Naval Facilities Engineering Command
Engineering and Expeditionary Warfare Center

Decision Framework for Selecting Multi-Technology Remedy for Complex DNAPL Remediation

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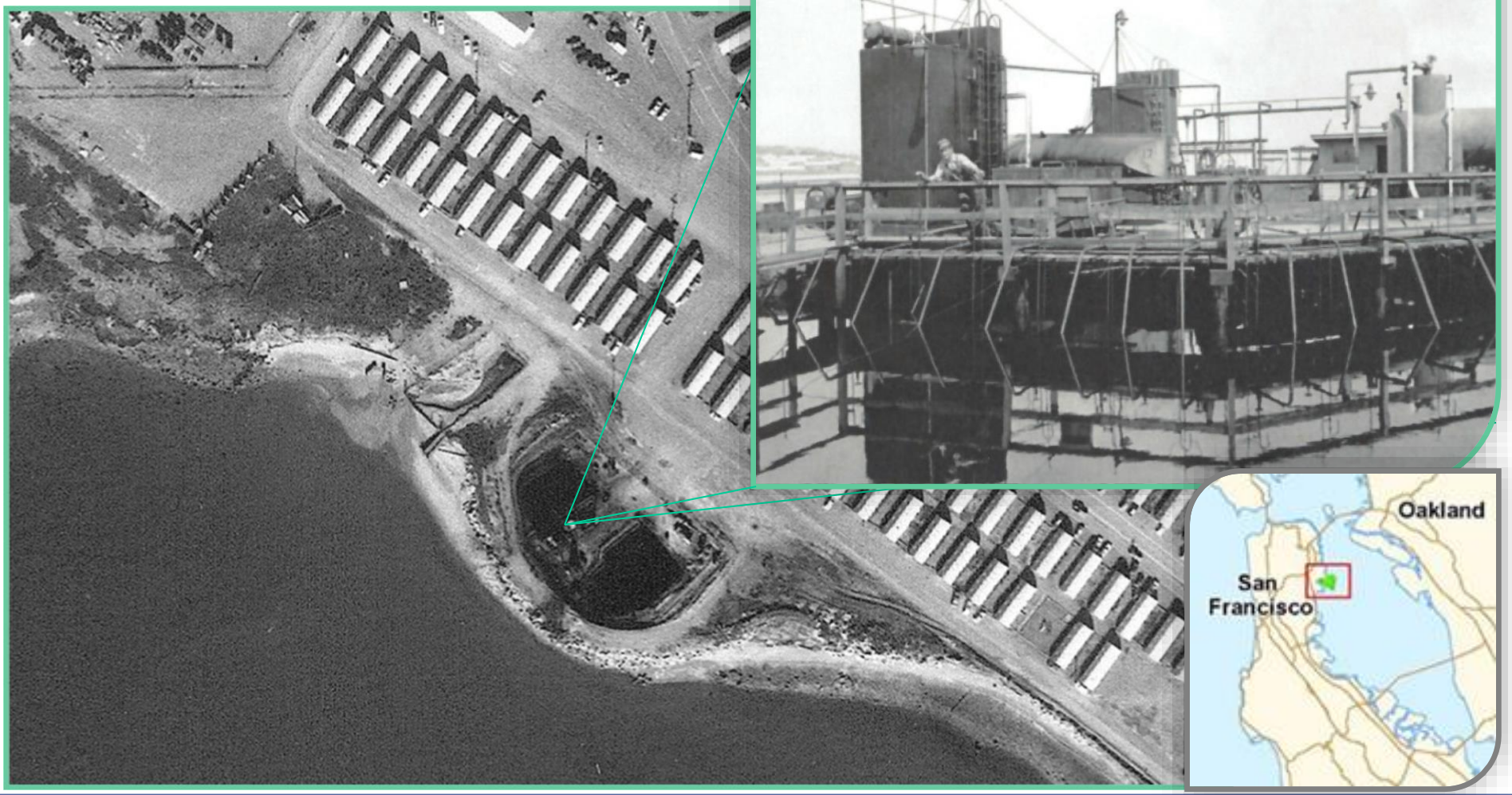
Overview

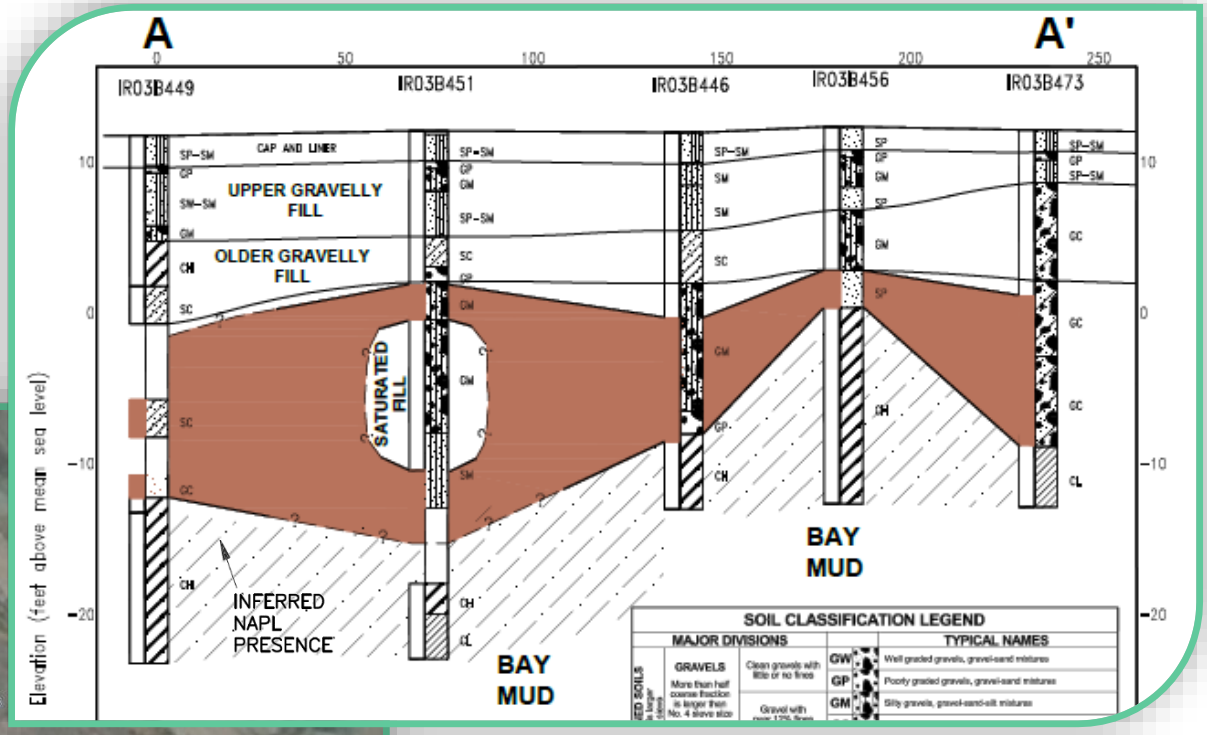
- **Evaluation of multi-technology treatment for former nonaqueous phase liquid (NAPL) ponds**
- **IR-03 at Hunters Point Naval Shipyard (HPNS)**
- **Pilot testing was conducted to evaluate:**
  - ***in situ* thermal remediation (ISTR) and**
  - ***in situ* solidification and stabilization (ISS)**
- **Criterium Decision Plus (CDP) support tool was used to evaluate NAPL remediation scenarios and develop a remedial strategy to achieve remedial goals:**
  - **Treat mobile NAPL and**
  - **Prevent mass discharge via groundwater to surface water (San Francisco Bay)**

