The 6th International Conference on Remediation of Chlorinated and Recalcitrant Compounds

Remediation Costing and Interim Measures Selection for NASA's Launch Complex 34

May 19, 2008

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Acknowledgements

NASA LC34 Team:

- Geosyntec (source characterization, modeling, technology evaluations)
- Tetra-Tech NUS (Data management, dissolved plume assessment/monitoring, technology evaluations)
- LFR (technology evaluations, previous pilot study technical evaluations)
- GeoTrans (model review, technology considerations)

Lesson Learned – A Team of 8 Professional Engineers and 7 Geologists can make for some very loooong conference calls

Goals / Overview

- Site History
- Site-specific Considerations
  - Location
  - Groundwater flow
  - DNAPL distribution and magnitude
  - Hydrogeologic setting
  - Remediation reality
- Technology Evaluations/Costing
- Costing Evaluation Ramifications
- Path Forward


Mosquito Lagoon
Merritt Island National Wildlife Refuge
Launch Complex 39 Area
Indian River
Kennedy Space Center
KSC Visitor Complex
KSC Industrial Area
Banana River
CCAFS Industrial Area
CCAFS
Port Canaveral
Route 528 (Beeline Expressway)
Kennedy Space Center
Gulf of Mexico
LC37
LC34
LC20
LC19
LC16
0.5 0 0.5 Miles
3 0 3 Miles

Site History

View From the Northeast

1961

2003

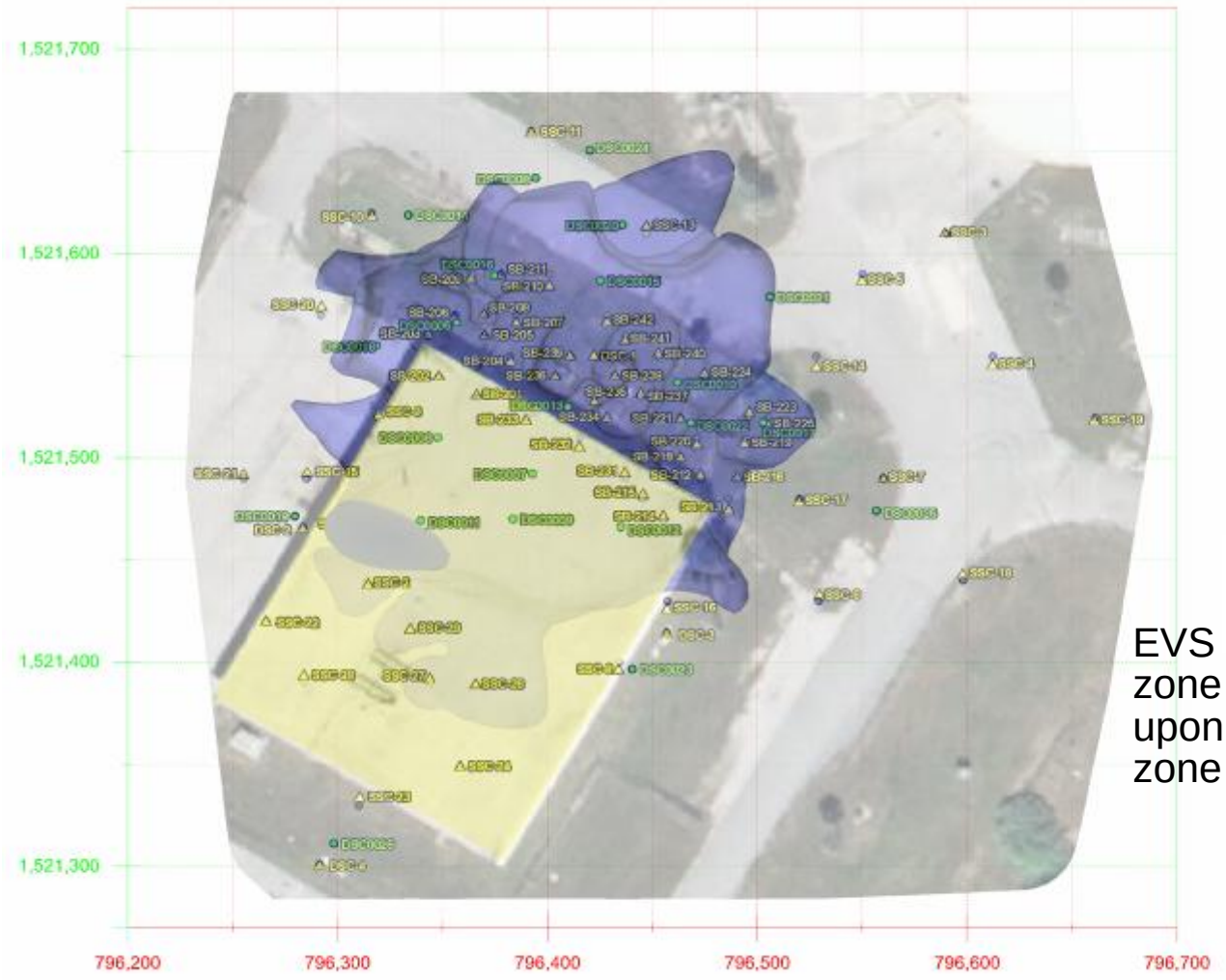
Site History

- Constructed between 1959 and 1961 for the Saturn 1 and 1B rocket program
  - Seven Saturn 1 and 1B launches from 1961-1968
  - Location of the Apollo 1 mishap
- Extensive cleaning of spaceflight components with trichloroethene (TCE)
- Following the success of Apollo 7 launch structures dismantled and buildings abandoned in place

