EPA United States Environmental Protection Agency

Monitored Natural Attenuation Case Study Evaluations

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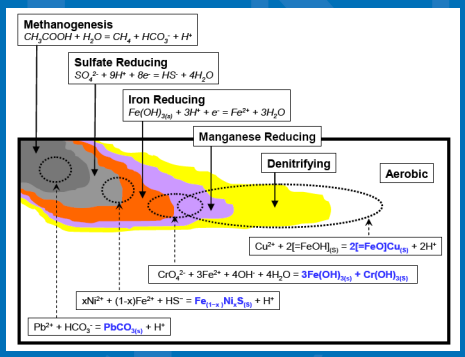


Office of Research and Development
Land Remediation and Pollution Control Division, Cincinnati, OH

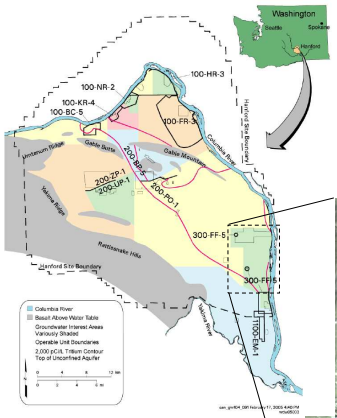
ITRC
23 April 2009
Cincinnati, OH

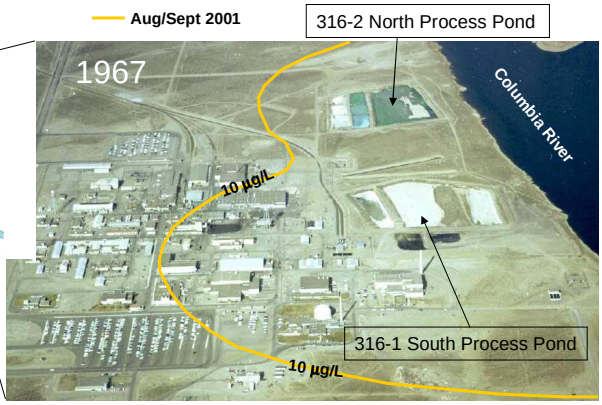
EPA United States Environmental Protection Agency

Hanford 300 Area

Hanford 300 Area Case Study

- Liquid wastes disposed in un-lined trenches and basins
- North and South Process Ponds
- Concept that uranium would flush from aquifer after surface removal





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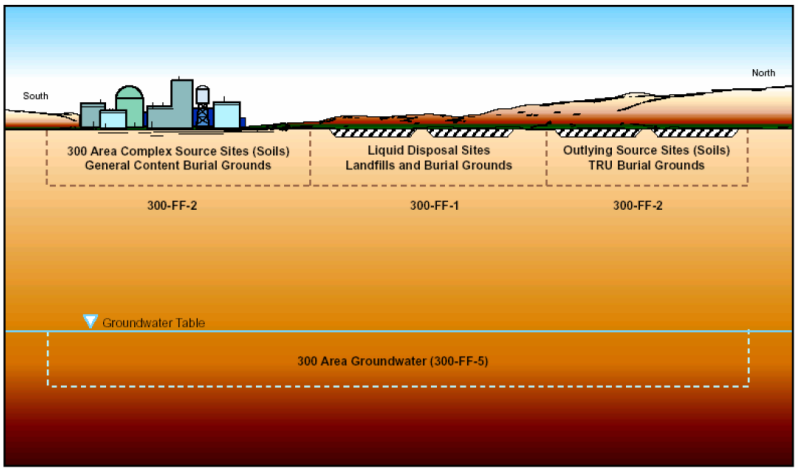
Hanford 300 Area Case Study

Cross-sectional view looking towards land from river…



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http://www.hanford.gov/docs/gpp/library/programdocs-300/300AreaWorkshop0807introA.pdf

Hanford 300 Area Case Study

EPA/ROD/R10-96/143, 07/17/1996
(*Directive 9200.4-17P published 1999*)

"This ROD addresses actual or threatened releases from the wastes sites in the 300-FF-1 Operable Unit and the ***groundwater in the 300-FF-5 Operable Unit***."

"The selected remedy for 300-FF-5 is an ***interim remedial action*** that involves imposing restrictions on the use of the groundwater until such time as health-based criteria are met for uranium, trichloroethene, and 1,2-Dichloroethene."