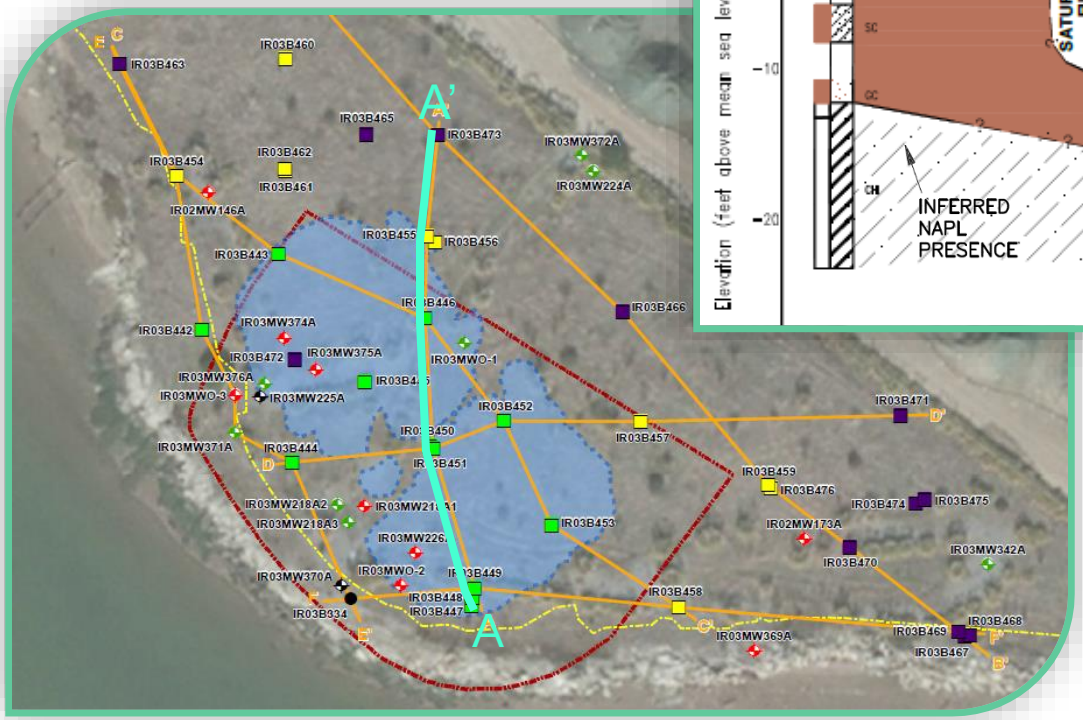
Parcel E, IR-03 Oily Waste Ponds, HPNS



Conceptual Site Model & Remedial Goals

TPH, PCBs, PAHs, aryl phosphates





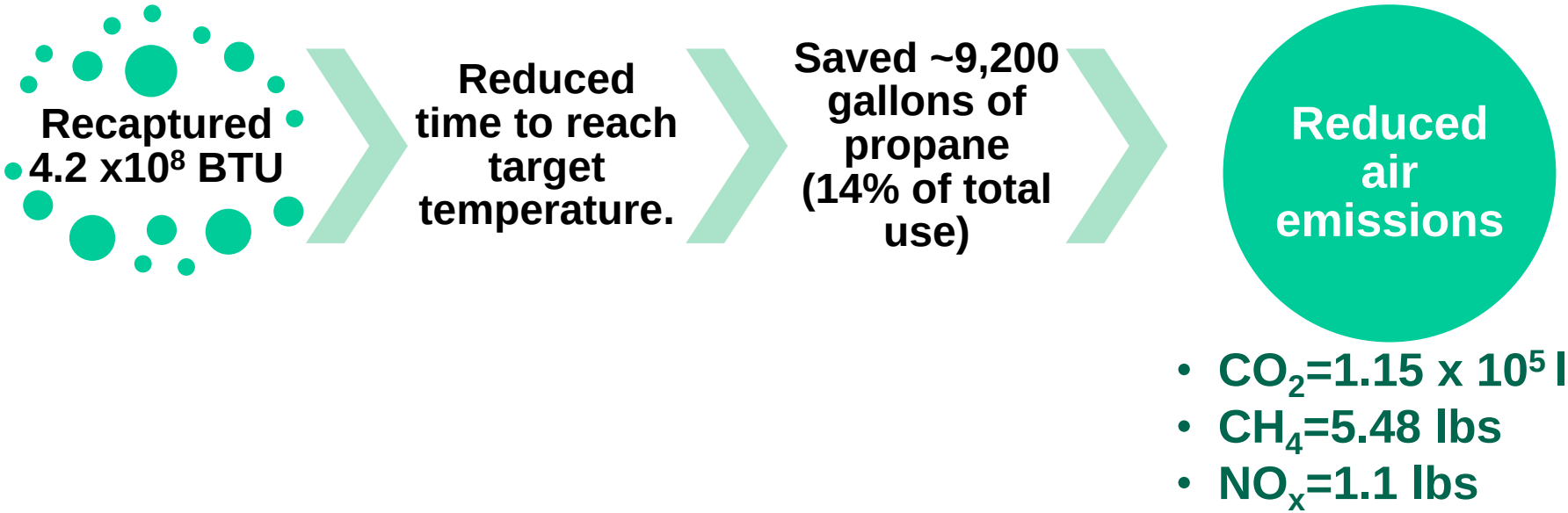
RGs based on ecological risk factors

Pilot Study: ISTR Field Implementation

- Remote location required fueling with propane
- Extracted groundwater reinjected to provide hydraulic containment
- Subsurface temperature monitoring
