ARCADIS Design & Consultancy for natural and built assets

LNAPL RECOVERY AND REMEDY TRANSITIONS

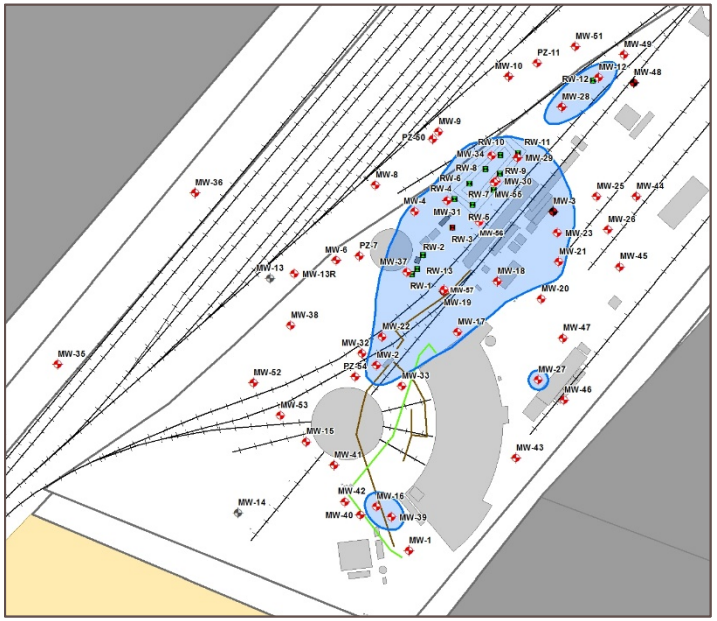
A CASE STUDY AT A RAILYARD FUELING FACILITY

JEREMY COUGHLIN AND LEEANN THOMAS, CP
ANDY PENNINGTON AND DAWN GABARDI, ARCADIS

CP

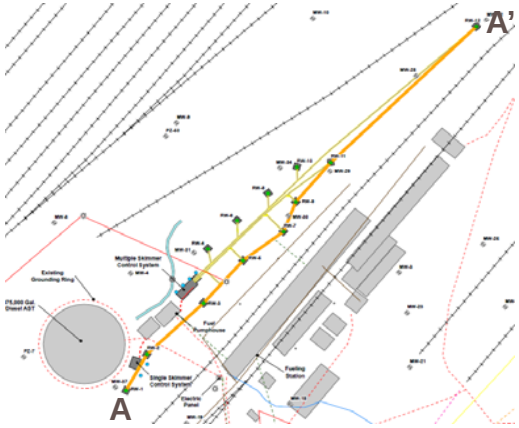
SITE BACKGROUND AND LCSM

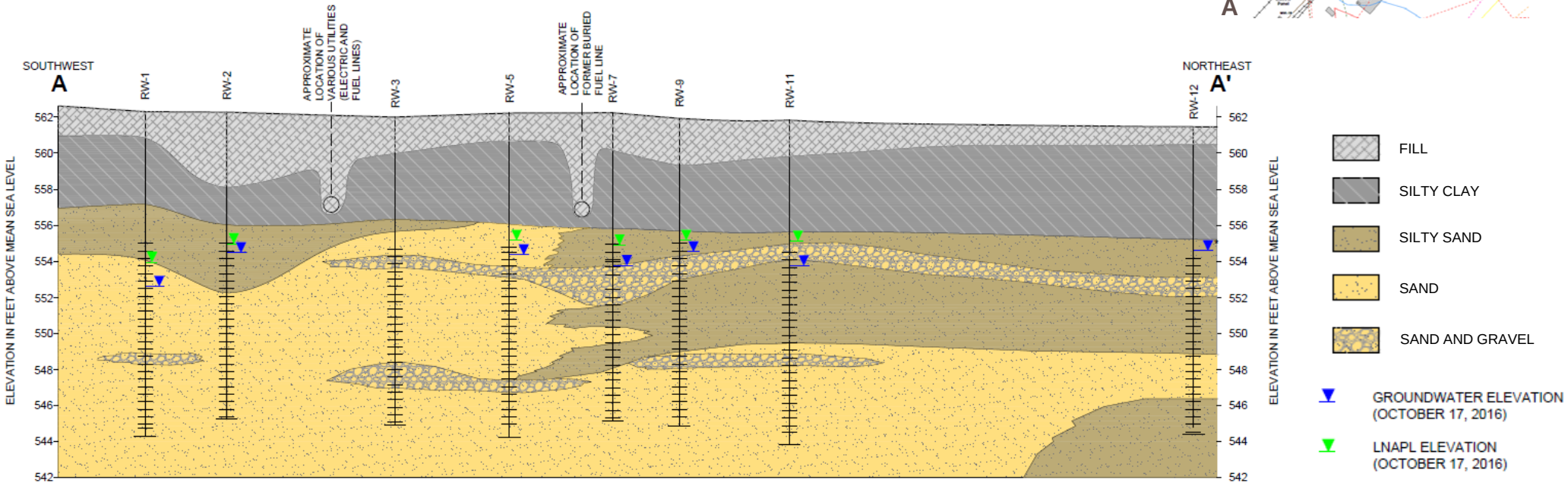
- CP acquired the railroad property in 2007-2008
- Site investigation/characterization 2009-2011
- Diesel LNAPL near fueling and wastewater facilities



