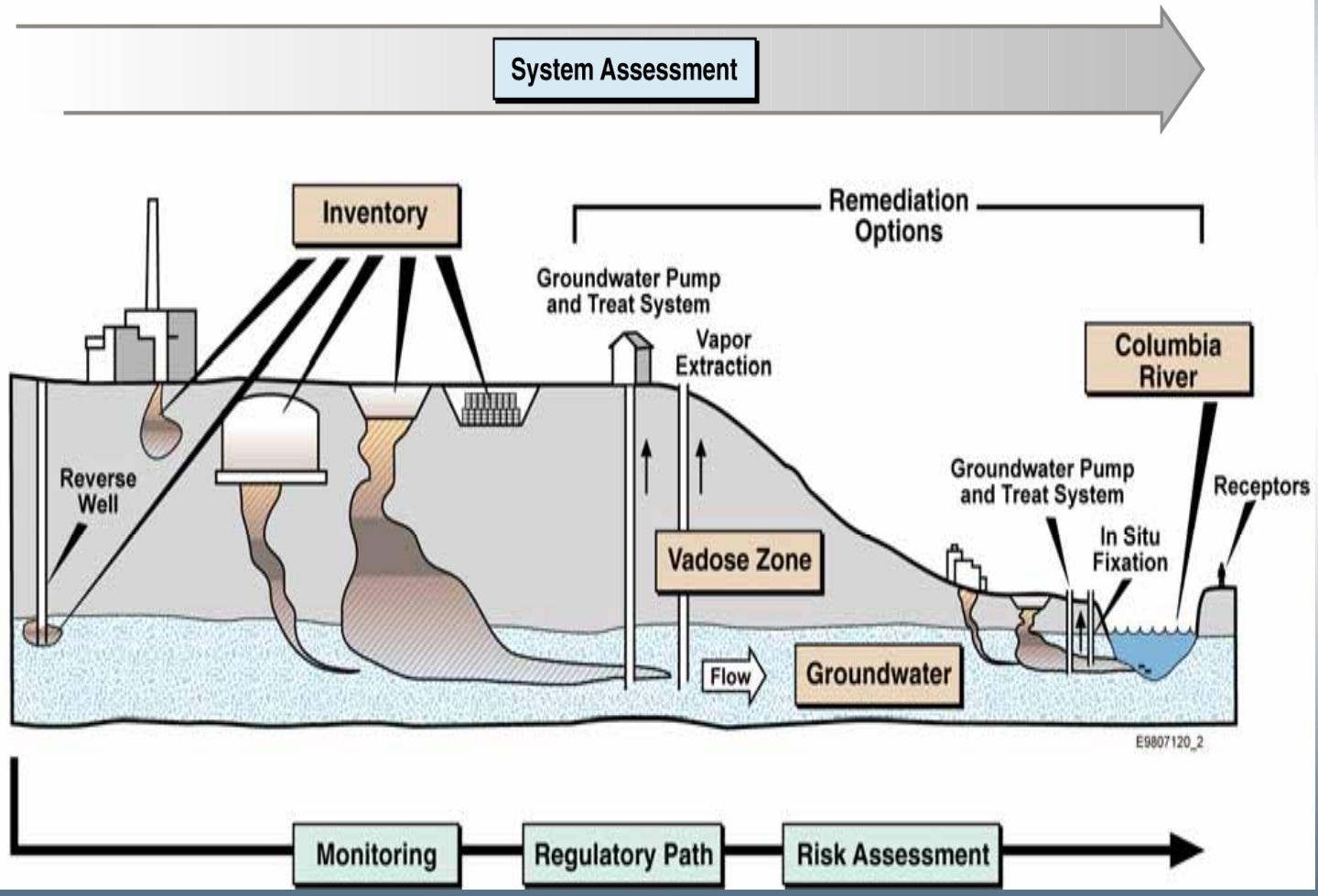
Hanford Groundwater Overview for Hanford Advisory Board River and Plateau Committee

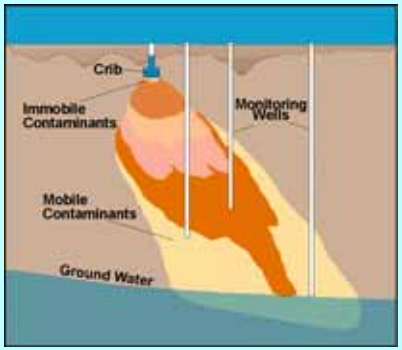
February 8, 2006

System Model

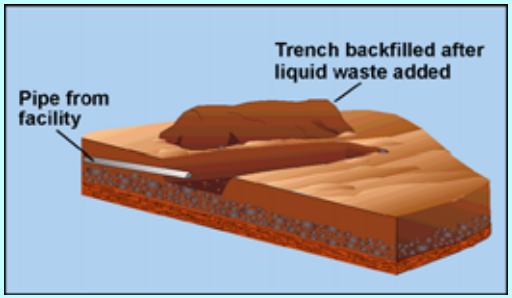


Methods of Planned Liquid Releases to the Ground

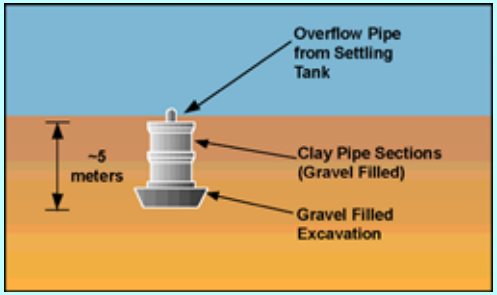
Cribs
1944-1990s



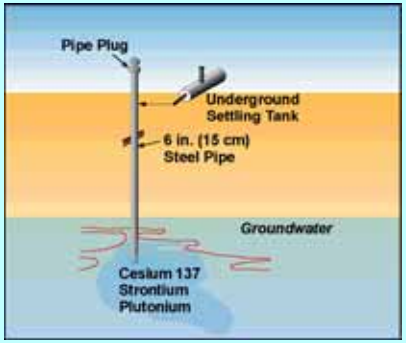
Specific Retention Trenches
1944-1973



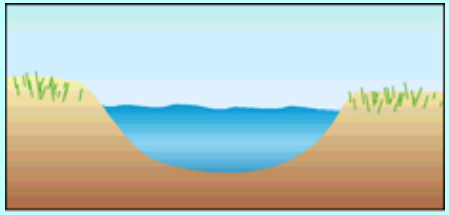
French Drains
1944-1980s



Reverse Wells
1945 - 1955
(one to 1980)

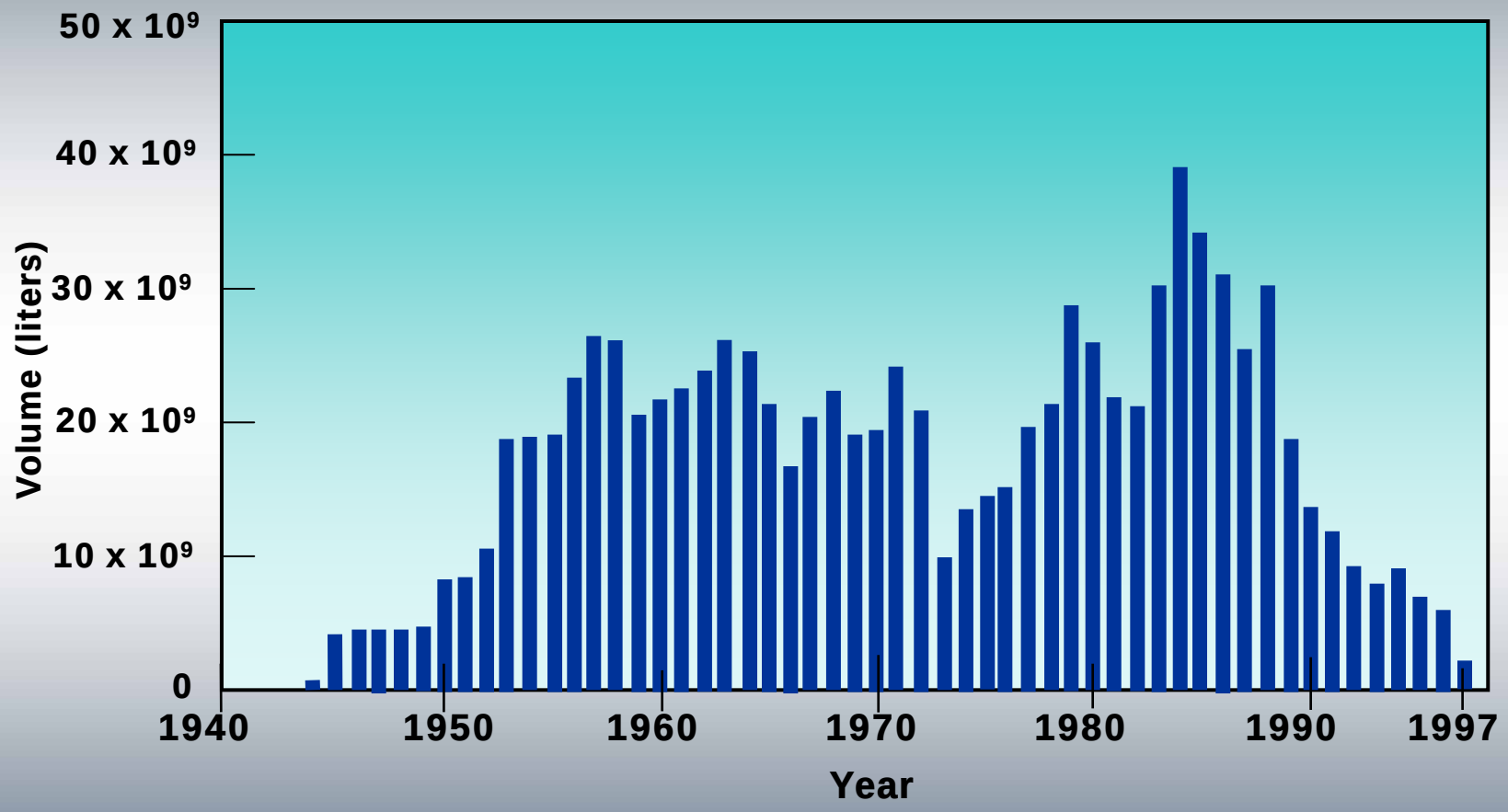


Ponds
1944-1990s



In addition to the planned releases to these engineered structures, unplanned releases, including spills and tank, pipeline and diversion box leaks, have also contributed to the liquid releases to the ground.

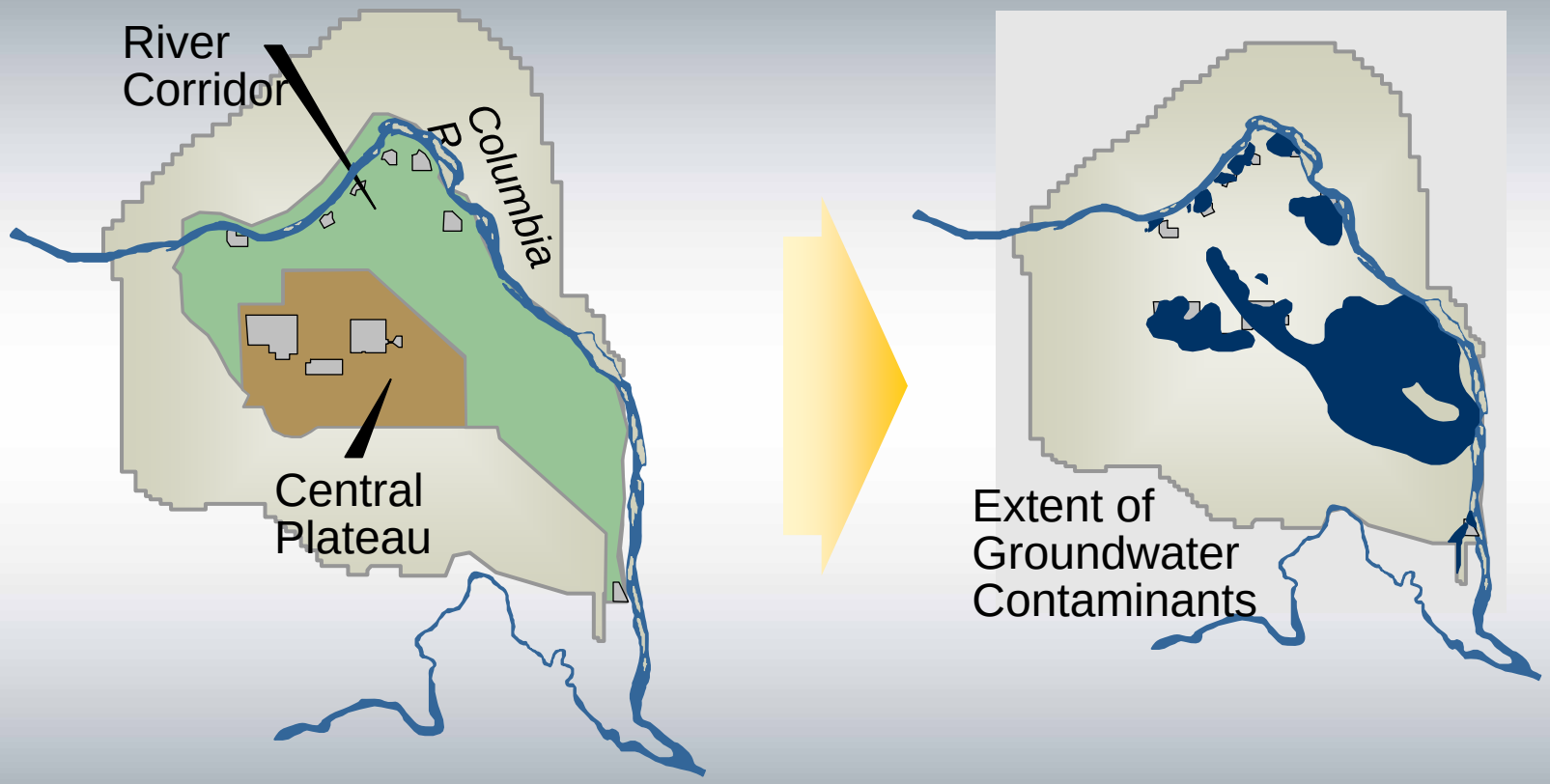
Liquids Discharged to Ground (450 billion gal)



Since 1997 planned liquid discharges have continued at the State Approved Land Disposal Site.

