

Fast-Track Implementation of the First In situ Thermal Treatment System at an Active Air National Guard Base

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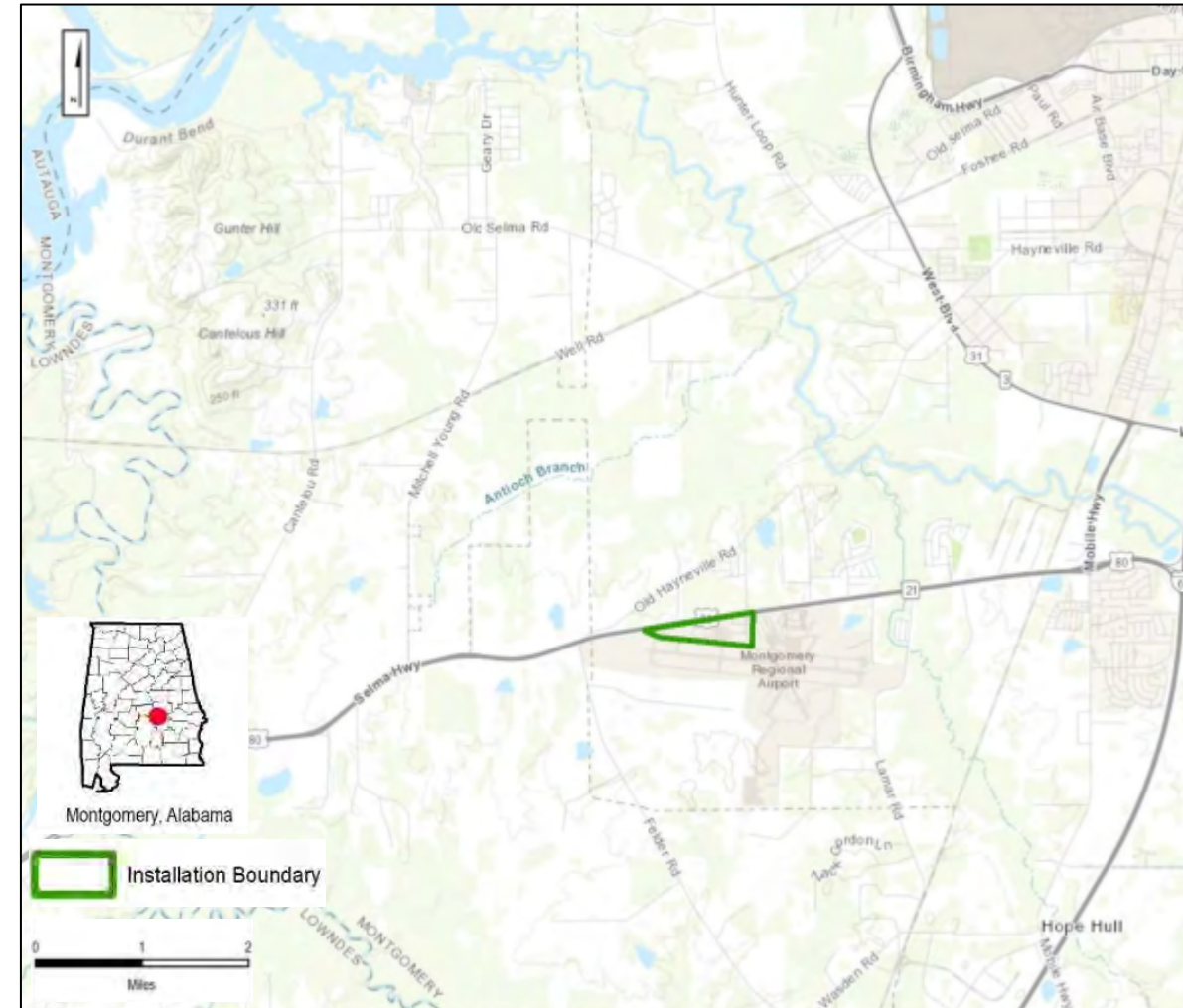
Thirteenth International Conference on Remediation of Chlorinated and
Recalcitrant Compounds

June 5, 2024

Agenda

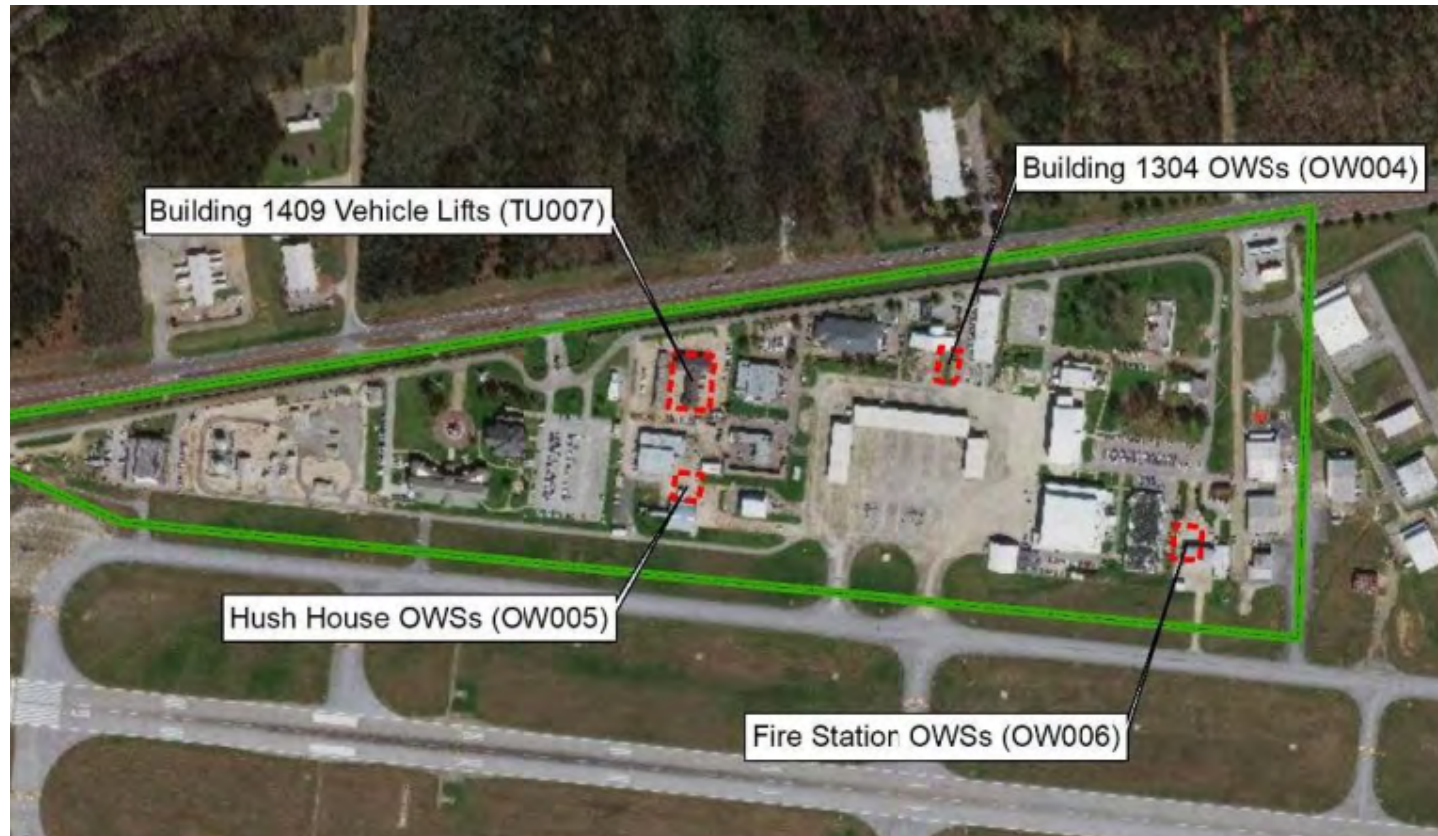
- Site background
- Technology selection
- Data gap investigation (DGI)
- In situ thermal treatment (ISTTT) system
 - Design
 - Construction
 - Operation
 - Goal achievement and site restoration

**Lessons learned/challenges discussed throughout presentation)*



Site Background

- Site OW004 consisted of Building 1304 (Fuel Cell Building) and a 120-gallon oil/water separator (OWS), both of which were demolished and removed in January 2021



