelopment plans/schedules for that location;

- Area 1: Soil Type – silt and clay
  LNAPL Type – heavy oil, some diesel
  Location – west of proposed building
  Issues – none identified
  Priority – low to medium (L-M)

# Strategic Approaches

- Area 2: Soil Type – sand
  LNAPL Type – diesel
  Location – northwest of proposed building
  Issues – adjacent to storm sewer and proposed building footprint
  Priority – medium to high (M-H)

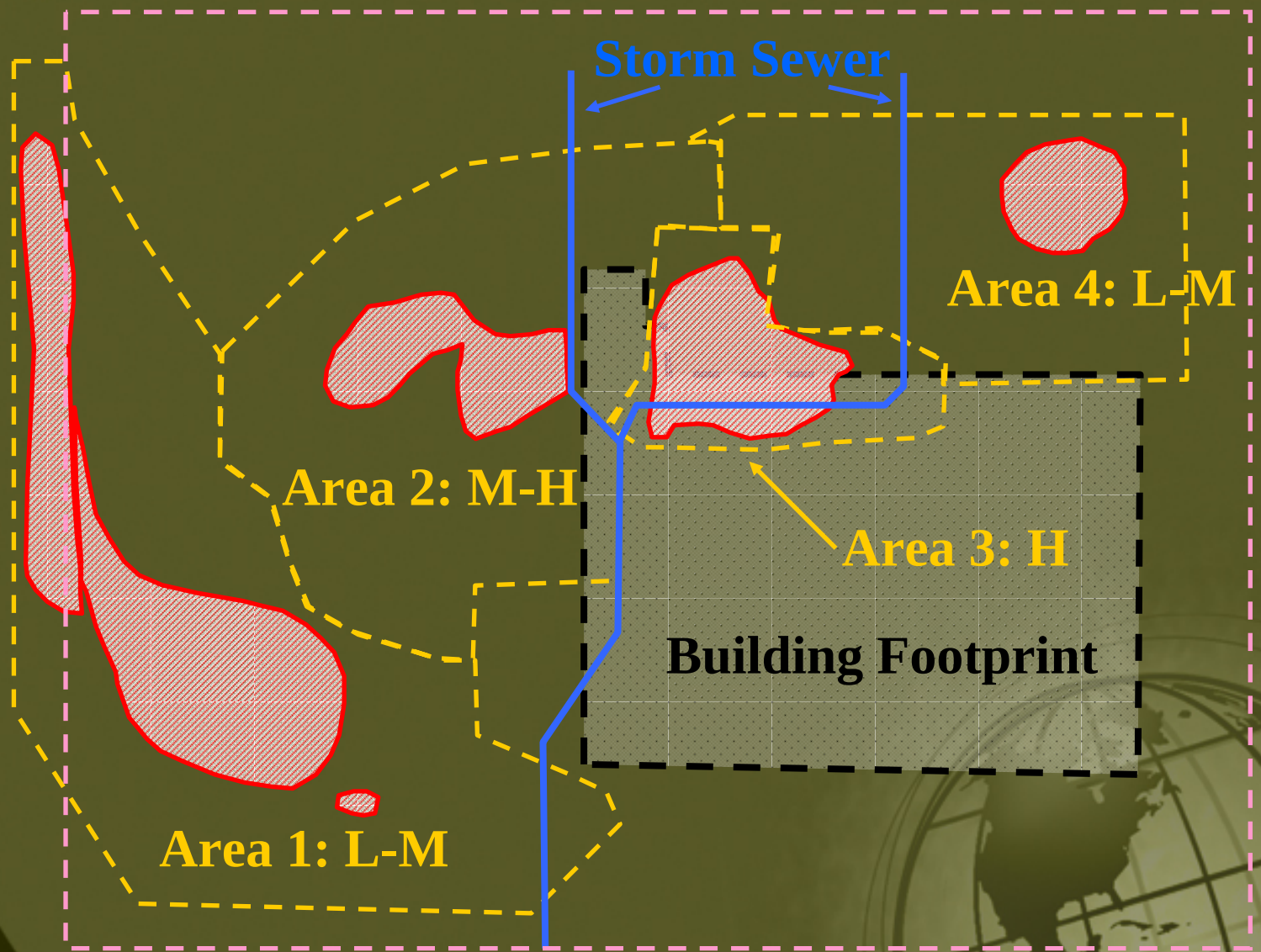
- Area 3: Soil Type – silt and clay with sand seams/layers
  LNAPL Type – diesel
  Location – beneath and north of proposed building footprint; surrounds sewer
  Priority – high (H)

# Strategic Approaches

- Area 4: Soil Type – silt and clay
  LNAPL Type – diesel, some light end hydrocarbons
  Location – north-northeast of proposed building footprint
  Priority – low to medium (L-M)