SITE BACKGROUND AND LCSM

- Smear zone ~6-12 feet bgs in sandy soil
- Limited, stable dissolved-phase impacts
- No groundwater or vapor-phase receptors; no off-site impacts





REMEDIAL OBJECTIVES

- No immediate LNAPL-related risks
- Mobile NAPL occurrence concerns drive objectives
- State regulations require that *all free product present in the mobile phase be recovered or treated to the extent technically feasible*

Mobile LNAPL Occurrence Concerns

- **Measurable LNAPL in monitoring wells**
- **Requirement to recover LNAPL to maximum extent practicable**

Risk and Safety Concerns

- **Fire/Explosion hazards**
- **Human or ecological exposures**

LNAPL Migration Concerns

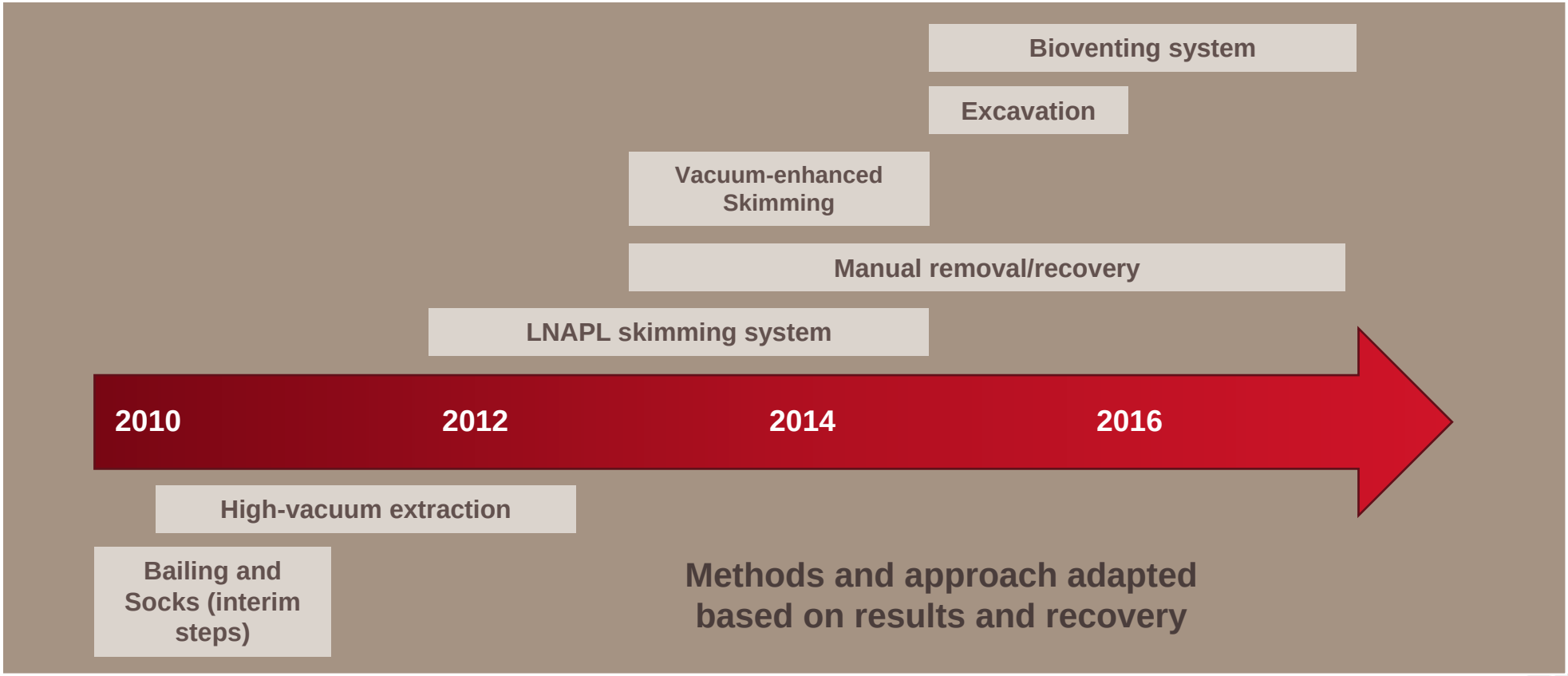
- **Ongoing/continuing release**
- **Migration of LNAPL to new areas or off-site**

