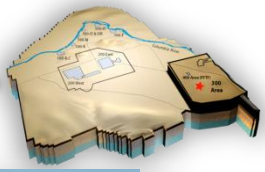
U.S. DEPARTMENT OF ENERGY | Richland Operations Office

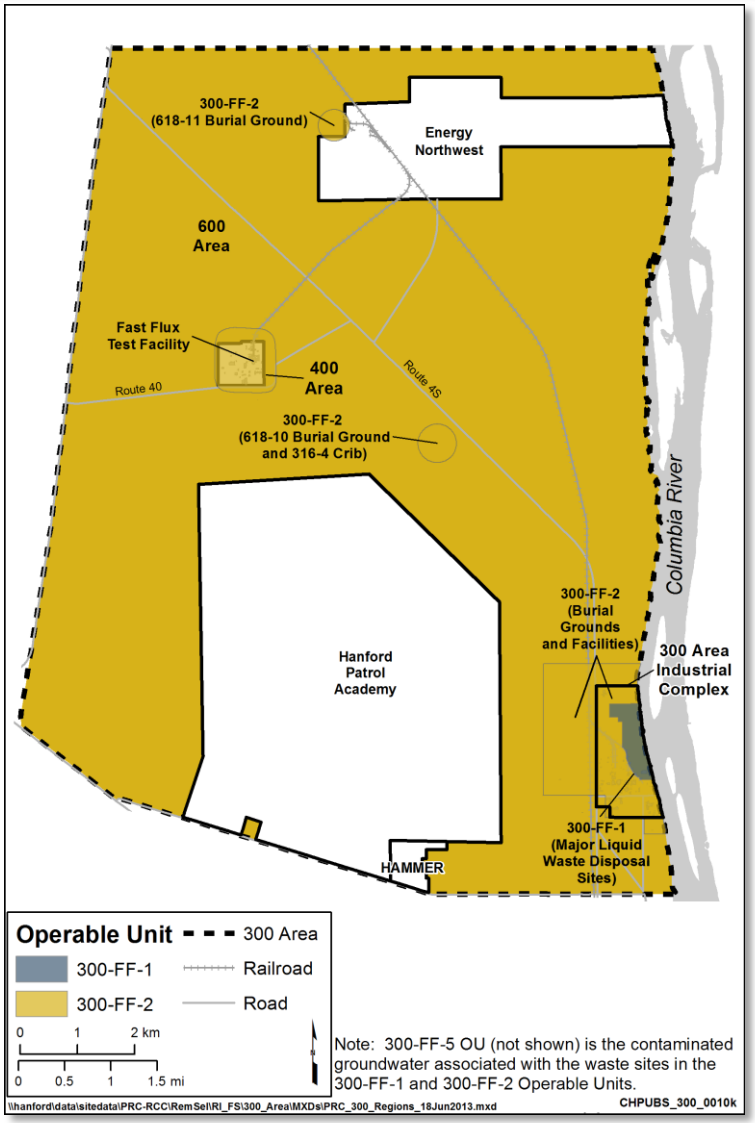
Hanford 300 Area CERCLA Proposed Plan

300 Area Location
Looking North From Richland, WA

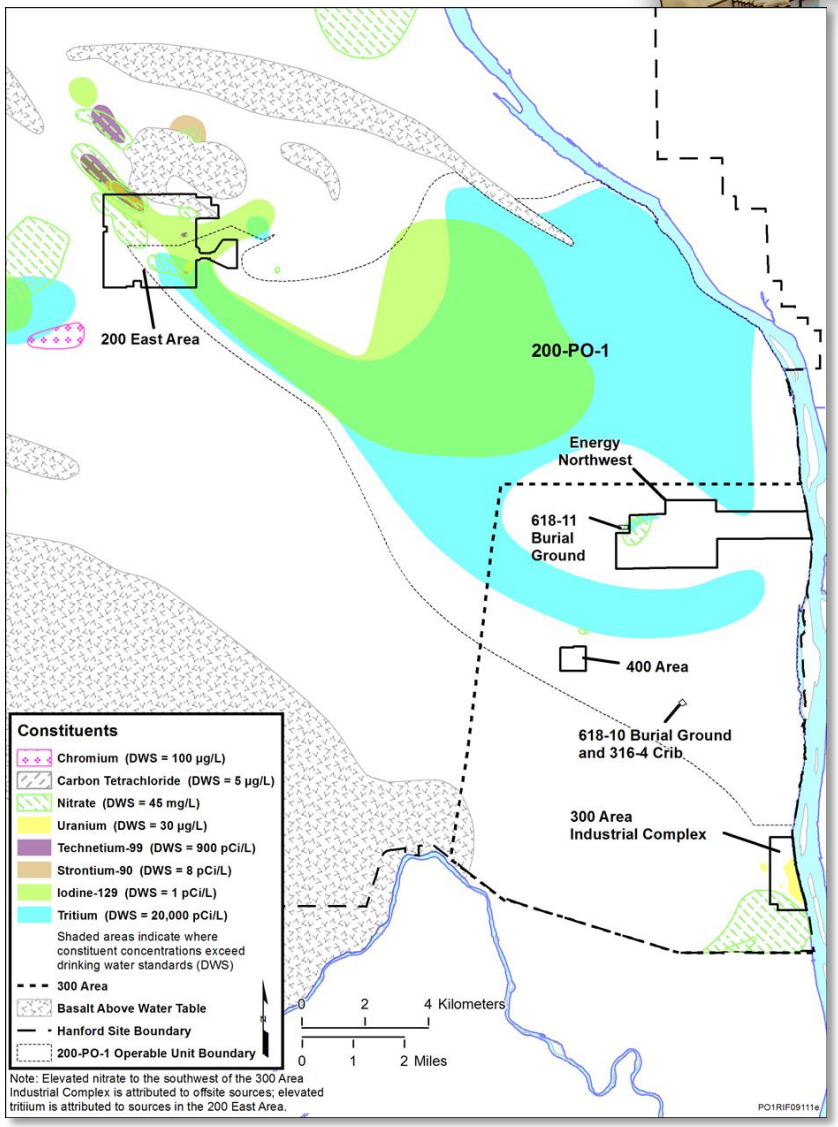


300 Area Operable Unit and Constituents

Hanford 300 Area CERCLA Proposed Plan



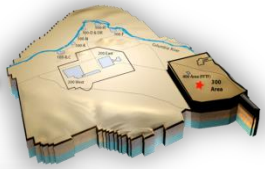
Note: 300-FF-5 OU (not shown) is the contaminated groundwater associated with the waste sites in the 300-FF-1 and 300-FF-2 Operable Units.



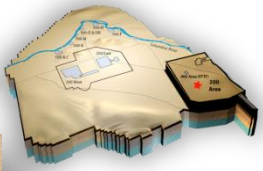
Primary Risk-Driving Contaminants of Concern

- Soils
  - Uranium (metal)
  - Uranium isotopes
  - Cesium-137
  - Cobalt-60
  - Strontium-90
  - PCB Aloclors
- Groundwater
  - Gross Alpha (U)
  - Uranium (metal)
  - Tritium
  - Nitrate
  - Volatile Organics (TCE & DCE)

300 Area Recent Remediation Progress

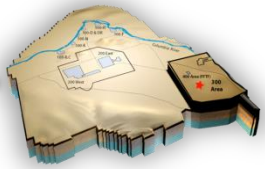


300 Area – Example of Facilities that have been Demolished



Hanford 300 Area CERCLA Proposed Plan

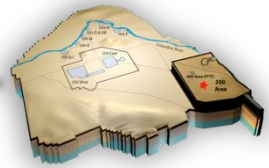
300 Area Progress & Challenges

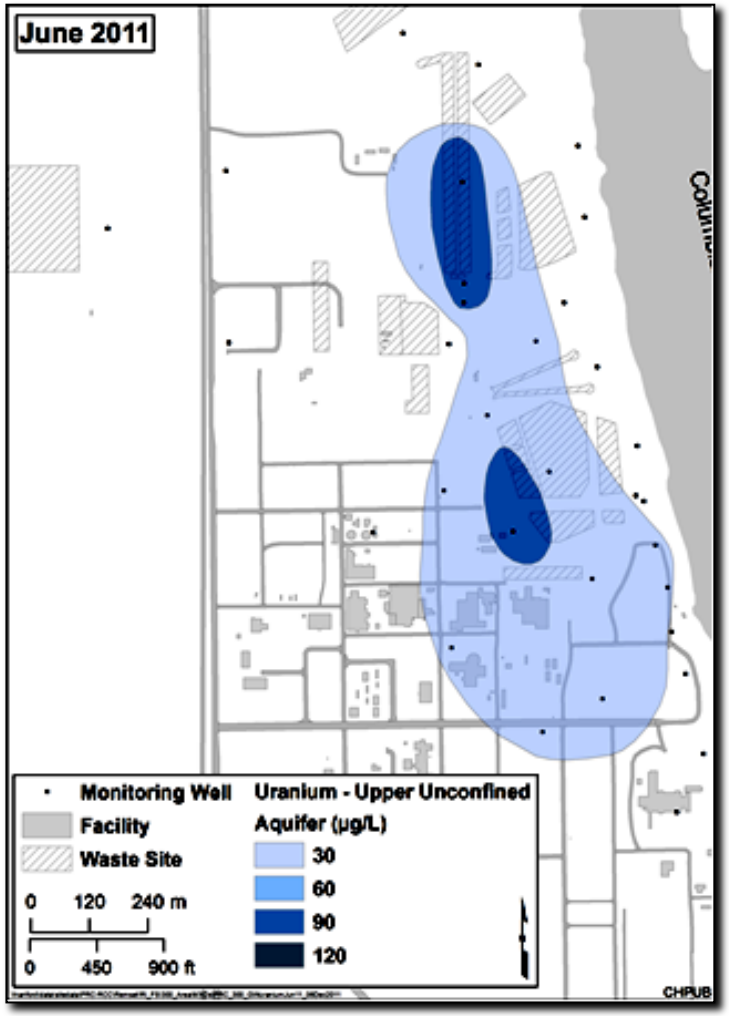


- Challenges
  - High radiation source removals (618-11, 618-10, 340 vault, soils below 324 Building)