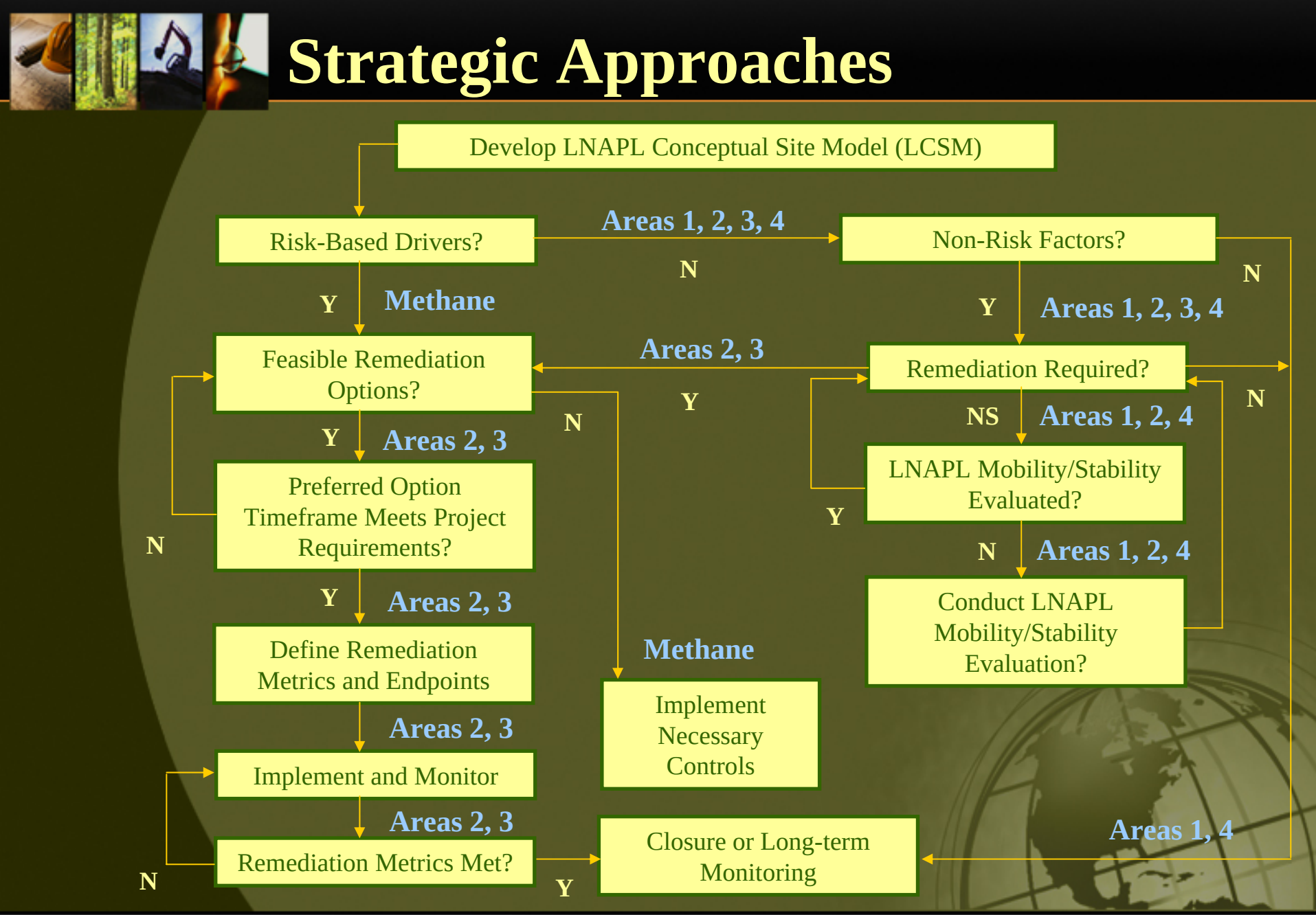
- Based on H priority designation, Area 3 was targeted for aggressive LNAPL recovery – endpoint was to recover as much LNAPL as feasibly practical prior to building construction in March 2006.