- Existing low-permeability cap

Pilot Study: ISTR Optimization

- **Exhaust heat captured from well casings, used to heat groundwater prior to reinjection.**



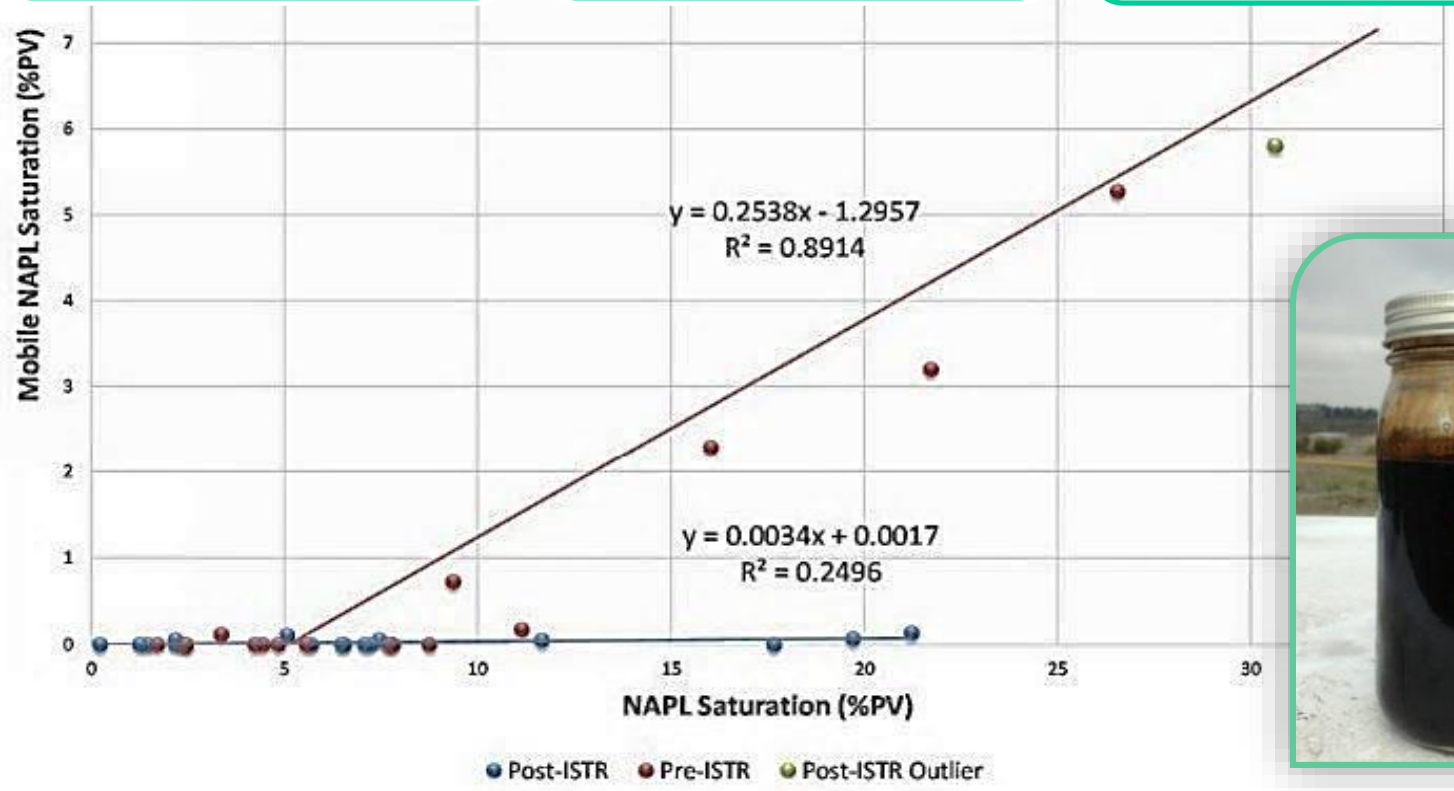
- **Demonstrated that this would be not only feasible but <u>recommended</u> for full-scale implementation**

Pilot Study : ISTR Performance Evaluation

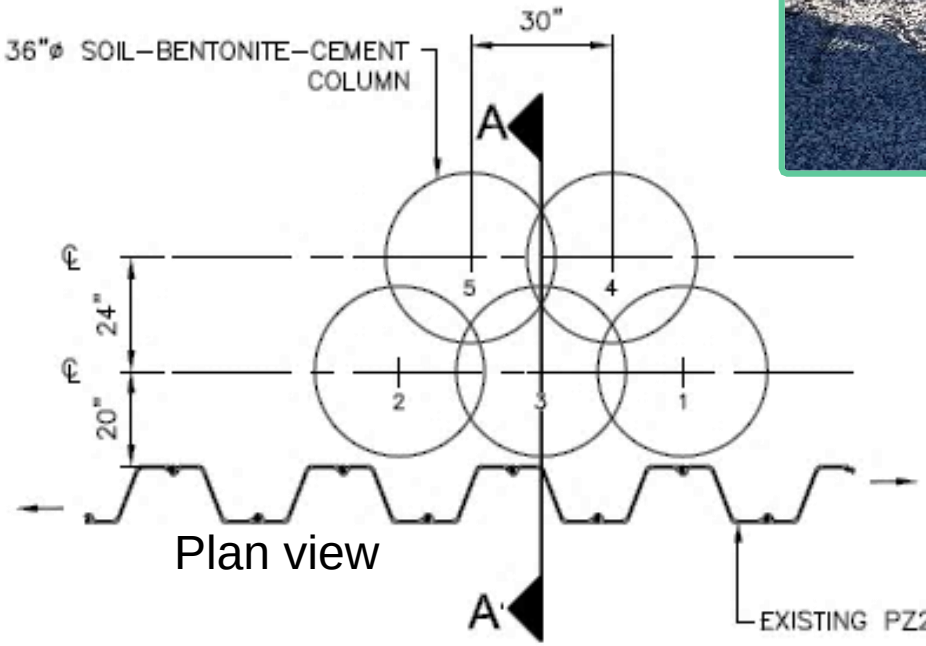
Total NAPL reduced from 6,600 to 4,113 gal (2,487 gal)