Hanford Site Groundwater Overview

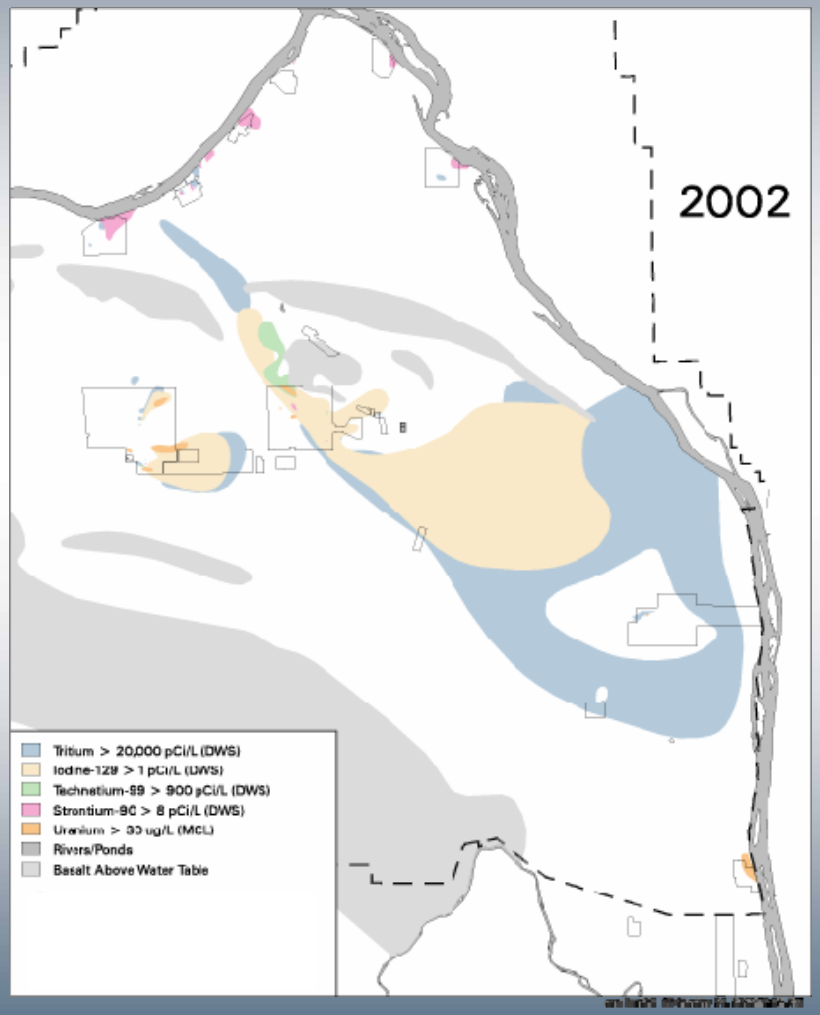
Current Extent of Groundwater Contamination



- Approximately 80 square miles of groundwater contaminated above drinking water standards
- Contaminants from 100/300 Areas and PUREX reach Columbia River

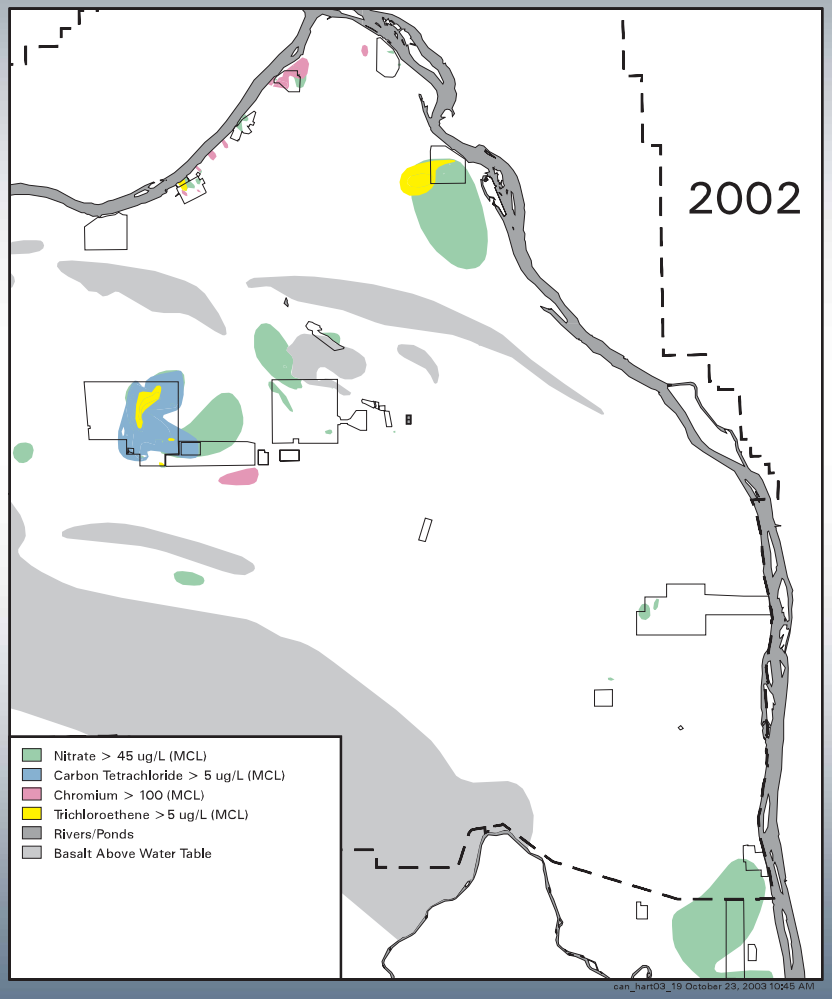
Radioactive Contaminants

- Tritium
- Iodine-129
- Technetium-99
- Uranium
- Strontium-90



Chemical Contaminants

- Nitrate
- Carbon tetrachloride
- Trichloroethene
- Hexavalent chromium



EPA Objectives for Groundwater Protection

"EPA expects to return usable ground waters to their beneficial uses wherever practicable, within a time frame that is reasonable given the particular circumstances of the site. When restoration of ground water to beneficial uses is not practicable, EPA expects to prevent further migration of the plume, prevent exposure to the contaminated ground water, and evaluate further risk reduction"

– 40 CFR 300.430(a)(1)(iii)(F).

C3T Hanford Site Groundwater Strategy

"Once groundwater becomes contaminated it is difficult and costly to remediate. Therefore, prevention of future groundwater contamination is the primary means of protecting groundwater."

– C3T, October 2002

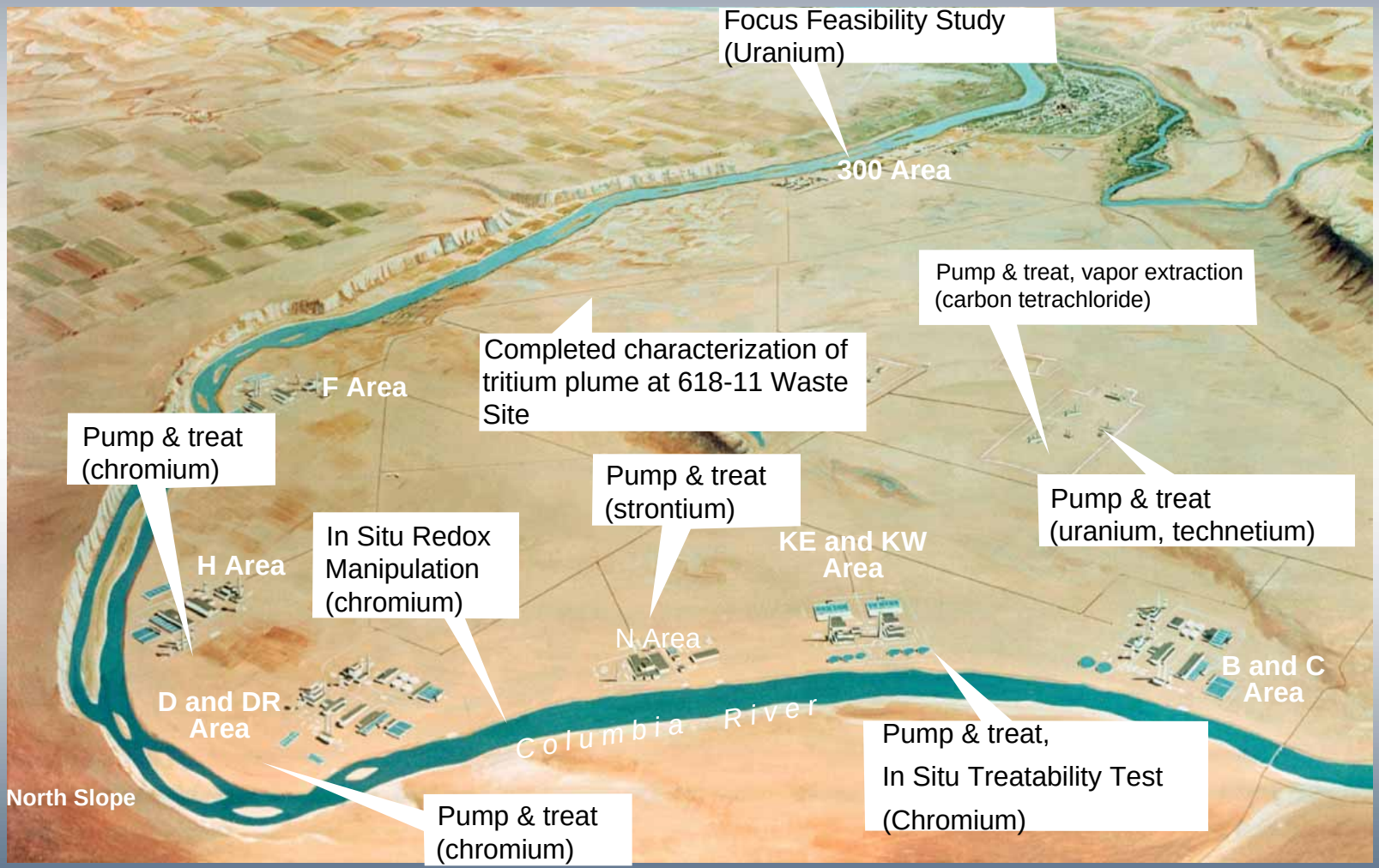
Congressional Mandate is Consistent with Stakeholder Values Articulated by the HAB

- Protect the Columbia River
- Deal realistically and forcefully with groundwater contamination
- Get on with cleanup
- Do no harm during cleanup
- Use the most practicable, timely, available technology, while leaving room for future innovation

Essential Actions for Groundwater Protection

1. Control high-risk sources of contamination.
2. Take groundwater protection measures to reduce the artificial recharge.
3. Implement effective groundwater remedies.
4. Shrink the footprint of the contaminated areas.
5. Integrate Hanford monitoring needs.