Other LNAPL Concerns

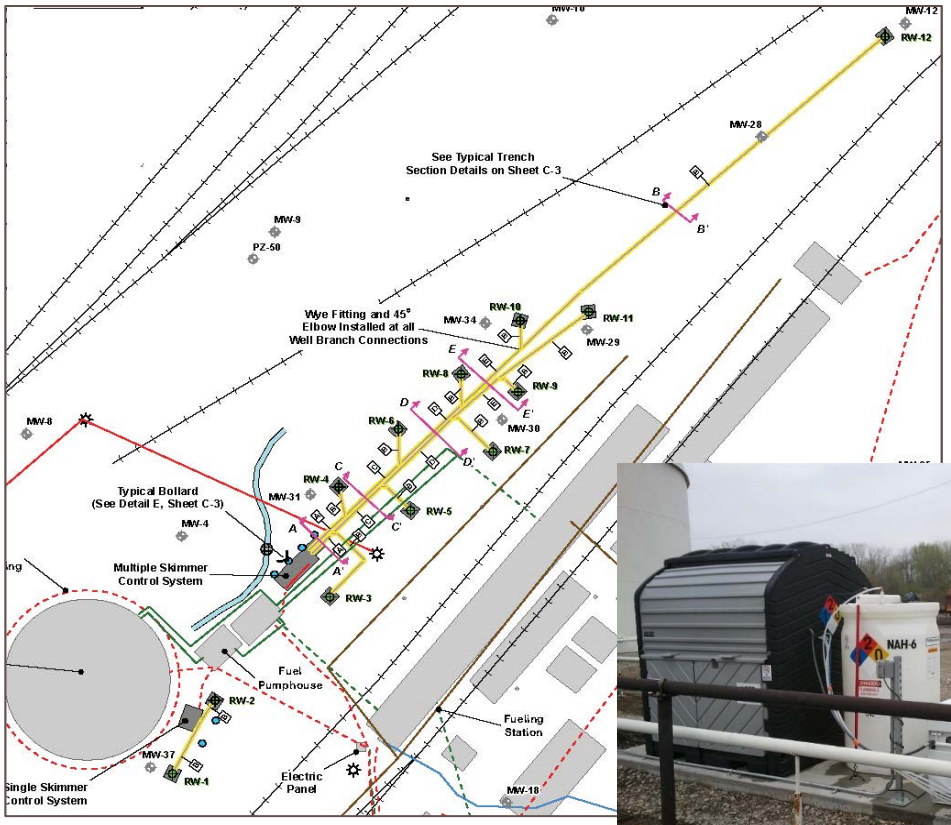
- **Staining or odors**
- **Stakeholder perceptions**
- **Geotechnical concerns**