# Strategic Approaches



# Strategic Approaches





# Area 3: LNAPL Remediation

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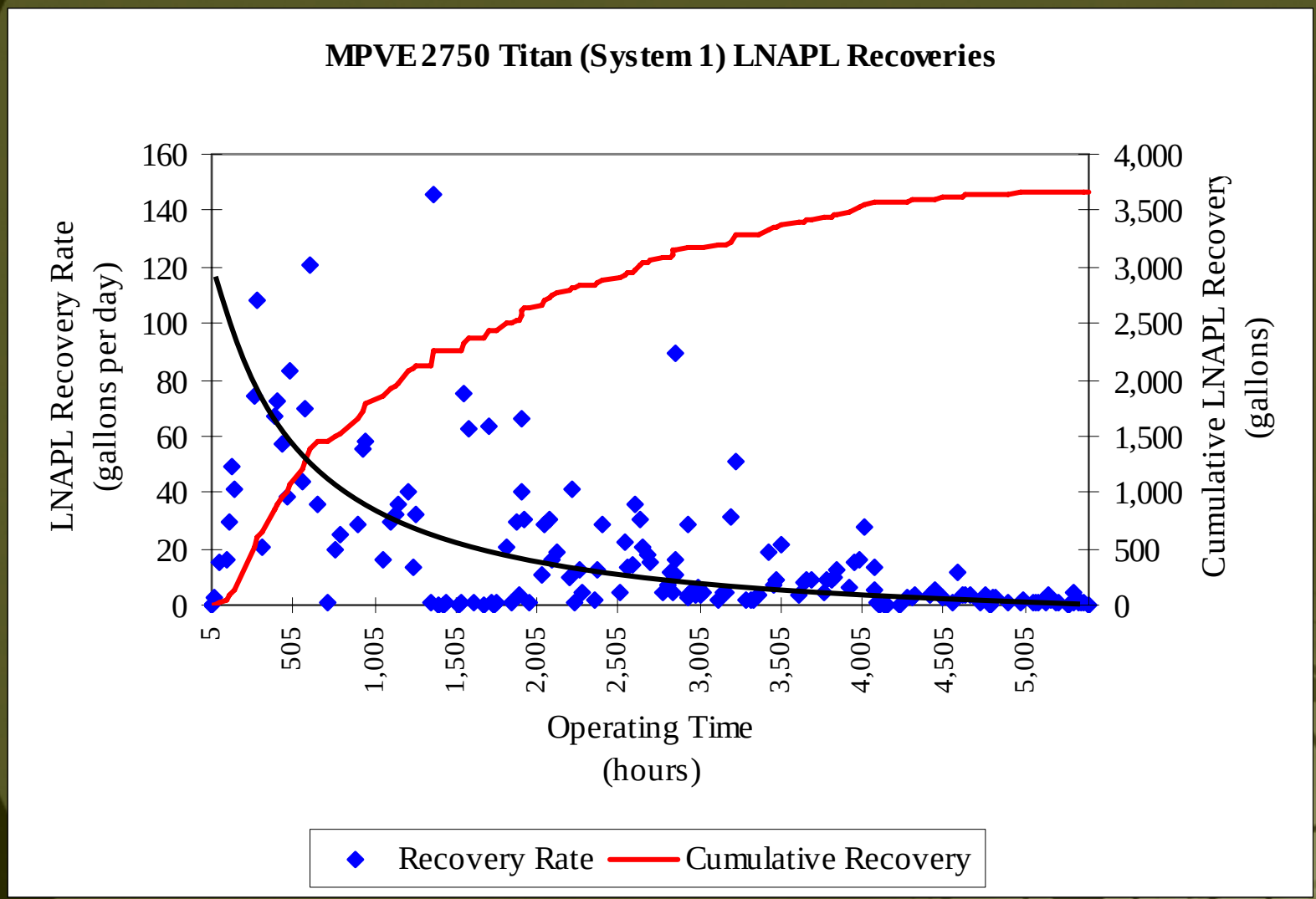