Mobile NAPL reduced from 548 to 13 gal (535 gal)

Mobile NAPL Reduced by 98%



Pilot Test: ISS Field Implementation & Optimization



Plan view

Optimization: Using on-site low permeability soils (Bay Mud) reduces the amount of cement and bentonite required for an effective ISS mix

Pilot Test: ISS Performance Evaluation

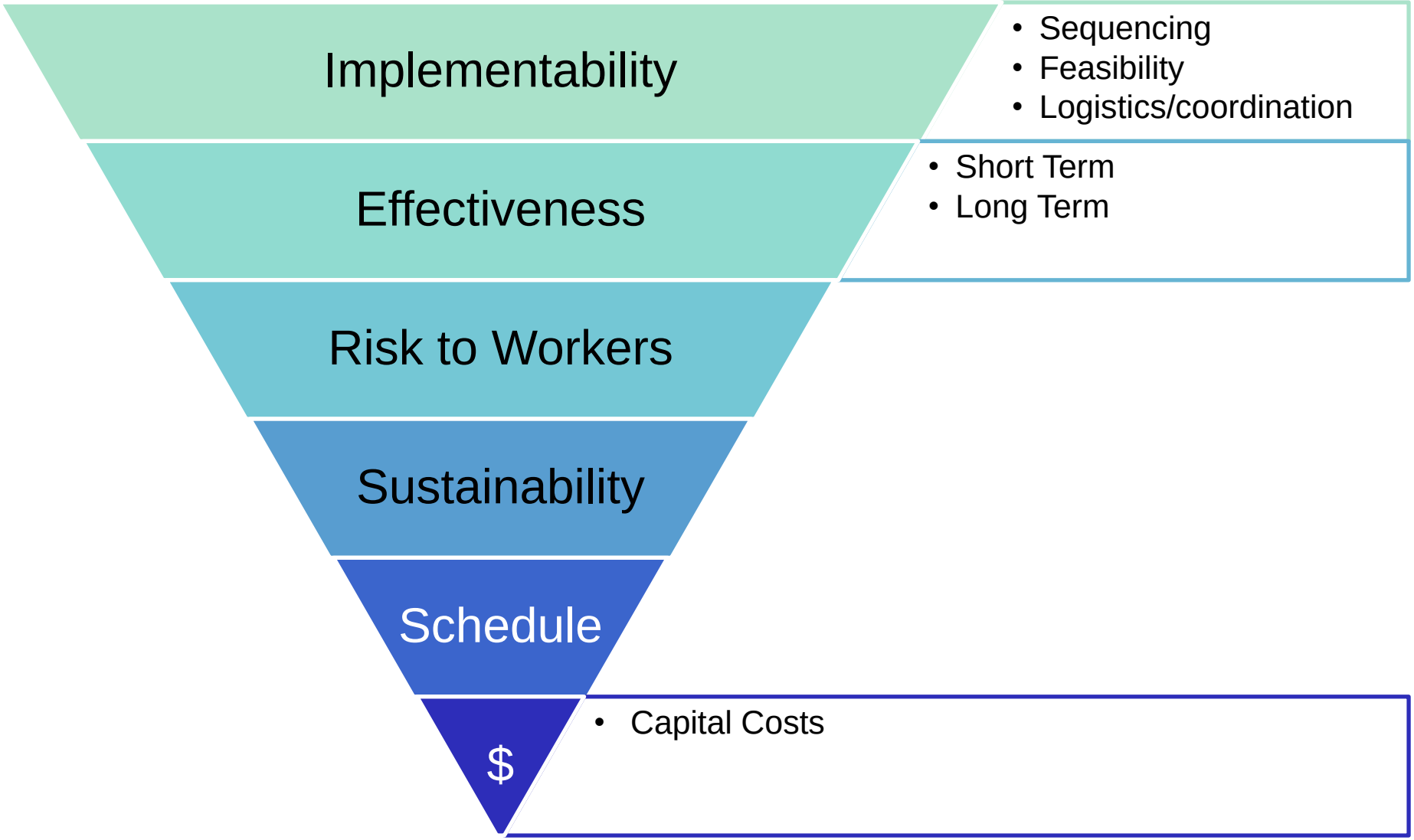
- Reached target permeability: 7.4×10^{-7} cm/s
- All SDL leachate samples below criteria for TPH and Metals
- PCB average leachate concentrations were below the criteria