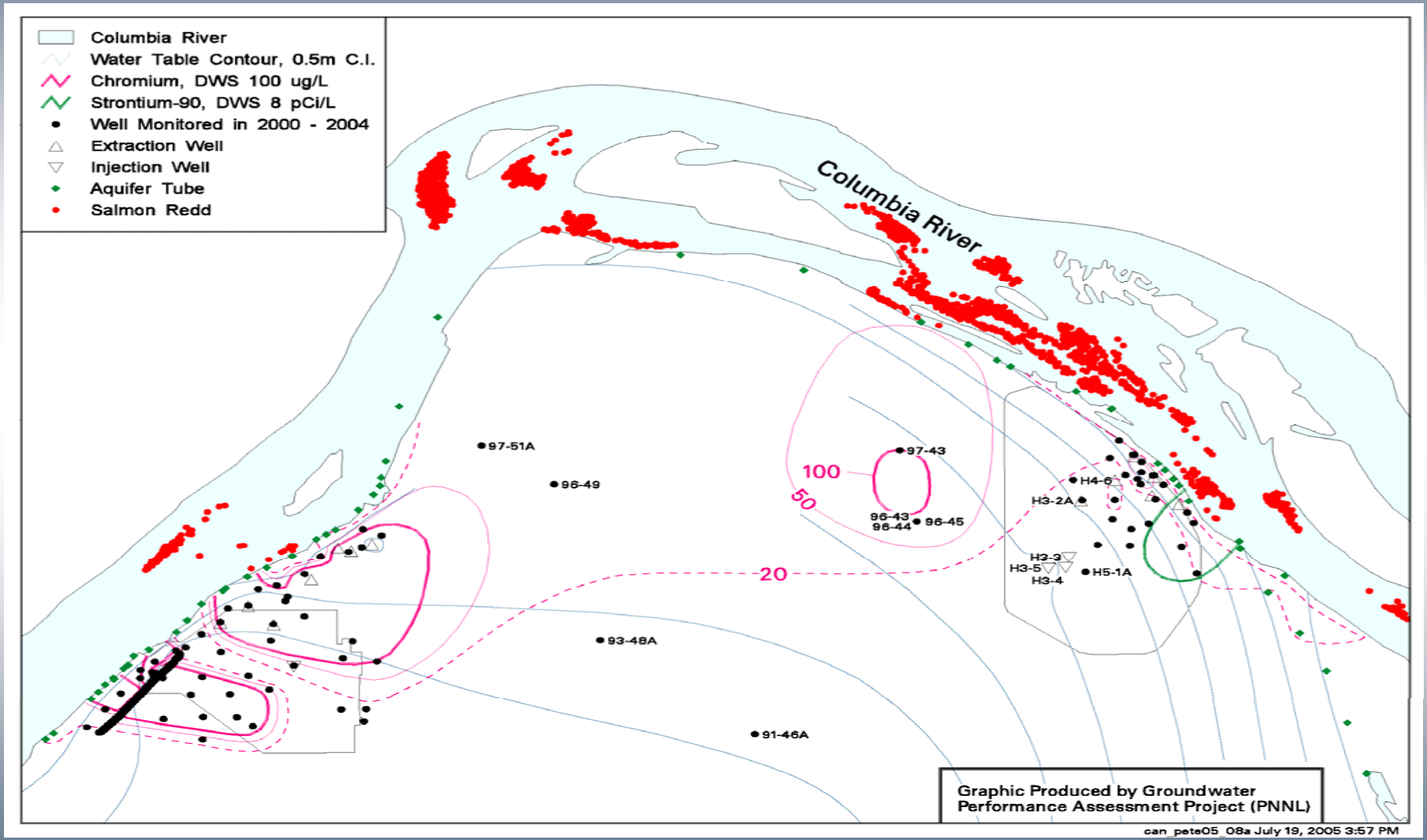
Attacking the Problem...



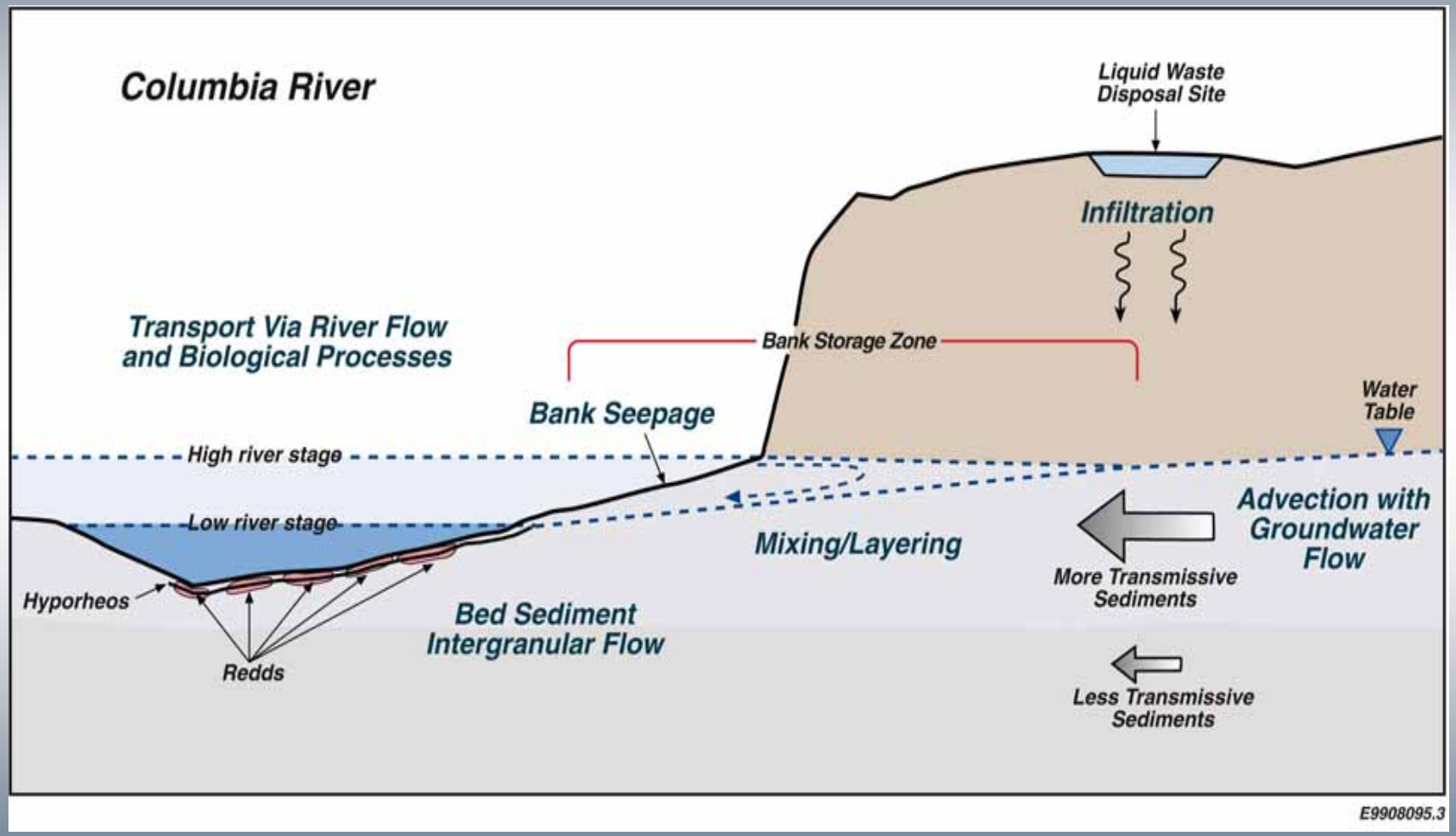
River Corridor

Main River Concern

Salmon Redds



The Aquifer and the Columbia River



Riparian Zone

The Riparian Zone is where contaminants in groundwater are first available to ecological species and are present for human contact.

Installation of Aquifer Sampling Tubes Using Air Hammer

Hanford's "Systems Approach" for Groundwater Protection

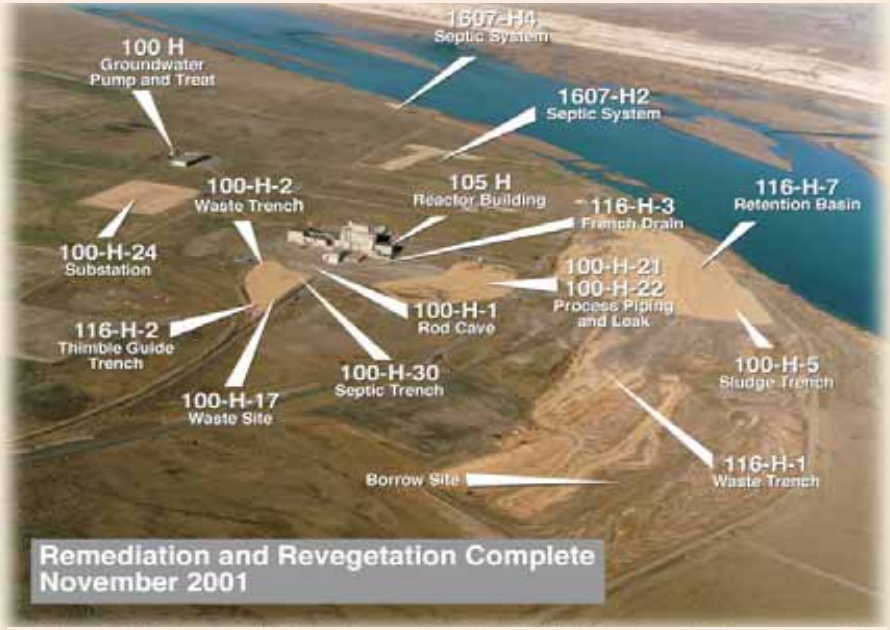
1. Implement remediation systems to protect the river, as required by Interim RODS (1997-present)
2. Find and remediate source terms impacting groundwater (1996-present)
3. Eliminate conditions that mobilize contaminants into groundwater (2001-present)
4. Clean up groundwater to levels required by the Interim ROD

Groundwater Plume Remediation

100 Areas

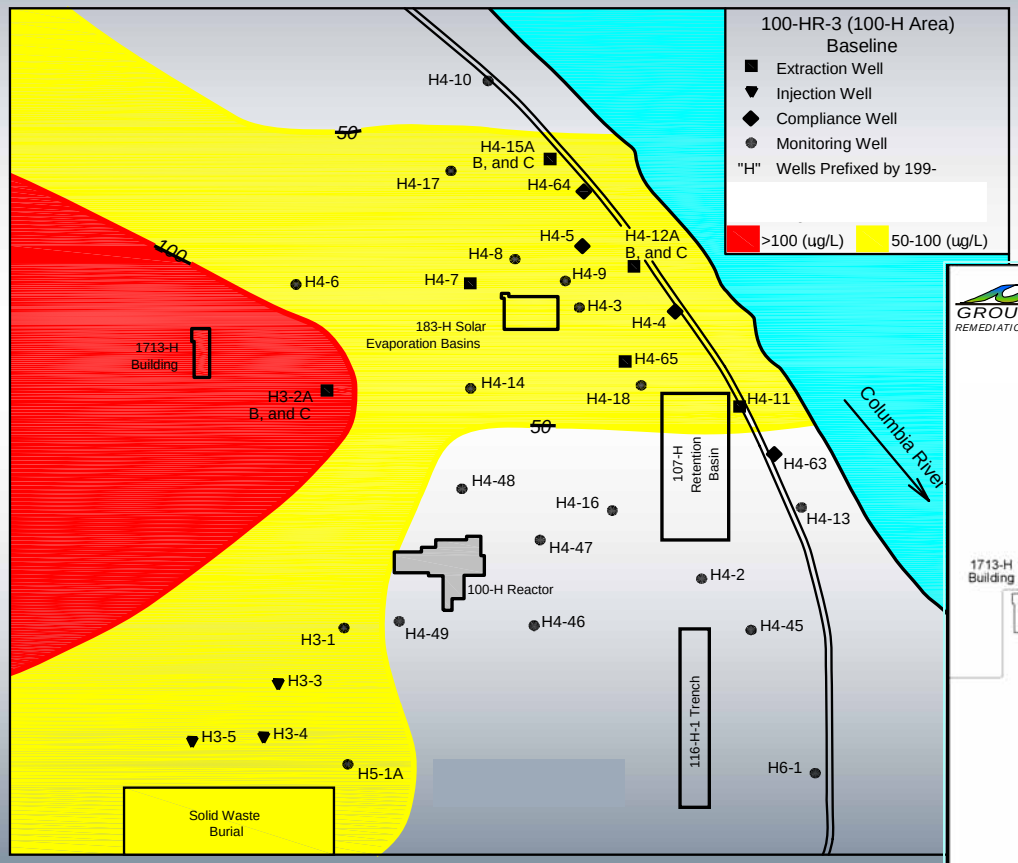
- **Chromium Plumes (100 H, 100 D/DR, and 100 K sites)**
  - Source: Additive to reactor cooling water during reactor operations; cooling water released to cribs and leaks occurred in external hold-up tanks
  - Pathway: Contaminants move through soil (less than one-half mile travel to river bank) and release along river bank and upwell in river
  - Risk: Salmon eggs and newly hatched smolt sensitive to Chromium 6. No human health risk.
  - Status: Active remediation underway; pump and treat, in-situ barrier, and chemical reduction
- **Strontium Plume (100 N)**
  - Source: Fission product from failed fuel; reactor cooling water feed and bleed to two cribs
  - Pathway: contaminants move through soil and release along river bank
  - Risk: No risk to Columbia River; Shoreline restrictions to exposure to seeps
  - Status: Pump and Treat being replaced with in-situ barrier along river shore.