"The selected interim remedy includes:
- Continued monitoring of groundwater that is contaminated above health-based levels to ensure that concentrations continue to decrease;
- Institutional controls to ensure that groundwater use is restricted to prevent unacceptable exposures to groundwater contamination…"

- ***If monitoring does not confirm the predicted decrease of contaminant levels, DOE and EPA will evaluate the need to perform additional response actions***.

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Hanford 300 Area Case Study

Conceptual Model Supporting Interim GW Action

- Most of the U mass is in the 1st few feet of sediments in the liquid waste disposal sites
- Remove this source and the U concentrations will attenuate to < DWS.
- Expedited Response Action in 1991 removed contaminated soil from trenches with dramatic U concentration decreases.
- The RI/FS Report (May 1995) suggested that the plume would attenuate to meet the drinking water standard in 3 to 10 years from late 1993.

http://www.hanford.gov/docs/gpp/library/programdocs-300/300AreaWorkshop0807introA.pdf

DOE/RL-2006-20 Revision 1

The Second CERCLA Five-Year Review Report for the Hanford Site

"Remediation of the uranium plume in the 300 Area groundwater through natural attenuation with monitoring ***has not achieved the remedial action objectives in the ten-year time frame*** envisioned when the ROD for interim action for groundwater was established."

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Administrative Record

2000 (June) Explanation of Significant Differences Expanded GW monitoring area and established procedure for O&M updates

2001 (April) First Five Year Review (Sitewide)

"Even though attenuation was predicted to occur for the uranium plume in 3 to 10 years from late 1993, several factors could be causing the continued existence of that plume above drinking water standards (e.g., the continued presence of soil/debris waste sites, ***water applied for dust control***, and/or complicating factors in the deep vadose zone)."

2006 (November) Second Five Year Review (Sitewide)

"Remediation of the uranium plume in the 300 Area groundwater through natural attenuation with monitoring has not achieved the remedial action objectives in the ten-year time frame envisioned when the ROD for interim action for groundwater was established."

"DOE is currently performing additional characterization activities and has initiated treatability studies supporting more aggressive treatment options."

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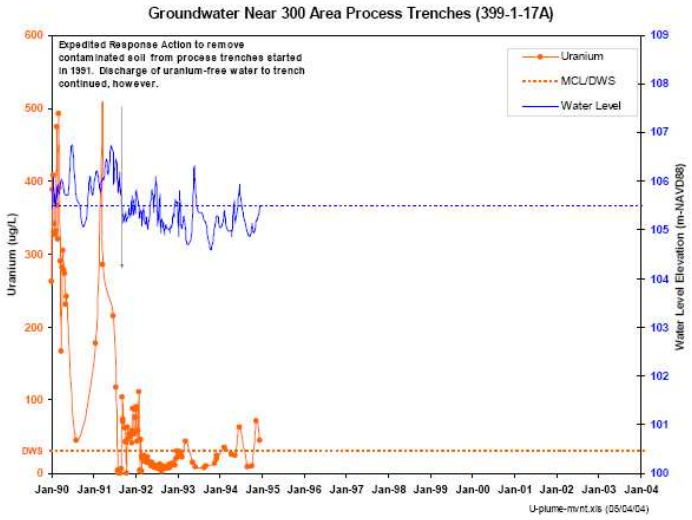
Hanford 300 Area Case Study



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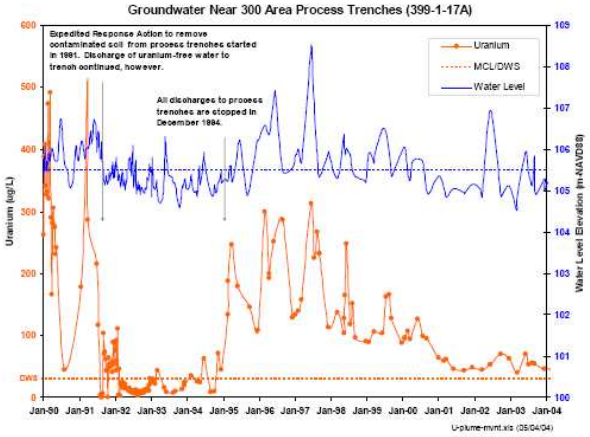
http://www.hanford.gov/docs/gpp/library/programdocs-300/300AreaWorkshop0807introA.pdf

Hanford 300 Area Case Study

"The Rest of the Story"