RCRA Corrective Action History

- 1994
  - Chlorinated solvent contamination discovered in groundwater
- 1996 - 2007
  - RCRA Facility Investigation & Corrective Measures Study
- Investigation Results
  - ~330 acres of groundwater negatively impacted by historic releases of chlorinated solvents (1 mile by ½ mile plume)
  - Source area groundwater contamination is present to 118 ft below land surface (bls)
  - Sand aquifer with inter-bedded silt, clay, and shell layers (8 Layers)
  - DNAPL (TCE) present between 18 ft & 80 ft bls
    - Shallow Zone <45 ft bls = 41,000 lbs TCE (saturated soil > 300 mg/kg)
    - Deep Zone >45 ft bls = 33,000 lbs TCE (sat. soil > 300 mg/kg)
    - Additional 12,000 lbs of TCE mass in “shell” of soil surrounding DNAPL (TCE sat. soil concentrations 100 - 300 mg/kg)

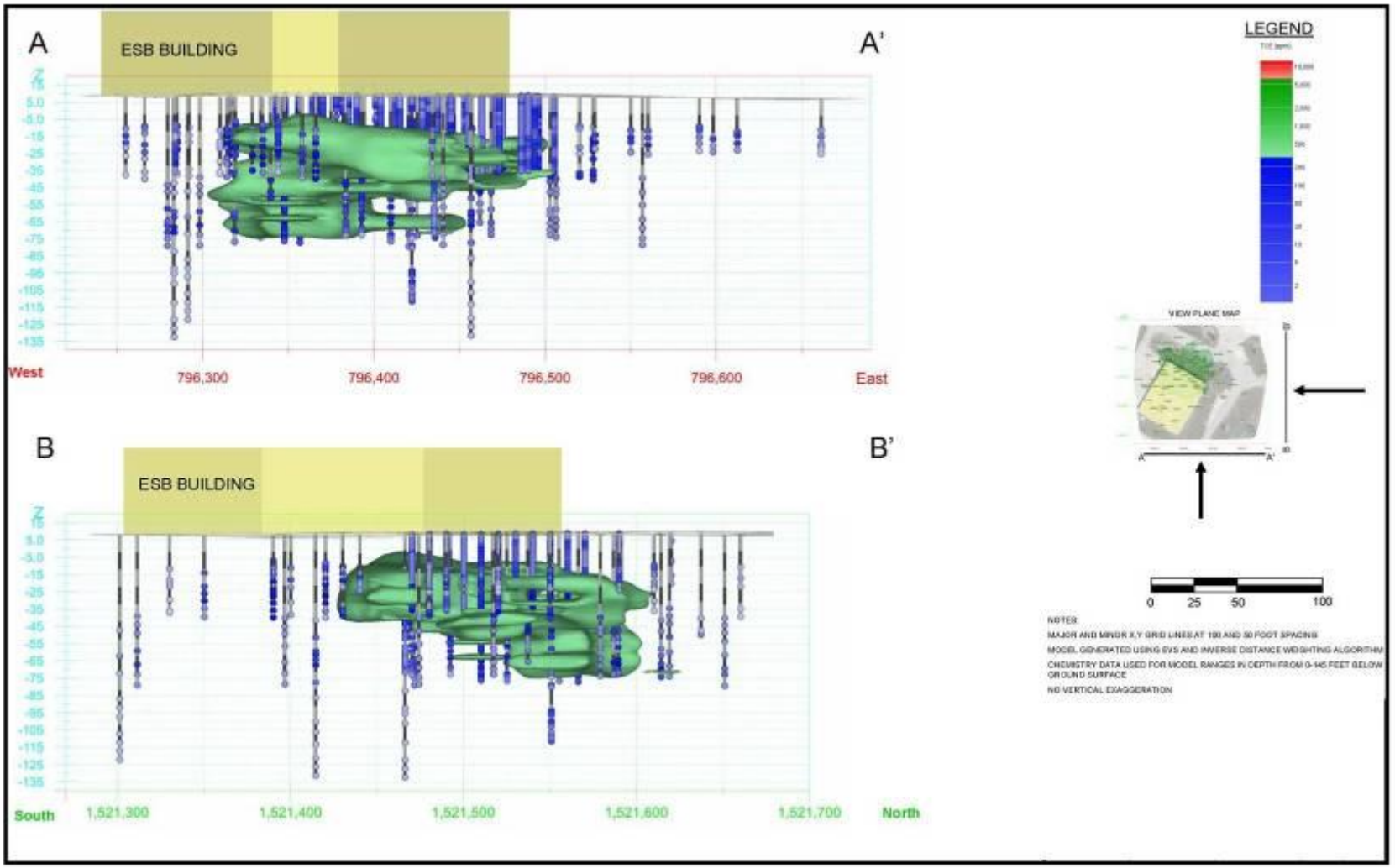
DNAPL Source Zone

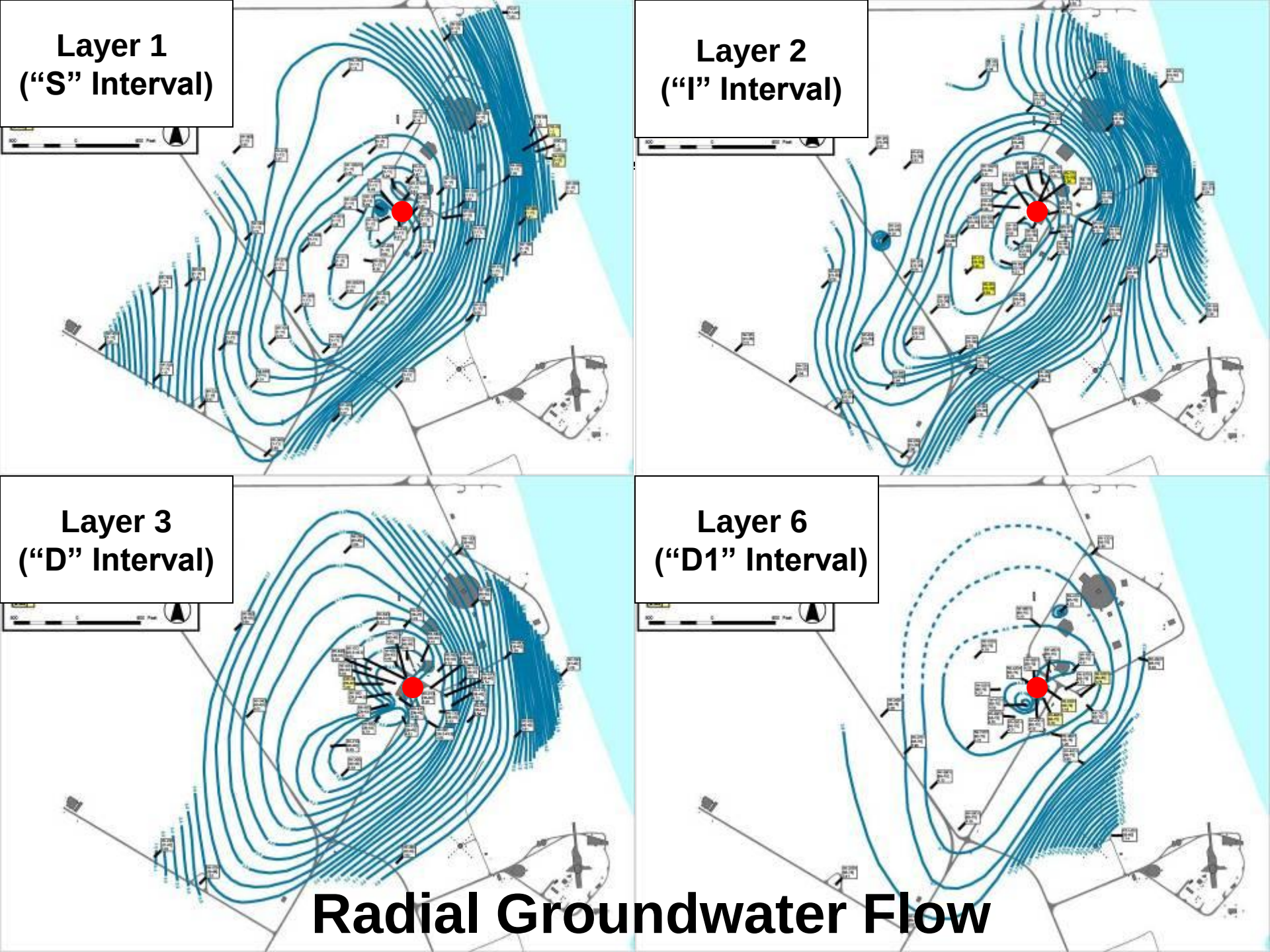


EVS solids model source zone (>300 mg/kg) based upon over 1,200 saturated zone soil samples