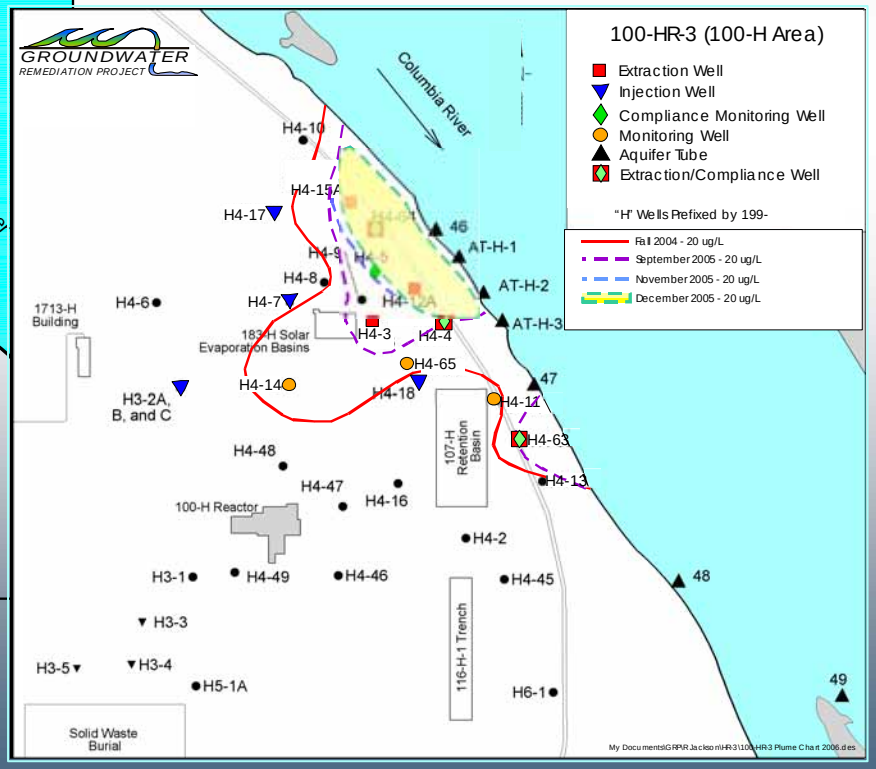
100-H Area
Remediation Progress



100-H Pump & Treat Operations

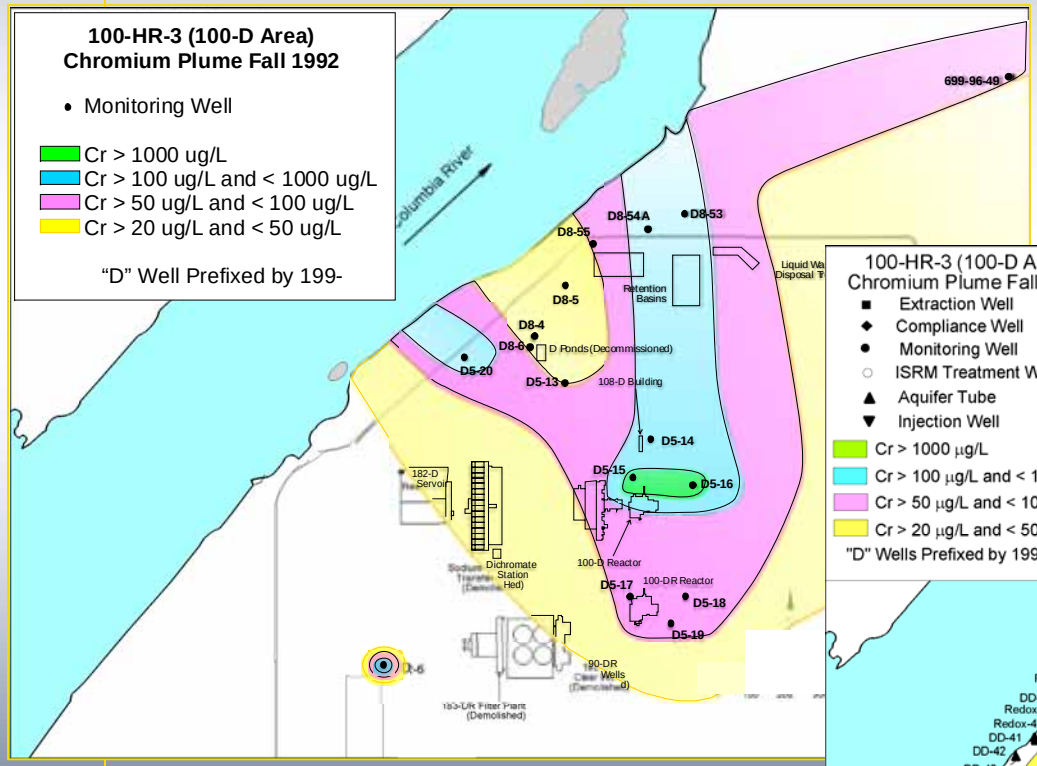
- Operated Since 1997
- ~ 42 Kg Removed
- Anticipated Cr+6 Below 20ug/L in 2006

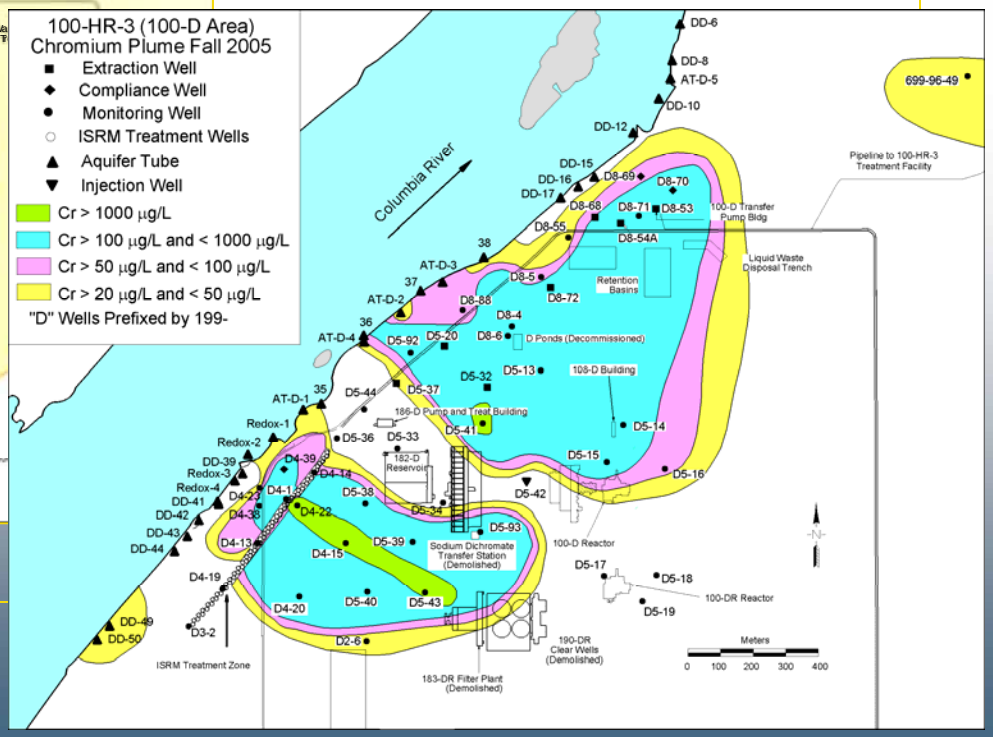




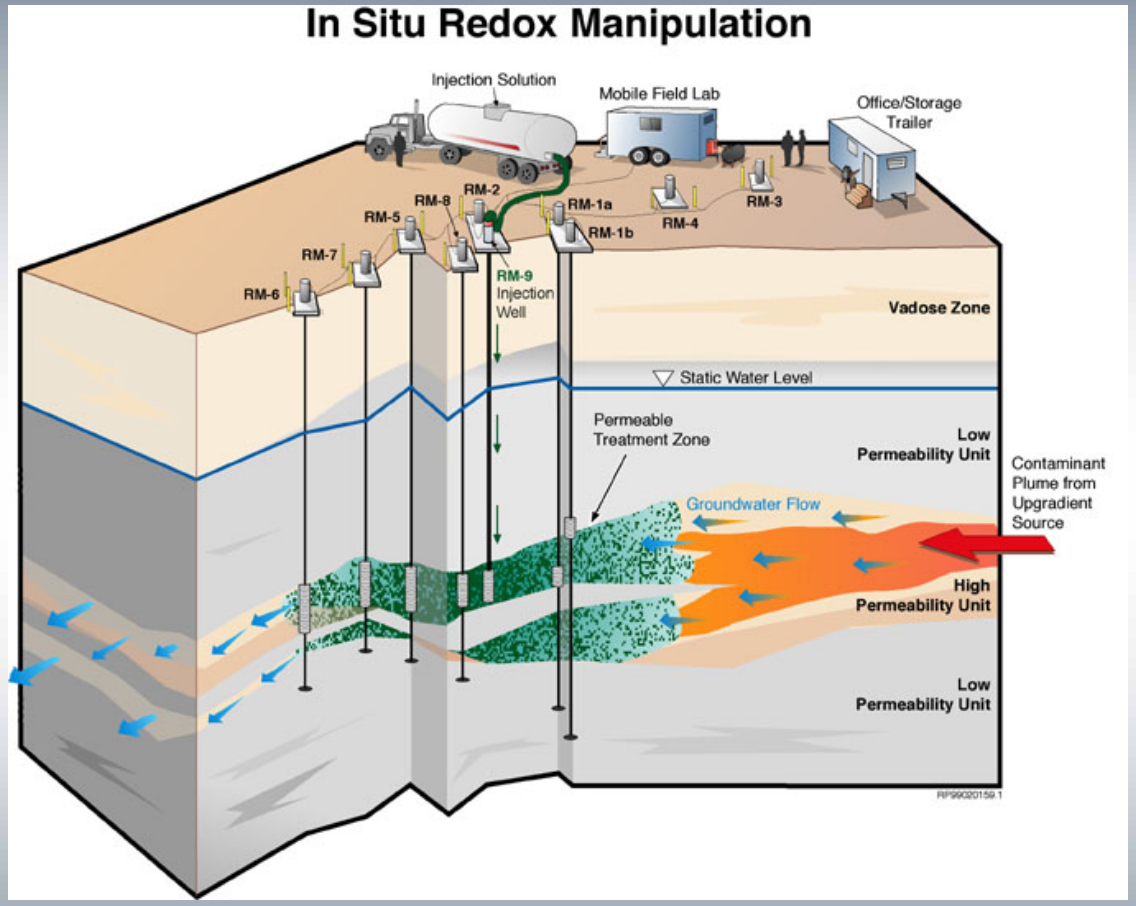
100-D Pump & Treat / ISRM System

- Uses Three Remediation Systems
- Initial System Operated Since 1997
- DR5 P&T System Operated Since 2004
- ISRM Barrier started in 1999
- Pump & Treats removed ~245kg of Cr+6



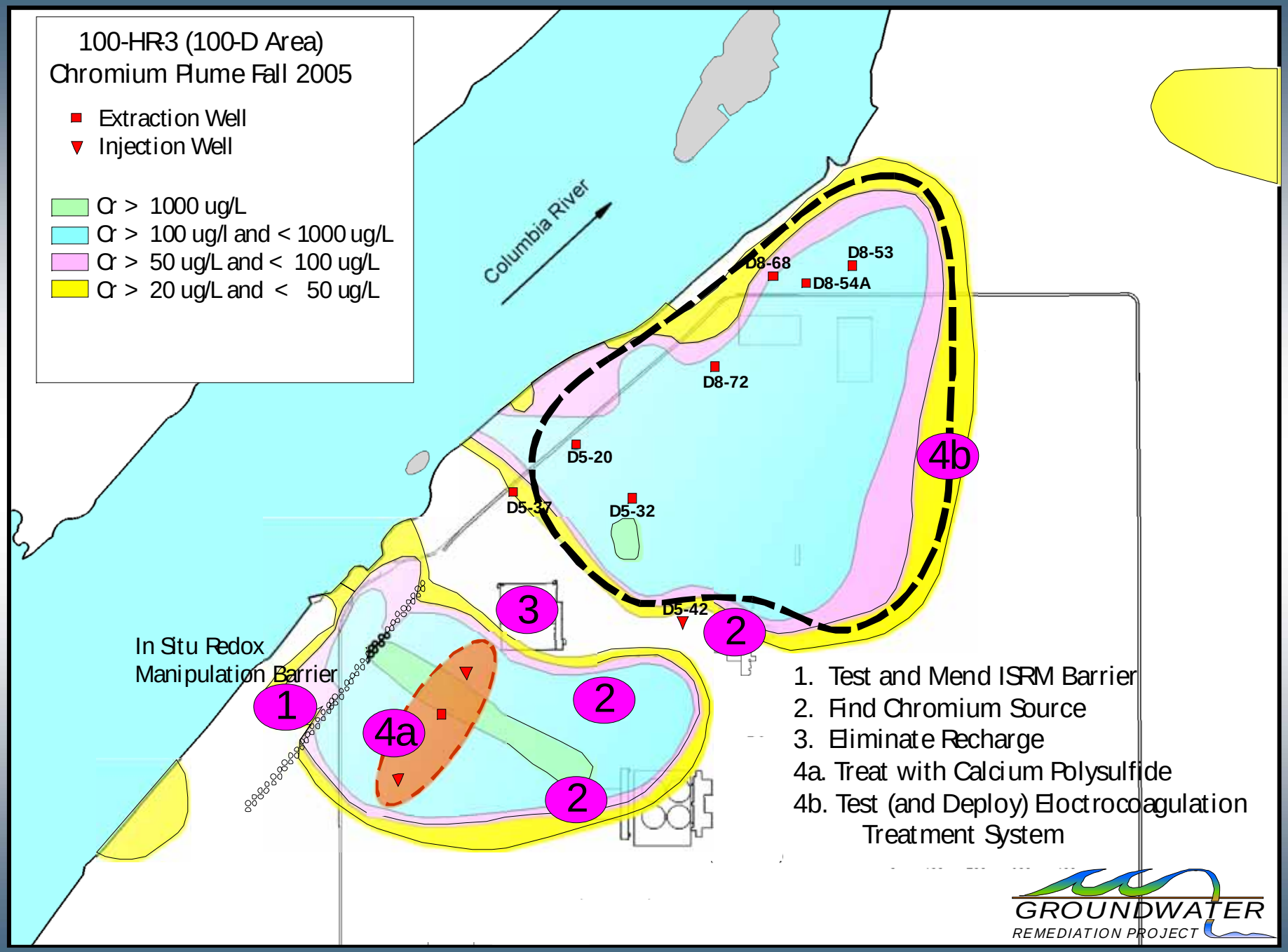


Continually Seeking Solutions: In Situ Redox Manipulation



In situ redox manipulation reduces the toxicity and mobility of chromium already in groundwater. This technique causes the mobile chemical species chromate to be chemically reduced to a less mobile form.