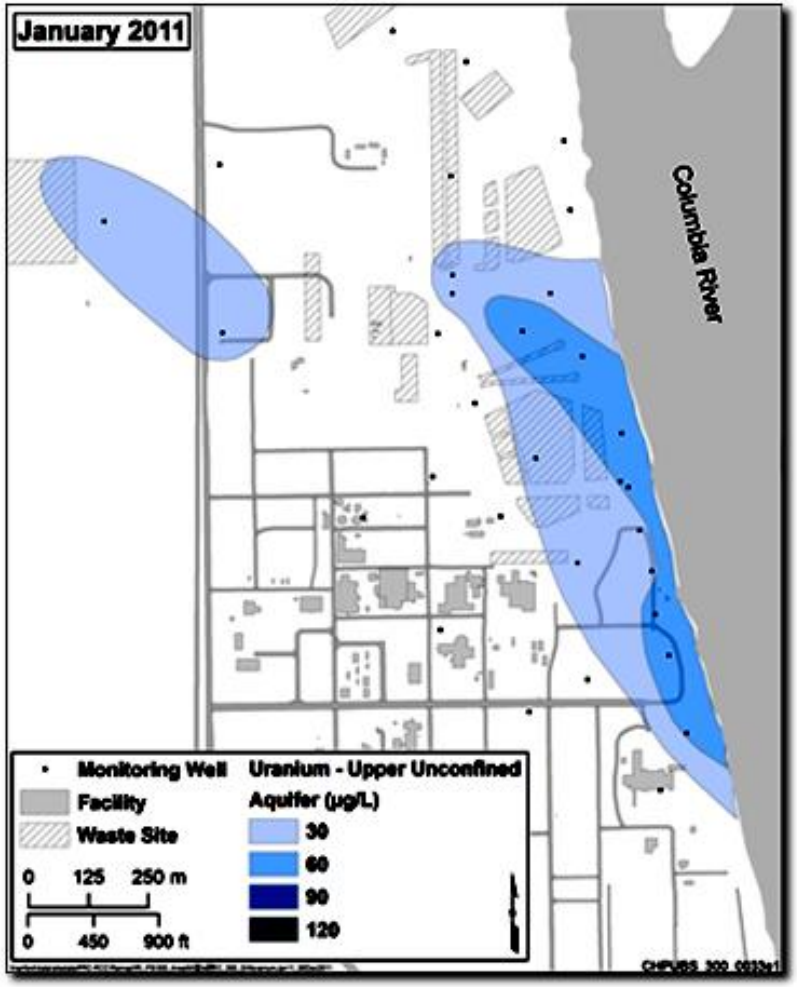
- Progress
  - Nearly 1 Million tons contaminated soil & debris excavated and disposed at ERDF
  - ~38 tons suspected transuranic waste removed & shipped to Central Waste Complex
  - All but ~ 34 of 130 waste sites have been remediated

Persistent & Dynamic Uranium Plume



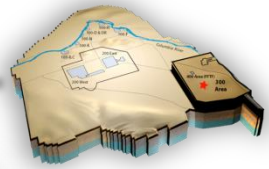


High River Stage



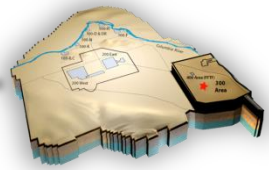
Low River Stage

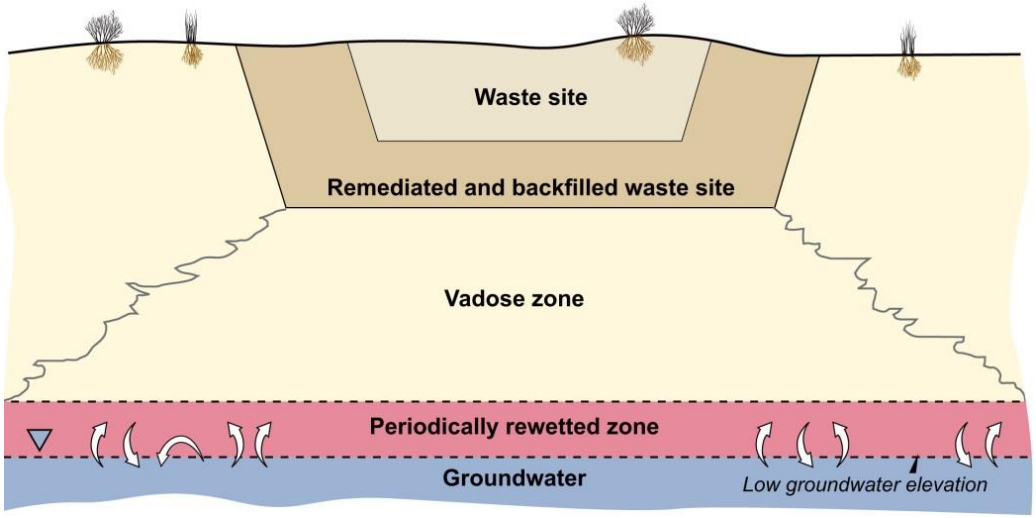
1975-1985 Process Trenches in Use



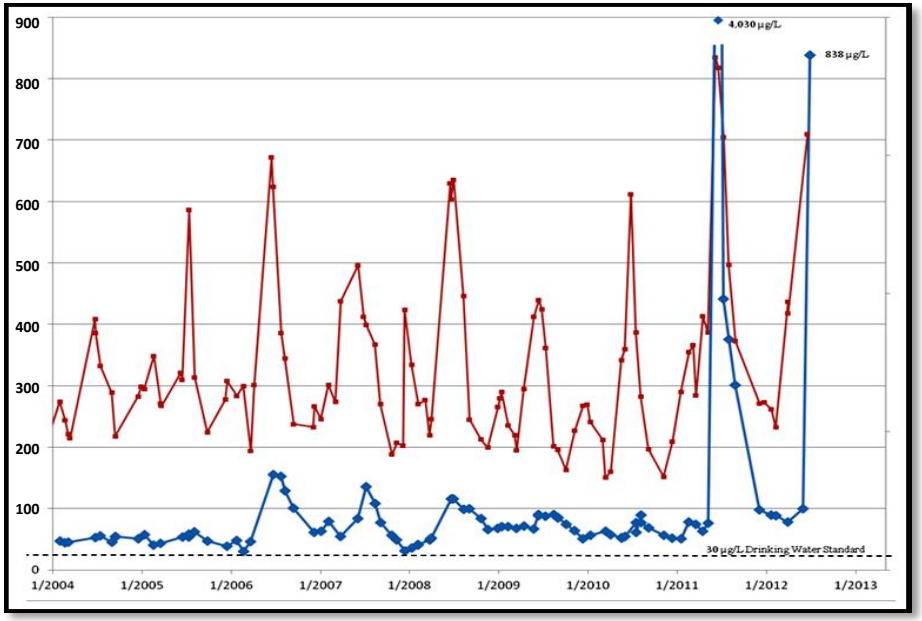
Challenge:
GW Cleanup Requires Addressing U in PRZ

Hanford 300 Area CERCLA Proposed Plan





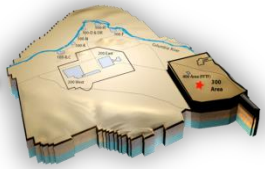
- Primary source of U to GW is the PRZ; ~30% of remaining U inventory is periodically saturated with high bicarbonate GW, replenishing the U plume in GW



Exposure to Contaminated 300 Area Groundwater

- 300 Area U mass flux to the Columbia River represents 2-8% of total U loading the Hanford Reach.
  - ~100-150 kg/yr U from 300 Area
  - ~1600 kg/yr from irrigation returns.
  - Yakima River U flux to the Columbia River is ~4,000 kg/yr
- U concentrations in the Columbia River downstream of 300 Area are below all human health and environmental standards and risk limits
- There is no statistical difference between U concentrations upstream vs. downstream of Hanford

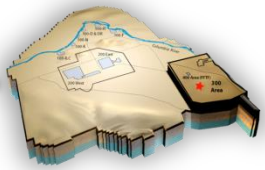
Groundwater Cleanup Goals



Groundwater cleanup is driven by three factors:

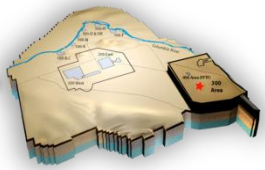
- Mitigate risk to human health from exposure to or consumption of contaminated groundwater.
  - U-contaminated GW is located in the core industrial zone; no residential use planned for the foreseeable future
  - Existing alternative water supply; Potable water to the industrial core area is provided by the City of Richland
- Mitigate risk to the environment where the contaminated groundwater discharges in the riparian (shoreline) and hyporheic (river bed) zones.
  - U concentrations upwelling through river substrate at times exceed federal DWS but do not exceed levels of environmental concern
- Restoration of the contaminated groundwater to its highest beneficial use (drinking water standards) within a time frame that is reasonable given the particular circumstances of the site." EPA - 40 CFR 300.430(a)(1)(iii)(F).

Common Elements of the Active Remedial Alternatives



- Remove/Treat/Dispose (RTD) contaminant sources;
- GW Monitoring for uranium attenuation and Nitrate;
- Monitored Natural Attenuation (MNA) for tritium and organic chemicals; and,
- Institutional controls (IC's) to control access to GW & manage surface infiltration until standards are met.