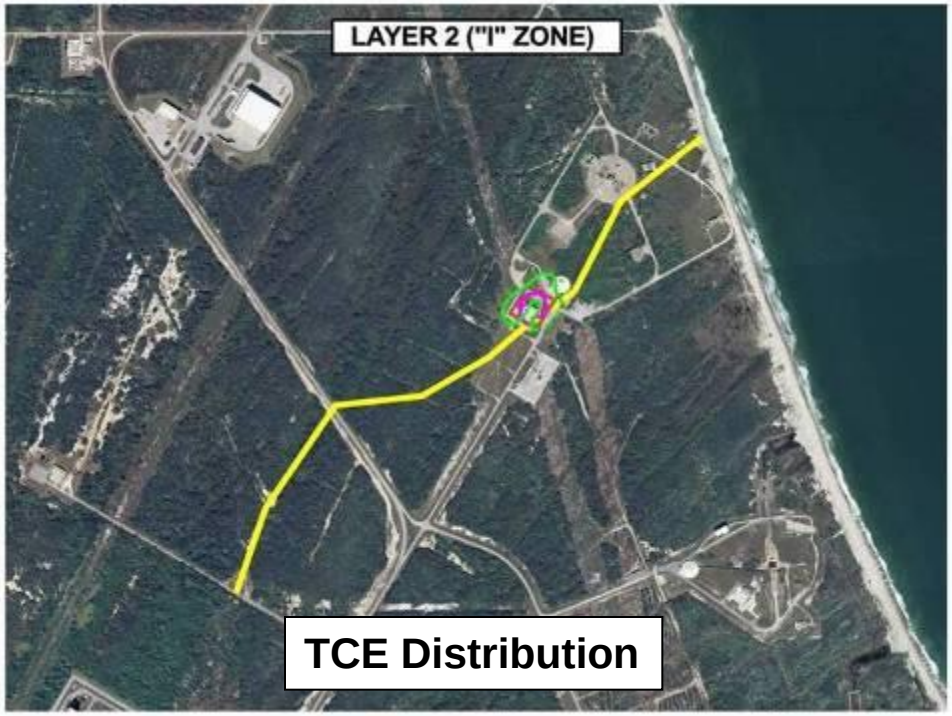
GeoSyntec 2005

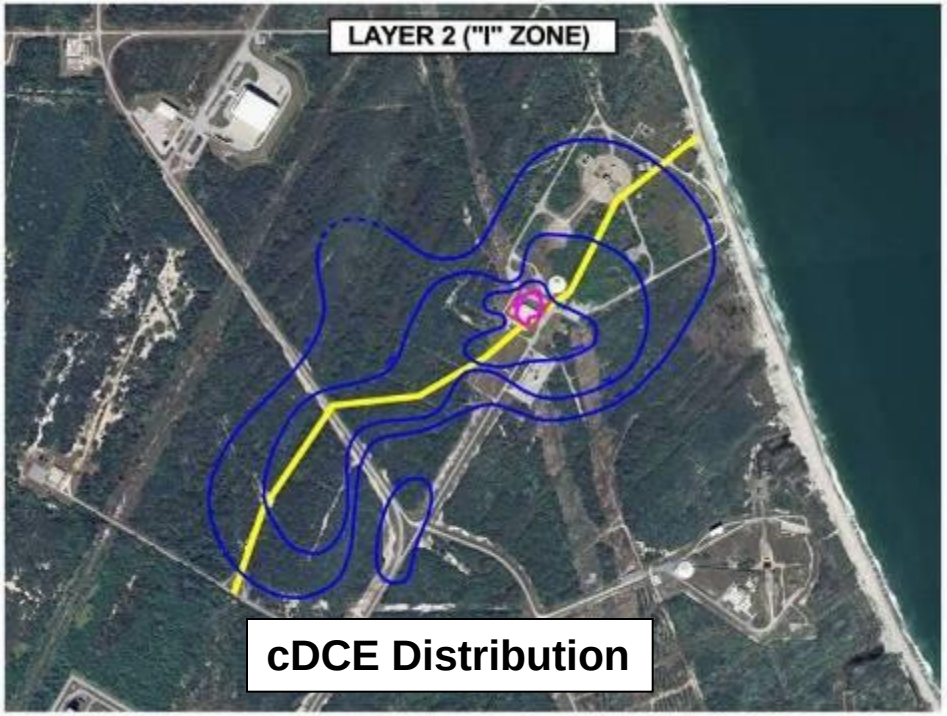
DNAPL Source Zone

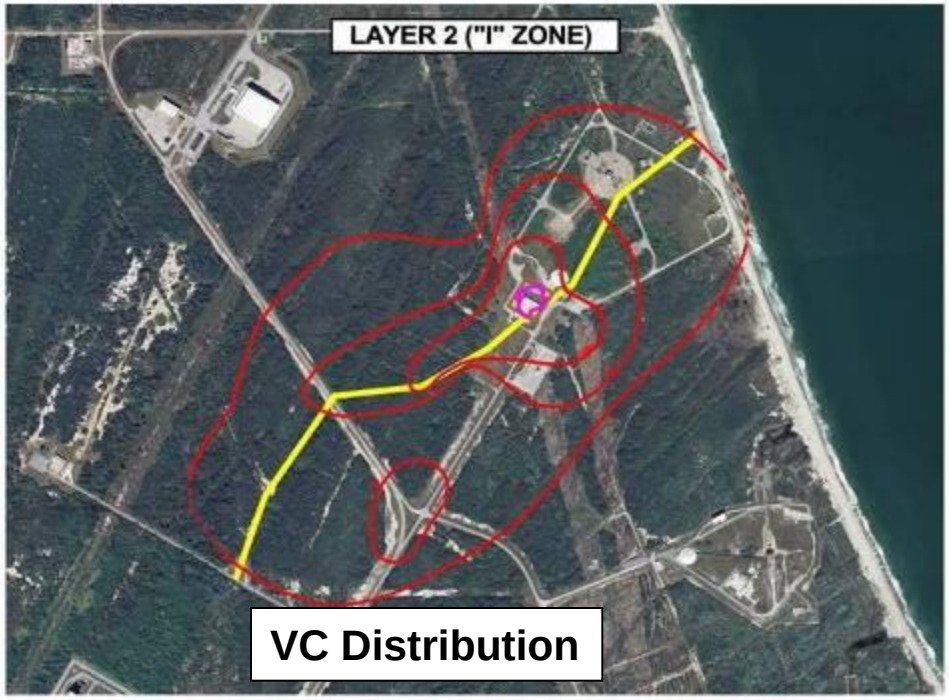




Radial Groundwater Flow







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Cross Section SW to NE - TCE