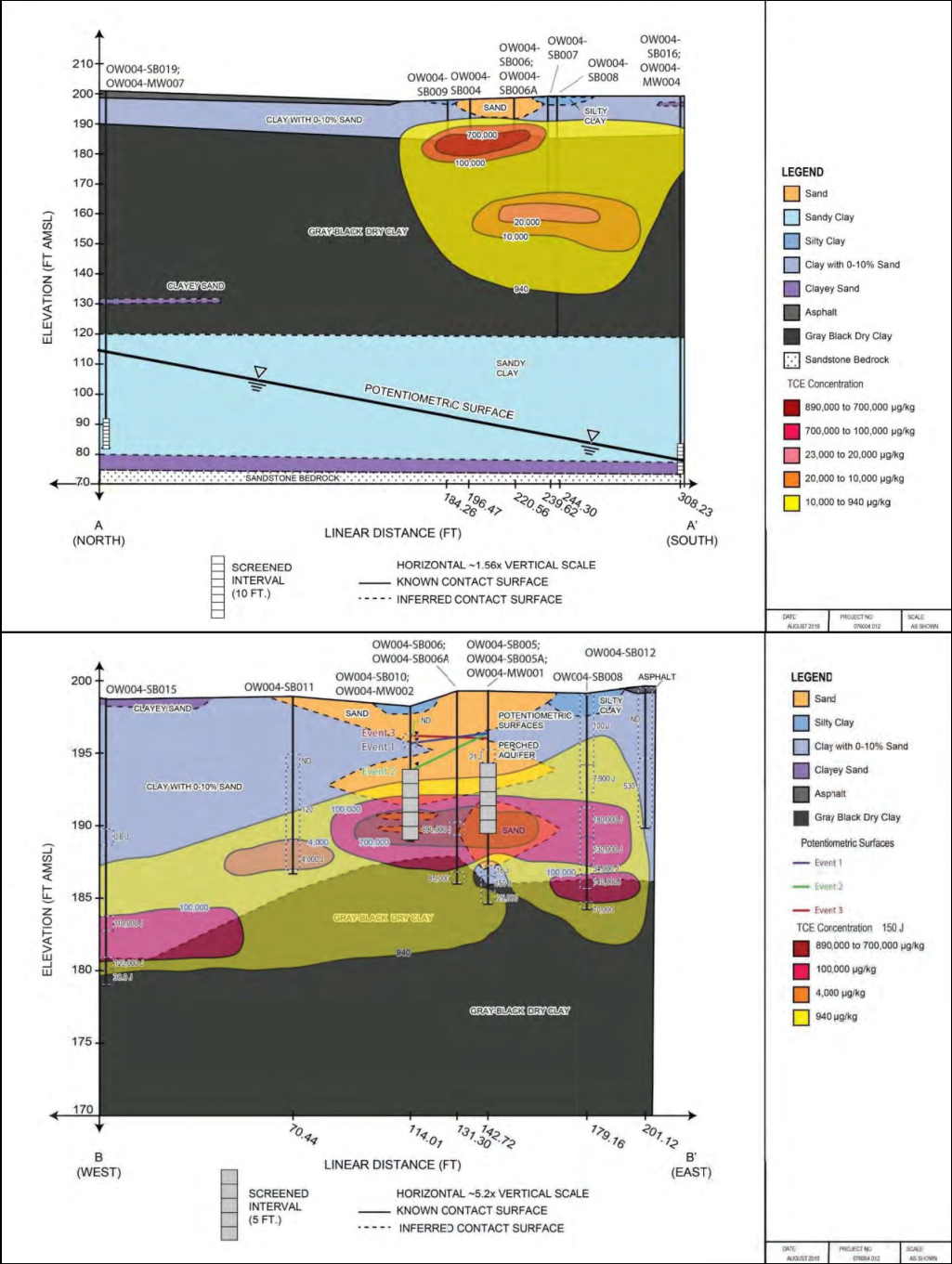
Site Background

- 2014 Site Investigation (SI)
- 2016-2019 Remedial Investigation (RI)
- Soil concentrations exceeded ADEM screening levels
 - Trichloroethene (TCE)
 - Vinyl chloride (VC)
 - 1,2,3-trichloropropane (TCP)

Soil Constituent	Max. Conc. (µg/kg)	ADEM Screening Level* (µg/kg)
TCE	890,000	940
VC	460	59
1,2,3-TCP	570	5.1

µg/kg = micrograms per kilogram

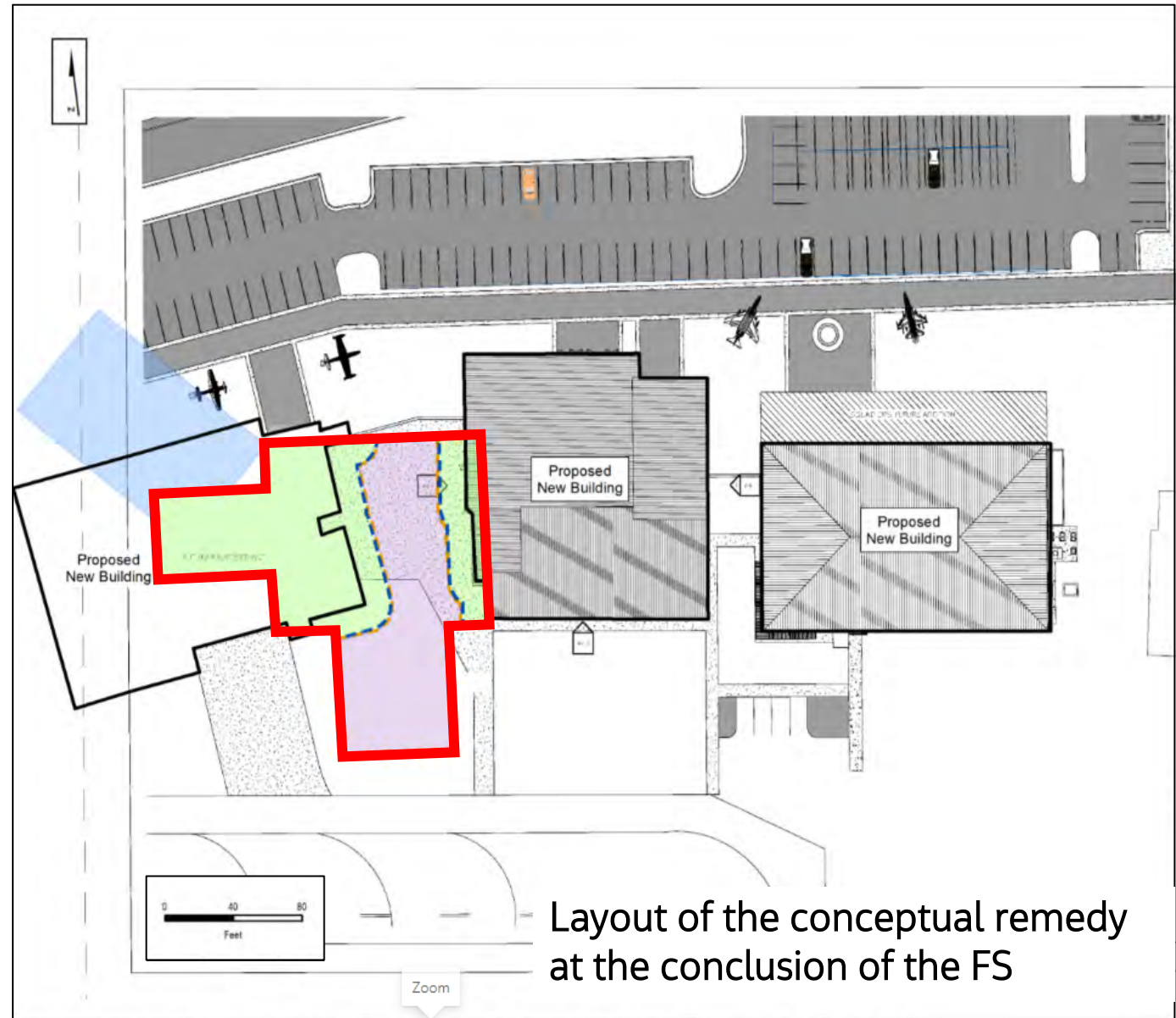
* Based on EPA residential Regional Screening Level (RSL)



Figures from Feasibility Study Report, 2020

Site Background

- Feasibility Study (FS) recommended in situ chemical oxidation (ISCO) via soil mixing for the impacted soil and groundwater in the source area
- FS also recommended a Data Gap Investigation (DGI) to refine the nature and extent of contamination
- Montgomery ANGB was selected for the beddown of the F-35 airframe, which require construction of new facilities to accommodate this mission