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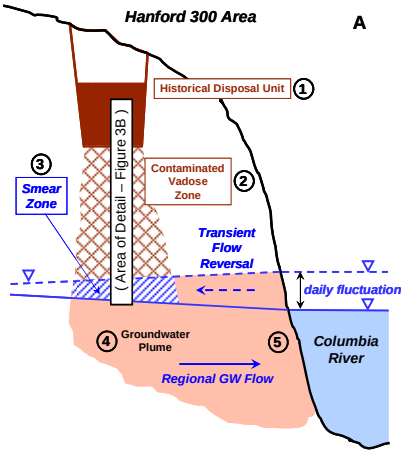
http://www.hanford.gov/docs/gpp/library/programdocs-300/300AreaWorkshop0807introA.pdf

Current Conceptual Site Model

Hanford 300 Area uranium plume provides an opportunity for retrospective analysis (EPA/600/R-08/114)



1. Contaminated surface soils (source removal)
2. Dispersed residual contamination in vadose solids
3. Zone impacted by water table fluctuations (GW-SW interactions)
4. Plume in continuously saturated zone
5. Transition zone between GW & SW (includes sediments)

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Modeling Uranium Transport

1993 Numerical Model

Modeling Assumptions in Phase I Remedial Investigation (1994)

- 3-D saturated unconfined aquifer; **vadose zone not modeled**
  - Spatially distributed hydraulic conductivity (4 hydrofacies types)
  - Flow field driven by monthly changes in river stage fluctuations
  - Uranium mobility controlled by constant K_d
  - Natural flushing predicted to largely decrease U to < 20 ug/L by 2018 (end of institutional controls)

Prediction Update for U < 20 ug/L in RI/FS (1995)

- "Refinement" of Phase I RI estimate: **3 to 10 years** from late 1993 to meet standard
- Analytical model assumptions
  - Steady-state saturated flow
  - Constant hydraulic conductivity: 1830 m/day
  - Constant hydraulic gradient: $5x10^{-4}$
  - 500 m travel distance from process trenches to Columbia River
  - Uranium mobility controlled by "best estimate" constant Kd ~ 1 to 2 mL/g
- No interaction between aquifer and river
- No interaction between aquifer and vadose zone

http://www.hanford.gov/docs/gpp/library/programdocs-300/300AreaWorkshop0807introA.pdf

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Contaminant Source Term

From PNNL-15121 Summary:

- "***Both precipitated and adsorbed U(VI) exists*** in the sediments."
- "An average of 37.5% of the residual, sorbed uranium appears accessible to dissolution/desorption…" "Adsorbed U(VI) predominates in sediments with total uranium <25 mg/kg."
- "The vadose zone sediments beneath both SPP and NPP will ***remain as potential source terms*** to maintain groundwater U(VI) concentrations at or above the drinking water standard."
- "Increasing groundwater levels at high river stage will solubilize sorbed U(VI) from the capillary fringe and lower vadose zone."

http://ifchanford.pnl.gov/pdfs/15121.pdf

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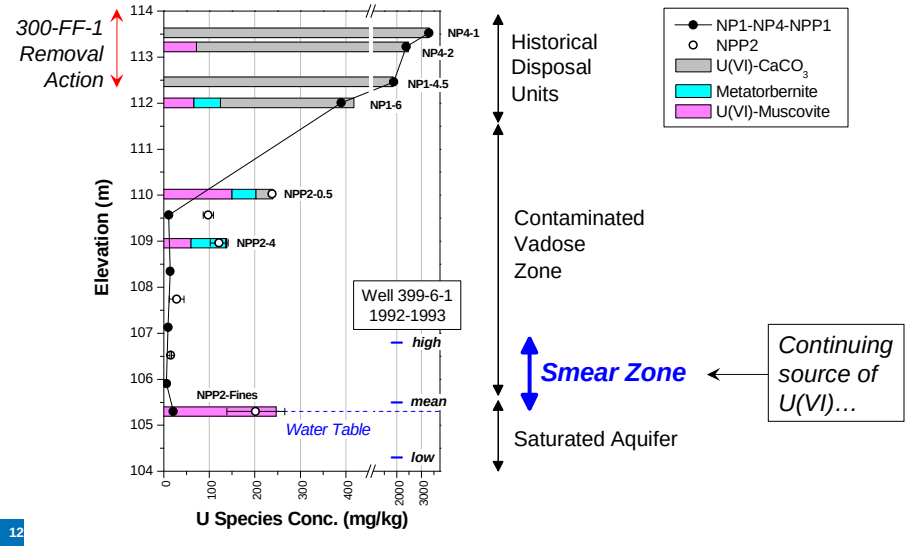
Contaminant Source Term