KSC-TA-8617
LC34 CMS Report
Revision: 0
February 2007

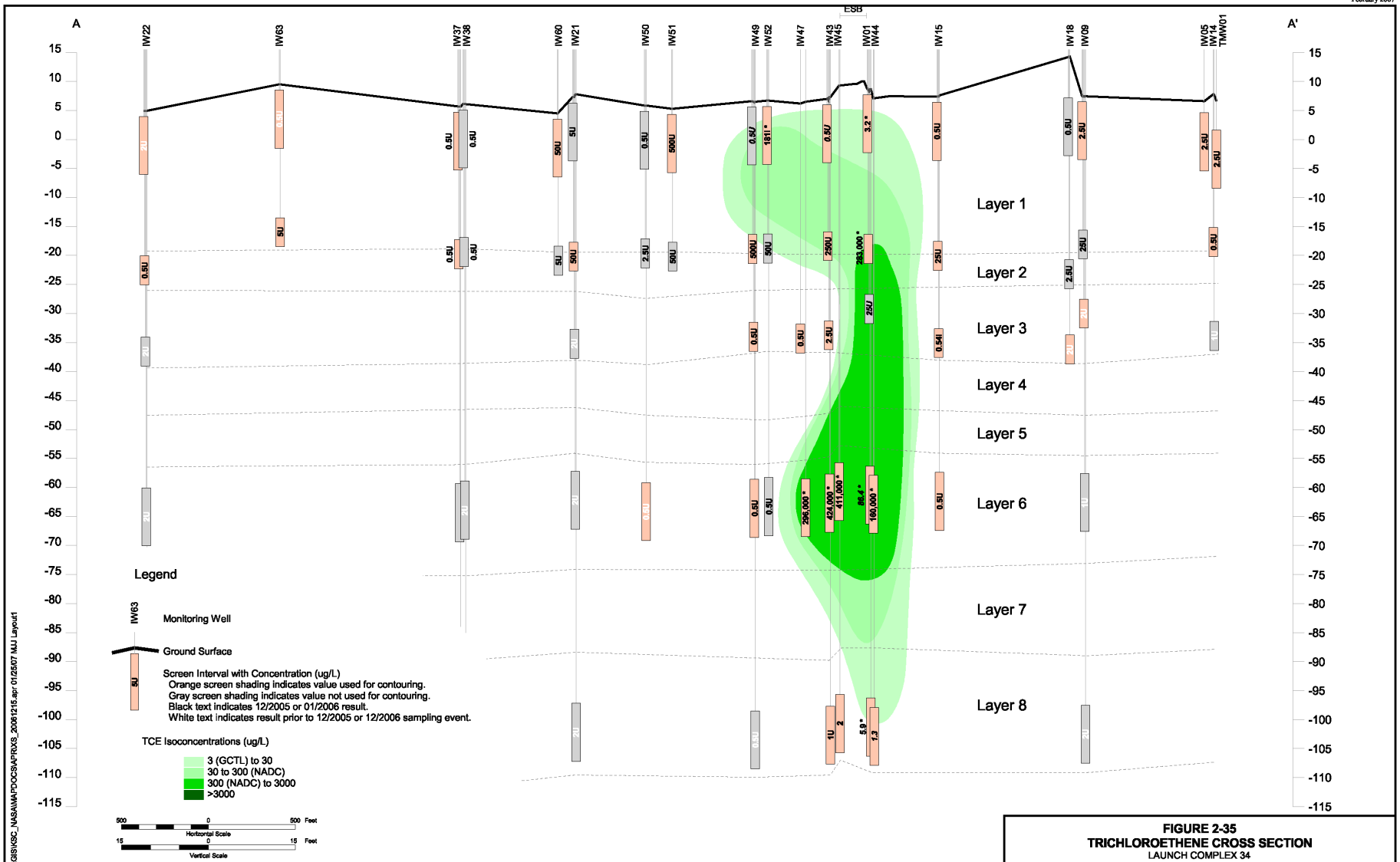

FIGURE 2-35
TRICHLOROETHENE CROSS SECTION
LAUNCH COMPLEX 34
CAPE CANAVERAL AIR FORCE STATION, FLORIDA

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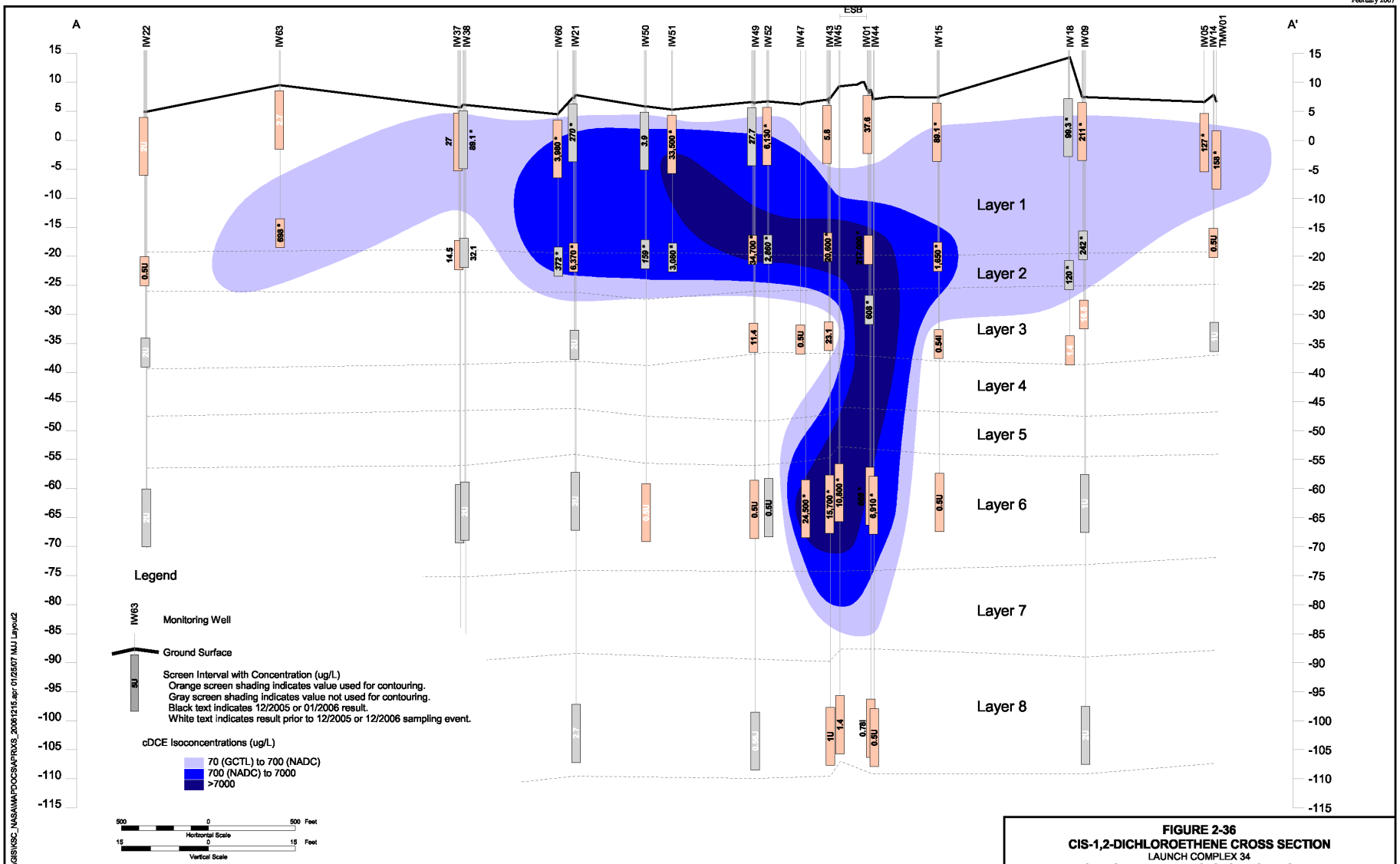