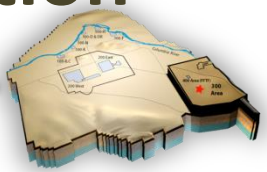
Remedial Alternatives
Described in The Proposed Plan



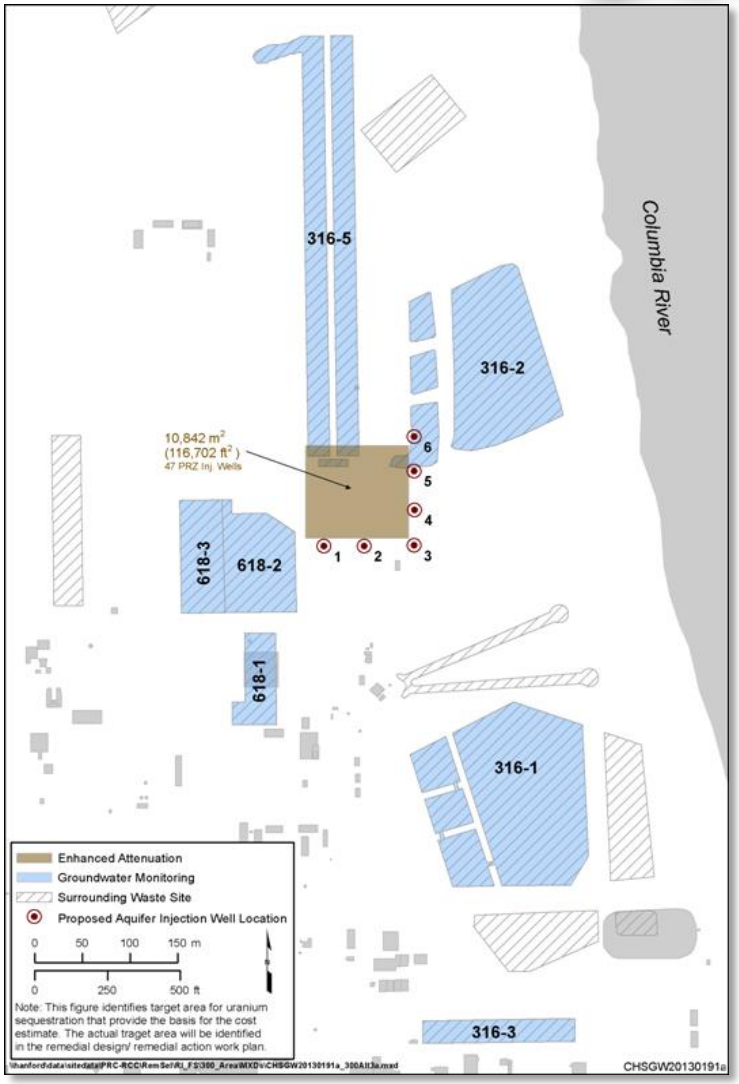
Alternative 1	• No Action
Alternative 2	• Groundwater Monitoring (GW may reach remediation goals in <50 yrs.
Alternative 3	• Two phases of Uranium Sequestration, MNA for tritium & organics and GW Monitoring for U plume
Alternative 3a	• "Enhanced Attenuation" Focused 3 Acre U sequestration, MNA for tritium & organics and GW Monitoring for U & nitrate plumes
Alternative 4	• Uranium Sequestration, Focused Deep RTD, and Groundwater Monitoring
Alternative 5	• Expansive deep RTD and Groundwater Monitoring

Reminder: Alternatives 2-5 include completion of RTD cleanup actions required in RODs for Interim Action; monitoring component for uranium; MNA for tritium and organic chemicals, and institutional controls to control access to GW & manage surface infiltration.

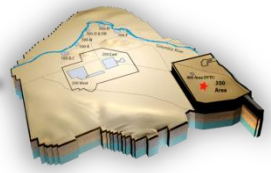
Preferred Alternative (3a) Enhanced Attenuation



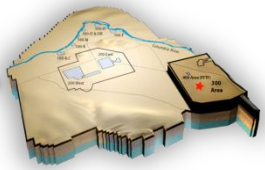
- 130 total waste sites
  - 38 no action
  - Removal, Treatment, and Disposal (RTD): 74 to industrial standards; 12 to residential standards
  - only 34 of 130 sites to RTD post ROD; 7 sites associated with enhanced attenuation
- Enhanced Attenuation for Uranium in the vadose zone and Periodically Rewetted Zone (PRZ);
  - Treatment of 3 acre area using uranium sequestration to immobilize the deep uranium contamination in the vadose zone and PRZ that is the highest source of contamination in groundwater
- Monitored Natural Attenuation (MNA) for tritium and organic chemicals in groundwater
- Groundwater Monitoring and Institutional Controls (ICs) for uranium, gross alpha, and nitrate in the groundwater. ICs are used to control access to residual contaminants in soil and groundwater as long as they exceed the cleanup levels as established in the Record of Decision associated with this Proposed Plan.



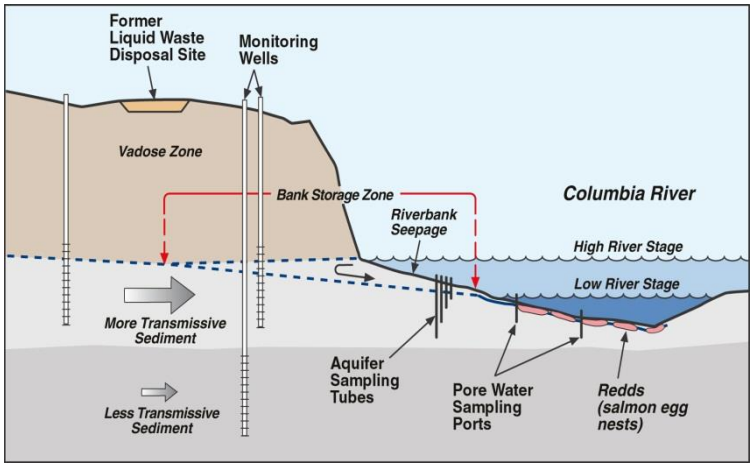
BACKUP SLIDES



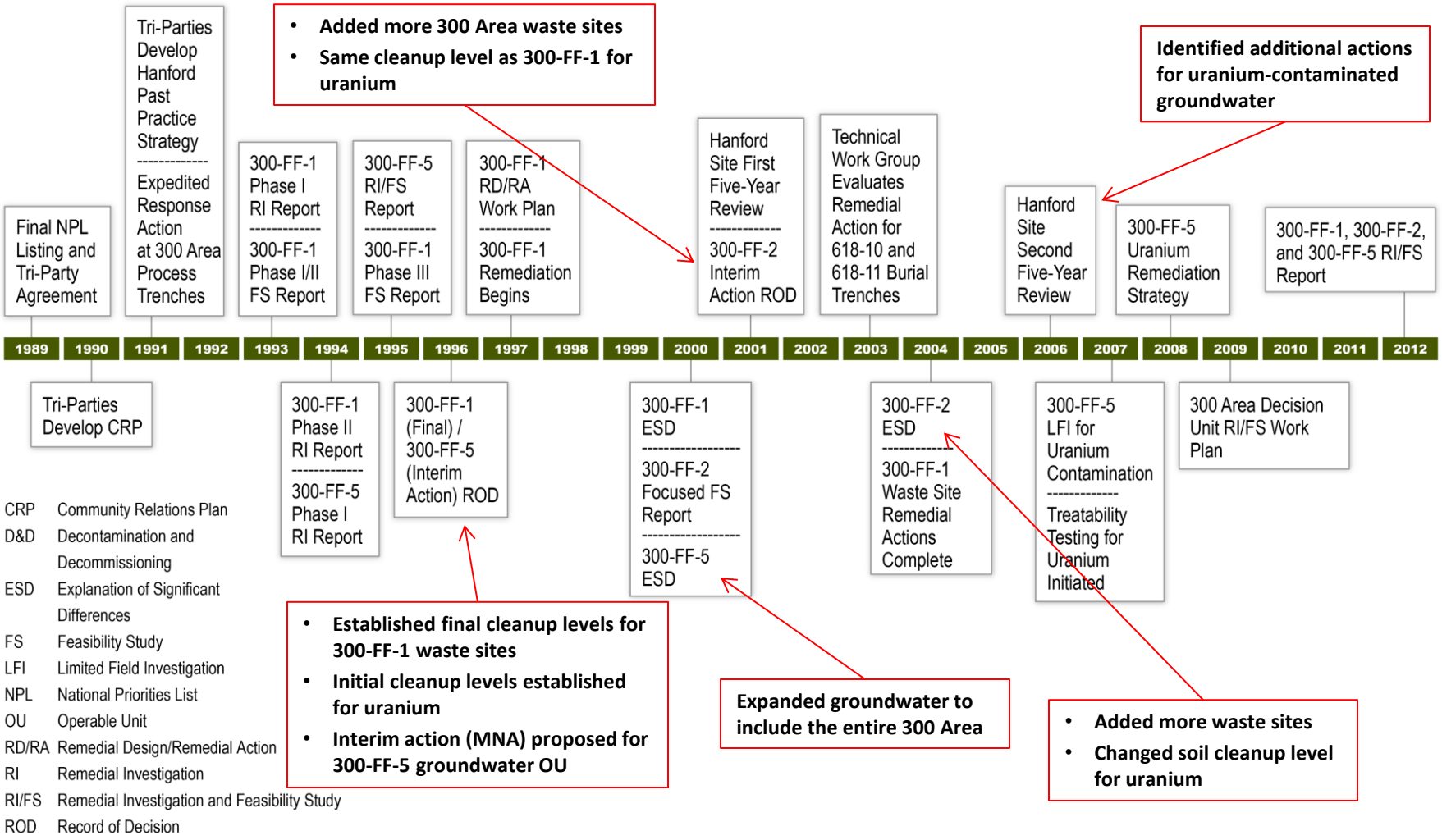
Current Exposure at the Columbia River From Hanford-Derived Contaminants to Humans and Other Biota is localized



- Hyporheic Zone - contaminated groundwater upwells into the gravel bed of the river
- Riparian Zone - seeps containing a mixture of river water and groundwater



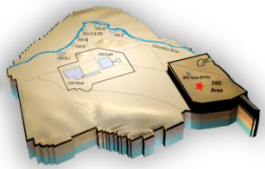
Previous 300 Area Regulatory Documents



CRP	Community Relations Plan
D&D	Decontamination and Decommissioning
ESD	Explanation of Significant Differences
FS	Feasibility Study
LFI	Limited Field Investigation
NPL	National Priorities List
OU	Operable Unit
RD/RA	Remedial Design/Remedial Action
RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
ROD	Record of Decision

CHPUBS_300_0036b

Remedial Action Objectives (RAOs)