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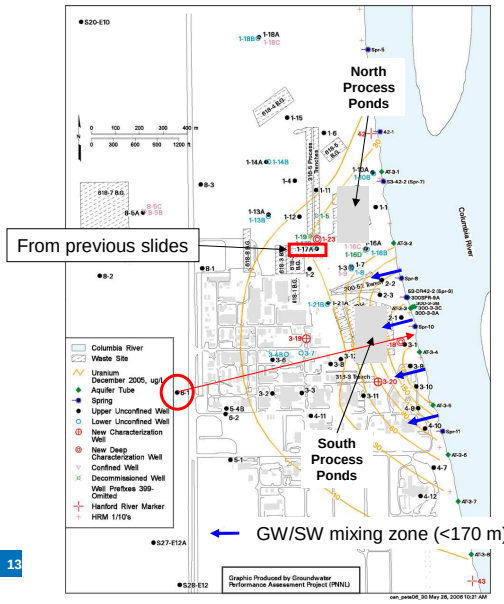
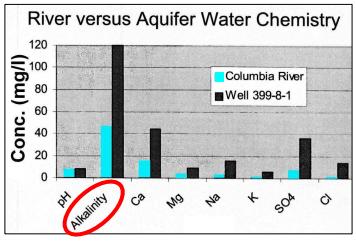
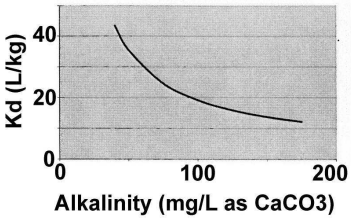
Influence of GW-SW Interaction

Chemistry



Magnitude of Kd fluctuates with river stage – U(VI) doesn't "flush" like anticipated…





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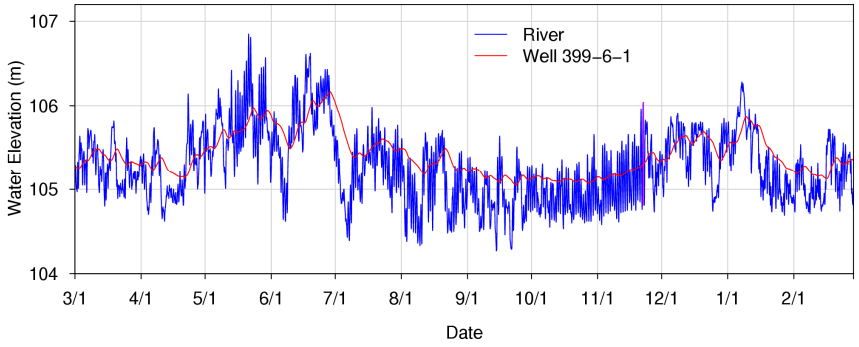
Influence of GW-SW Interaction

Hydrology

- Well 399-6-1 is **~900 meters** inland from Columbia River
- Year-long monitoring record from March 1992 to February 1993



Waichler, S. R. and S. B. Yabusaki. Flow and Transport in the Hanford 300 Area Vadose Zone-Aquifer-River System. PNNL-15125, Pacific Northwest National Laboratory, Richland, WA (2005). http://www.hanford.gov/docs/gpp/library/programdocs-300/PNNL-15125.pdf

Yabusaki, S. B., Y. Fang, and S. R. Waichler (2008), Building conceptual models of field-scale uranium reactive transport in a dynamic vadose zone-aquifer-river system, Water Resour. Res., 44, W12403, doi:10.1029/2007WR006617.

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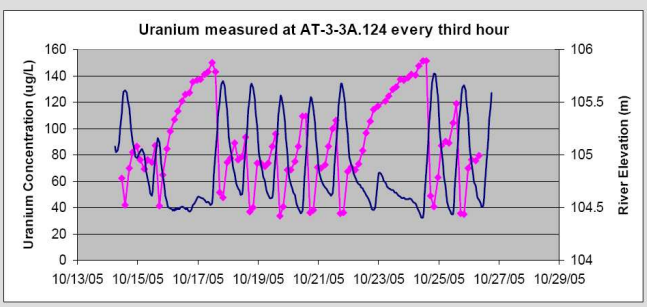
Influence of GW-SW Interaction

Hydrology & Chemistry (DQO)

GW/SW Transition Zone (riverbank)

"…variations in concentrations are a function of dilution rather than any chemistry effects caused by the difference in water chemistry between groundwater and river water."