From Feasibility Study Report, 2020

Site Background

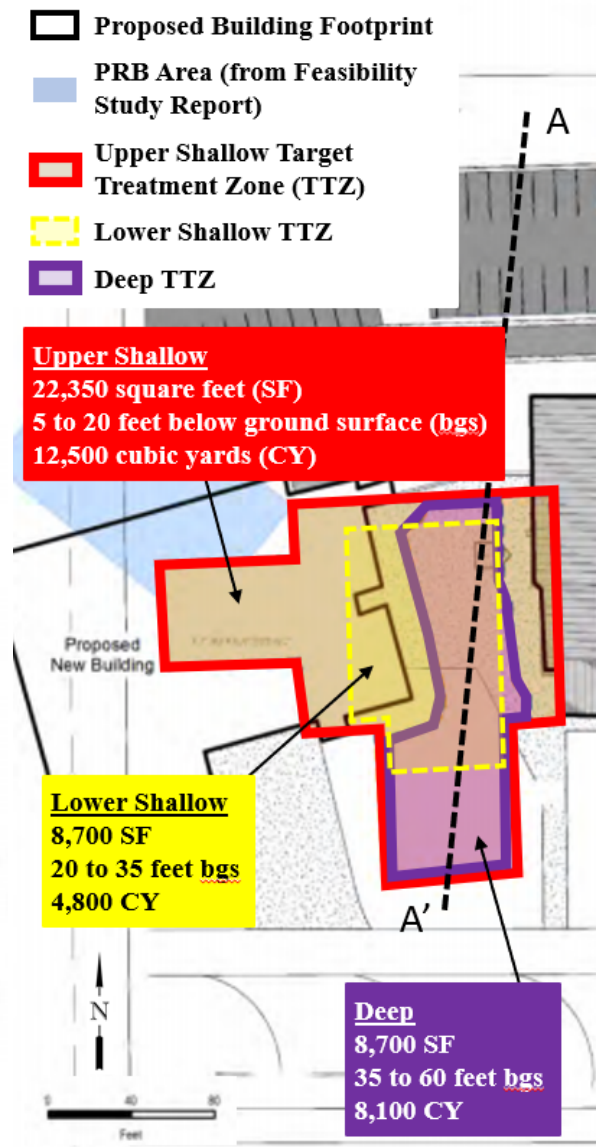
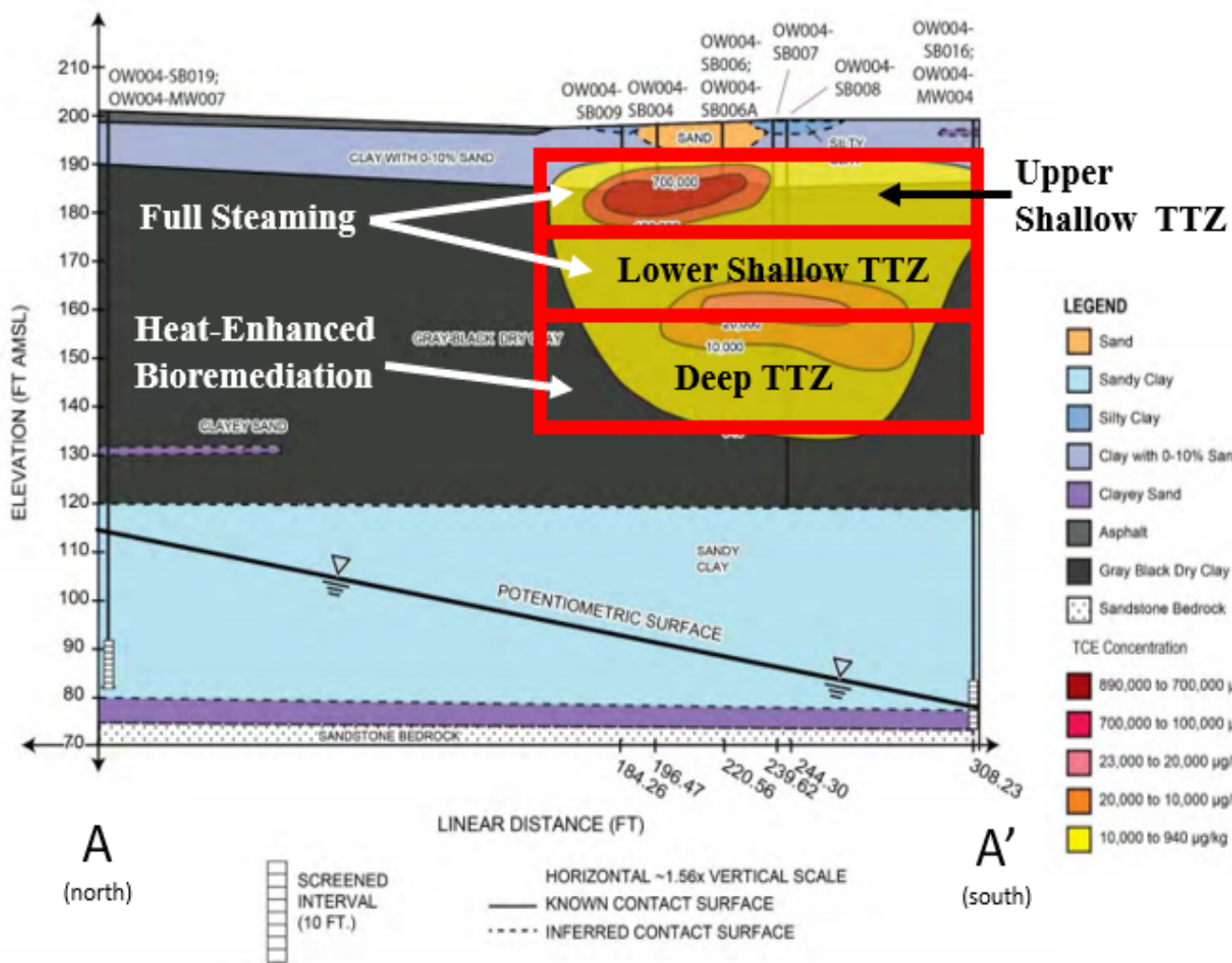
- A Non-Time Critical Removal Action (NTCRA) was initiated to address subsurface contaminants and prepare the site for clean construction of required F-35 facilities, which was slated to commence in July 2023
 - Remediate soil to 35 feet below ground surface (bgs) to levels below ADEM screening levels for TCE, VC and TCP
 - Promote the treatment of deep soil (below 35 feet bgs) to advance the site toward closure
- To complete the NTCRA within the required schedule, three approaches were (re)considered:
 - ISCO via soil mixing
 - Excavation with offsite transportation and disposal
 - ISTT

Technology Selection (Fall 2021)

- Why not ISCO?
 - Unknown oxidant demand
 - Uneven oxidant distribution
 - Risk of rebound
 - Unstable soils following mixing
 - Depth limitations
- Why not excavation?
 - Hazardous waste generation
 - Unknown hazardous waste quantity
 - Base traffic disruption
 - Resource limitations
 - Logistic challenges
 - Limited flexibility
 - Constructability challenges
 - Health and safety concerns
- Why ISTT?
 - High certainty of treatment including ability to treat clayey soils
 - Flexibility during operations
- Why ERH instead of TCH?
 - 100°C target suitable for site contaminants
 - Lower maximum temperatures preferred given the post-ISTT construction schedule
 - Offered better low temperature control to stimulate bioremediation of the deep portion of the site to meet long-term goals
- Fixed price contract
- Aggressive and inflexible schedule
- Client with no previous ISTT experience

Lessons Learned/Challenges

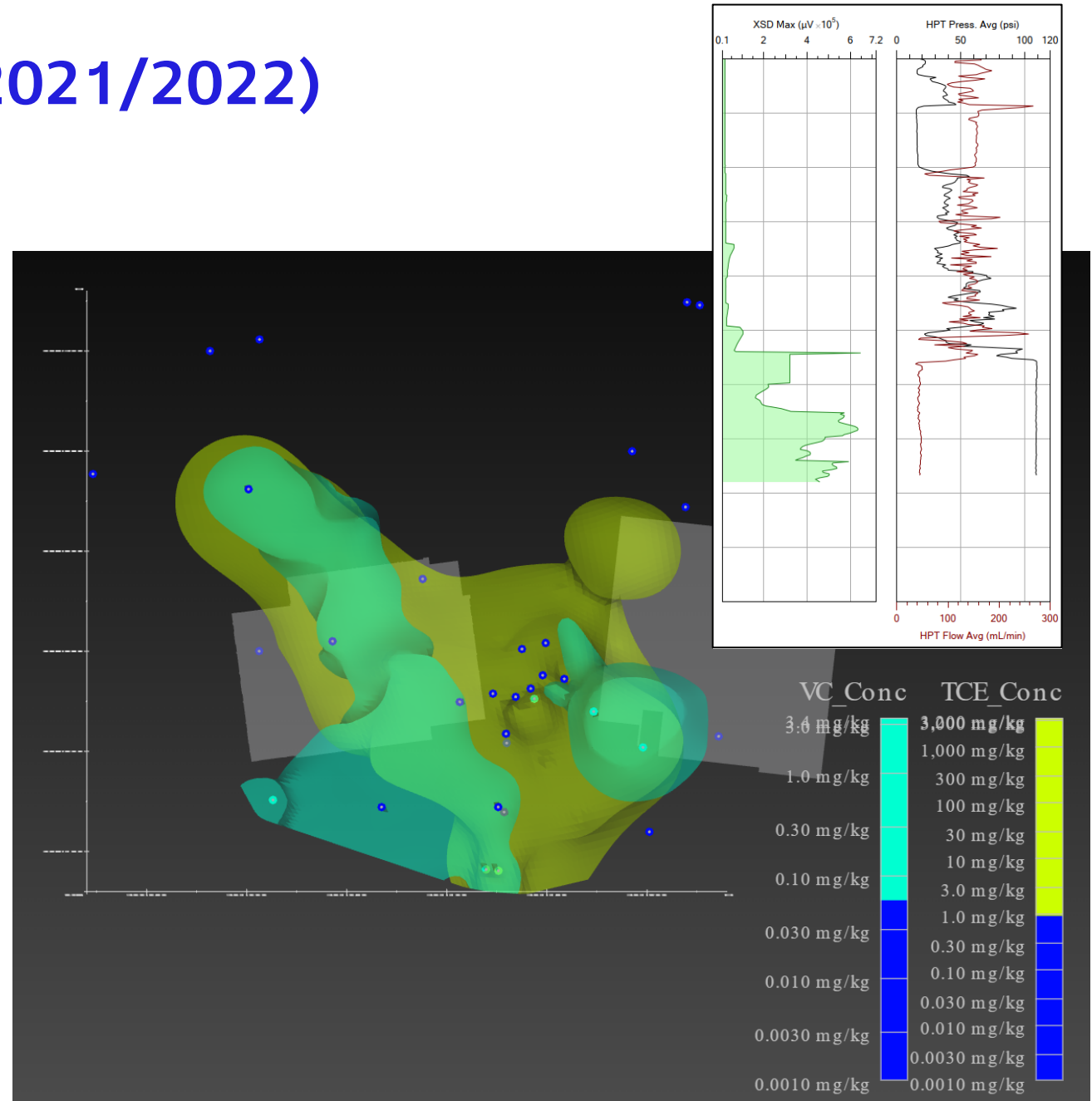
Technology Selection (Fall 2021)