Adapted from ITRC LNAPL Update

LNAPL REMEDIAL EFFORTS



LNAPL SKIMMING & BIOVENTING

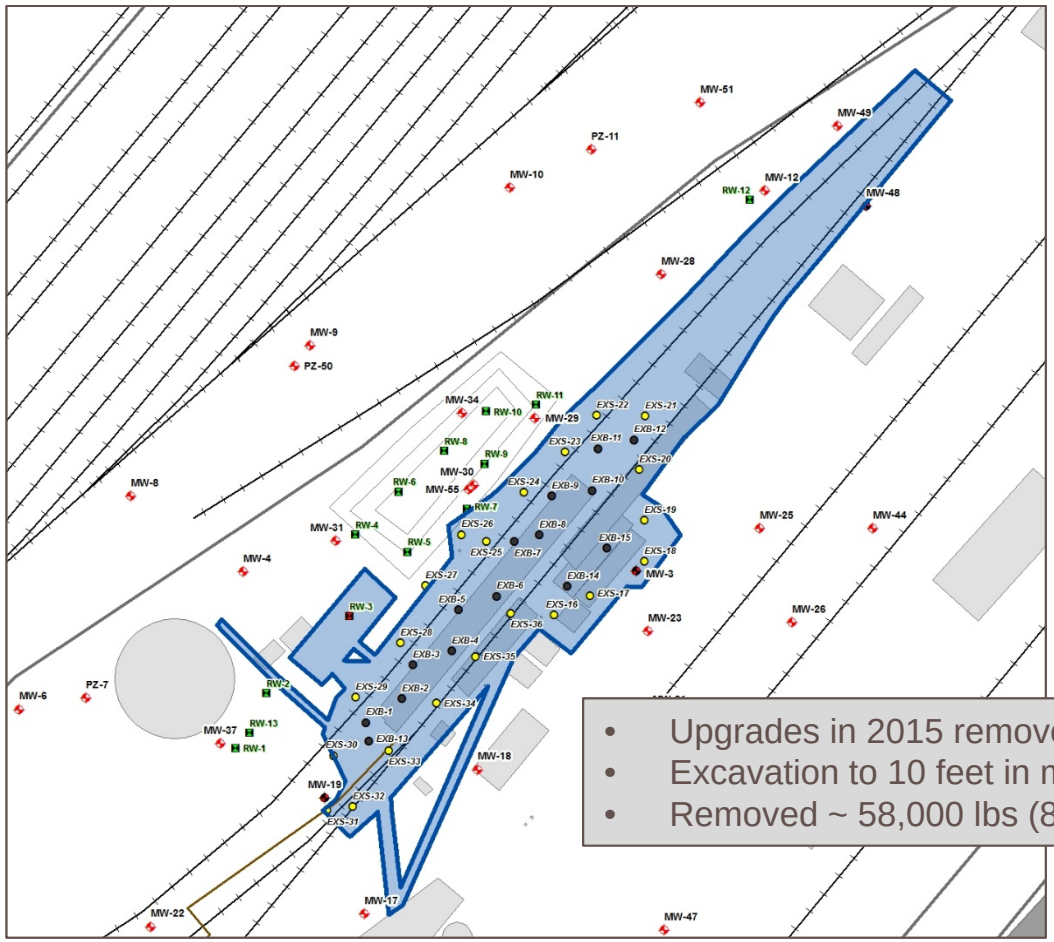


- Skimmer system installed 2011, with recovery rates tracked by well
- Vacuum enhancement in 2013 - blower connected to subsurface piping/wellheads
- No significant increase in LNAPL recovery, but significant benefit via bioventing (tracking CO_2 effluent)

Performance Indicators

- **LNAPL Recovery Rates and Volume**
- **LNAPL Transmissivity**
- **Biodegradation Rates**

FUELING AREA EXCAVATION



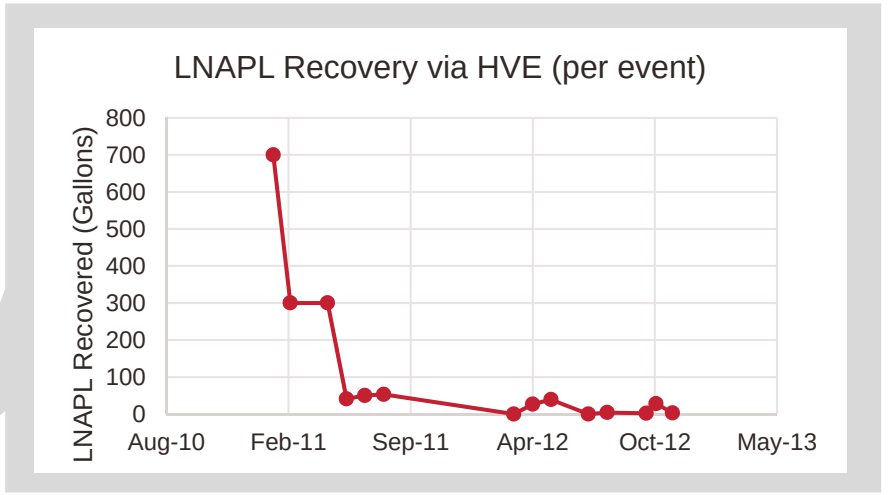
- Upgrades in 2015 removed buried piping and ~ 6,600 tons of impacted soil
- Excavation to 10 feet in main fueling area, 5 feet along buried piping runs
- Removed ~ 58,000 lbs (8,000 gals) diesel petroleum hydrocarbons