- High frequency water sampling for uranium in October 2005
- River elevation shown in blue, uranium concentration shown in red



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Source: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-16805.pdf

EPA United States Environmental Protection Agency

Modeling Uranium Transport

Both hydrology and chemistry matter…

- "…rising and falling river stage provides a ***hydrologic mechanism to mobilize U(VI) from the vadose zone*** and transport it to groundwater." **PNNL-15121**
- "U(VI) forms neutral and ***anionic aqueous-carbonate complexes*** in Hanford Site pore and groundwaters that ***suppress adsorption, enhance U(VI)-precipitate solubility, and lower retardation factors***." **PNNL-17031**
- "U(VI) Kd values for Hanford sediments show significant variability (0 to >100 mL/g). The primary factors affecting Kd are a) ***sediment texture***, as a control on reactive-surface area and adsorption-site concentration, b) ***clay and silt fraction mineralogy***, as a control on adsorption-site strength, and c) ***pH and dissolved inorganic carbon***, as a control on U(VI) aqueous speciation." **PNNL-17031**

http://ifchanford.pnl.gov/pdfs/15121.pdf
http://ifchanford.pnl.gov/pdfs/chg_final_rpt_17031.pdf

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EPA United States Environmental Protection Agency

Lawrence Livermore National Laboratory Site 300

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LLNL Site 300 Operable Units

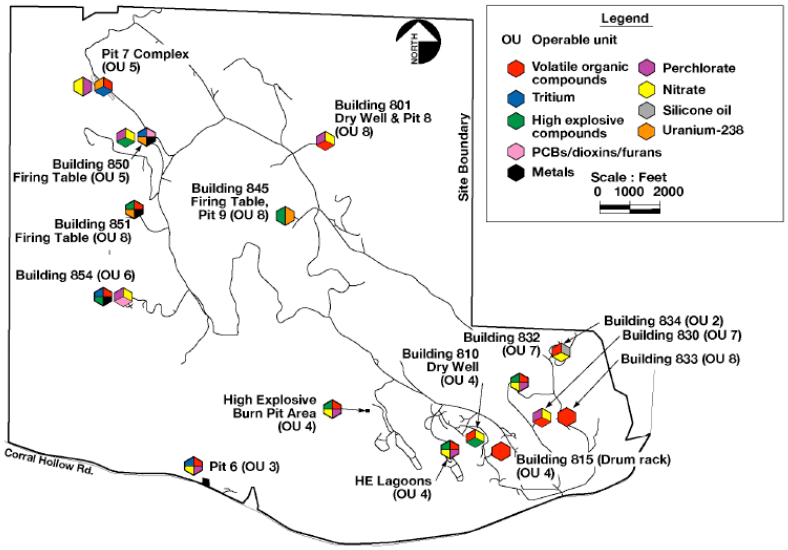

Figure 3. Contaminants of concern at Site 300 for surface soil, subsurface soil/rock, surface water, and ground water.

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https://www-envirinfo.llnl.gov/content/enviroRecent/site300/S300_SWPP_5-18-07.pdf

LLNL Site 300 Operable Units

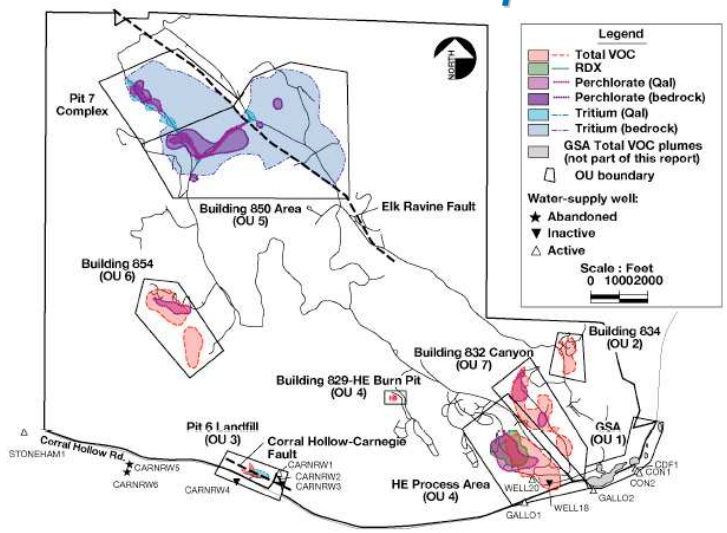

Figure 4. Map of Site 300 showing operable units with ground water plume outlines and operational water-supply wells.