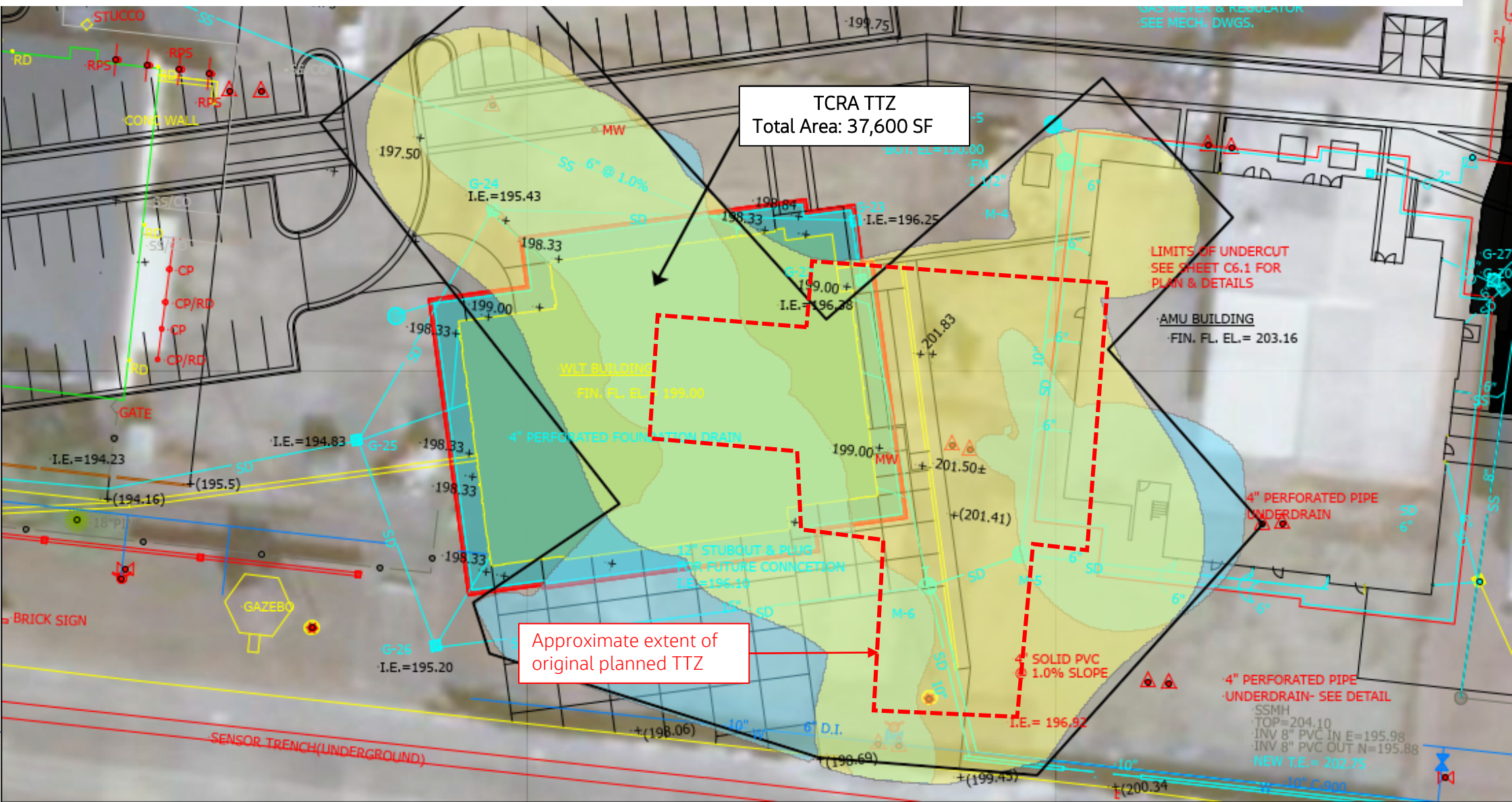
■ Nature and extent of contamination was uncertain because it was based on data collect during a streamlined RI

Data Gap Investigation (Winter 2021/2022)

- Conducted by subcontractor of architect of F-35 facilities
 - Membrane interface with hydraulic profiling tool (MiHPT)
 - Soil sampling
 - Monitoring well installation and sampling
- Jacobs integrated the lithologic observations, MiHPT responses, and existing and new laboratory data and used Earth Volumetric Studio (EVS) to refine the nature and extent of contamination and establish a revised target treatment zone (TTZ)
- Conducted concurrent with ISTT design



Data Gap Investigation (Winter 2022)



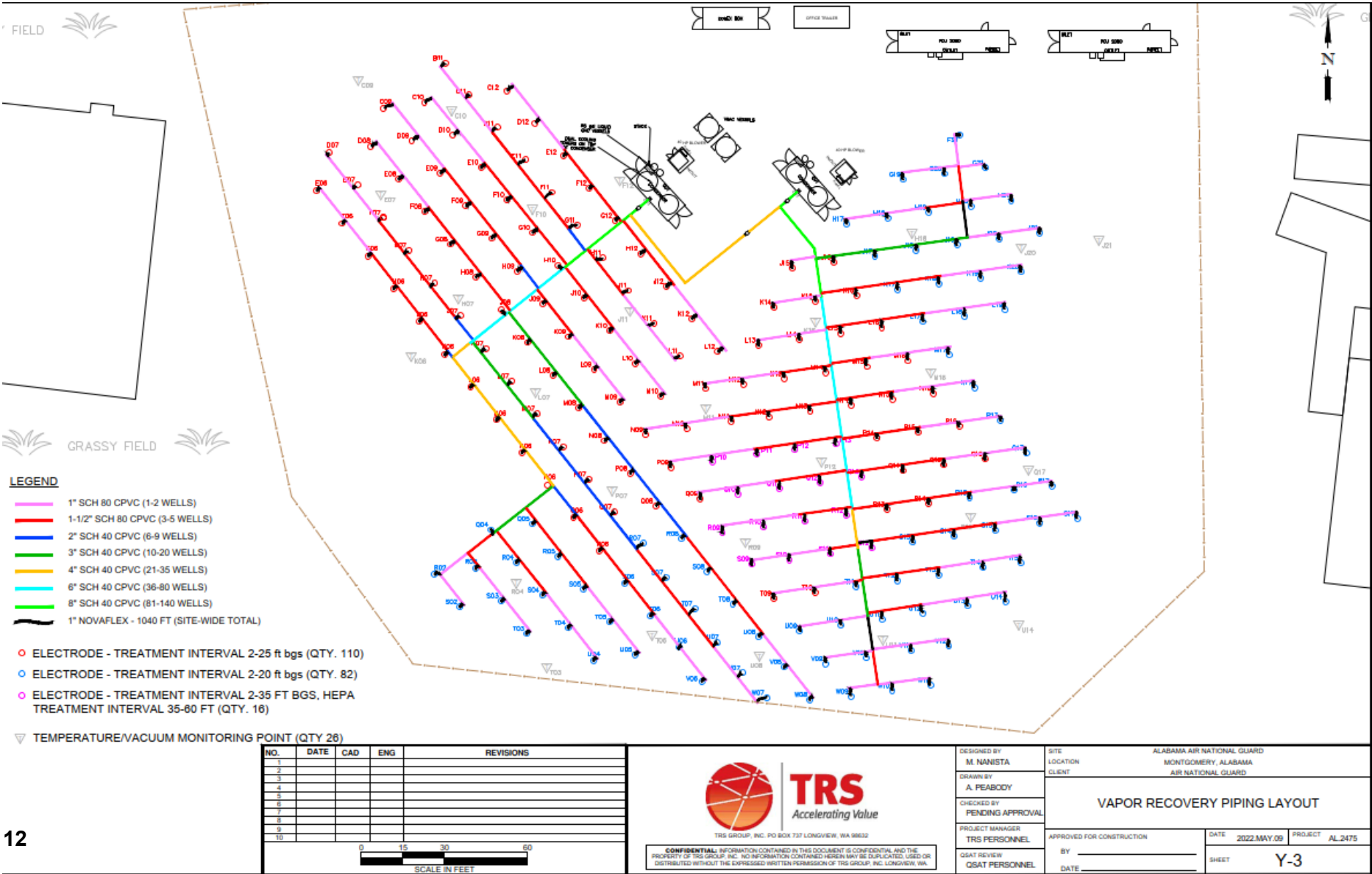
Data Gap Investigation (Spring 2022)