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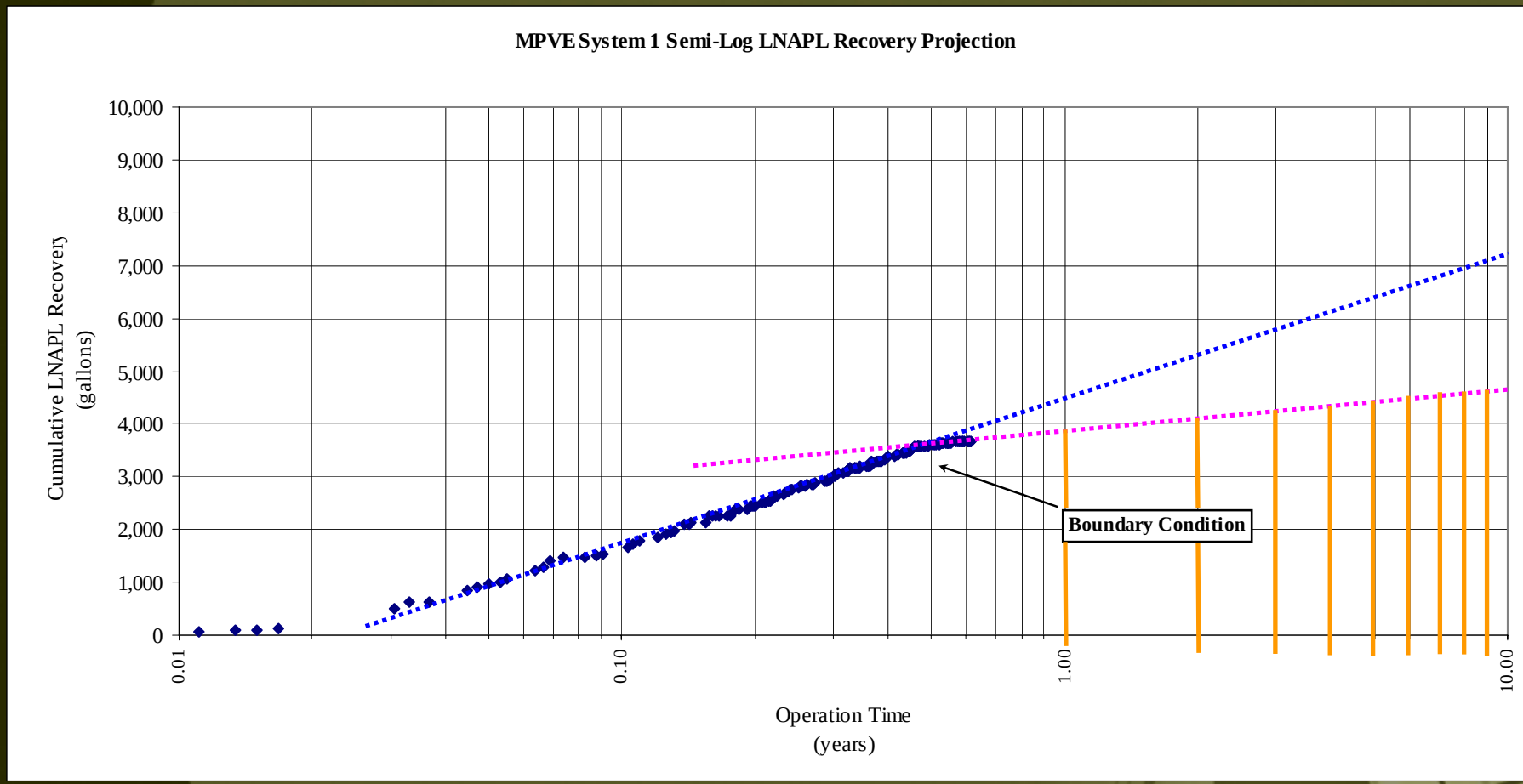

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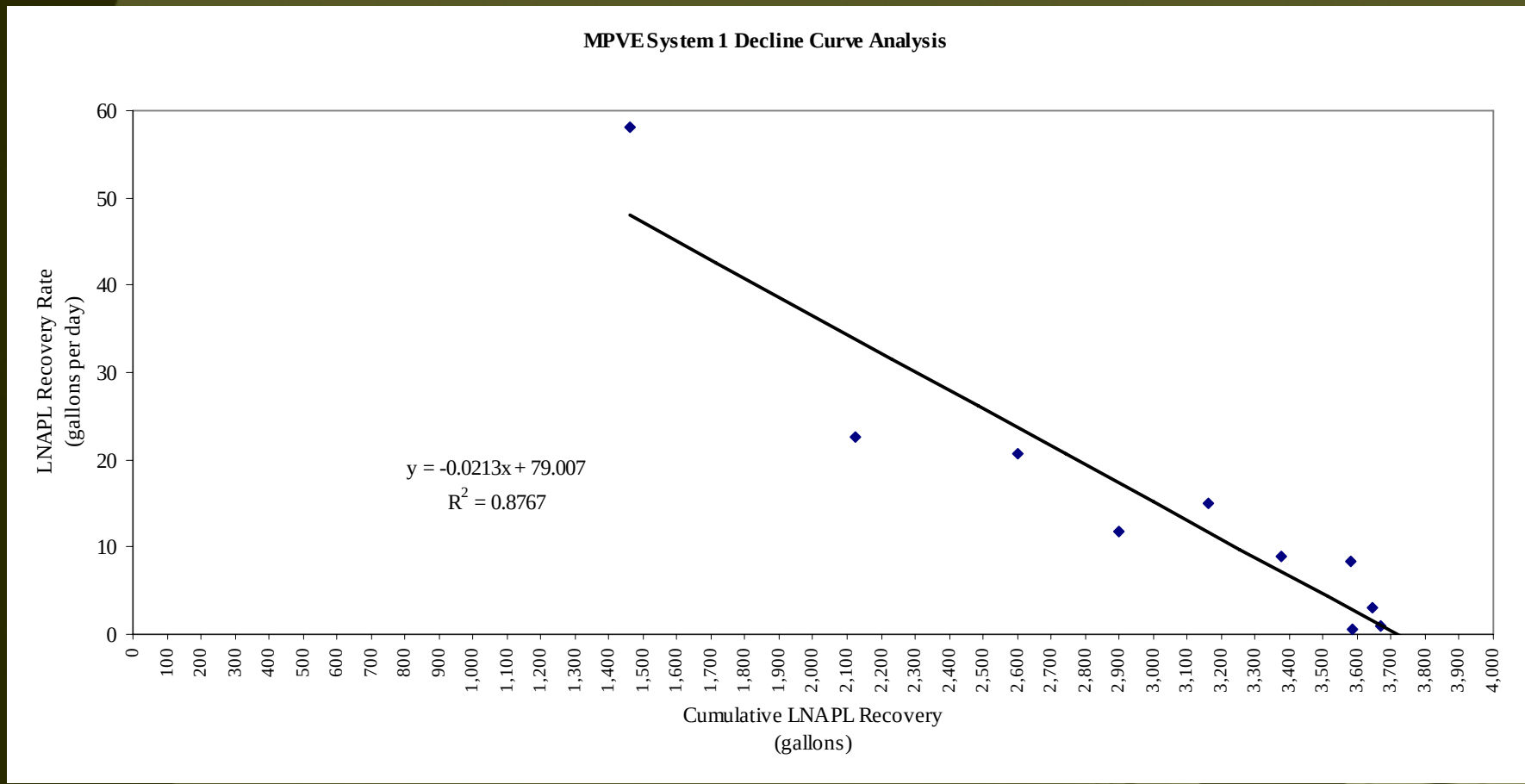