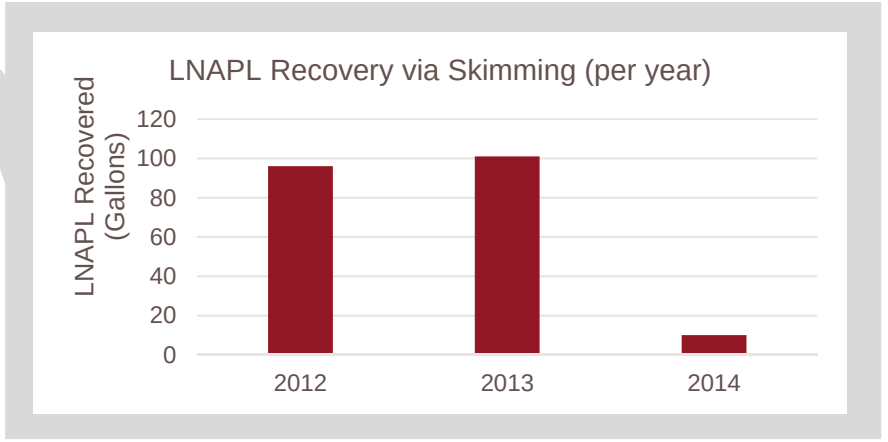
FUELING AREA

Current layout
(2016)

LNAPL RECOVERY

Recovery/Removal Method	Total Volume (gallons)	Years Active
Manual/periodic removal	250	2010 - present
High-vacuum extraction	1,550	2011 – 2012
Skimming	206	2012 – 2014
Bioventing/vacuum-enhanced biodegradation	1,800	2013 – present
Excavation/Soil Removal in Fueling Area	8,220	2015