Corehole #2; Sample Depth 17-18 feet

Corehole #2; Sample Depth 18-19 feet

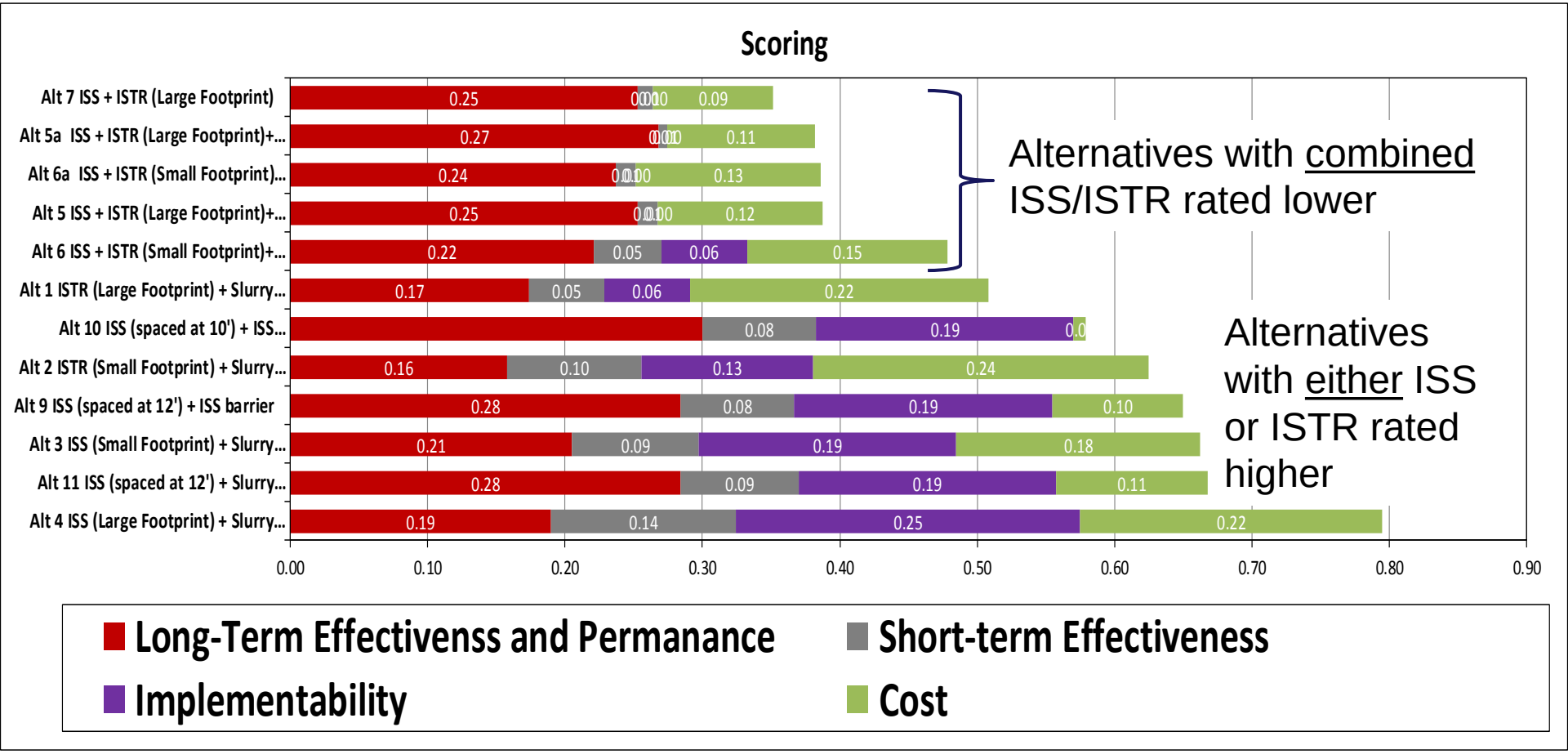
Corehole #2; Sample Depth 19-20.5 feet

Decision Criteria for NAPL Treatment Strategy

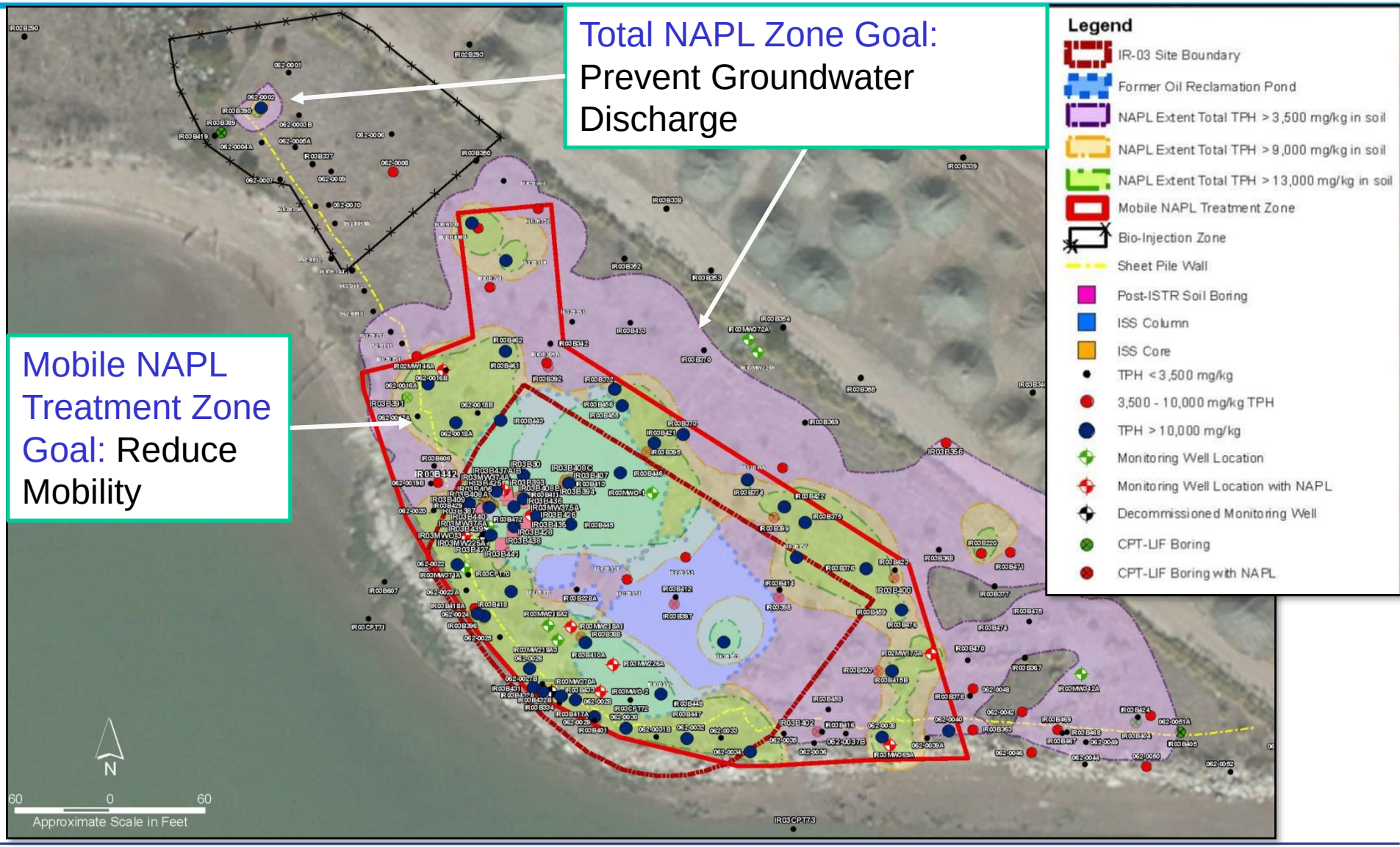


Evaluate multiple technology combinations

- **Criterium Decision Plus (CDP)- multi-criteria decision making software using the Analytic Hierarchy Process and the Simple Multi-Attribute Rating Technique.**



Define NAPL Treatment Zones



Implementability: ISTR

- Full scale requires complicated sequencing
- Requires highly adaptable system design
- Generates multiple waste streams