FIGURE 2-36
CIS-1,2-DICHLOROETHENE CROSS SECTION
LAUNCH COMPLEX 34
CAPE CANAVERAL AIR FORCE STATION, FLORIDA

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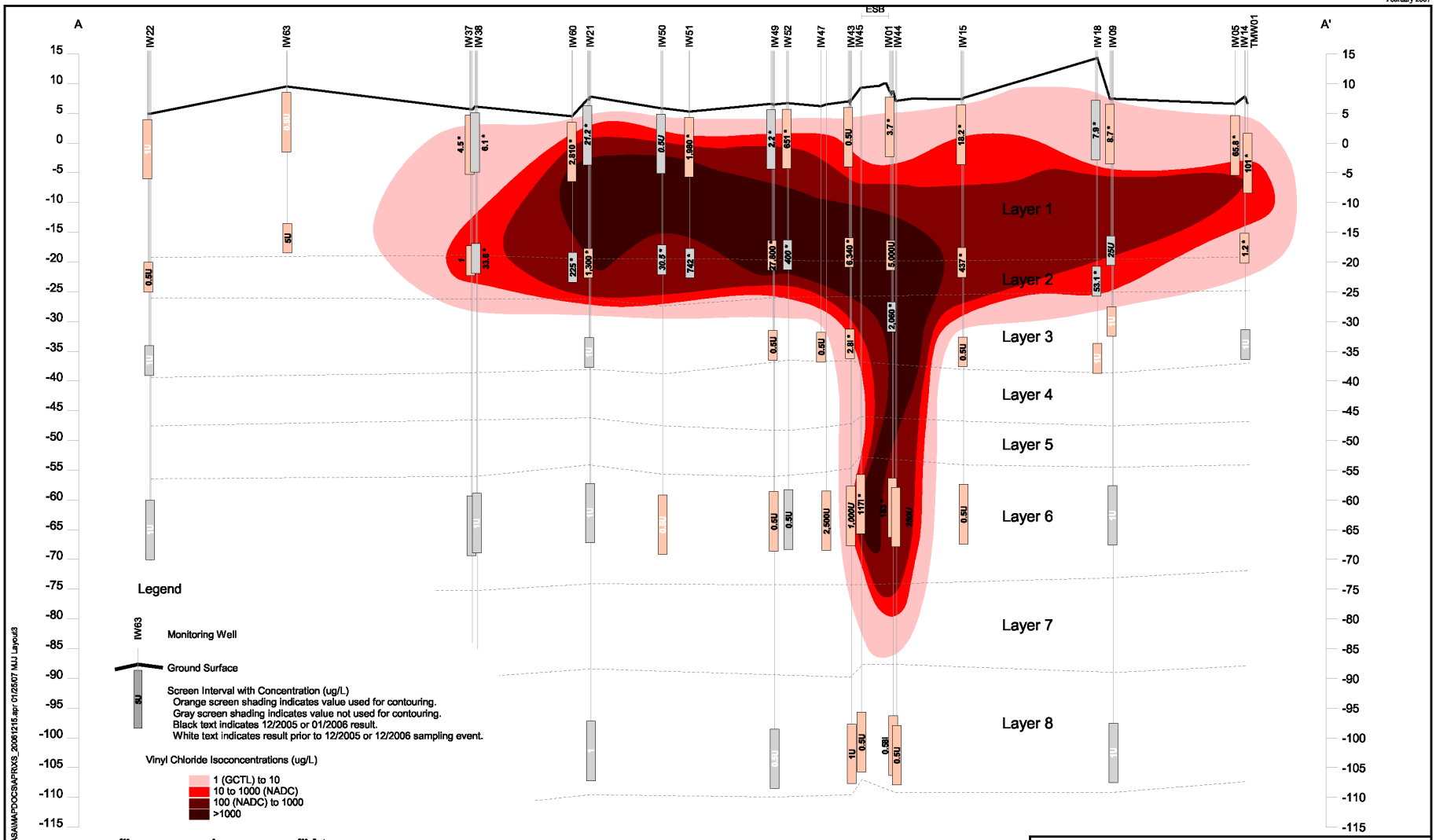