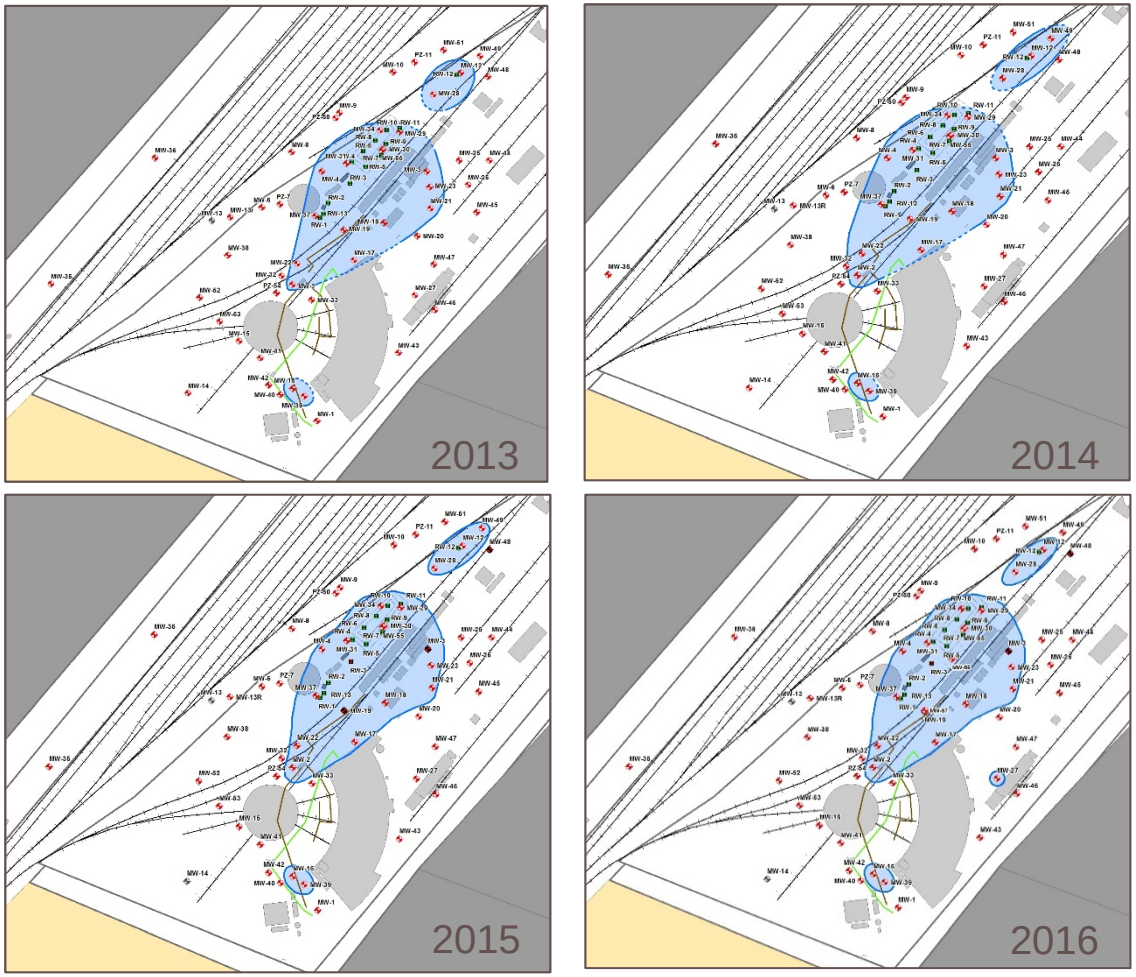


LNAPL RECOVERABILITY METRICS

T_n as a **Threshold Metric:** Is action warranted to address concerns?	• 2012 – T_n between 2 and 10 ft^2/d in center of area • 2013 and 2014 – low T_n around perimeter of LNAPL
T_n as a **Performance Metric:** Is action beneficial and still needed?	• T_n calculations from skimming data • 2017 – two rounds of baildown tests • Results within or below 0.1-0.8 ft^2/d range

LNAPL recovery data corroborate transmissivity results - readily recoverable LNAPL has been removed.

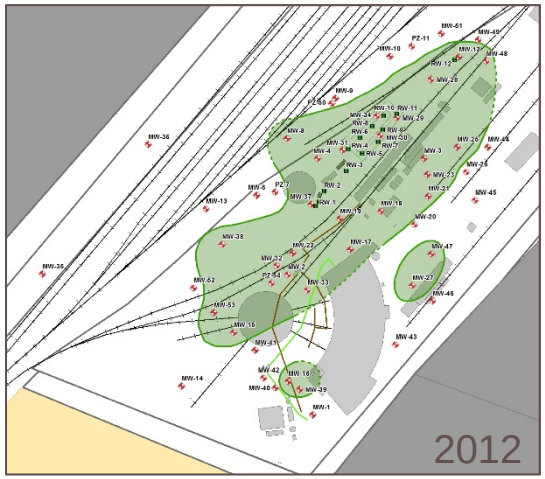
LNAPL FOOTPRINT OVER TIME

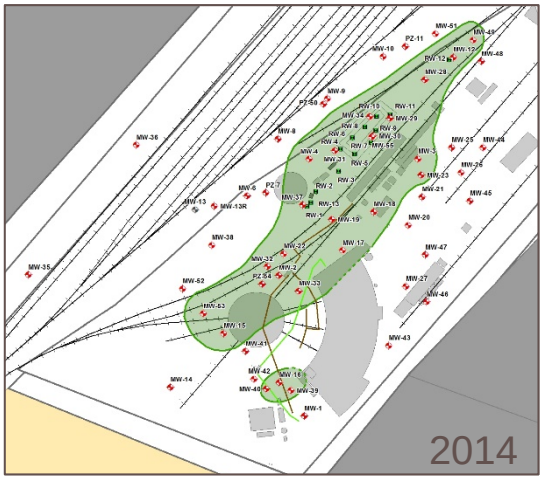


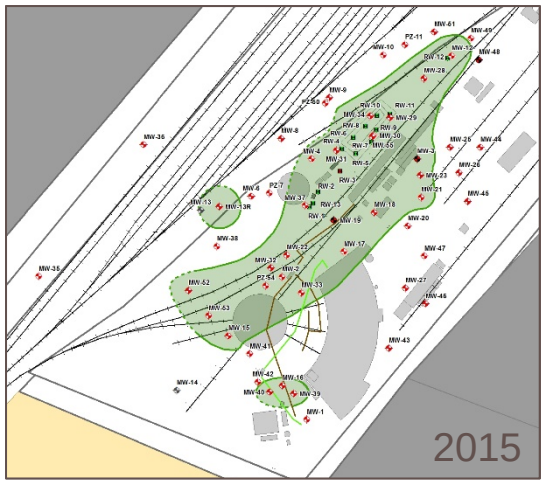
- LNAPL footprint consistent year-over-year
- LNAPL is not expanding or migrating