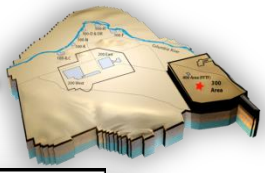


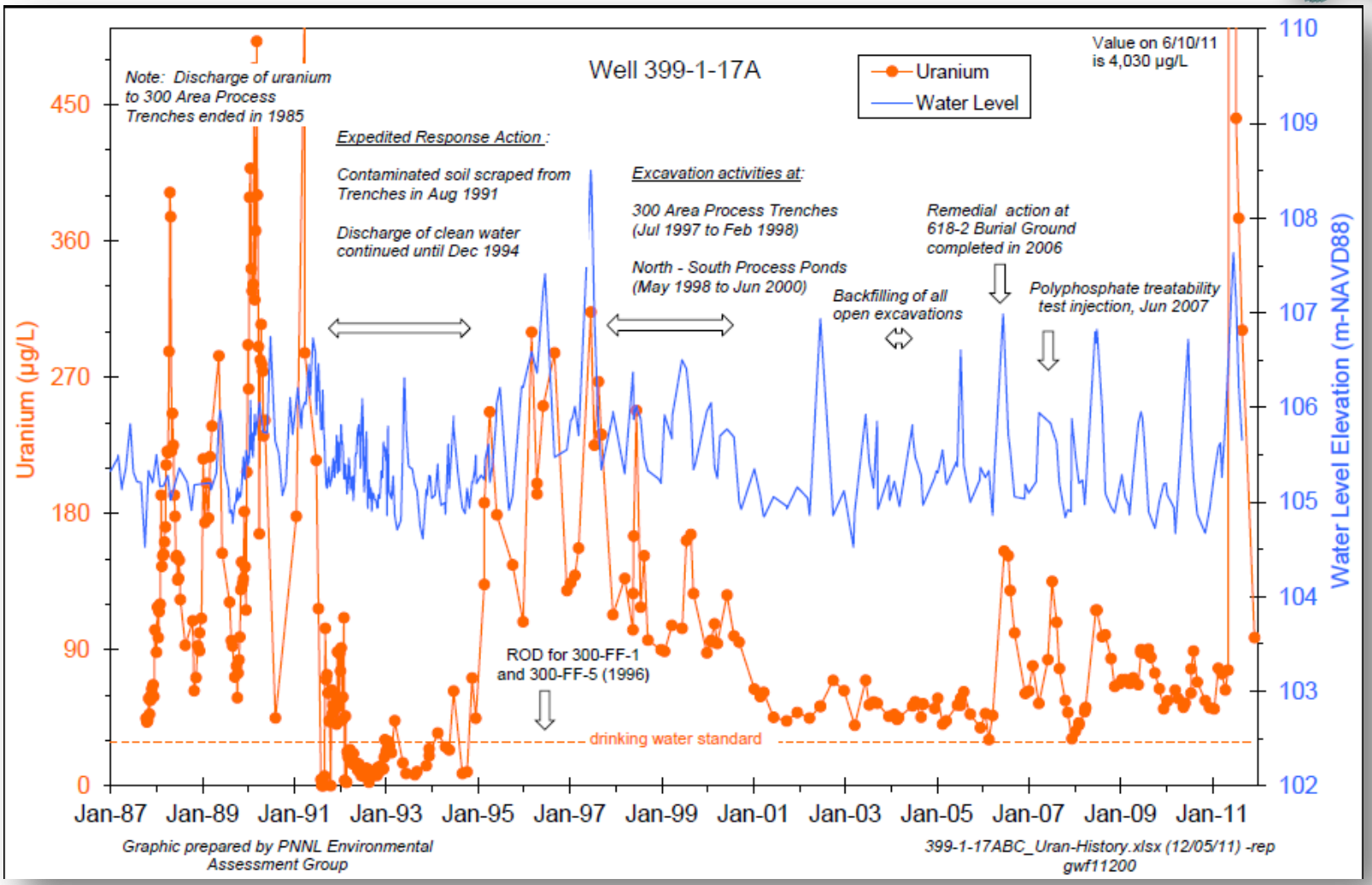
- RAO 1. Prevent human exposure to groundwater containing COC concentrations above PRGs.
- RAO 2. Prevent COCs migrating and/or leaching through soil that will result in groundwater concentrations above PRGs for protection of groundwater, and of surface water at locations where groundwater discharges to surface water.
- RAO 3. Prevent human exposure to the upper 4.6 m (15 ft) of soil and structures and ***debris*** contaminated with COCs at concentrations above PRGs for residential use in areas outside both the 300 Area Industrial Complex and waste site 618-11 (adjacent to Energy Northwest).
- RAO 4. Prevent human exposure to the upper 4.6 m (15 ft) of soil and structures and debris contaminated with COCs at concentrations above PRGs for industrial use in the 300 Area Industrial Complex and waste site 618-11 (adjacent to Energy Northwest).
- RAO 5: Manage direct exposure to contaminated soils deeper than 4.6 m (15 ft) to prevent an unacceptable risk to human health and the environment.
- RAO 6. Prevent ecological receptors from direct exposure to the upper 4.6 m (15 ft) of soil and structures and debris contaminated with COCs at concentrations above PRGs.
- RAO 7. Restore groundwater impacted by Hanford releases to PRGs within a timeframe that is reasonable given the particular circumstances of the site.

Aquifer Restoration is Driving the Cleanup Decision

- Restoration of the aquifer (achieve federal DWS) within a time frame that is reasonable given the particular circumstances of the site." EPA - 40 CFR 300.430(a)(1)(iii)(F).
- Primary source of U contamination contaminating GW is the mobile fraction of U in the PRZ; seasonal high water continues to feed U to GW.
- ~1% of remaining inventory is dissolved in GW; ~ 100-150 kg/yr U removed from the aquifer/yr (transported to the river)
- Size and mass of the U plume exceeding DWS varies in accordance with river stage conditions, varying between 0.4 – 0.5 square km and 40-83 kg
- Attenuation of the U plume to CERCLA EPC cleanup levels is estimated to be 30-40 years; ~ 200 yrs. to achieve < DWS in all wells all the time

Observed U Behavior to River stage and Remedial Actions





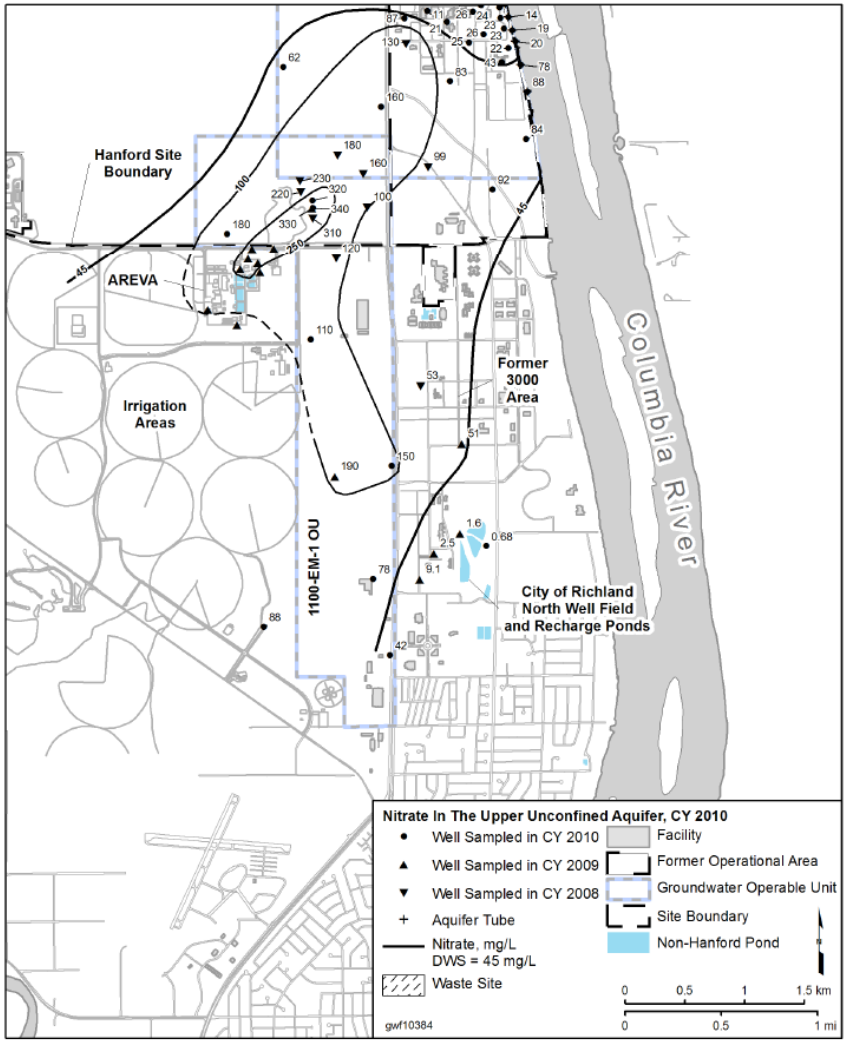
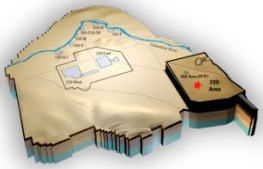


Figure 4-70. Areal Extent of Nitrate in Groundwater Beneath the Southeast Portion of the Hanford Site

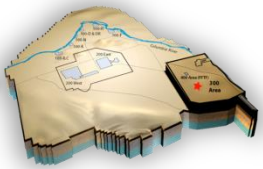
Large-Scale RTD of VZ & PRZ



Hanford 300 Area CERCLA Proposed Plan

- **Will release more U to GW/river than other technologies including "no action"**
- **RTD of VZ alone will not meet remediation goals (Active source is the PRZ; ~30% U mass)**
- **RTD dust control is required for worker protection – Impact to GW (Experience at 618-7 & 618-10 BGs)**
- **Immense scope/cost of excavation (11M cubic yards/>$1B)**
- **28.4M gallons diesel fuel consumption**
- **367K tons carbon dioxide emission**

U Sources are the Liquid Waste Disposal Systems



NPP 1948-1975

SPP 1943-1975

~18 Acres total area

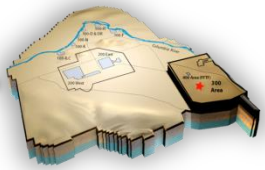
~33 ft to water table

410K to 2M gal/day discharge to ponds

pH varied 1.8 to 11.4

U inventory estimates vary from 40-65 tons

Estimated Contaminant Inventory (kg) for 300 Area North & South Process Ponds



Chemical	South Pond	North Pond
Sodium[b]	2,000,000	2,000,000
Sodium hydroxide	1,000,000	800,000
Nitrite	900,000	700,000
Mercury	60	40
Chromium (VI)	5,000	3,000
Cadmium	80	60
Lead	4,000	2,000
Fluoride	7,000	5,000
Trichloroethylene	100,000	100,000
Uranium	40,000	30,000
Sodium aluminate	2,000,000	2,000,000
Nitrate[c]	1,000,000	800,000
Sodium silicate	100,000	90,000
Nickel	10,000	8,000
Zinc	5,000	3,000
Silver	1,000	900
Beryllium	40	30
Copper	60,000	50,000
Nitric acid	1,000,000	900,000

(a) U. S. Department of Energy (DOE). 1986. Draft Phase I Installation Assessment of Inactive Waste-Disposal Sites at Hanford, Richland, Washington.
(b) Includes sodium from compounds other than those listed.
(c) Includes nitrate from compounds other than those listed.