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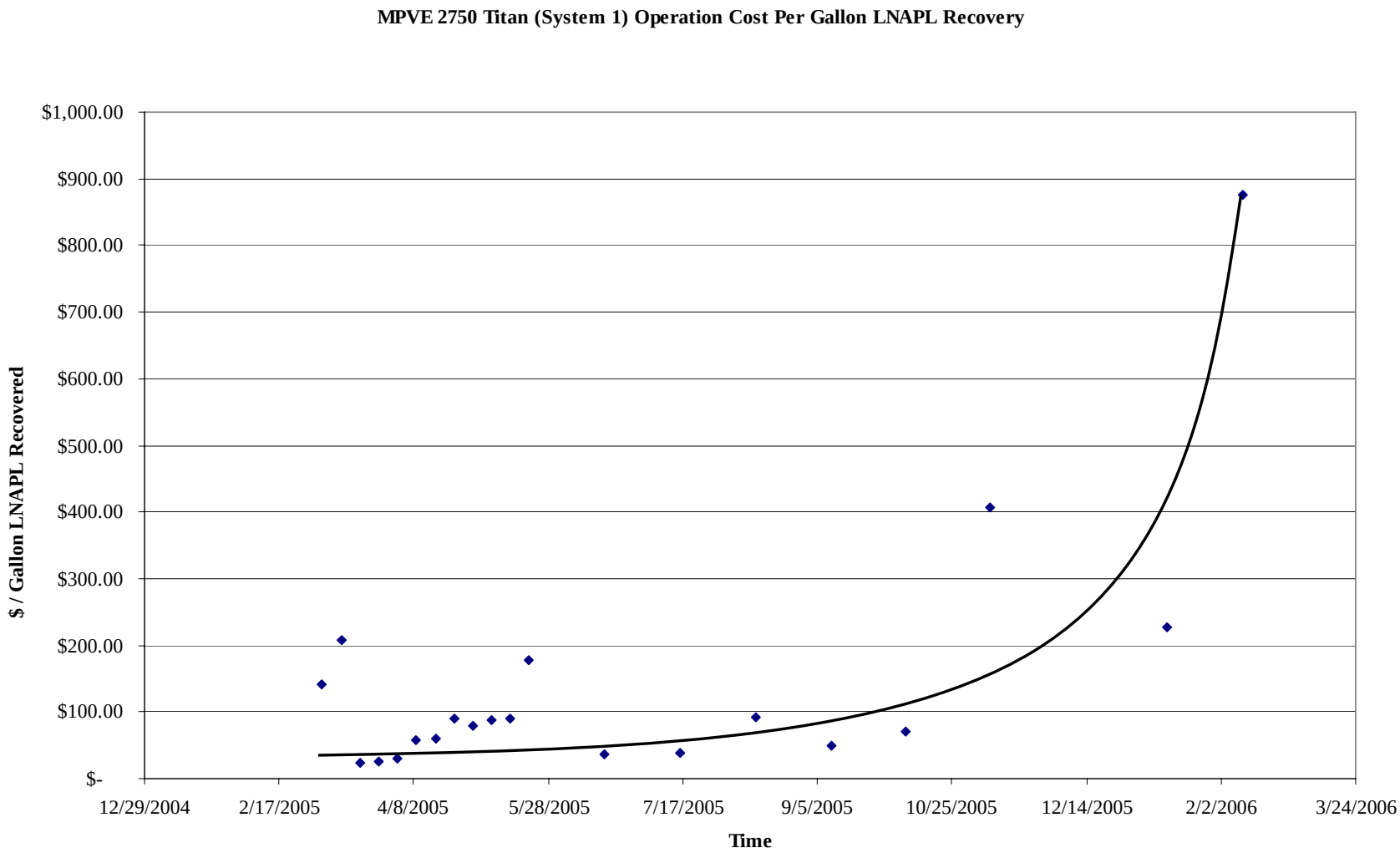


# Area 3: LNAPL Remediation

- Based on evaluation of remediation metrics, active recovery was terminated in February 2006;
- Some wells (in poor recovery areas) continued to exhibit up to 8 feet of LNAPL;
- Large in-well thicknesses despite low recovery suggest that LNAPL is present in various seams under confined conditions;
- U.S. Environmental Protection Agency (U.S. EPA) reviewed LNAPL performance and agreed that aggressive recovery using MPVE systems could be terminated.