- Stringent treatment required for on-site discharge

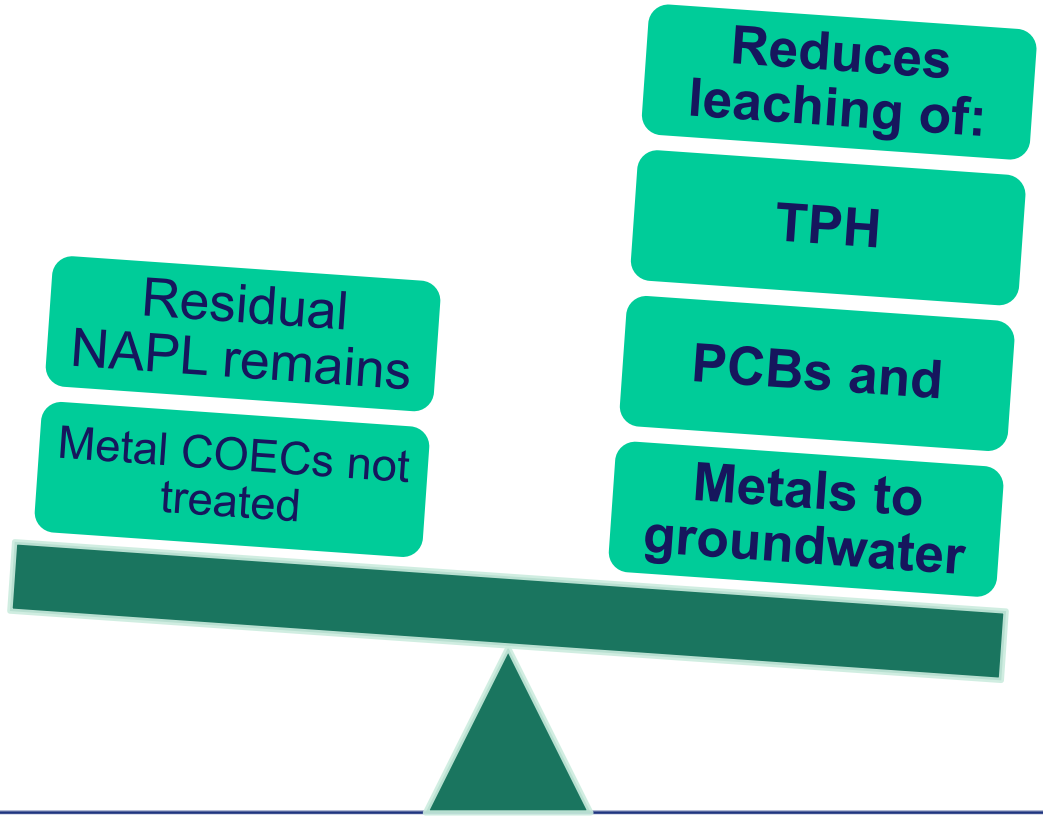
Implementability: ISS

- Complicated implementation
- Coordination to tie into slurry wall
- Interference from subsurface obstructions
- Small amount of NAPL disposal
- Manage excess bentonite mix

Effectiveness

ISTR
(3 yrs)

ISS
(2 yrs)



Slurry wall required for hydraulic containment of groundwater discharging to San Francisco Bay for both technologies.

Risks to Workers

ISTR

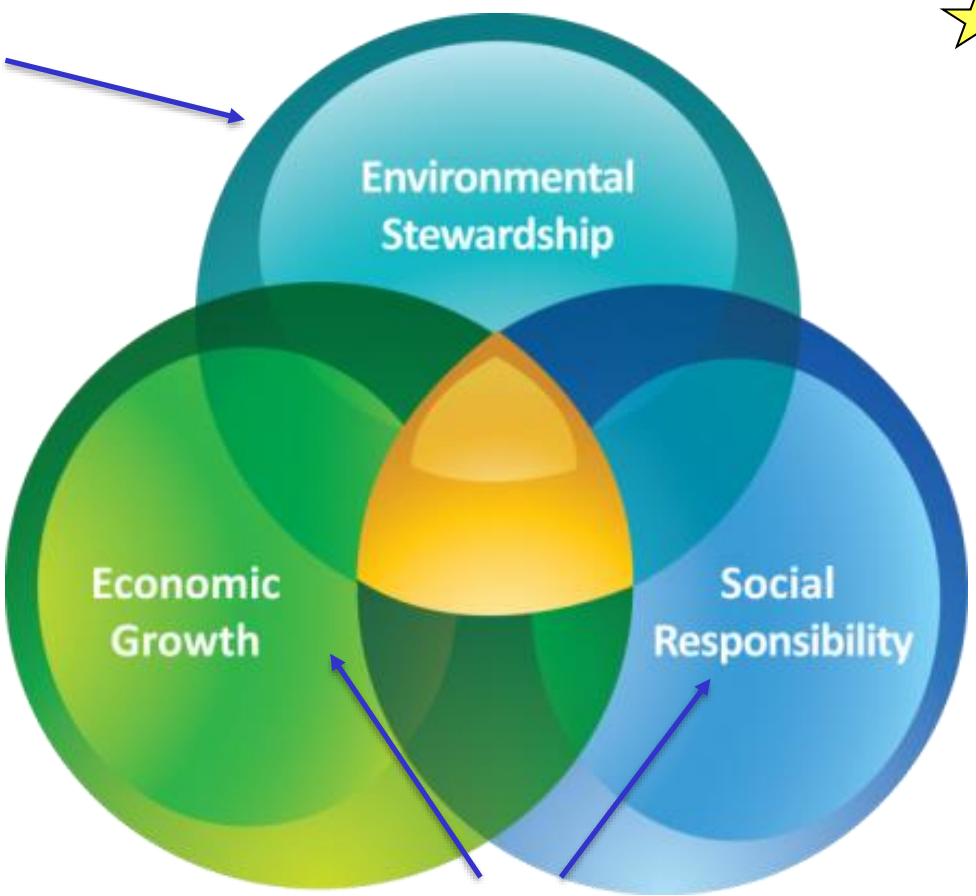
- High temperature thermal decomposition from complex NAPL
- Management of large NAPL volumes and waste streams
- High temperature environment, complex operations