NPP 1948-1975

SPP 1943-1975

~18 Acres total area

~33 ft to water table

410K to 2M gal/day discharge to ponds

pH varied 1.8 to 11.4

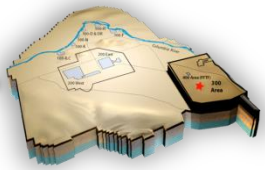
U inventory estimates vary from 40-65 tons

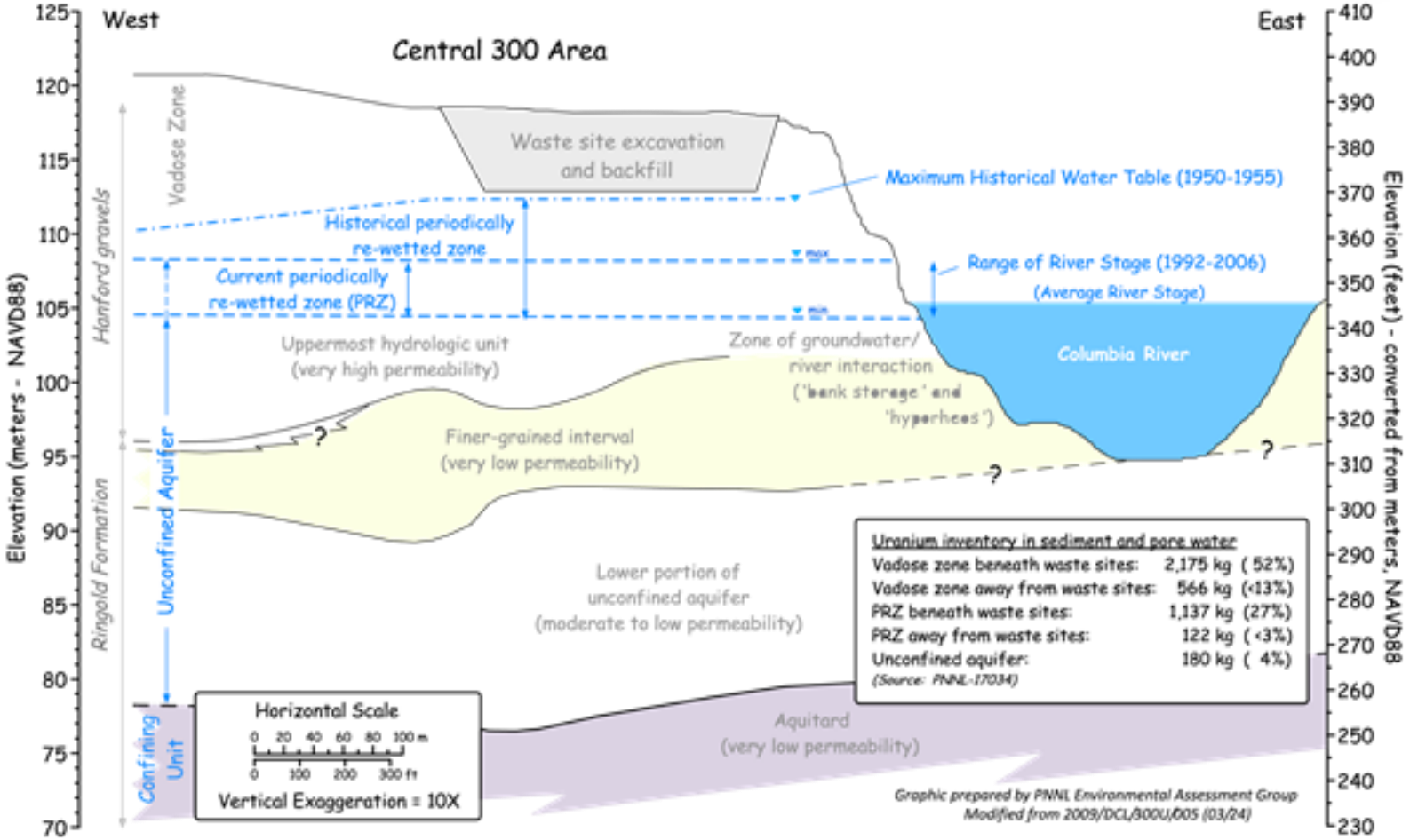
Cu inventory ~266 tons

Sodium Aluminate precipitate

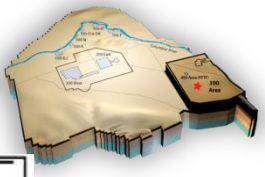
Process Trench 1975-1985

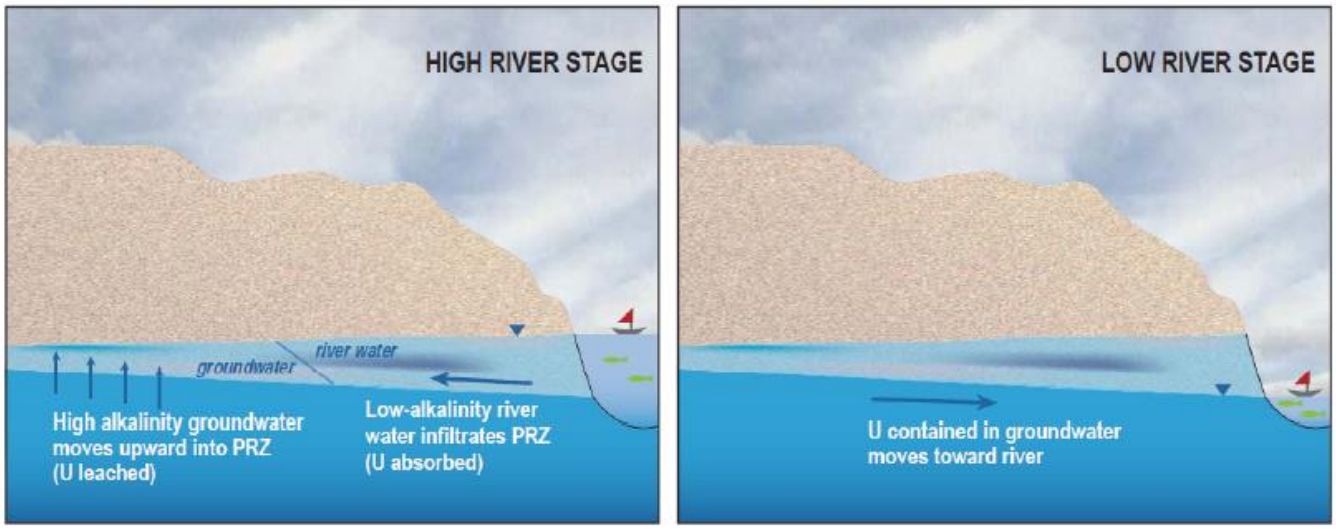
Uranium Inventory Estimate





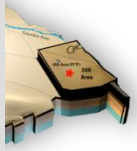
River-Influenced Uranium Transport

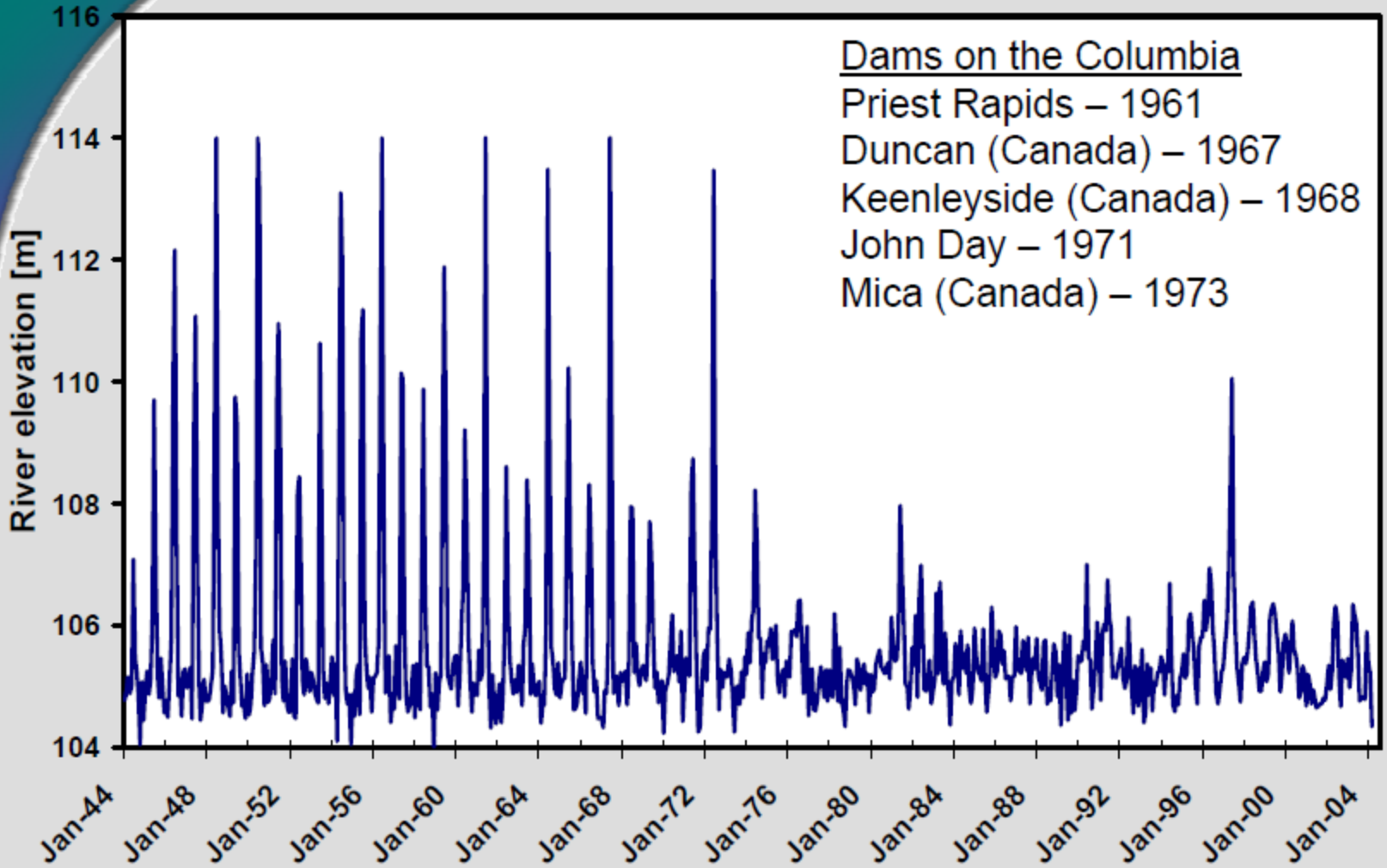




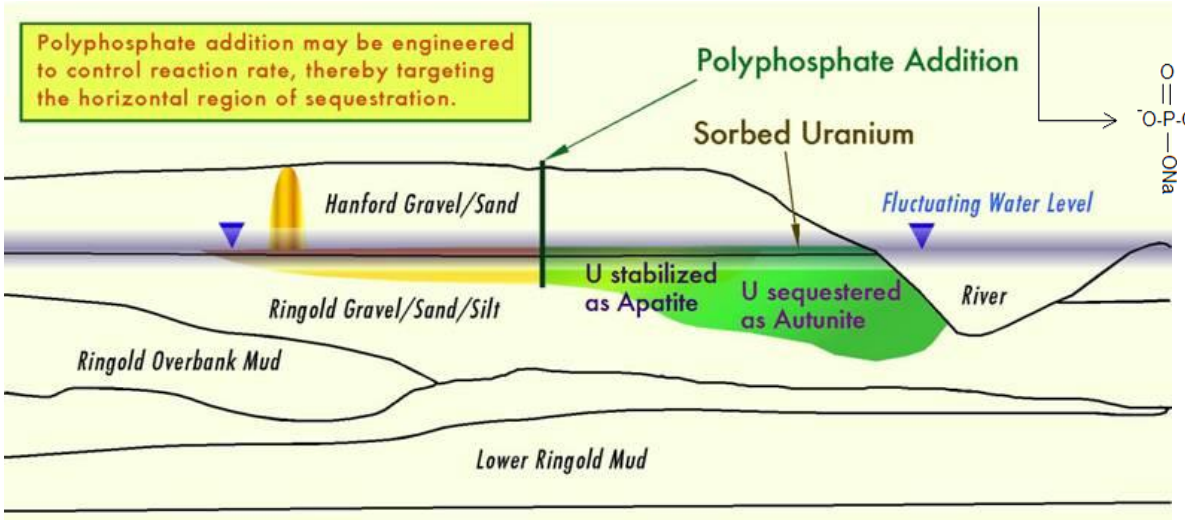
Conceptual Cross Section of River-Influenced Uranium Transport

Reconstruction of Historical River Stages





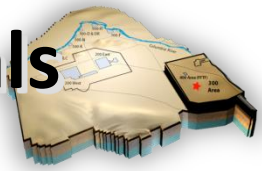
Field Treatability Test of Polyphosphate Addition to Sequester Uranium in the 300 Area