# Areas 1, 2 and 4: LNAPL Mobility

## Methodology

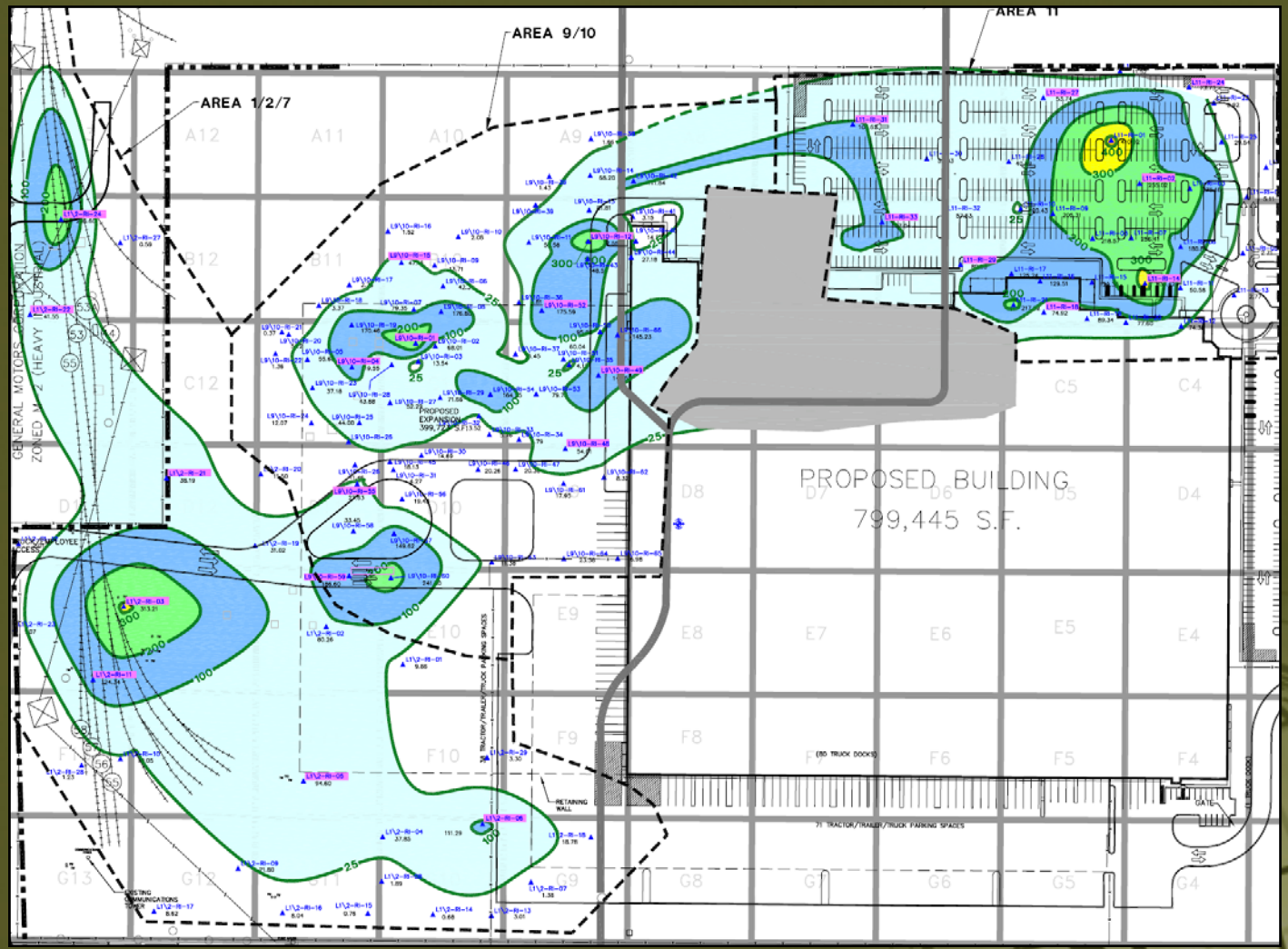
- Conducted laser induced fluorescence (LIF) survey using Rapid Optical Screening Tool (ROST) technology (128 survey points);
- Collected undisturbed soil cores in select (24) locations of soil zones exhibiting varying degrees of relative fluorescence during ROST;
- Submitted soil cores for laboratory photography and testing of key LNAPL mobility parameters;
- Evaluated LNAPL mobility using three methods;

# Areas 1, 2 and 4: LNAPL Mobility

- Method 1: Compared laboratory measured LNAPL saturation against corresponding residual saturation;
- Method 2: Used laboratory measured oil and water conductivity results (on fully saturated samples) to calculate LNAPL mobility and velocity values;
- Method 3: Used laboratory measured LNAPL saturation results and API/Charbeneau methods to calculate LNAPL relative permeability, conductivity, mobility and velocity values.