FIGURE 2-37
VINYL CHLORIDE CROSS SECTION
LAUNCH COMPLEX 34
CAPE CANAVERAL AIR FORCE STATION, FLORIDA

Critical Points Regarding Site Impacts

- No complete exposure pathway
  - Site located on a barrier island
  - Highly unlikely source of future potable groundwater
  - No surface water present within plume footprint
  - Engineering Support Building removed (slab left behind)
- Radial groundwater flow from source area
- Significant mass, ~100,000 lbs
- Large variations in hydraulic conductivity ($1x10^{-3}$ cm/sec to $1x10^{-8}$ cm/sec
- DNAPL extending to 80 ft bls
- 40+ yr old release

Critical Points Regarding Site Impacts

- DNAPL source area encompasses ~2 acres (no recoverable product present)
- Dissolved groundwater plume of ~330 acres
- Groundwater modeling results
  - No Action – >900 yrs to reach MCLs
  - 85% DNAPL Source Removal and Dissolved Plume Hydraulic Control – 750 yrs to reach MCLs
  - 99% DNAPL Source Removal (feasible?) and Dissolved Plume Hydraulic Control – 250 yrs to reach MCLs
- So how much $ do you spend to reduce the cleanup timeframe from "very long" to "long" on a barrier island with no exposure pathway?

Technology Screening

- Divided site into three areas
  - DNAPL Source Zone (DSZ)
  - High Concentration Plume
  - Low Concentration Plume
- Aquifer was split vertically based upon technology limitations and lithology (<55 ft bls and 55-85 ft bls)
- Presentation focuses on DSZ

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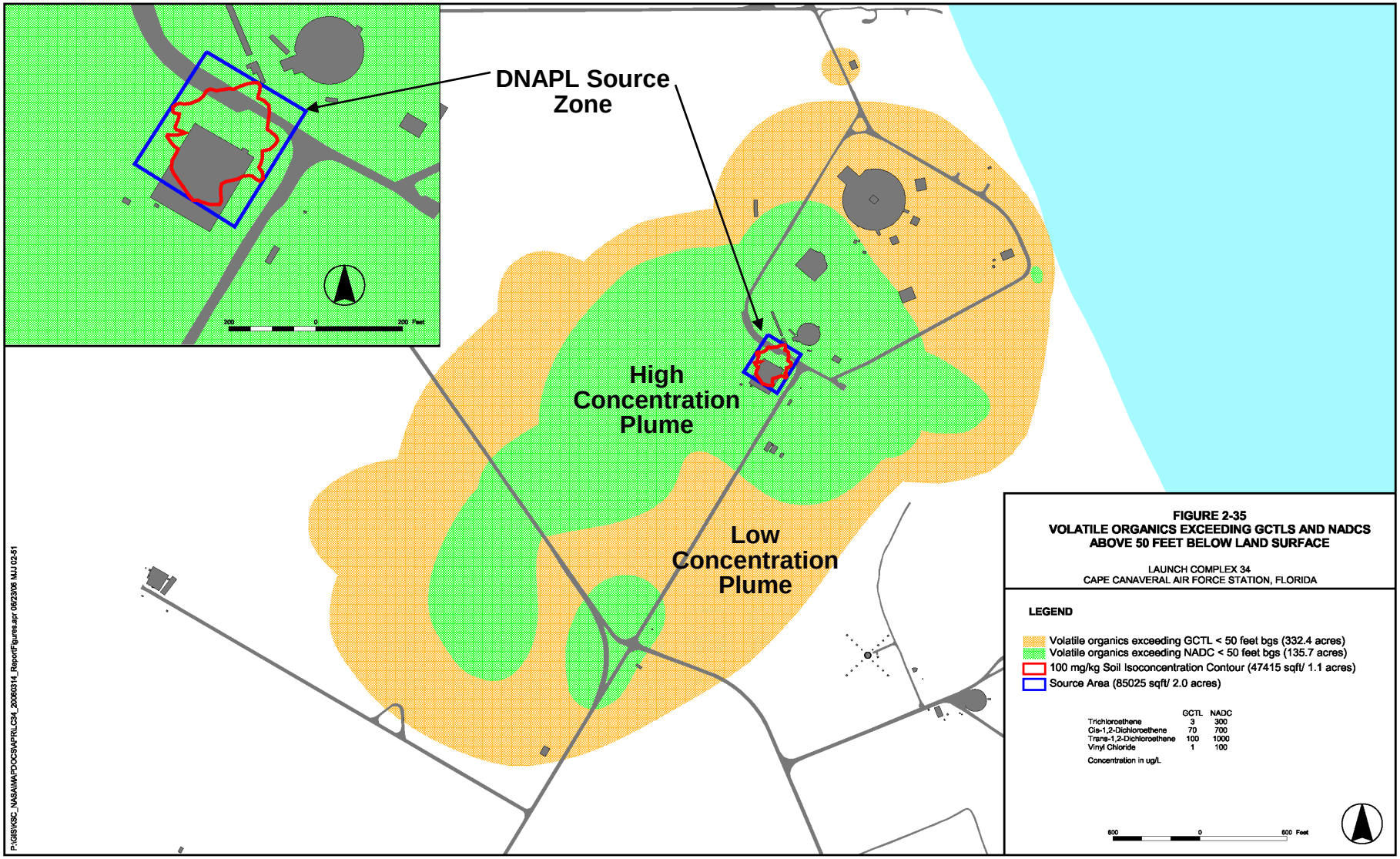
Treatment Zones