- Impact on ISTT system design

	FS (Pre-DGI)	Post-DGI	Change
Area (SF)	22,350	37,600	67%
Electrodes	120	208	61%
Full-heating volume (CY)	17,300	25,600	48%
TRS preliminary contaminant mass estimate (lb)	6,000	Up to 10,000	67%
Highest TCE concentration (mg/kg)	890	3,200	260%
Heating time (months)	4.5	5.6	24%
Full-heating + enhanced bioremediation volume (CY)	25,400	26,400	4%

Full-heating volume = volume where TCE exceeds its ADEM screening level of 940 µg/kg
Enhanced bioremediation volume = volume where 35-40°C goal to be achieved

ISTT System Design (Spring 2022)



- Key design elements
 - Electrodes on 15-foot centers
 - Two treatment systems
 - Surface plenum to enhance vapor recovery
 - Two 2,000-kilowatt (kW) power control units to deliver 9,000,000 kW-hours

Finalization of the Work Plan (Spring 2022)

- Design, procurement, and work plan finalization occurred concurrently to meet schedule
- Presented work plan to ADEM prior to their review to reduce the time to approve approach
- Tiered goals based on 95% upper confidence limit (UCL)
 - **NTCRA Treatment and Contract Goal:** meet ADEM screening level criteria *with no TCE concentrations in any individual confirmation soil sample above 2,060 µg/kg (50% of the TCE regulatory treatment goal of 4,120 µg/kg)* and maximize contaminant mass reduction
 - **Regulatory Goal:** meet site-specific risk-based target levels to protect construction and onsite workers and minimize risk of schedule extension

COC	Regulatory Treatment Goal (µg/kg)	NTCRA Treatment Goal (µg/kg)
TCE	4,120	940
VC	Not applicable	59
1,2,3-TCP	Not applicable	5.1

COC = constituent of concern

ISTT System – Construction (Summer 2022)



Auger drill rig



Layout of drilling locations,
facing northeast

- Changed drilling technique for 7,000 feet of borings from sonic to solid stem augers within first week of construction
- Used two rigs to meet schedule
- Had to navigate remnants of previous building

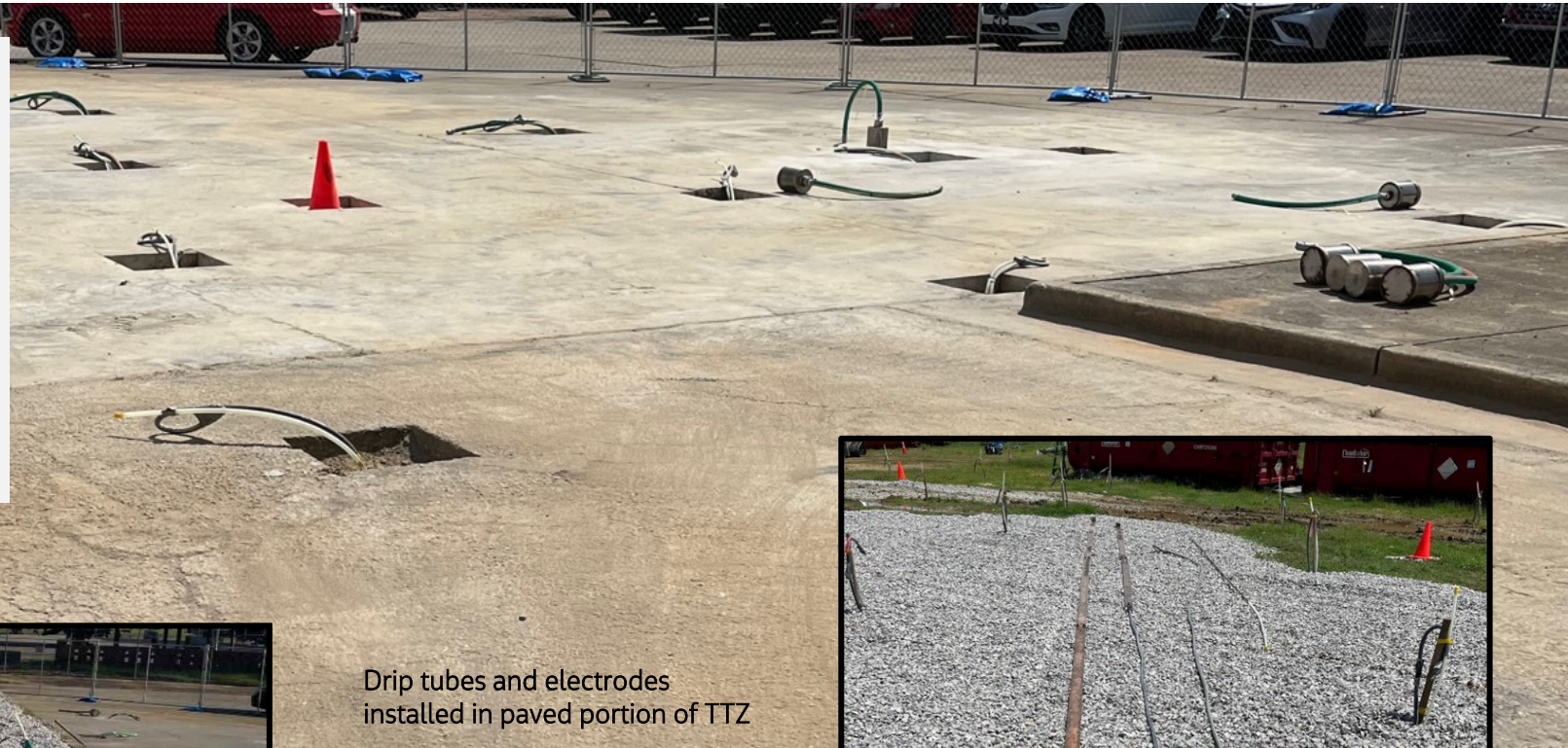


Concrete cores removed from drilling
locations on the west side of the TTZ

ISTT System – Construction (Summer 2022)

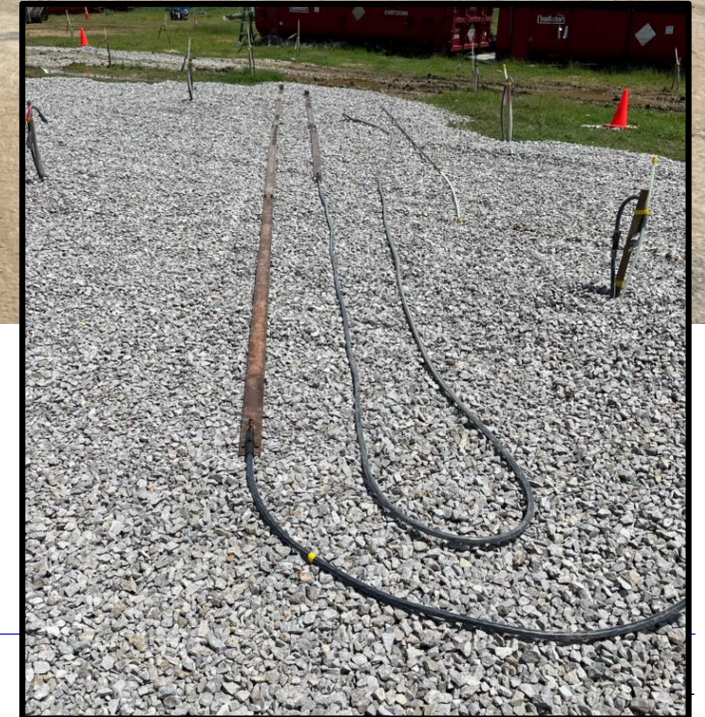
- In addition to vapor recovery wells co-located with the electrodes, the design included a 40,000-square foot plenum and vapor cap because the groundwater was within 2 feet of the ground surface

Installation of the gravel plenum for vapor recovery, facing south



Drip tubes and electrodes installed in paved portion of TTZ

Deep electrodes prior to installation



ISTT System – Construction (Summer 2022)