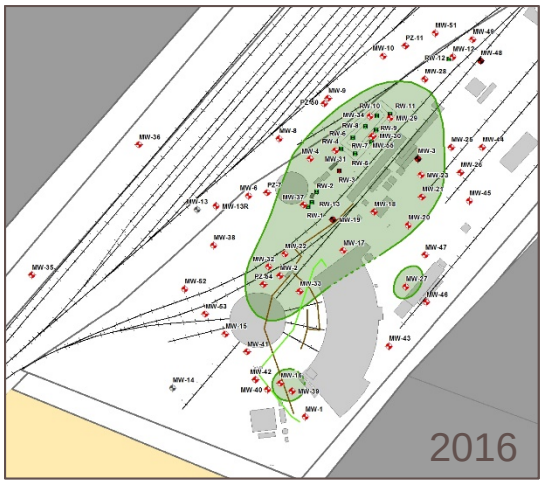
Stability data support remedy transition

DISSOLVED-PHASE FOOTPRINT OVER TIME









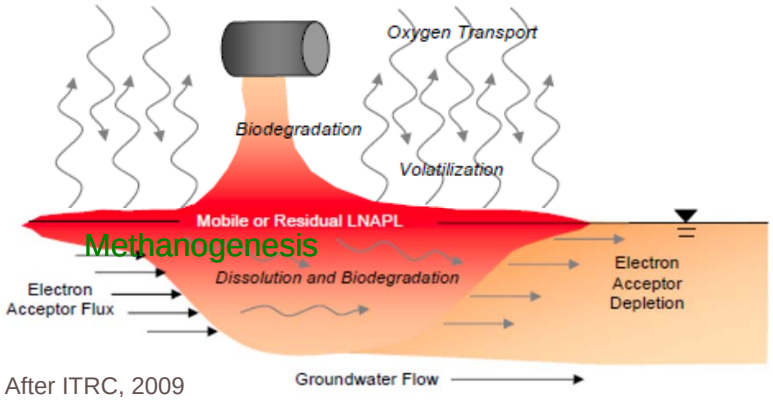
- Consistent TEHc footprint in groundwater, centered around LNAPL-impacted areas, consistent with residual LNAPL footprint
- Down-gradient wells (along western edge of site) consistently below criteria
- Localized geochemistry changes
- No consistent VOC issues

Stability data support remedy transition

NATURAL SOURCE ZONE DEPLETION ASSESSMENT - 2016

How does natural degradation compare to feasible recovery rates?

- Carbon dioxide flux out of the ground surface correlates to natural LNAPL degradation
- Measured CO_2 flux at 30 locations with a flux chamber and 8 locations with time-averaged sorbent traps
- Conducted after Fueling Area excavation