ISS

- Augering and excavation

Green and Sustainable Remediation (GSR) Assessment

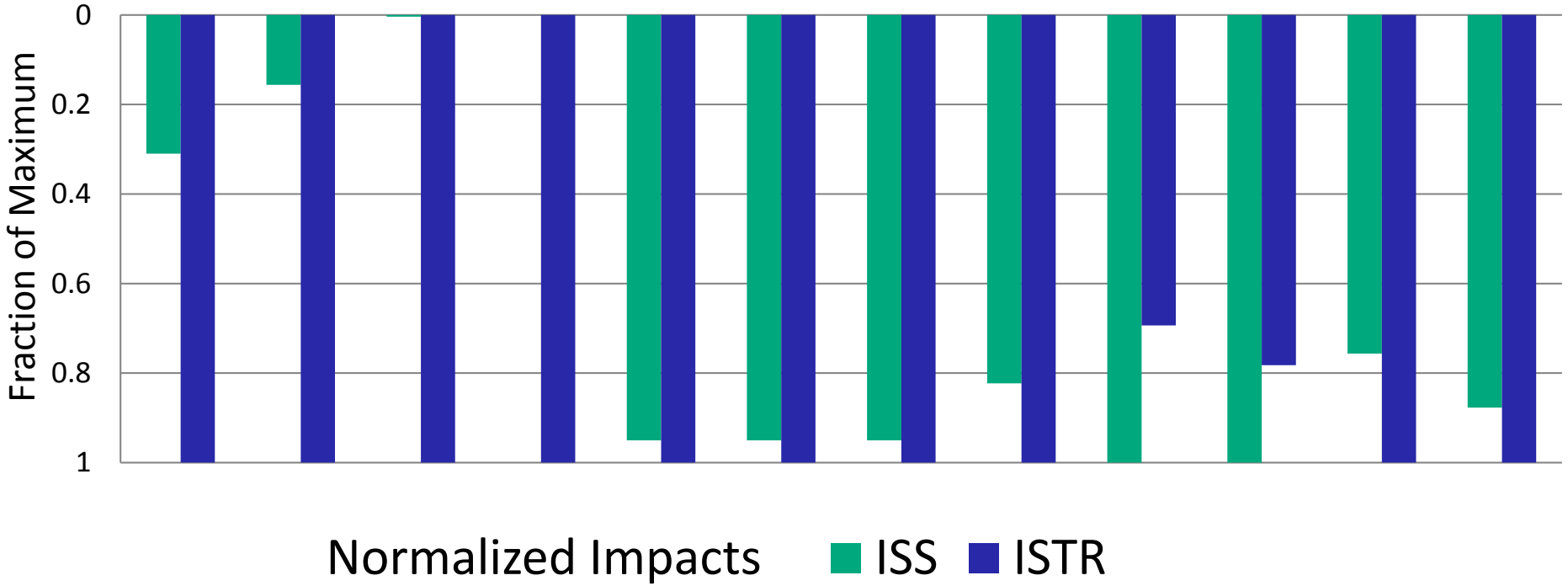
SiteWise™ *environmental footprint tool*



"The idea behind GSR is to improve the cleanup program by meeting the existing requirements, while minimizing potential negative environmental, societal and economic impacts that could occur during or as a result of remedial actions." (NAVFAC, 2012)

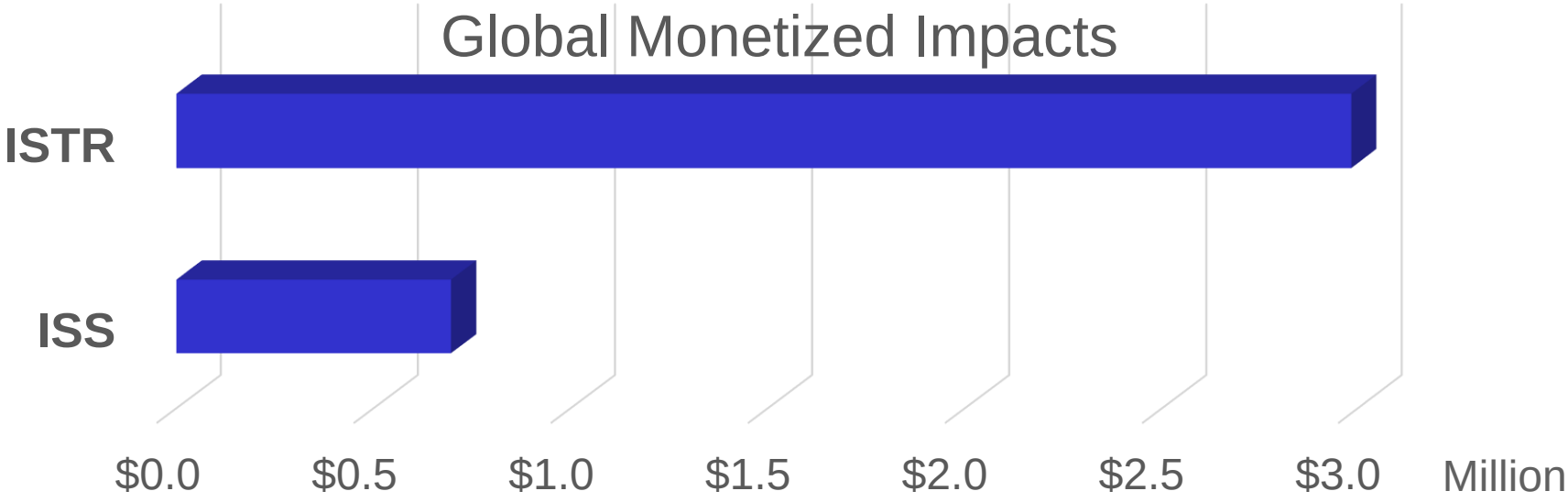
GSR Environmental Footprint Analysis: SiteWise™