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https://www-envirinfo.llnl.gov/content/enviroRecent/site300/S300_SWPP_5-18-07.pdf

LLNL Site 300 Remedies

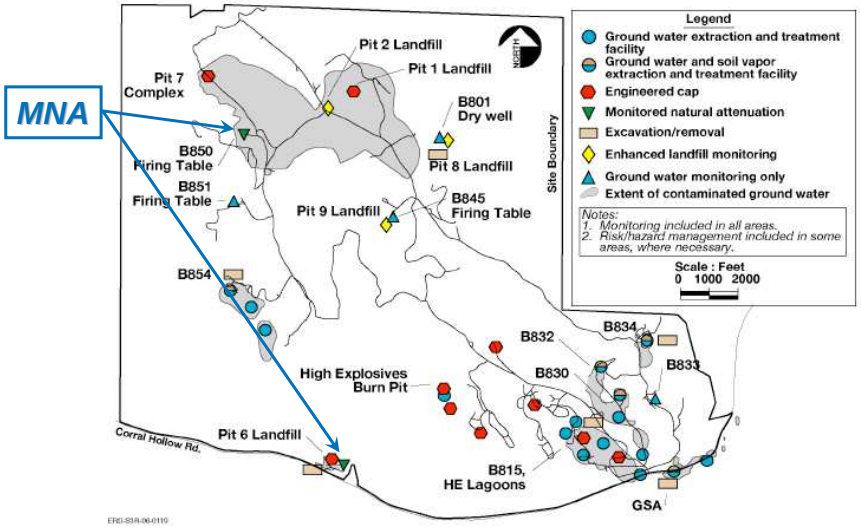

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Figure 6. Cleanup remedies implemented at Site 300.

https://www-envirinfo.llnl.gov/content/enviroRecent/site300/S300_SWPP_5-18-07.pdf

Building 850 Tritium Plume

- Other GW contaminants include uranium, nitrate, perchlorate
- "Natural nitrate source" & limited extent >MCL
- Uranium <MCL & limited extent
- In-situ bioremediation treatability study for perchlorate

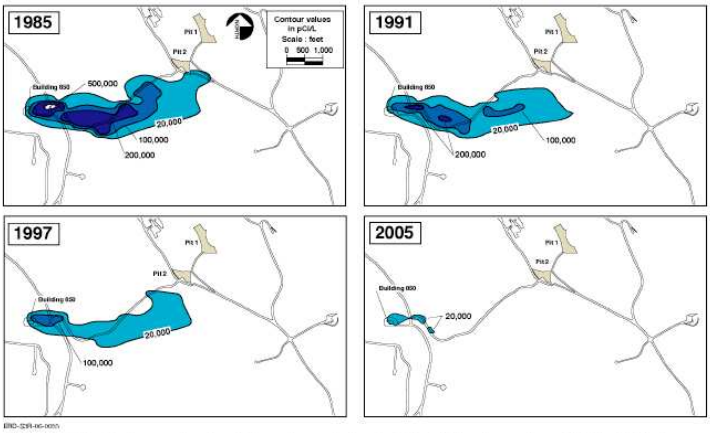

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Figure 7. Extent of ground water tritium plume in the Building 850 subarea from 1985 to 2005 at concentrations exceeding the 20,000 pCi/L drinking water standard.

https://www-envirinfo.llnl.gov/content/enviroRecent/site300/S300_SWPP_5-18-07.pdf

LLNL Site 300: Site-Wide ROD

- Site Wide ROD published July 2008 [Building 850/Pit 7 Complex (OU 5)]

http://www-erd.llnl.gov/library/Docs_Audit/SWROD_2008_UCRL-AR-236665.pdf

- Interim ROD signed February 2001
- "The Pit 7 Complex of OU 5 was not included in the Interim Site-Wide ROD. An Amendment to the Interim Site-Wide ROD (U.S. DOE, 2007a) for the Pit 7 Complex was signed in January 2007."
- "…OU has been divided into two areas for cleanup evaluation purposes: the Pit 7 Complex and the Building 850 Firing Table area."

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Arsenic Sites

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Remediating Subsurface Arsenic Contamination with Monitored Natural Attenuation, H. James Reisinger, David R. Burris, Janet G. Hering, Environmental Science & Technology 2005 39 (22), 458A-464A