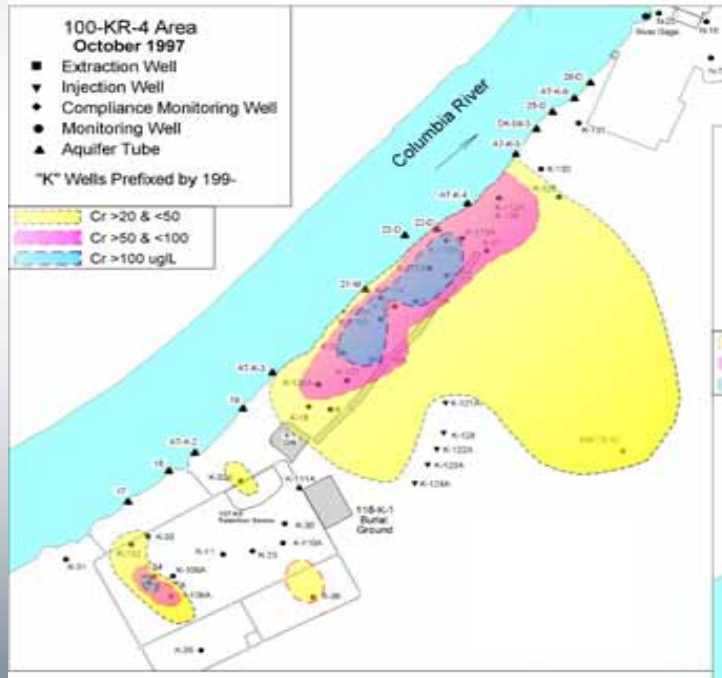
100-D Area
ISRM Barrier

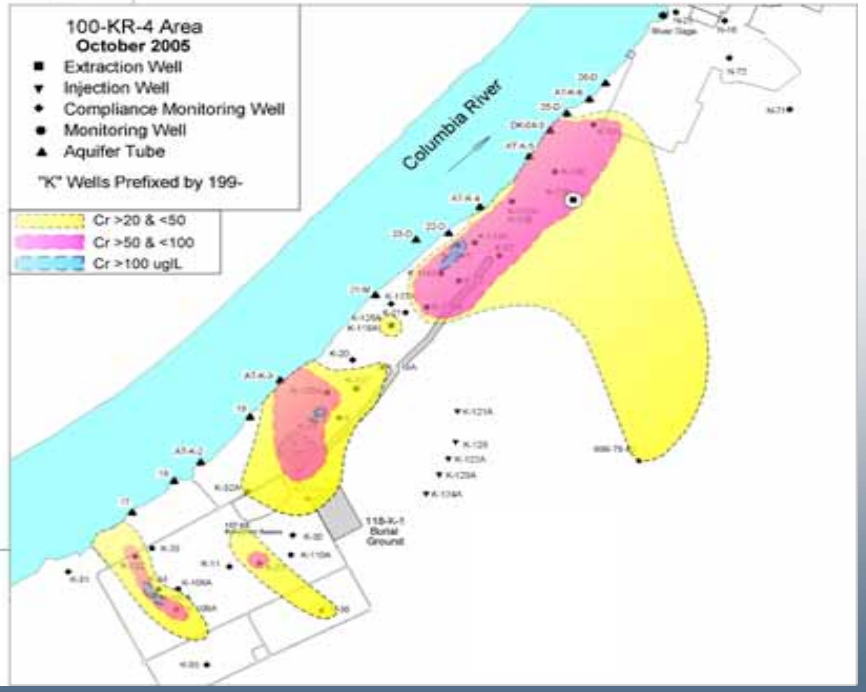

100-HR-3 (100-D Area)
Chromium Plume Fall 2005
Extraction Well
Injection Well
Cr > 1000 ug/L
Cr > 100 ug/l and < 1000 ug/L
Cr > 50 ug/L and < 100 ug/L
Cr > 20 ug/L and < 50 ug/L
Columbia River
D8-68
D8-53
D8-54A
D8-72
D5-20
D5-37
D5-32
D5-42
4b
3
2
2
2
1
4a
In Situ Redox
Manipulation Barrier
1. Test and Mend ISRM Barrier
2. Find Chromium Source
3. Eliminate Recharge
4a. Treat with Calcium Polysulfide
4b. Test (and Deploy) Electrocoagulation
Treatment System
GROUNDWATER
REMEDIATION PROJECT

100-K Area
Chromium Plume Distribution

100-K Pump & Treat Operations

Operated Since 1997
~265 Kg Removed
Observed elevated Chromium in Aquifer Tubes Near The KW Reactor Area in 2004

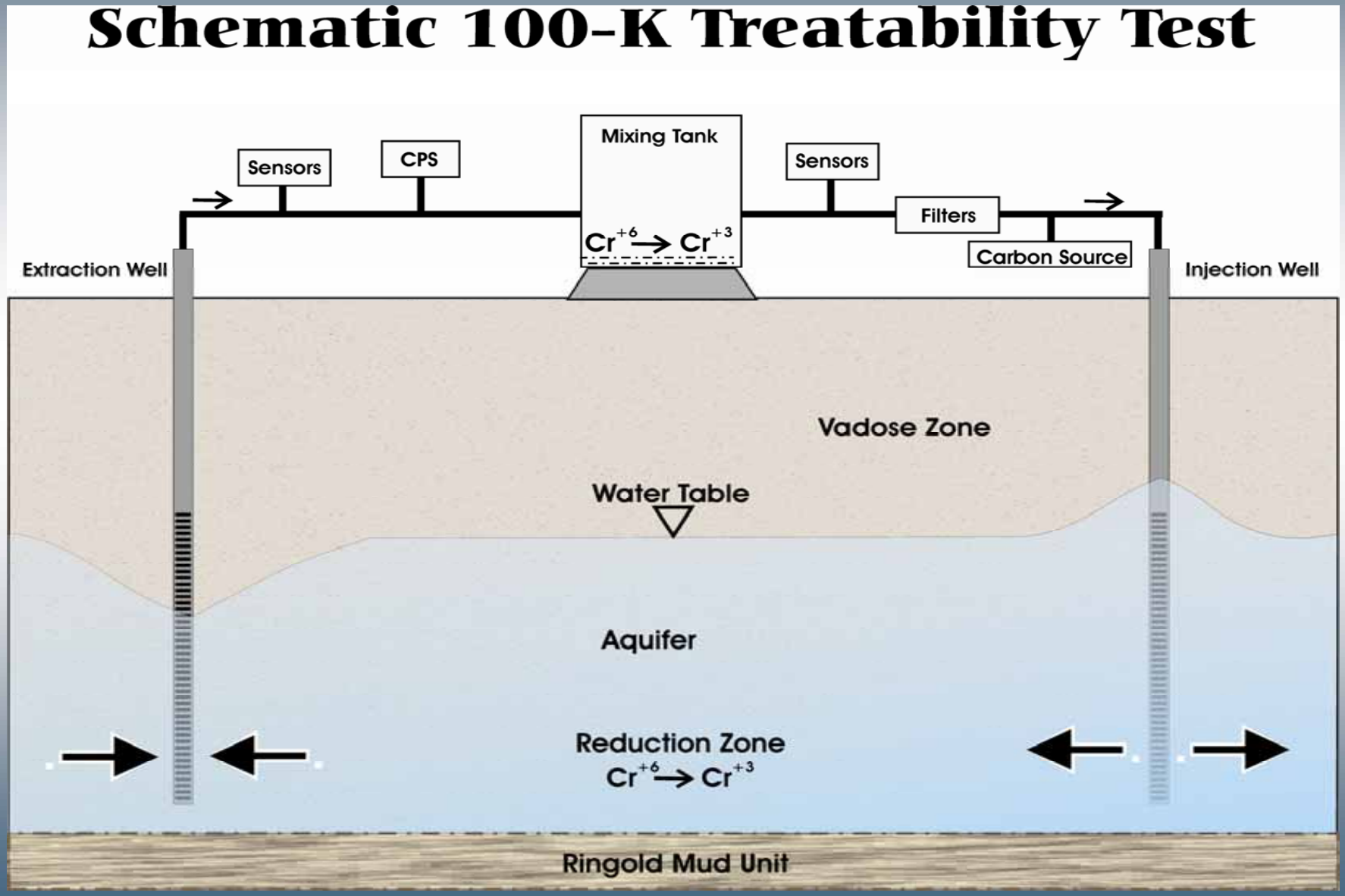




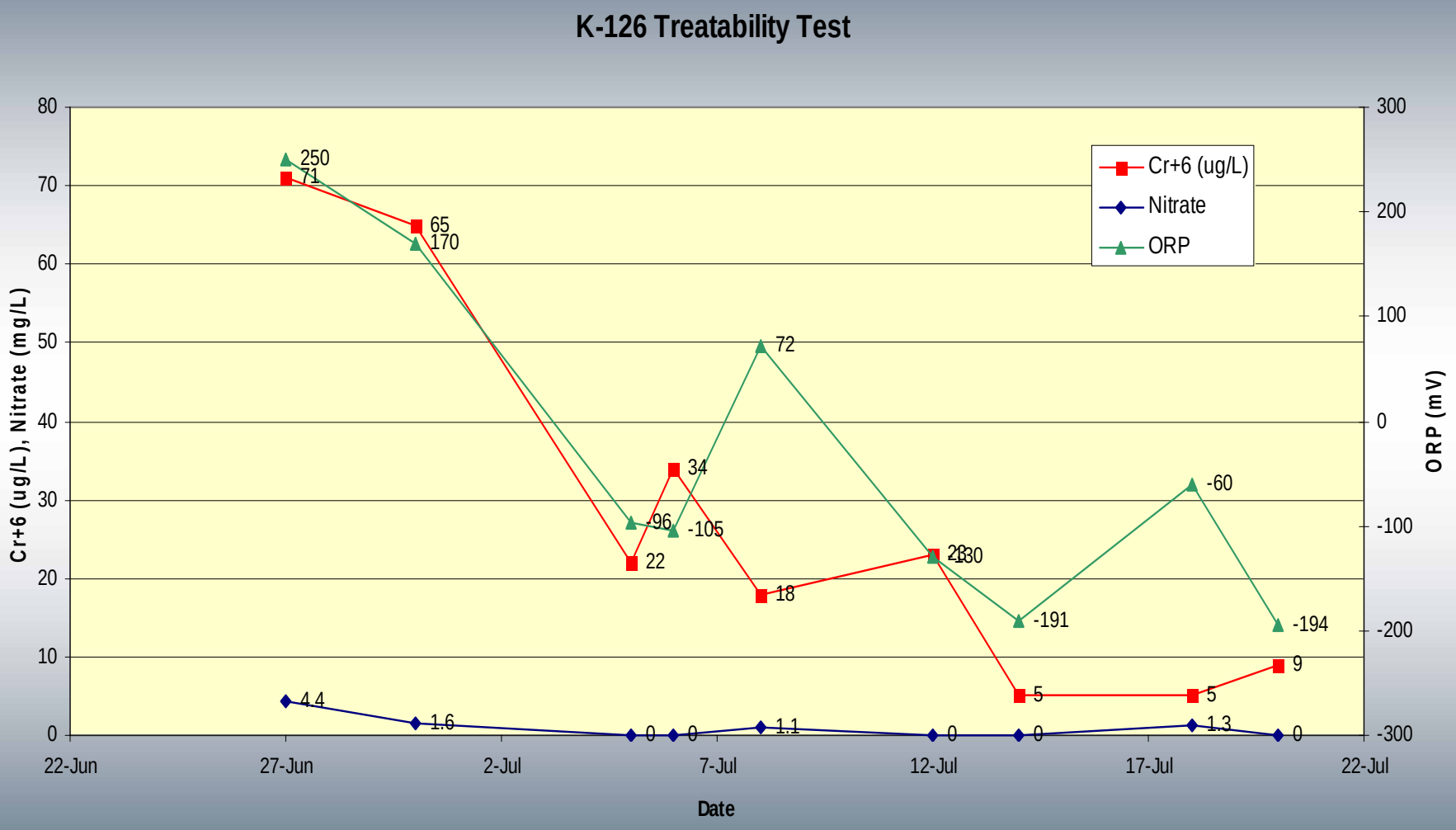
Past Direct Discharges During Reactor Operations
KE Reactor Retention Basins and Crib During Operations