# Areas 1, 2 and 4: LNAPL Mobility

- Averaged (1-foot thick) ROST Plan View



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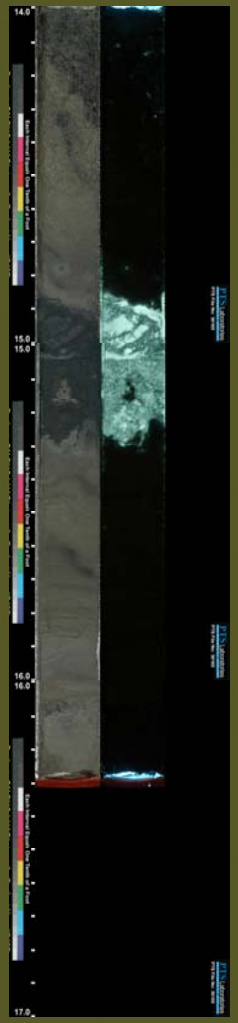
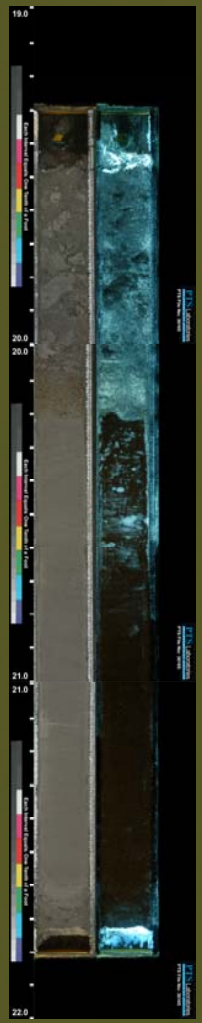
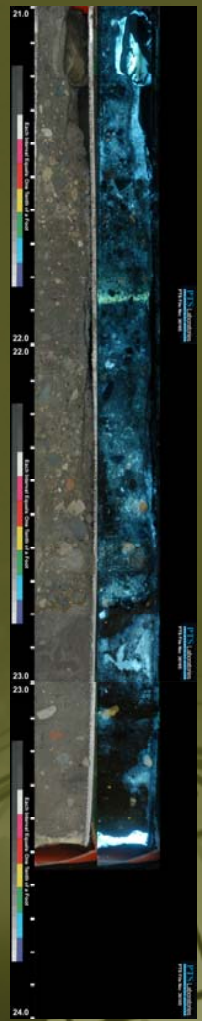






# Areas 1, 2 and 4: LNAPL Mobility

## Method 1:

- Single point centrifugal test: 16 of 16 LNAPL saturations greater than residual saturation (4 significantly greater);
- Capillary pressure test: 4 of 6 LNAPL saturations greater than residual saturation (3 significantly greater);
- Results suggest potential for inherent LNAPL mobility in interior portions of LNAPL areas, with limited or no mobility near fringe areas.

# Areas 1, 2 and 4: LNAPL Mobility

## Method 2:

- Laboratory measured oil saturation and conductivity values were used to calculate LNAPL mobility and velocity values.

# Areas 1, 2 and 4: LNAPL Mobility

## Method 3:

- The laboratory measured LNAPL saturation value was deemed to represent the maximum LNAPL saturation point at the sample location (based on ROST and UV photography);

- This measured maximum saturation was then used to determine LNAPL relative permeability, conductivity, mobility and velocity.