TABLE 1

Summary of sites

	Site 1	Site 2	Site 3	Site 4
Location	Florida	Georgia	Utah	Florida
Name	Eglin AFB (Shoal River cattle vat)	Industrial landfill	Hill AFB (Bamberger Pond)	Cape Canaveral (Fire Training Area 1)
Source of arsenic	Cattle dipping vat	Boiler ash	Natural	Natural
Co-contaminants	None	Wood and paper waste	None; DNOM	Petroleum fuels; chlorinated solvents
Maximum [As] in groundwater	2.3 mg/L (total) 1.1 mg/L (dissolved)	1.2 mg/L (total) 1.2 mg/L (dissolved)	0.18 mg/L (total)	0.13 mg/L (total)
Timeline of site investigation and/or remediation	1997–1998: Site investigation; 1998: Soil excavation	1997–2001: Site investigation; 2001: MNA accepted	1989–1992: Pre-RI activities; 1993–1994: RI; 1994–1999: GW monitoring; 2000: NFRAP acceptance	1984–1988: Pre-RI activities; 1988–1997: RI/FS; 1997: LTM plan
Remedies	Source-area soils removed	NA with LTM and landfill capping	NFRAP	NA with LTM and land-use controls

What is the currrent status of these sites?

Site 1: MNA was not applied to this site, no LTM data exist

Site 2: LTM data exist, but the state agency indicated the data need to be retrieved in person

Sites 3 and 4, described on subsequent slides

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SITE 3: Hill AFB, OU5, sub-unit Bamberger Pond

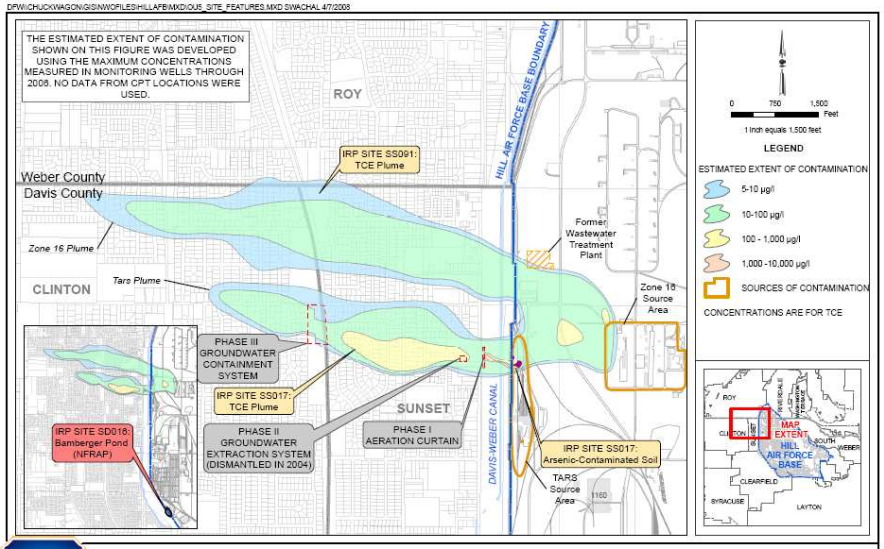

FIGURE OU 5 - 1
SITE FEATURES OF OPERABLE UNIT 5
2008 FIVE-YEAR REVIEW
IRP SITES: SS091, SS017, SD016
HILL AIR FORCE BASE, UTAH

75th AIR BASE WING

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SITE 3: Hill AFB, OU5, sub-unit Bamberger Pond

- A third IRP site (at OU5), Bamberger Pond, has been removed from further investigations because arsenic in groundwater was determined to be naturally occurring. The Bamberger Pond was accepted by the EPA and the UDEQ as a closed CERCLA site with no further action required in September 2000.
  - Taken from the Hill Air Force Base 5 Year Review (published Dec 2008)

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SITE 4: Cape Canaveral Fire Training Area 1 (FT16)

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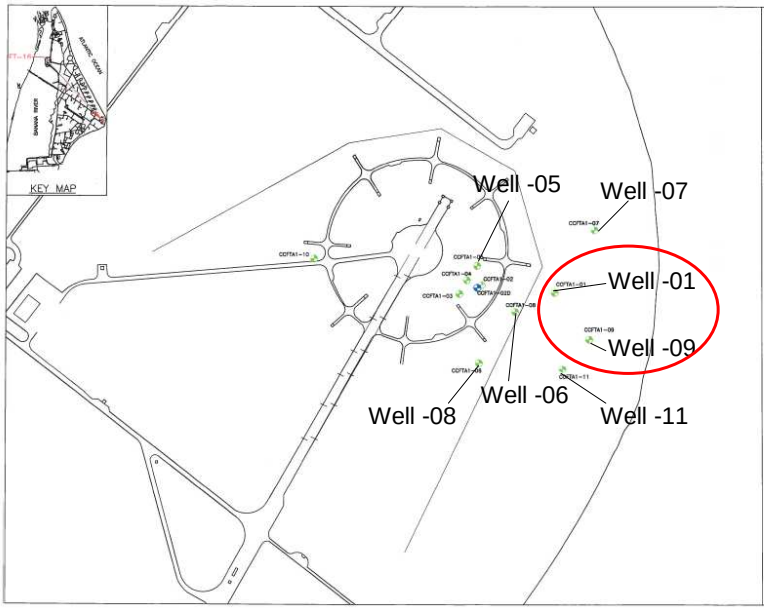
SITE 4: Cape Canaveral Fire Training Area 1 (FT16)