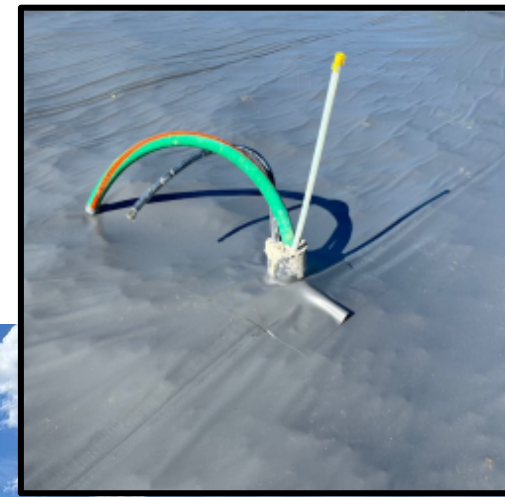


Installation of vapor barrier atop the gravel plenum to facilitate vapor capture, facing northwest



Vapor barrier along tarmac, facing west

Electrode, drip tube, and vapor recovery piping



- Frequent coordination required with the ANG base because the TTZ extended to the edge of the active tarmac

ISTT System – Construction (Summer 2022)



Construction of the conveyance piping and wiring, facing south (above) and north (left)

- Design had to manage grade and surface material variations across the TTZ

ISTT System – Construction (Fall 2022)



Vapor barrier sealed on the perimeter

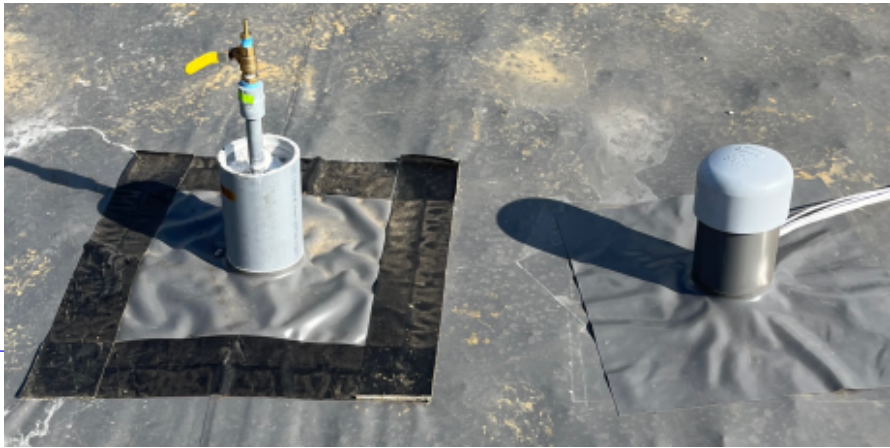


Placement of aboveground electrical equipment using crane



Installation of 3,600 feet of conveyance piping and 26,000 feet of electrical lines, facing west

Vacuum and temperature monitoring points

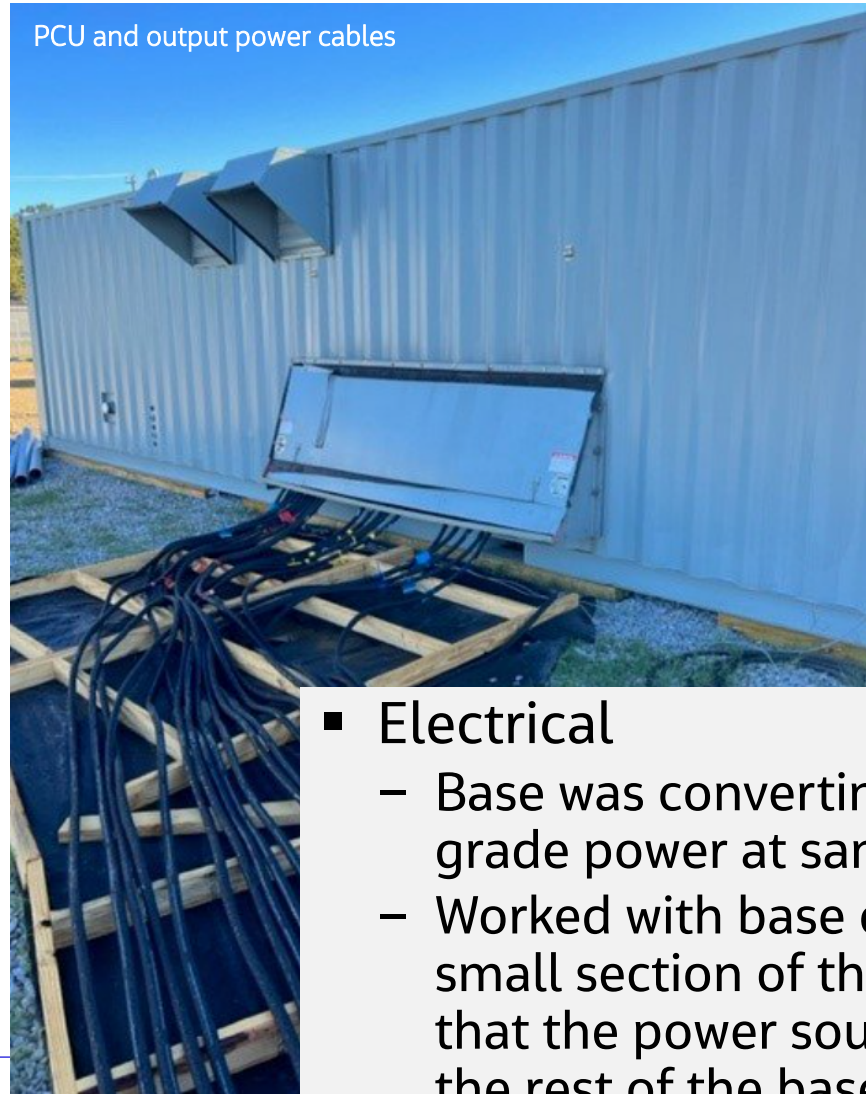


ISTT System – Construction (Fall 2022)

New Alabama power service



PCU and output power cables



Step-down transformer (10)



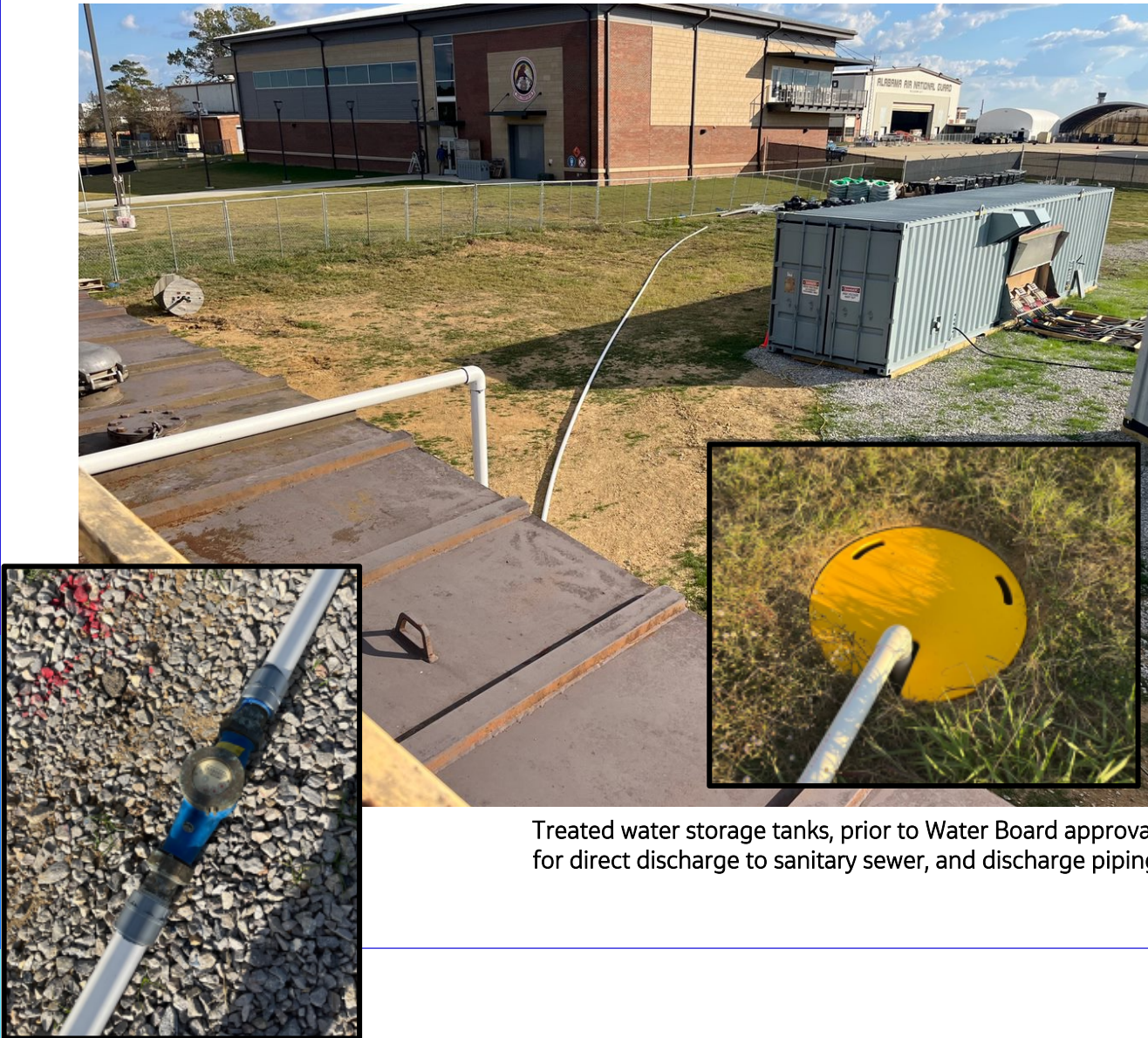
■ Electrical

- Base was converting all overhead power to sub-grade power at same time as ISTT project
- Worked with base civil engineering to retain a small section of the overhead powerlines so that the power source could be independent of the rest of the base and metered independently