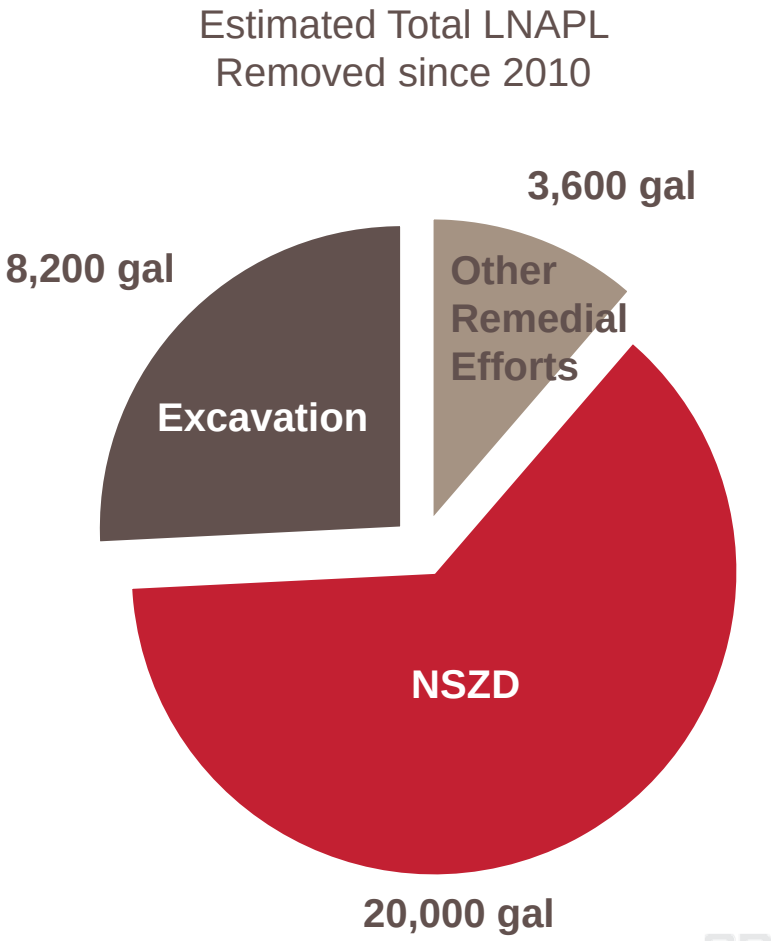
After ITRC, 2009

CO_2 Flux Chamber

CO_2 Sorbent Trap

NSZD RESULTS

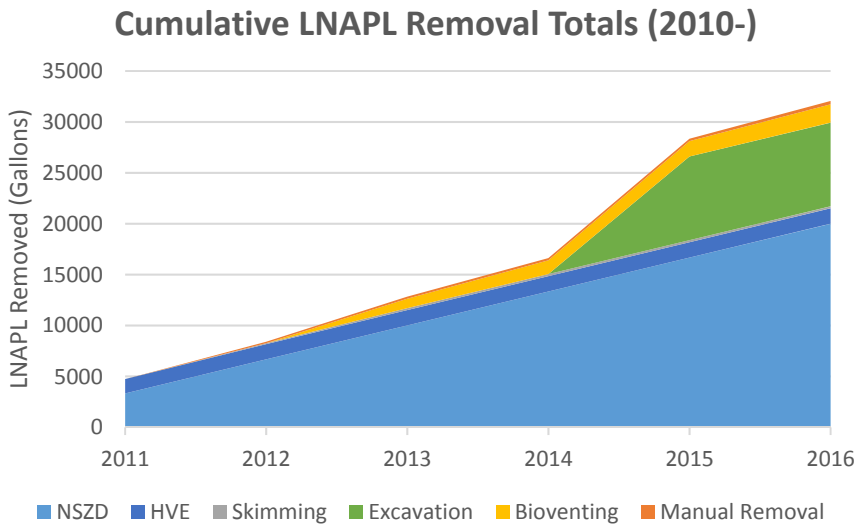
- NSZD rate estimated at 1,500 gallons per acre per year
- Approximately 3,000-4,000 gallons per year site-wide (compared to ~640 gallons per year from other remedies)
- Natural LNAPL losses since 2010 on the order of 20,000 gallons



TREATMENT TRAIN CONCEPT

As remediation progresses, different technologies become more suited to reaching project goals

Threshold/performance metrics and LCSM guide remedy selection and transition



Characterize Concerns/Objectives; Short-term Response

Address Mobile LNAPL Occurrence Concerns and Regulatory Requirements with LNAPL Mass Removal

Transition to lower-energy, phase-change technologies

NSZD underlies all efforts and is the final technology in the treatment train

Layered technologies help match resource use to risk and goals

CURRENT STATUS; LOOKING BACK

- Transition to NSZD
- Working with agency to establish that policy requirements are met
- What would we have done differently in retrospect?
  - Early definition of endpoints
  - More use of T_n as a performance metric
  - Define strategy and goals to agency and anticipate questions

Technologies and Metrics Used

Concern	Technology	Data/Metrics Informing Selection and Transition
LNAPL Migration	Short-term containment or recovery	• Site Characterization • Fluid Level Monitoring • Short-term recovery data
Recoverable LNAPL in Wells	Skimming, Manual Removal, NSZD	• LNAPL Transmissivity • Recovery Decline Curves • NSZD rates
Non-recoverable but mobile LNAPL	Bioventing, NSZD	• CO_2 production • NSZD rate measurements • Ratio of active recovery to NSZD
Residual LNAPL presence	NSZD	• NSZD rate measurements

ARCADIS Design & Consultancy for natural and built assets

QUESTIONS & DISCUSSION

CP