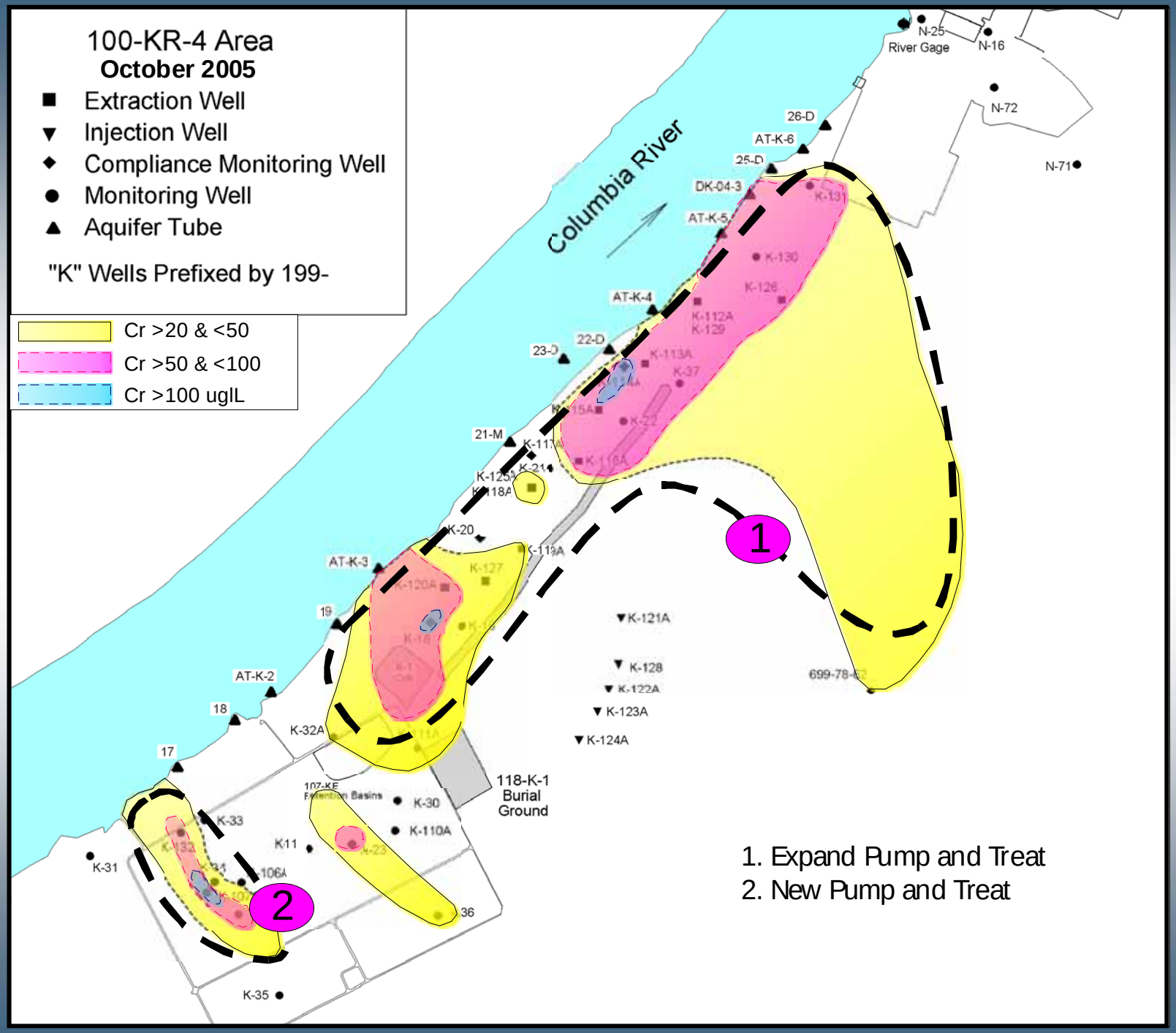
100-K Area
Soil Remediation 116-K-2 Trench

100-K Area


Schematic 100-K Treatability Test
Mixing Tank
Sensors
CPS
Sensors
Filters
Carbon Source
$Cr^{+6} \rightarrow Cr^{+3}$
Extraction Well
Injection Well
Vadose Zone
Water Table
Aquifer
Reduction Zone
$Cr^{+6} \rightarrow Cr^{+3}$
Ringold Mud Unit

100-K Area


K-126 Treatability Test
Cr+6 (ug/L), Nitrate (mg/L)
ORP (mV)
Date
Cr+6 (ug/L)
Nitrate
ORP
80
70
60
50
40
30
20
10
0
300
200
100
0
-100
-200
-300
22-Jun
27-Jun
2-Jul
7-Jul
12-Jul
17-Jul
22-Jul
250
71
65
170
22
-96
34
-105
72
18
23
-130
-191
-60
5
5
9
-194
4.4
1.6
0
0
1.1
0
0
1.3
0

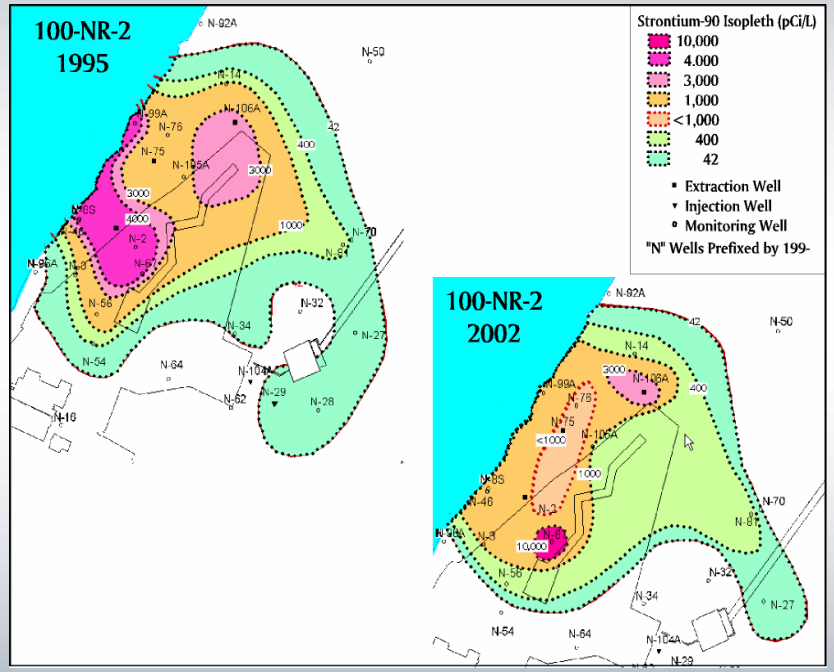

100-KR-4 Area
October 2005
Extraction Well
Injection Well
Compliance Monitoring Well
Monitoring Well
Aquifer Tube
"K" Wells Prefixed by 199-
Cr >20 & <50
Cr >50 & <100
Cr >100 uglL
Columbia River
N-25
River Gage
N-16
N-72
N-71
26-D
AT-K-6
25-D
DK-04-3
AT-K-5
AT-K-4
22-D
23-D
21-M
AT-K-3
19
AT-K-2
18
17
K-20
K-32A
K-33
K-31
K11
106A
K-35
K-30
K-110A
36
118-K-1
Burial
Ground
K-121A
K-128
K-122A
K-123A
K-124A
1
2
1. Expand Pump and Treat
2. New Pump and Treat

100-N Area

Past Discharge at N–Springs

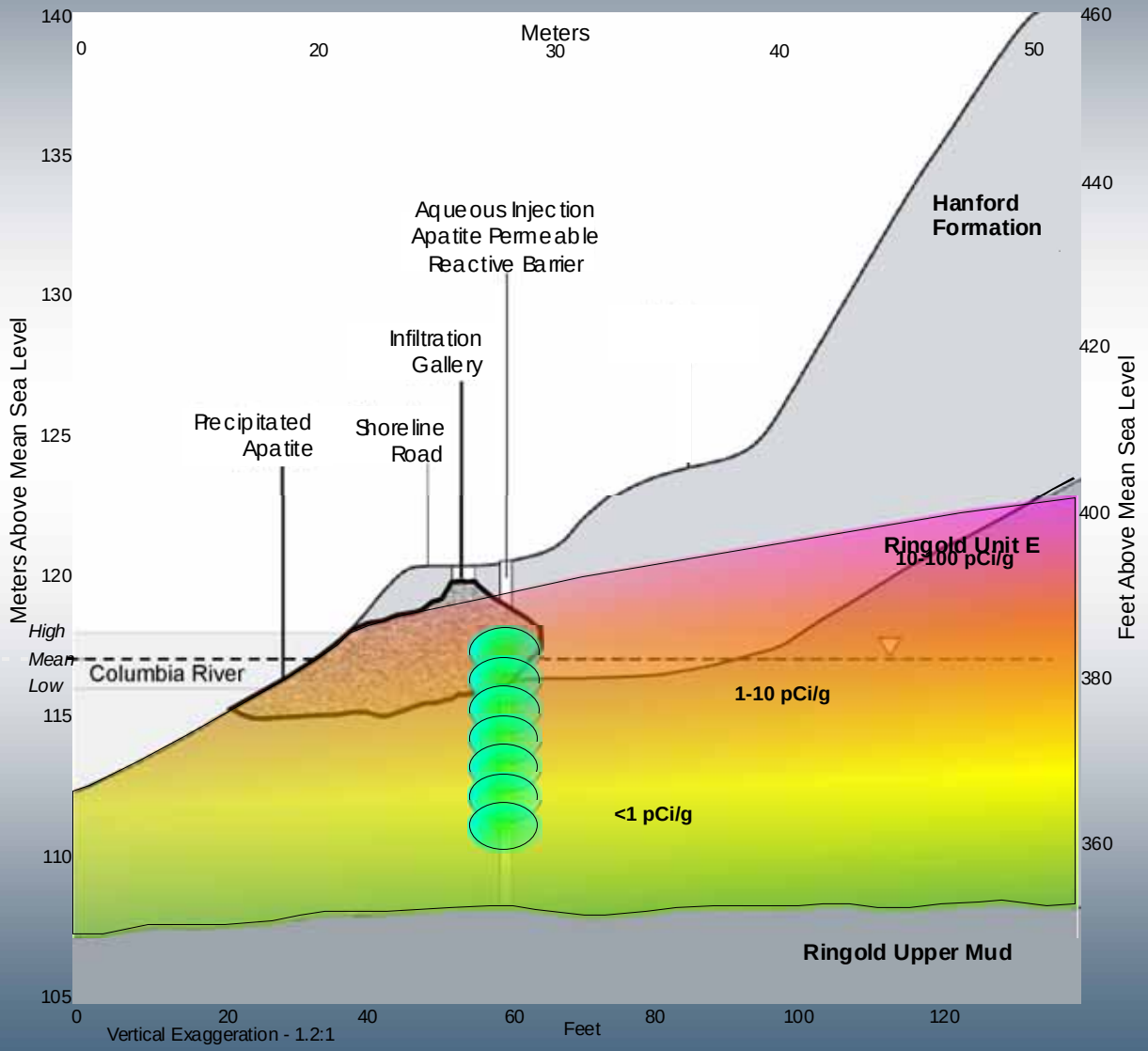
Summary of Pump & Treat Operations

- Operated since 1995
- ~0.2 Ci/yr Sr-90 removed, total of 1.7 Ci or 2% of aquifer inventory
- Global fallout ~0.5 Ci/yr



Alternative Interim Remedy: Apatite Sequestration

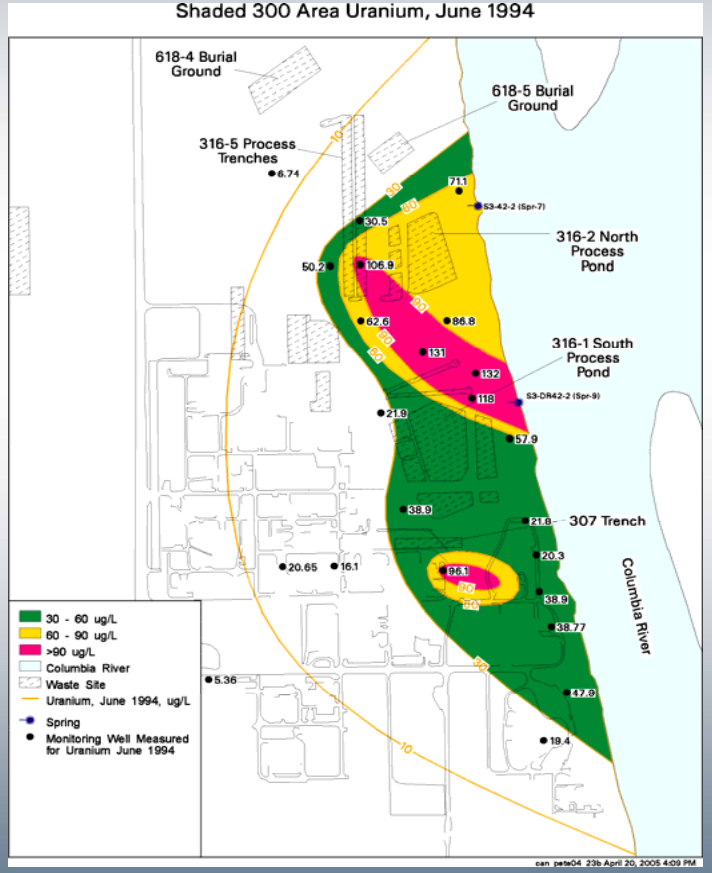
- Apatite chemical injection test & 300-ft PRB in FY2006
- Target highest clam/porefluid Sr-90
- Infiltration gallery to treat vadose zone (FY06-FY07)