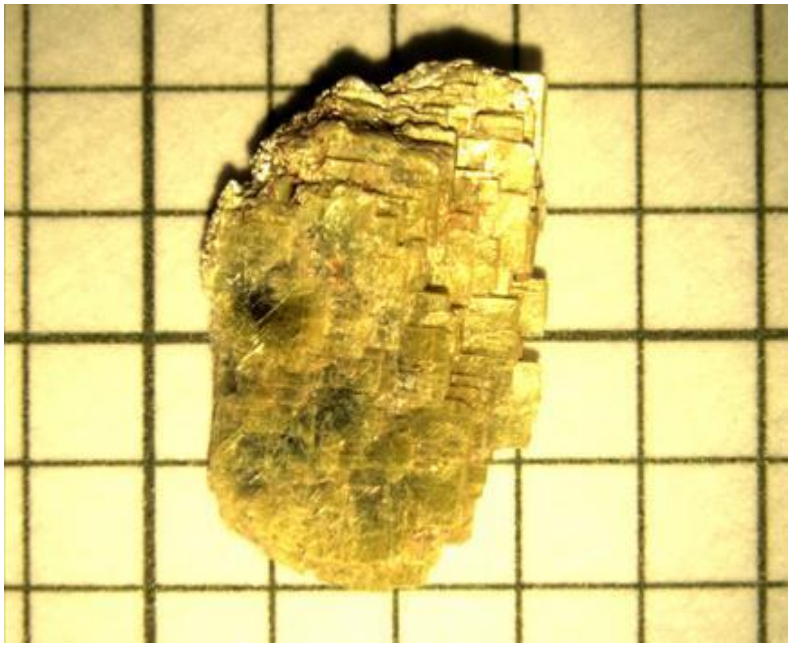
- Injection of soluble polyphosphate
- Lateral plume treatment
- Uranyl phosphate mineral (autunite) formation
  - Immediate sequestration
  - Stable mineral form
- Apatite formation
  - Sorbent for uranium
  - Conversion to autunite

- Phosphate Sequestration – Reduces groundwater uranium concentrations in by precipitating highly insoluble uranium phosphate minerals.
- Reduced Plugging - Polyphosphate acts as time-release of phosphate.

Uranium-Phosphate (Autunite) Minerals



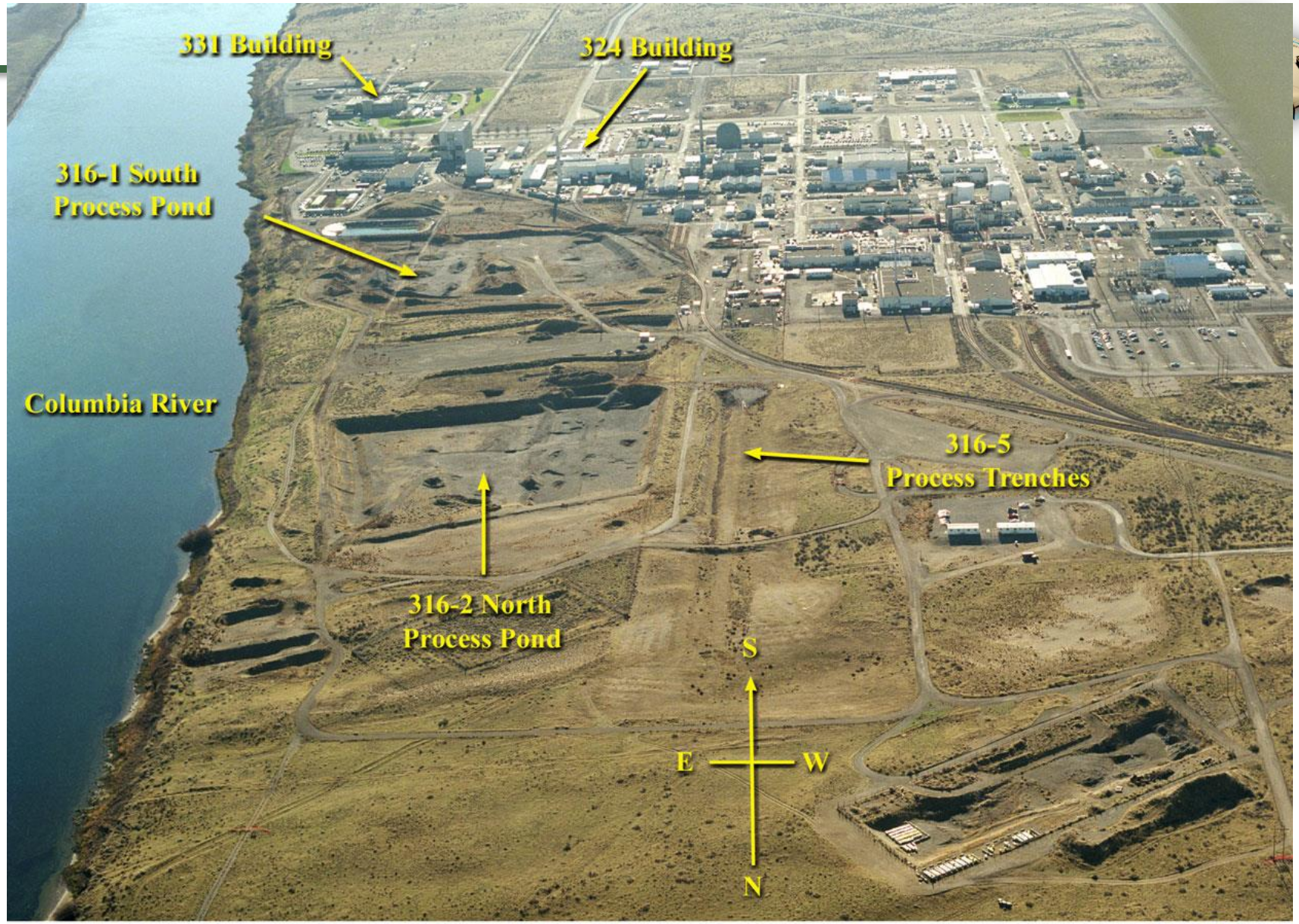
- Autunite [$Ca(UO_2)_2(PO_4)_2 \bullet nH_2O$] is a natural mineral characterized by a very low solubility.
- Formation does NOT depend on changing the redox conditions of the aquifer.
- Not subject to reversible processes such as reoxidation or desorption.