	Usage			Emissions							Accident Risk	
	Energy	Water	Elec	GHG	Onsite NOx	Onsite SOx	Onsite PM10	Total NOx	Total SOx	Total PM10	Fatality	Injury
ISS	Low	Low	Low	Med	High	High	High	High	High	High	Low	Low
ISTR	High	High	High	High	High	High	High	High	Med	High	Low	Low



GSR Assessment: Socio-Economic Impacts

Environmental Impact Analysis Sustainability Metrics × **Unit Societal Cost of Sustainability Metrics** = **Global Monetized Impacts**

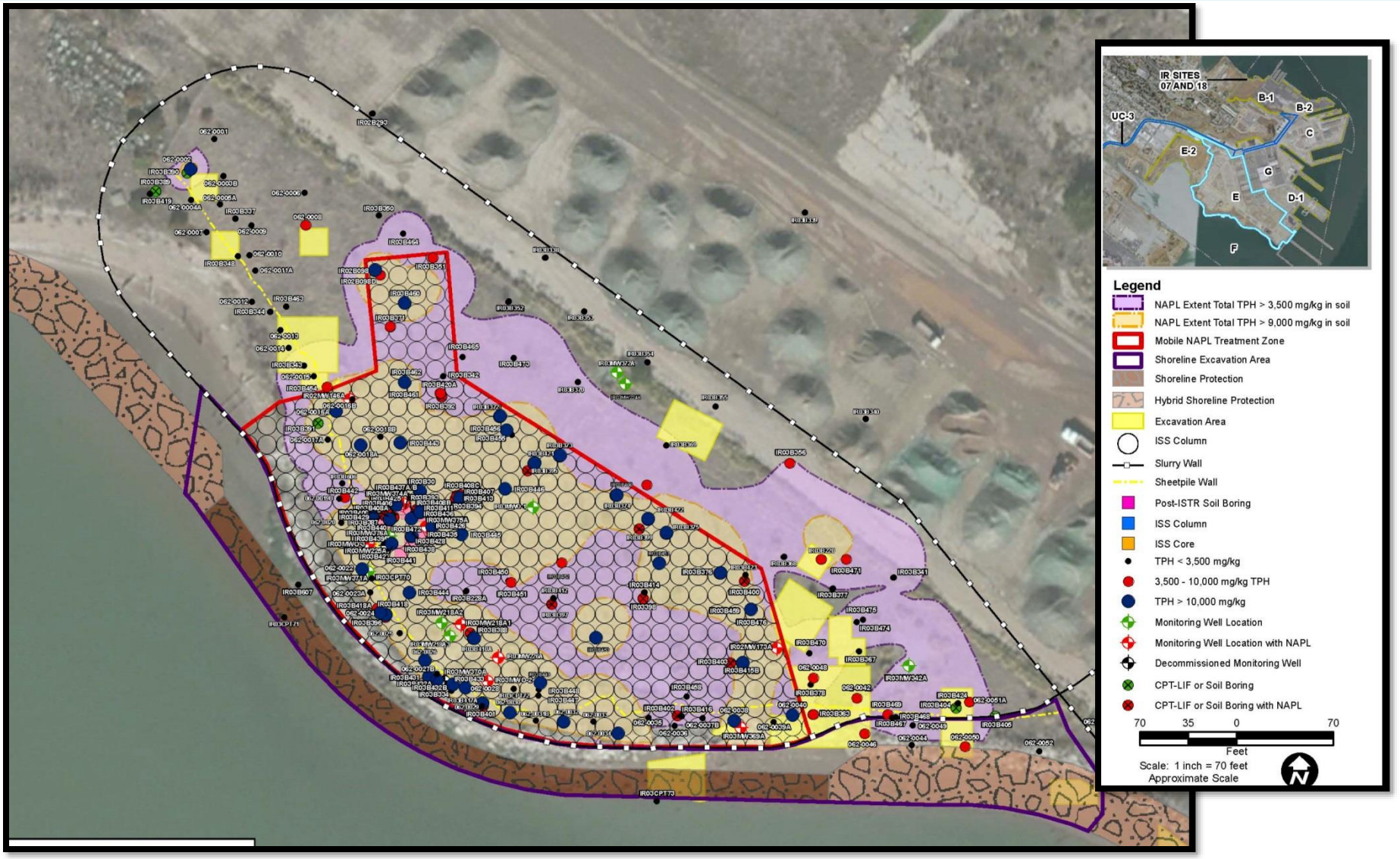


76% reduction in global impacts in selecting ISS over ISTR

Summary of Decision Criteria Evaluation

Objective	Metric	ISTR+Slurry wall	ISS+Slurry Wall
Risks to Community or Workers	Qualitative [hazardous materials and process hazards]	Moderate	Low
Environmental Footprint	Numeric [SiteWise]	High	Moderate
	Global Monetized Impacts	High	Low
Schedule	Numeric [Time to implement remedy]	3 Years	2 Years
Implementation	Qualitative [complexity of implementation]	Difficult	Moderately Difficult
Capital cost	Capital cost ($M)	$14.7	$13.7
CDP Score	Numeric [CDP]	0.52	0.81

Full-Scale Design Treatment Strategy




Questions/ Discussion

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