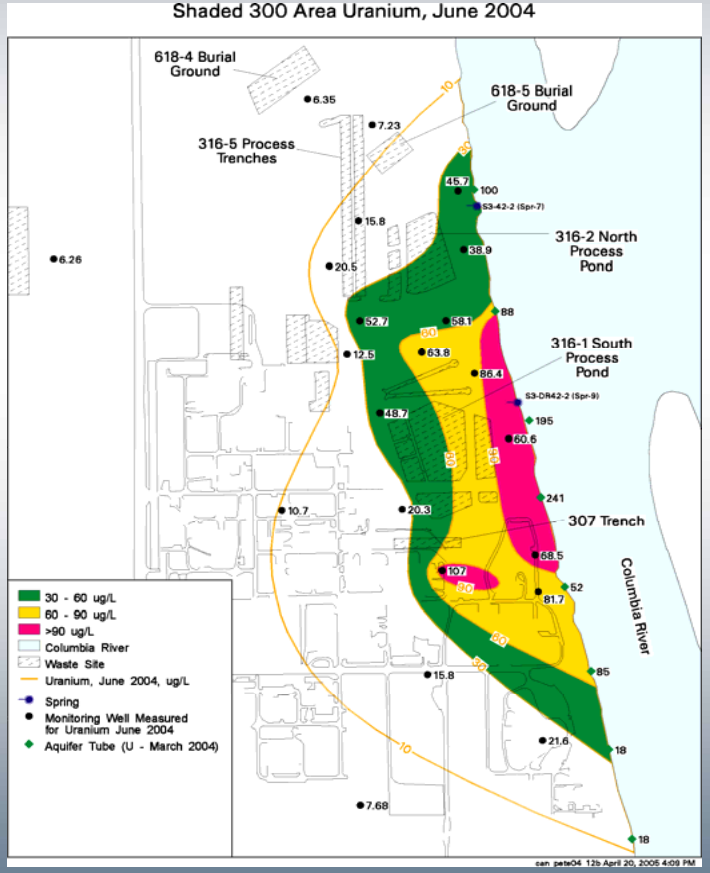


- Sr-90 in zone of water table fluctuation and shallow aquifer
- Due to high Sr-90 Kd and decay, only zone near river would enter river (if no treatment)

300 Area

300 Area Uranium Plume Exceeding Current Drinking Water Standard 1994 & 2004





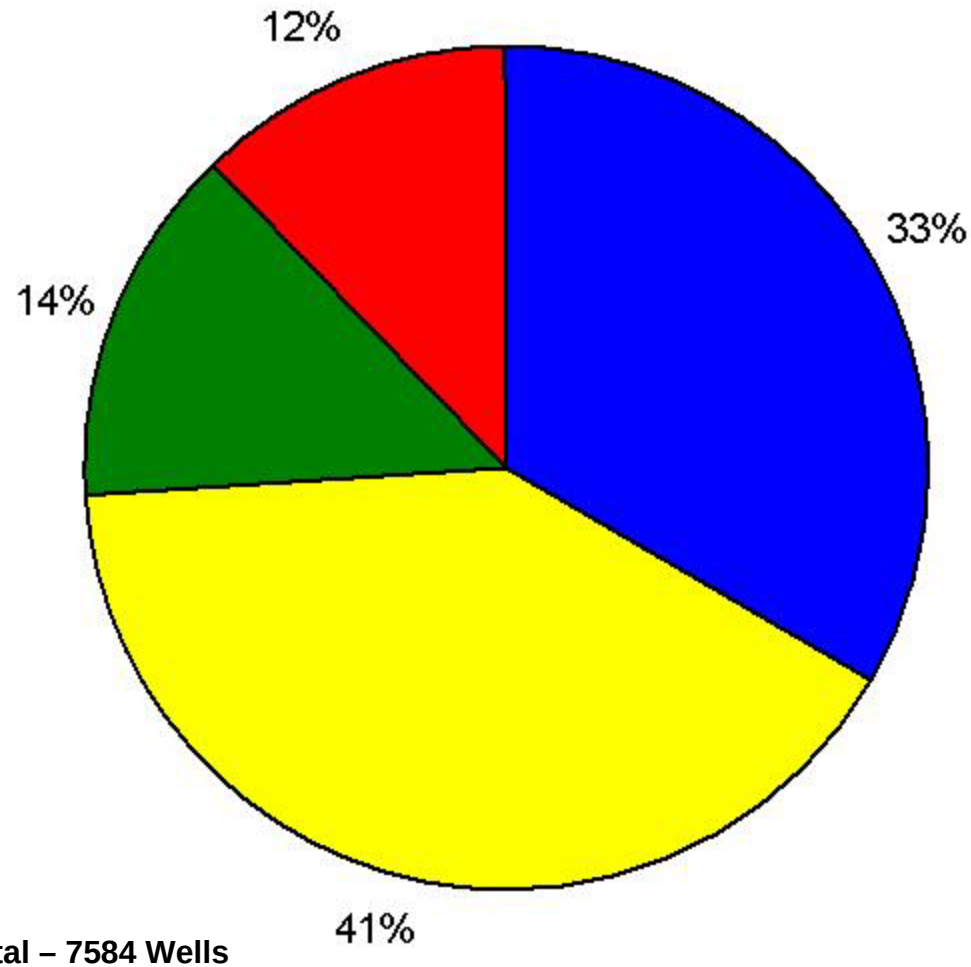
Candidate Technologies for Uranium in Groundwater

1. No Action
2. Institutional Controls and Monitoring
3. Monitored Natural Attenuation
4. Hydraulic Containment
5. Nanoparticle/colloidal Injection
6. Uranium Sequestration by Polyphosphate Addition
7. In-situ Reductive Manipulation by Dithionite
8. Flushing with Mobilizing Agent
9. In-situ Uranium Bioreduction

Central Plateau

Well D&D Graph

Hanford Site "Wells"



Legend

Decommissioned to Date	2258
In Use, Tank Farm and Offsite (1)	3077
Candidates for Administratively Decommissioning (2)	1055
Candidates for Physically Decommissioning (3)	924

(1) Includes 316 Aquifer Tubes, 146 Soil Gas Samplers, and 36 Geoprobes

(2) Require Reconciliation of HWIS With Actual Well Status in the Field

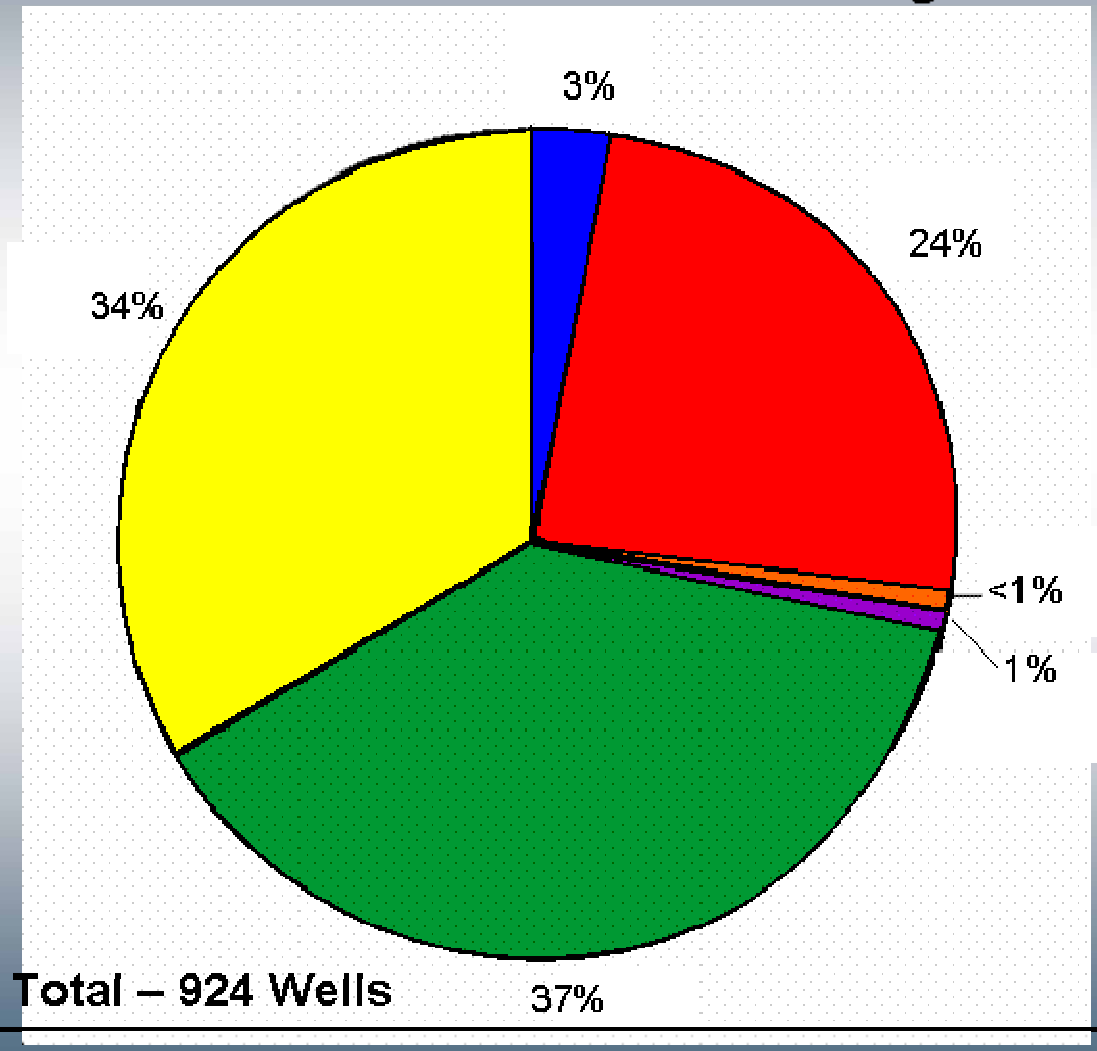
(3) Require Actual Plugging and Sealing in the Field

Total – 7584 Wells

Data as of 01/06

Well D&D graph

Geographic Distribution of Physical Decommissioning Candidates



100 Area	28
200 Area	220
300 Area	5
400 Area	9
600 Area	351
Other ①	311

① Includes – ALE, Wahluke, McGee Ranch, Dunes Areas (includes Soil Gas Samplers and Geoprobes)