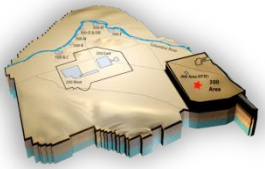

Polyphosphate
treatability test site
Integrated Field-Scale
Research Challenge
test site
Photo: April 16, 2009
(B.N. Bjornstad)

RTD Cleanup Goals for GW protection used in interim actions are determined by VZ transport of U by surface infiltration; U in PRZ is not addressed

Hanford 300 Area CERCLA Proposed Plan

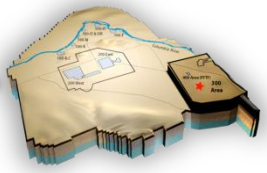

331 Building
324 Building
316-1 South
Process Pond
Columbia River
316-5
Process Trenches
316-2 North
Process Pond
S
E
W
N
01110088-1cn

300-FF-05 Record of Decision for Interim Action 1996

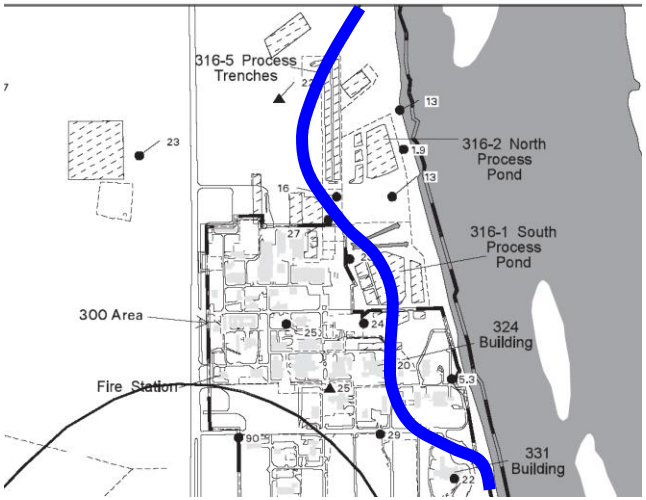


- The 300-FF-5 CERCLA Record of Decision (ROD), July 1996, selected groundwater monitoring and natural attenuation as the interim remedial action.
- The decision to select natural attenuation was based on the 300-FF-05 RI/FS that predicted the Remedial Action Objective (RAO) of meeting the drinking water standard for uranium would be attained in 3 to 10 years (from late 1993).
- The IROD requires continued groundwater monitoring “to verify modeled predictions of contaminant attenuation and to evaluate the need for active remedial measures”.
- The IROD also requires that, “If monitoring does not confirm the predicted decrease of contaminant levels, DOE and EPA will evaluate the need to perform additional response actions.”

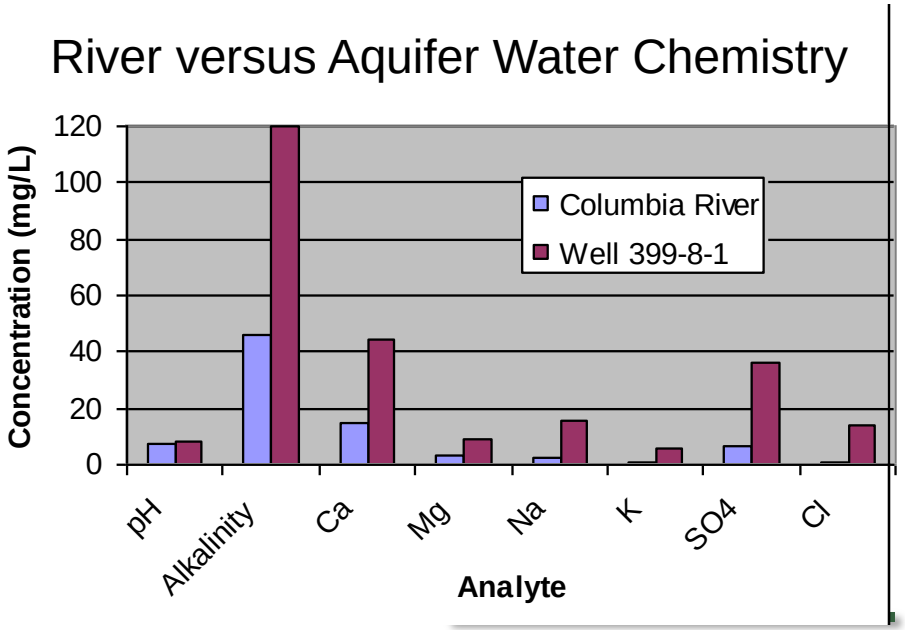
Aquifer-River Mixing Processes

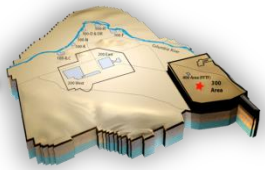


- River water influx occurs during high stage
- Prolonged seasonal high stage period allows mixing in aquifer with river water
- Significant differences in solution chemistry
- High pore velocity observed: 10 m/d pore velocity (Cline et al. 1985)