Retained Technologies

- DNAPL Source Zone
  - Hydraulic containment via P&T to 85 ft bls
  - Permeable Reactive Barrier to 85 ft bls
  - Enhanced Bioremediation to 85 ft bls
  - Excavation to 55 ft bls/Enhanced Bioremediation 55-85 ft bls
  - Large Diameter Auger (LDA)/Steam/Iron to 55 ft bls/ Enhanced Bioremediation to 85 ft bls
  - ZVI Clay or Slurry Wall Barrier to 85 ft bls*

* barrier technologies evaluated independent from CMS

Costing

- CMS and/or FS costs are typically presented as +50% to -30% and NPV is utilized
  - LC34 costs were based upon vendor quotes and/or best practical engineering estimates
- Net Present Value (NPV)
  - Required approach for presenting costing pursuant to NASA's HSWA permit
  - Issue with NPV – not consistent with NASA funding approach
    - Implies full upfront cleanup funding
    - NASA funds projects annually, therefore NPV can underestimate actual costs
- Non-Discounted "Pay As you Go" Dollars
  - May be more representative of the actual cost to implement a cleanup
  - Important in projects with ongoing O&M&M

Corrective Measures Study Costs

Treatment Zones and Alternatives	First Year Cost (Capital Cost + First Year O&M&M Cost)	Total Cost (First Year Cost + Total Non-Discounted O&M&M)	Total NPV (First Year Cost + Total O&M&M NPV)
DNAPL Source Zone			
Pump and Treat	$1M	$100M	$4M
Permeable Reactive Barrier	$12M	$60M	$15M
Enhanced Bioremediation	$5M	$45M	$10M
Conventional Excavation to 55 feet bls, Enhanced Bioremediation 55-85 feet bls.	$40 - $50M	$54M	$42 - $50M
LDA/Steam/Iron to 55 feet bls, Enhanced Bioremediation 55-85 feet bls	$50 - $70M	$100M	$55 – 75$M
ZVI Clay or Slurry Wall Barrier to 85 ft bls (Containment - No Treatment Provided)	$5 - $6M	$5 - $7M (based upon 30 yrs)	$5 - $6M (based upon 30 yrs)

Technology Considerations

- Technologies such as PRB and/or Barrier Wall do not provide significant DSZ treatment
  - Primary objective is to control flux from DSZ
  - Would likely require adding a technology that provides source treatment
- Highly aggressive technologies provide for significant DSZ mass reduction - however:
  - Even 95% DSZ mass removal leaves 1,000's of pounds of mass in place
  - Time to MCLs still significant (centuries)
  - Follow-up technology to provide remaining mass flux control likely required
- Hydraulic containment via P&T offers advantage of flux control (primary objective) and mass removal (secondary benefit) over time
- Hydraulic containment via P&T represents an active site management strategy that provides NASA with risk management at a low capital and annual cost
  - System is not envisioned to operate for 100's of yrs as a final DSZ remedy
  - Technology can be potentially enhanced as a component of a final remedy (next step in the 'treatment train")

P&T Technology Considerations

- Typically not considered suitable for achieving MCLs at DNAPL sites
  - At LC34 no technology will rapidly achieve MCLs (100% mass removal)
  - Represents an interim measure which can be supplemented in the future:
    - bio-recirculation, surfactants, oxidants, etc.
    - “treatment train” approach
- Considered an expensive technology due to ongoing annual O&M&M costs
  - Lowest capital costs and NPV costs (though not realistic)
  - Highest overall “pay as you go” costs
  - Annual O&M&M costs that are manageable
- Not considered a sustainable technology
  - NASA is evaluating providing 100% of energy requirements via solar/wind turbines
  - Electrical demand is not excessive (12 to 15 hp) compared to overall energy requirements of other aggressive technologies

Technology Considerations

- How much P&T does $6 million buy at LC34?
  - P&T/GAC @ 25,000 µg/L VOC influent: 42 yrs
  - P&T/GAC @ 50,000 µg/L VOC influent: 37 yrs
  - P&T/GAC @ 100,000 µg/L VOC influent: 26 yrs
  - Advanced Oxidation Systems: 28 - 32 yrs
- As influent concentrations decline, O&M costs drop (off-setting inflation on annual O&M),
- At an influent concentration <10,000 µg/L and 35 gpm, off-gas treatment not required
  - reduction in annual costs of >$40,000
  - significant savings benefit not factored into P&T analysis

Corrective Measures Study Costs

- P&T to provide hydraulic containment
  - Primary objective is hydraulic containment of DSZ
  - A byproduct of containment will be significant mass removal (tons per yr)
  - Not anticipated as a m
- Hydraulic containment represents an active site management strategy that provides risk management at a low capital and annual cost
  - System is not envisioned to operate for 100's of yrs as a final DSZ remedy
  - Technology can be potentially enhanced as a component of a final remedy (next step in the treatment train)
- DNAPL will continue to "fuel" dissolved plume until source is deple

Selected Remedy

- System eliminates flux & can remove significant mass
- Allows time for new technologies to be developed
- Cost
  - Capital cost for implementation of the DNAPL Source Zone remedy will be ~$1M with annual O M & M costs of $150K
    - O M & M costs will be required for multiple decades and/or centuries
  - Total CMS cost for the selected remedy for all three treatment zones is $339M
    - Total does not include the supplemental assessments and groundwater “Hot Spot” treatments that are included in the proposed remedy for the High Concentration Plume
    - Additional “Hot Spot” treatment will reduce the time required for the entire plume to reach required cleanup levels

Questions