ISTT System – Operation (late Fall 2022)

- Constructed from June to November 2022; system started on November 17, 2022
- Remote and on-site monitoring
- Daily field and weekly laboratory sampling at the influent, mid-fluent, and effluent of the vapor treatment system
- Twice monthly laboratory sampling at the influent, mid-fluent, and effluent of the liquid treatment system
- Monthly reporting to Water Board of total effluent results and discharge volume
- Monthly operations reporting to NGB

ISTT System – Operation (Winter 2023)

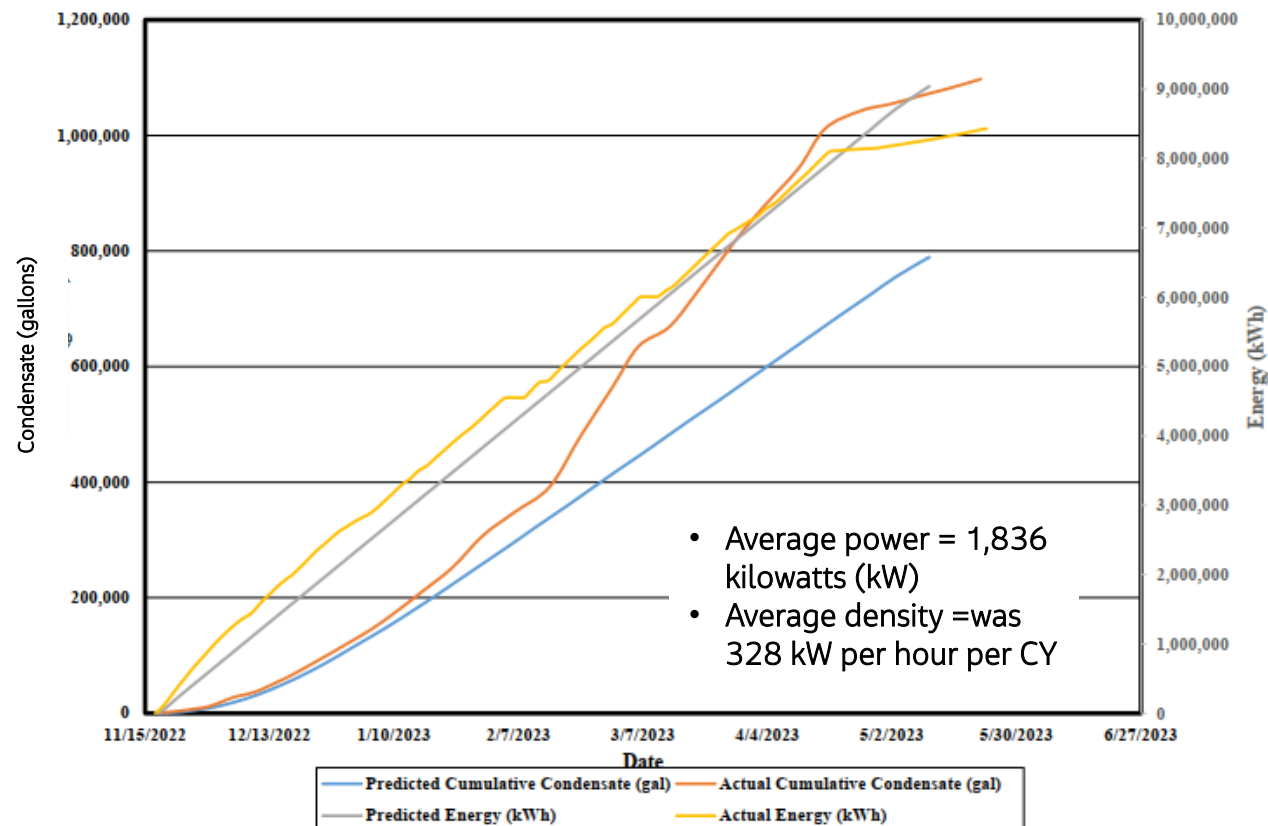
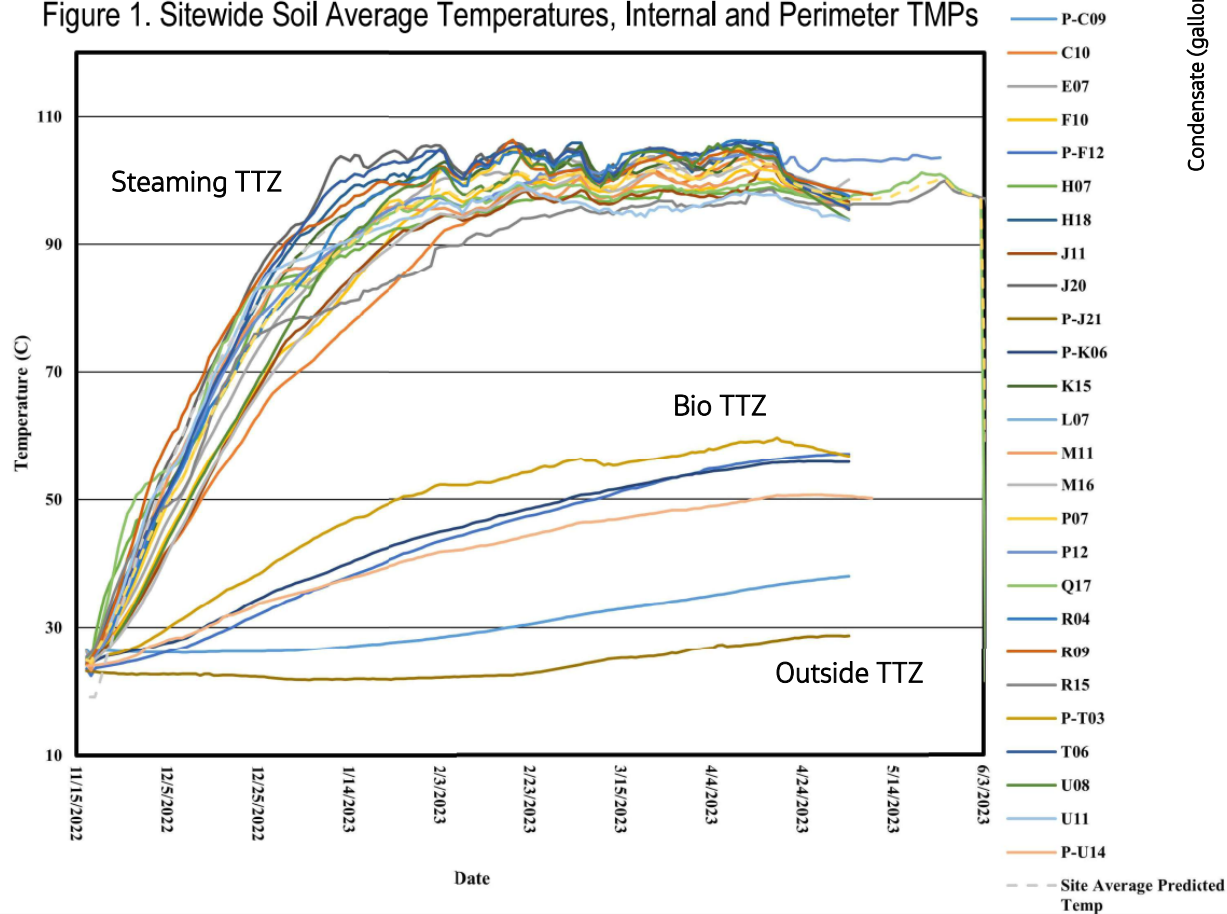


Treated water storage tanks, prior to Water Board approval for direct discharge to sanitary sewer, and discharge piping

- Acetone in treated water discharge
 - Due to time constraints, accepted initial discharge limit of 100 parts per billion total volatile organic compounds (VOCs)
 - Batch testing and discharge before approval of continuous operation
 - After two months, acetone concentration exceeded 100 ppb goal and the ISTT system was shut down (Feb. 2023)
 - Leveraged relationship between the Base Environmental Scientist and the Water Board to increase the total VOC limits to 350 ppb and restarted ISTT system
 - After another exceedance, the ISTT system was shut down (March 2023) and the discharge limits were revised to 100 ppb total VOCs except for acetone, which had a new limit of 2,000 ppb (daily maximum) and 1,000 ppb (monthly average)
 - No further exceedances