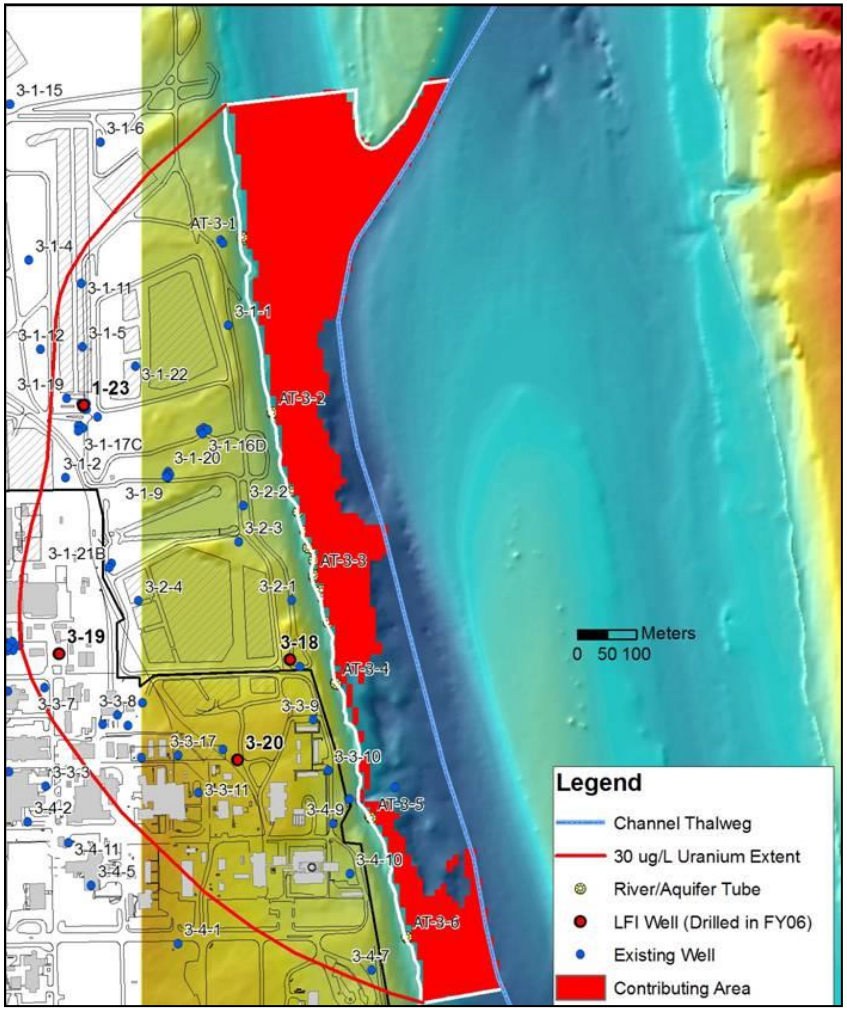


2002 Nitrate Concentration





Area of Riverbed Influenced by Discharge from Saturated Hanford Gravels Unit



Source:
Mackley and Fritz 2007

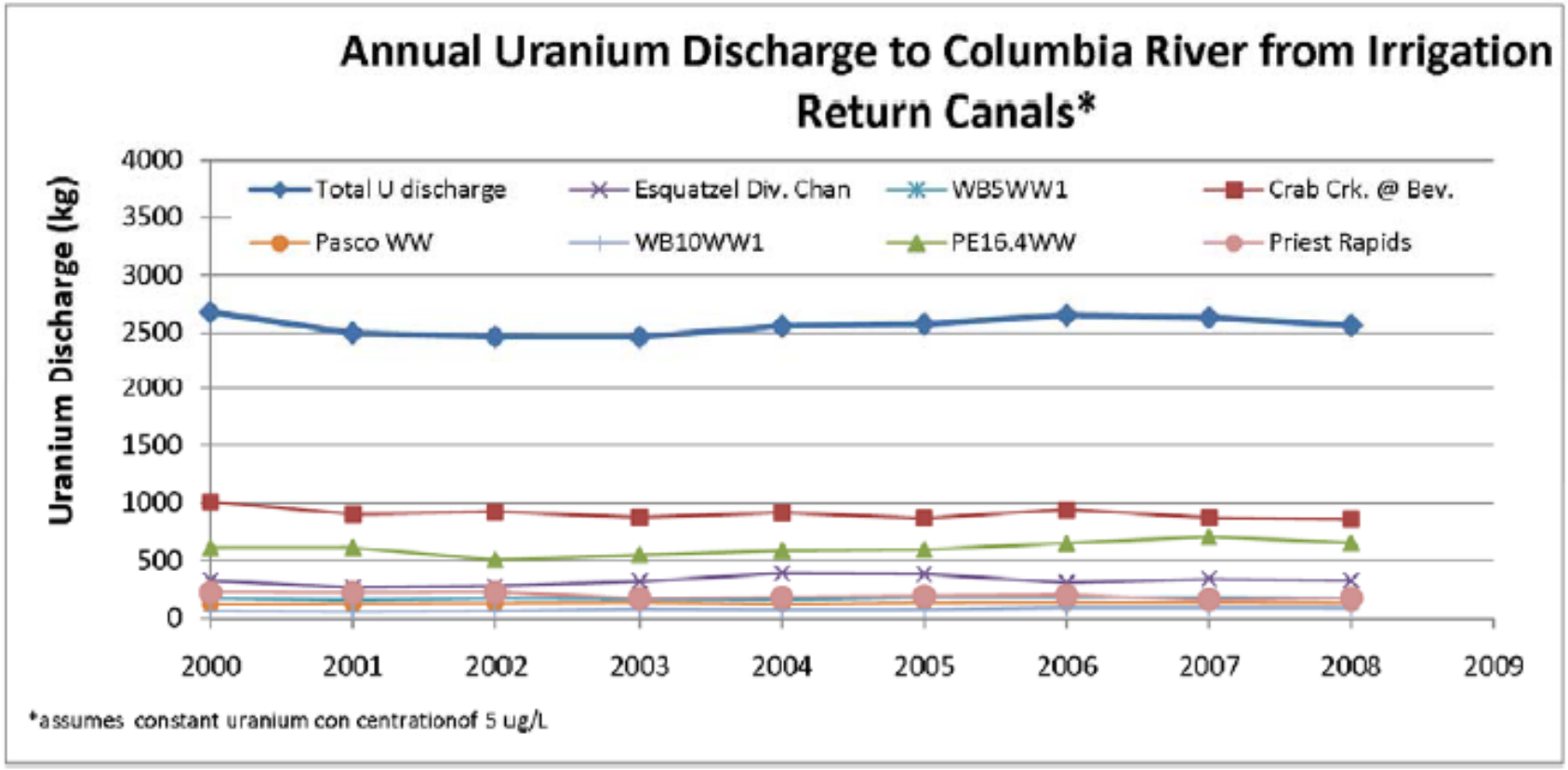
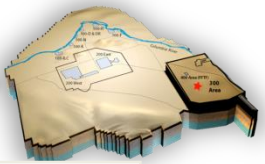


Figure 3-9. Potential Total Uranium Discharge to the Columbia River from 15 Irrigation Waste Ways in the Lower Columbia Basin, Also Showing Discharge from the Top Seven Contributors



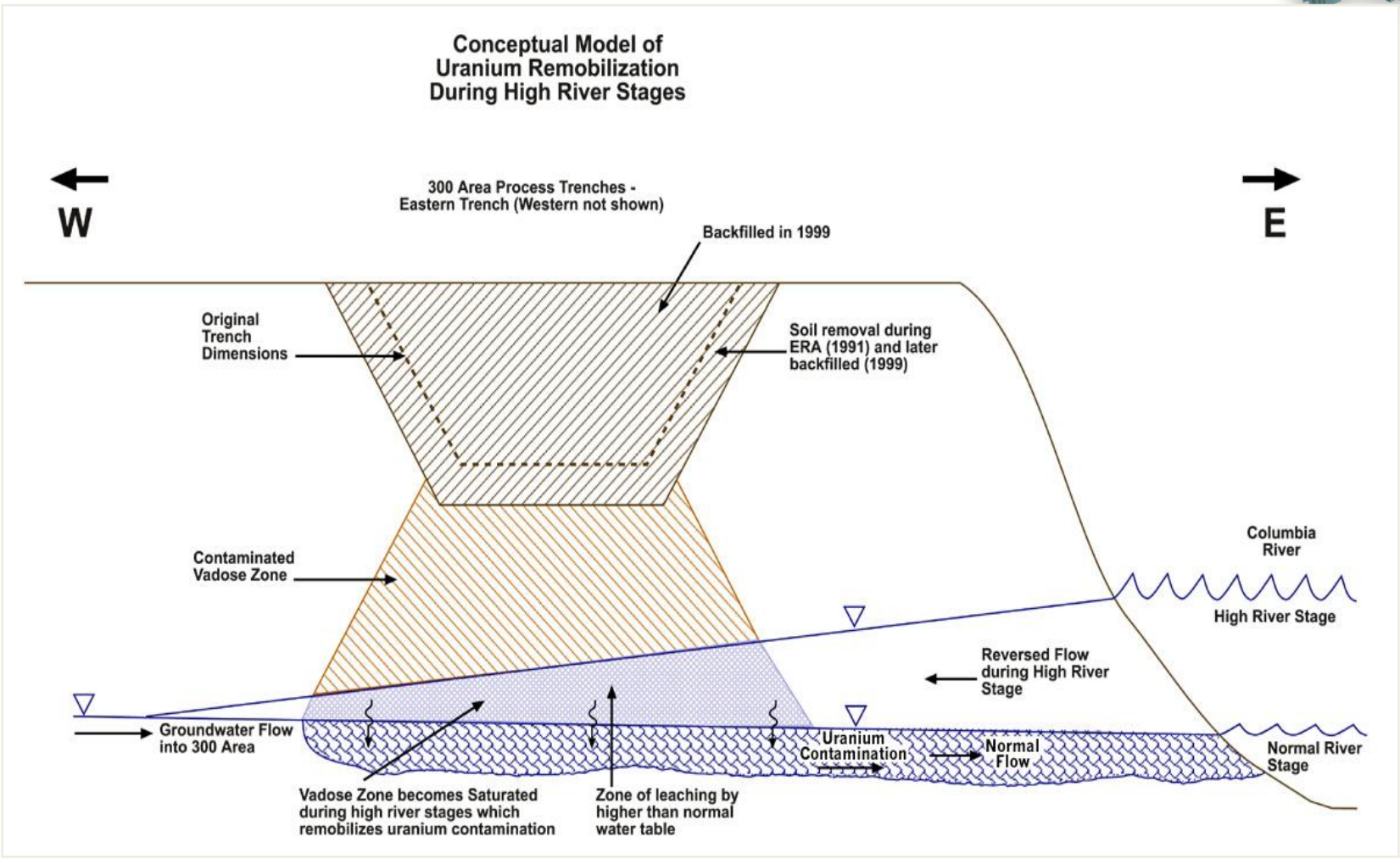
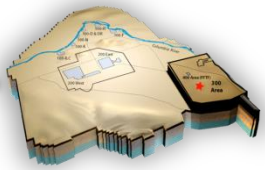


Figure Source: Lindberg 2002

1993 Numerical Model



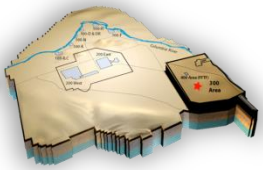
Modeling Assumptions in Phase I Remedial Investigation (1994)

- 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)

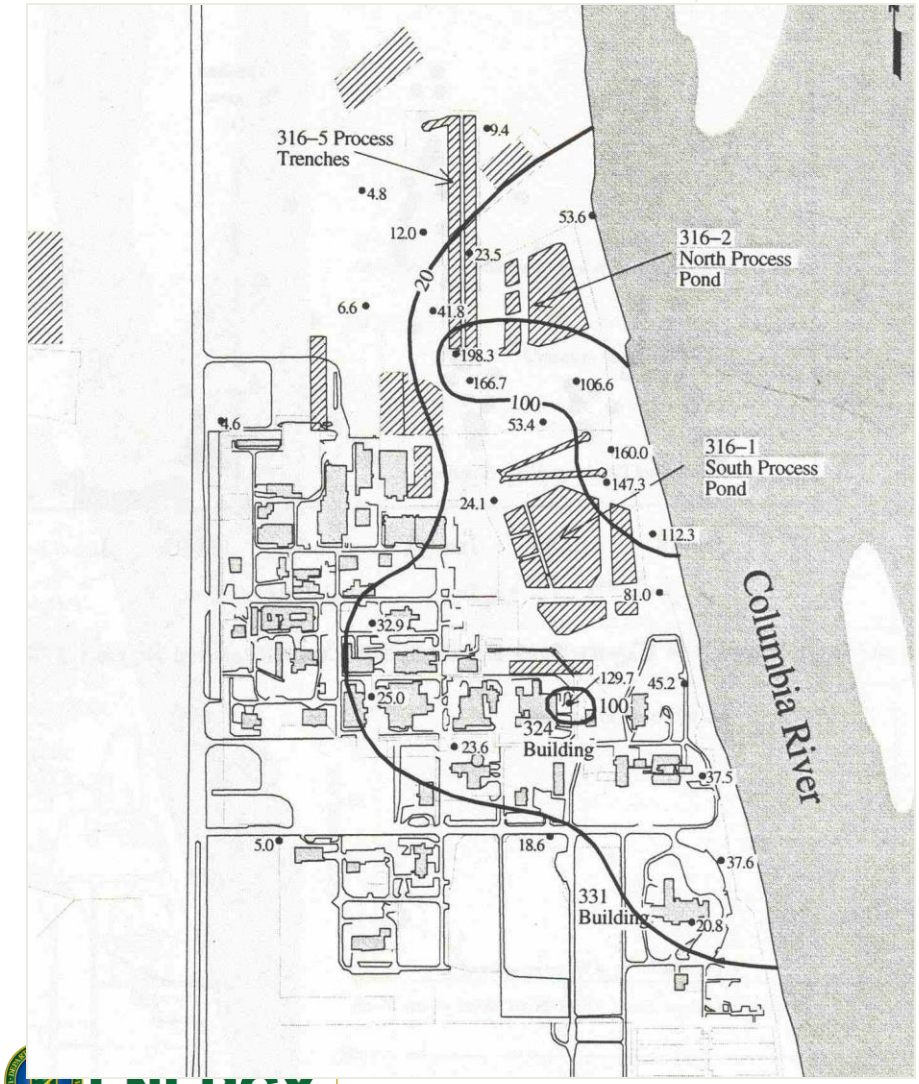
Prediction Update for U < 20 ug/L in RI/FS (1995)

- "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

Conceptual Model 1996 Interim ROD



300 Area Uranium Plume, 1995



- 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.
- A Record-of-Decision was made in 1996 with that assumption.