# Areas 1, 2 and 4: LNAPL Mobility

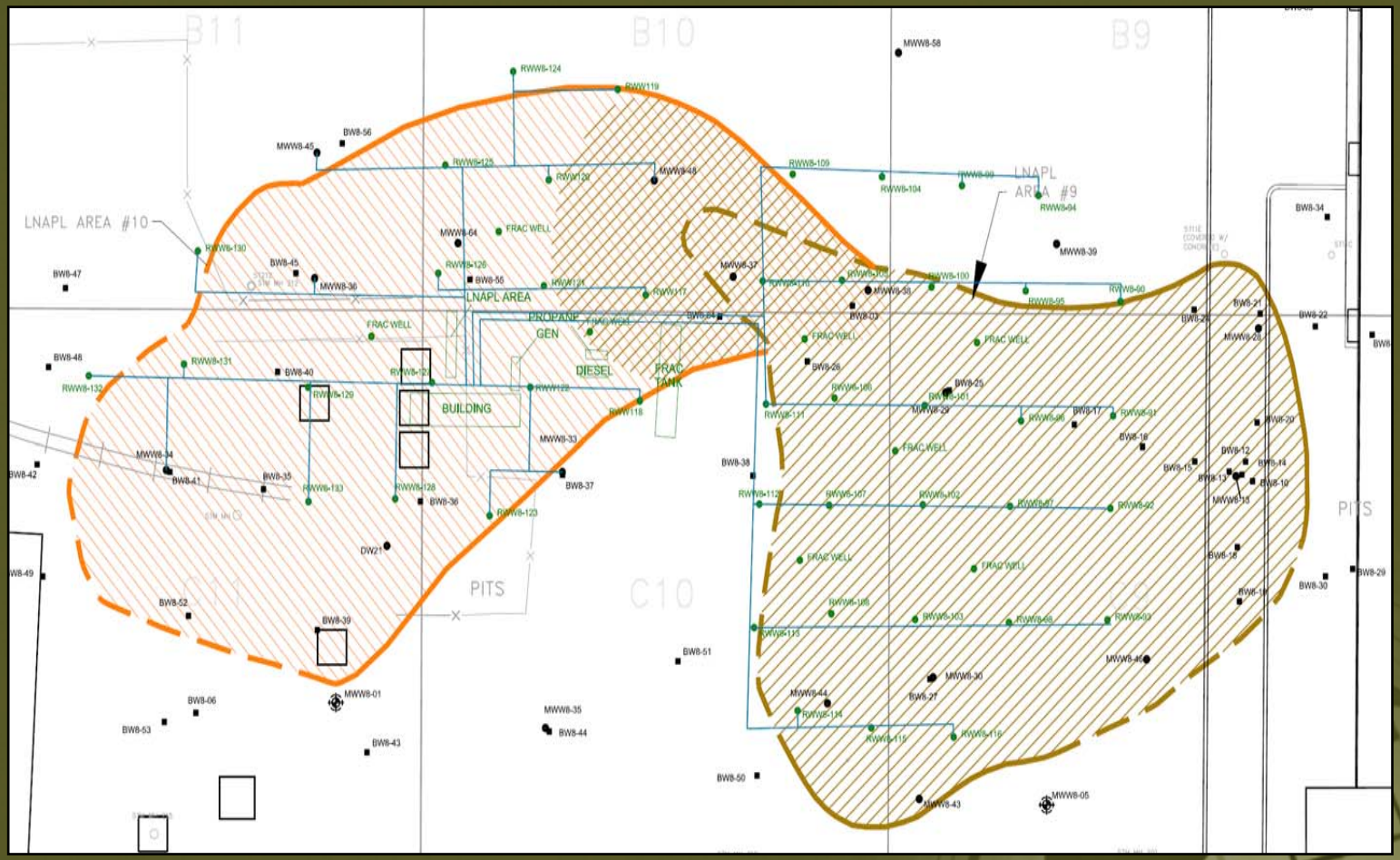
- Based on the Method 2 calculation results, 3 of 6 test locations exhibited an LNAPL velocity in excess of $1 \times 10^{-6}$ cm/s, which represents the *de minimis* mobility threshold for LNAPL (ASTM, 2007);

- Based on the Method 3 calculation results, none of the 24 test locations exhibited an LNAPL velocity in excess of $1 \times 10^{-6}$ cm/s.

# Area 2: LNAPL Remediation

- Based on the M-H priority rating for Area 2 and the results of the LNAPL mobility evaluation, it was determined that aggressive LNAPL recovery (using MPE/PAL and PF) would be conducted in this area.
- A network of fifty 4-inch PVC extraction wells were installed in Area 2;
- MPE/PAL and PF operations were conducted using a 100 Hp MPVE system.

# Area 2: LNAPL Remediation



# Area 2: LNAPL Remediation

- After approximately 104 hours of MPE operation, a total of 28 gallons of LNAPL and 28,165 gallons of water were recovered;
- LNAPL recovery went asymptotic almost immediately;
- Based on the relatively low LNAPL recovery rates, and costs to run the MPVE system, LNAPL recovery was terminated in Area 2.

# Regulatory Feedback

- LNAPL Mobility Evaluation Report (including Area 2 LNAPL remediation) submitted to U.S. EPA;
- Currently responding to U.S. EPA comments.

# Redevelopment Status

- 3rd Party tenant commenced concrete removal and crushing activities and property grading in Spring 2005;
- Vertical construction of building commenced as scheduled in March 2006, after the completion of Area 3 LNAPL remediation activities;
- All LNAPL extraction wells in Areas 2 and 3 abandoned in Summer and Fall 2006;
- Outer shell of building completed in late 2006.

# Redevelopment Status

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