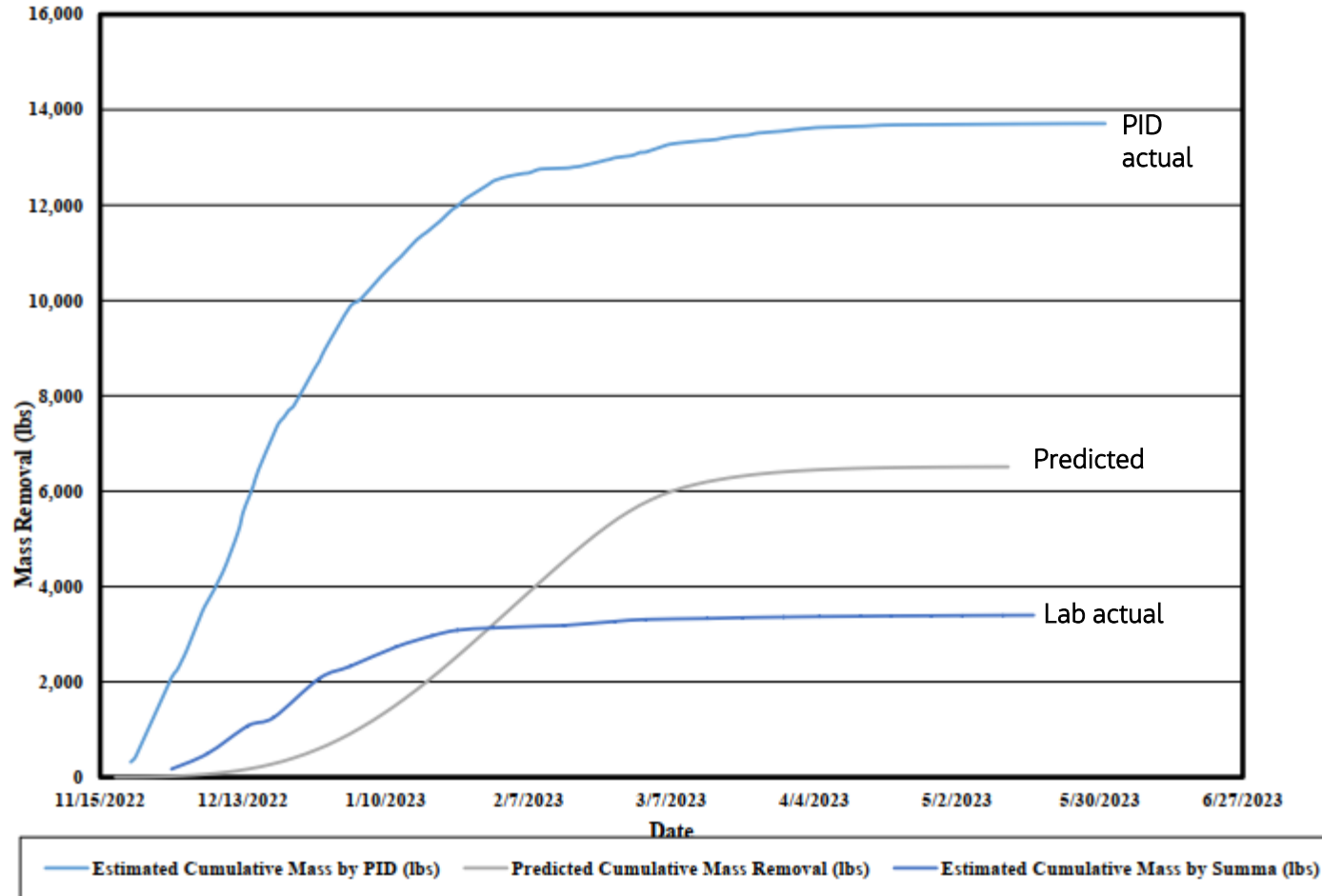
ISTT System – Operation

Figure 1. Sitewide Soil Average Temperatures, Internal and Perimeter TMPs



- Condensate generation and energy use was higher than expected because there was more groundwater than initially expected
- However, energy use decreased after the first soil confirmation sampling event due to treatment effectiveness

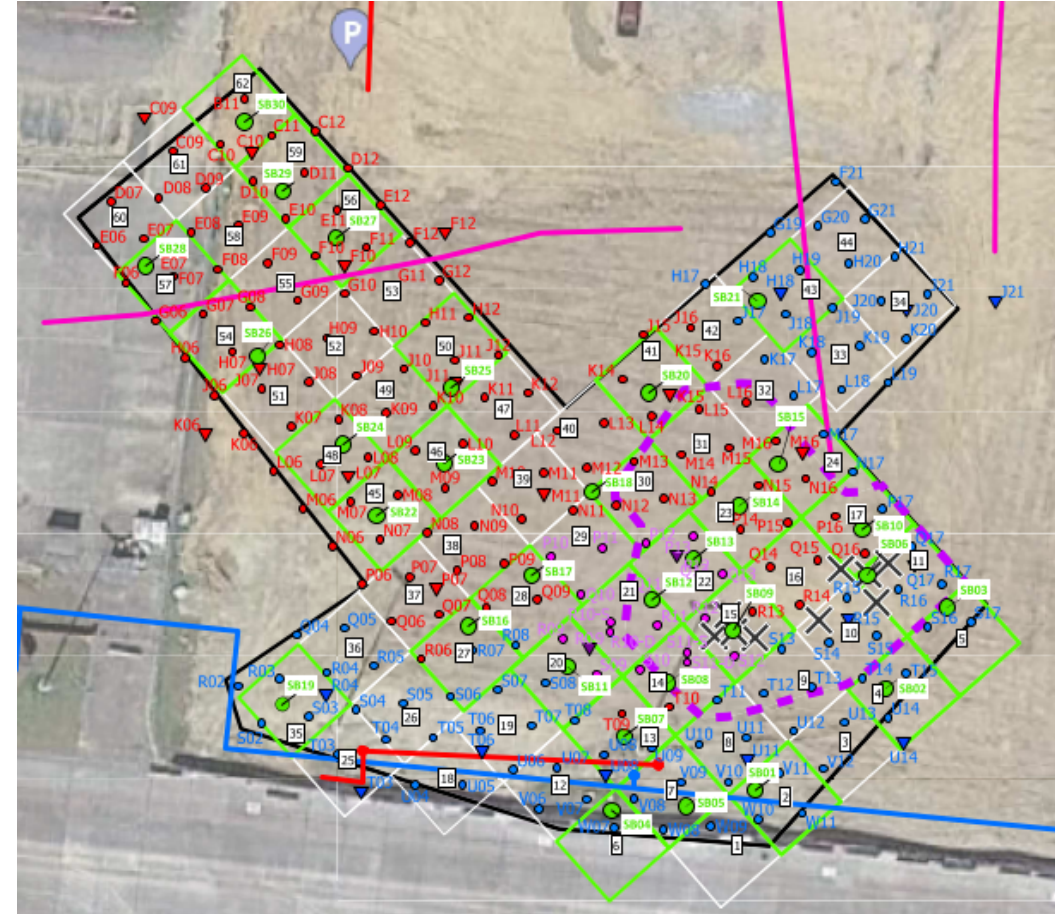
ISTT System – Operation



- Though the field- and laboratory-based estimates differed, COC mass recovery during initial operating period was much higher than expected (based on typical ISTT projects)
- The GAC change-out frequency was adjusted to be more conservative than planned to prevent breakthrough (following the surprise)

ISTT – Operation (Spring 2023)

- Confirmation sampling and optimization
 - Timing based on energy use, mass recovery, and temperatures; 130 days after start-up
 - Conservative sampling approach to verify treatment
 - 95% UCL of the TCE, VC, and 1,2,3-TCP concentrations compared to the following:
 - TCE = 940 µg/kg (maximum of 2,060 µg/kg at any location)
 - VC = 59 µg/kg
 - 1,2,3-TCP = 5.1 µg/kg
 - Five of 60 samples exceeded the targets
 - Maximum TCE concentration = 19,000 µg/kg (99.4% reduction)
 - ISTT system optimization
 - Western PCU deactivated
 - Added supplemental electrodes and continued power delivery to residual impacted areas



ISTT – Goal Achievement (late Spring 2023)

- Six more weeks of operation
- Second round of soil confirmation samples indicated goals were achieved
 - Maximum TCE concentration = 620 µg/kg (99.98% reduction)
 - 95% TCE UCL = 38.2 µg/kg
 - Excess lifetime cancer risk 6×10^{-8}
 - Hazard index was 0.01
- The remaining electrodes were shut off on day 190 and vapor extraction stopped on day 197
- All aboveground treatment equipment furnished and installed for ERH system operation was removed
- Complete demobilization on June 27, 2023, three days ahead of schedule
- **Total time from contract award to demobilization was 21 months**



Post-Remediation Site Restoration and Development (2023/2024)

- After a short cool-down period, the architecture firm re-mobilized to the site to collect geotechnical samples to verify soil stability
- One final benefit to the ISTT approach is that the low final soil concentrations in the treated soil allowed the ANG to achieve response complete for the full depth of site soil



Construction progress as of late April 2024

Acknowledgements

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Co-Authors are noted in bold and italics

Thank you

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