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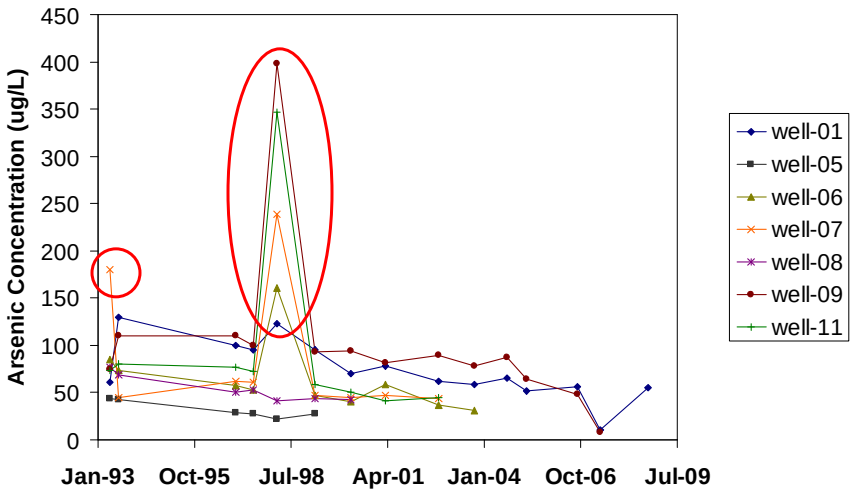
SITE 4: Cape Canaveral Fire Training Area 1 (FT16)

Long Term Monitoring Data: *Importance of Consistent Sampling Procedures*



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SITE 4: Cape Canaveral Fire Training Area 1 (FT16)

Lessons Learned: *Importance of Consistent Sampling Procedures*

"During the March 1998 sampling event, the As concentration did not continue its constant trend, established over the prior four years, in wells CCFTAl-01, CCFTAl-09, and CCFTAl-11, but rather increased markedly. During the March 1998 sampling event, low-flow sampling techniques were not employed and NTU readings greater than 5 were reported. The use of a non low-flow technique likely contributed to the sharp increase in As concentrations. The presence of more fine-grained sediment in the water, suggested by the higher NTU readings, would provide As the opportunity to be adsorbed to the sediment particles. The presence of sediment (with As adsorbed) could act to increase the apparent concentration of As in the groundwater sample."

-Long Term Monitoring Report, March 1999

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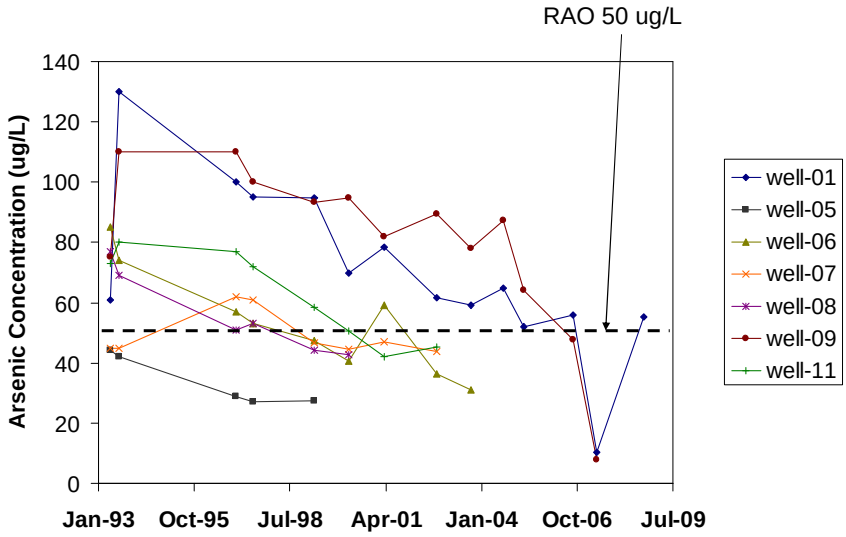
SITE 4: Cape Canaveral Fire Training Area 1 (FT16)

- excluding the high-turbidity samples



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