Total – 924 Wells

Data as of 01/06

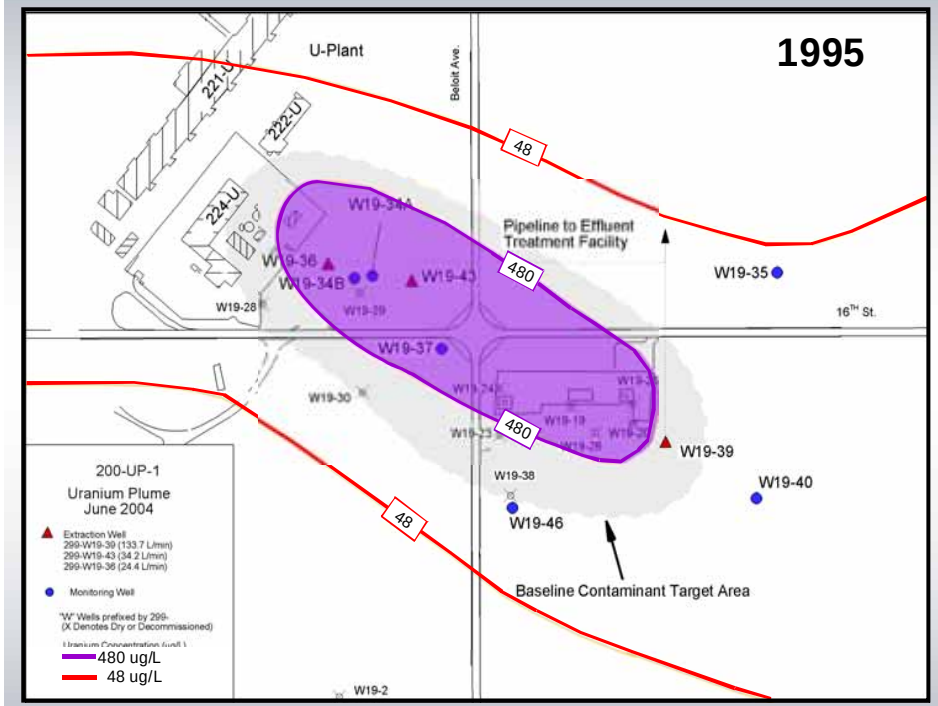
Stringer

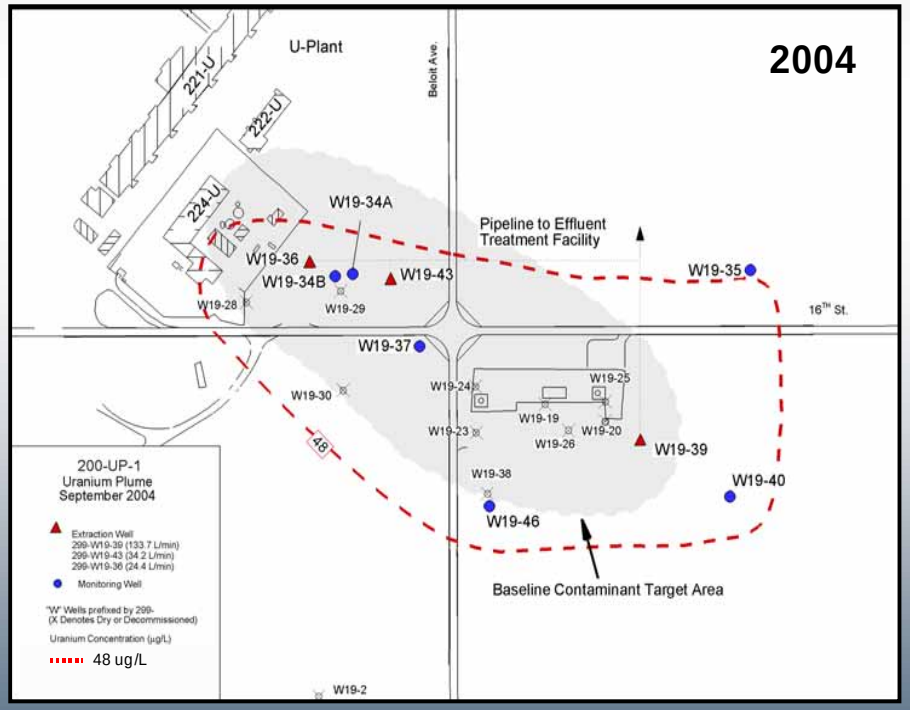
Eliminate Leaking Water Lines

Existing Water Line

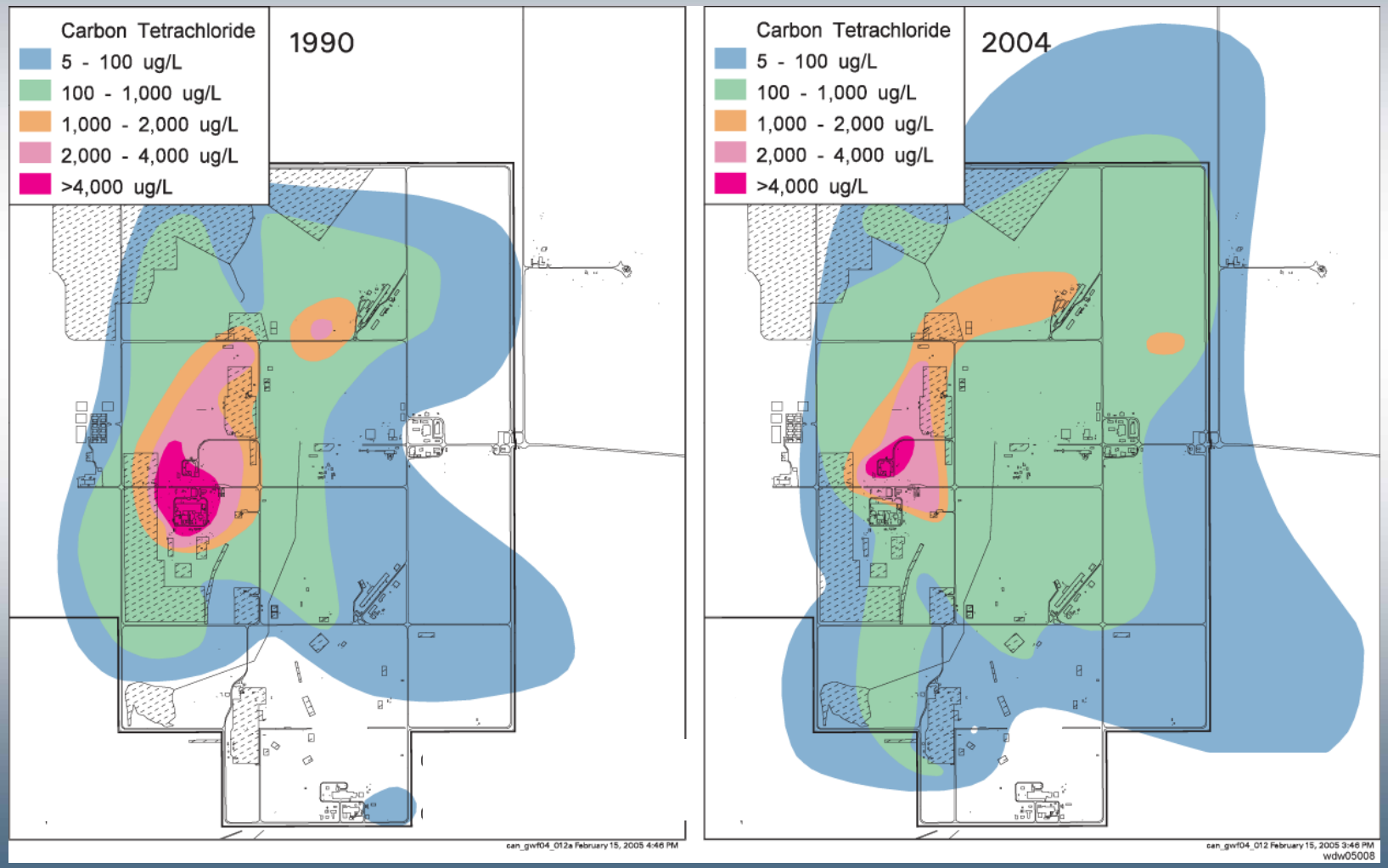
Relined at 1/4 the Cost

Uranium Concentrations in Groundwater – 1995 and 2004





Carbon Tetrachloride Concentrations in Groundwater – 1990 and 2004

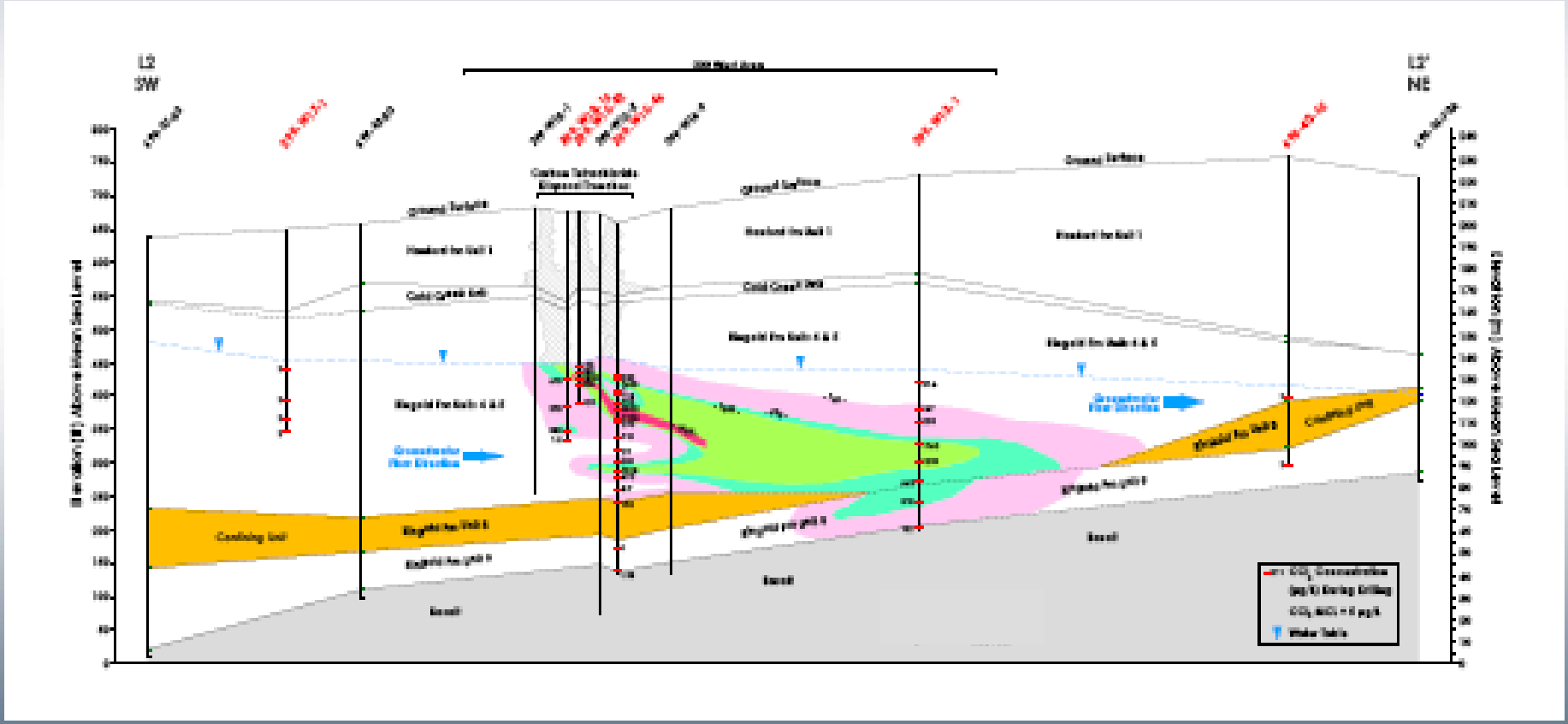


Carbon Tetrachloride Soil Vapor Extraction

200-ZP-2 Vapor Extraction Performance 1991 - 2005

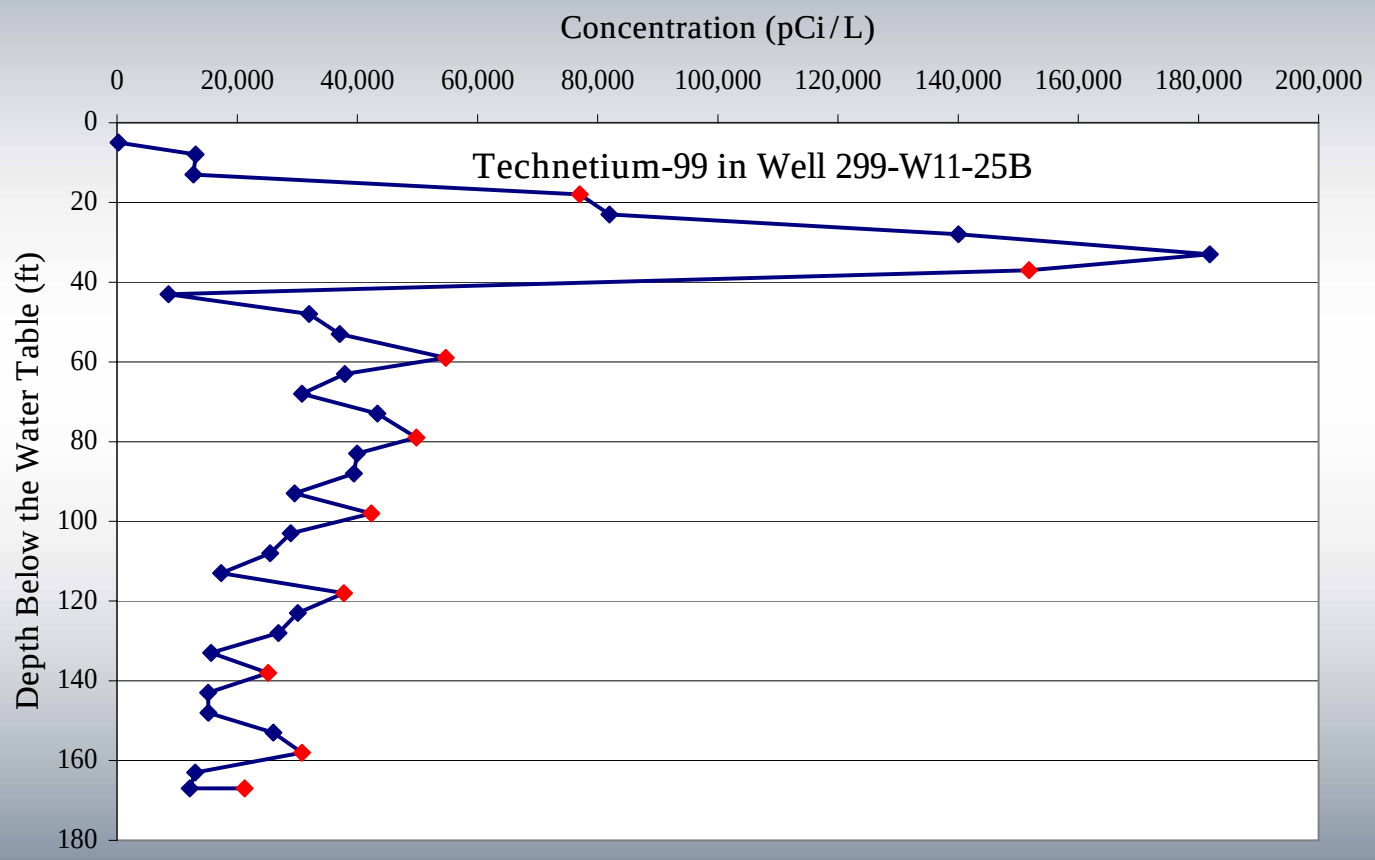
- Carbon Tetrachloride Removed: ~ 79 tons
  - 69% removed in vicinity of 216-Z-9
  - 31% removed in vicinity of 216-Z-1A/Z-18
- Total mass removed between pump & treat and vapor extraction ~ 90 tons

The Existing P&T System does not Significantly Impact the CCl-4 Deep in the Aquifer



Z9

Emerging plume at T Farm Area



Groundwater Plume Remediation
200 Area East

- 200 PO-1 Tritium Plume
  - Source: PUREX cribs associated with PUREX Plant operations
  - Pathway: Contaminants move through soil to the groundwater; average travel time to river approximately 15 years.
  - Risk: no human health risk as long as groundwater use prohibited.
  - Status: No active remedial action. Concentrations continue to decline due to natural attenuation from radioactive decay
- 200 PO-1 Iodine Plume
  - Source: PUREX cribs associated with PUREX Plant operations
  - Pathway: Contaminants move through soil to the groundwater
  - Risk: no human health risk as long as groundwater use prohibited
  - Status: No active remedial action. Plume extends southeast into the 600-Area and appears to coincide with the tritium and nitrate plumes– plume is dispersing at a very slow rate
- 200 BP-5 Uranium Plume
  - Source: 241-B/BX/BY Tank Farms and adjacent cribs
  - Pathway: Contaminants injected into groundwater
  - Risk: No risk as long as groundwater use prohibited in 200 Areas.
  - Status: No active remedial action.

Summary Table of Initial Selections: Implement/Consider

	Approximate Funding (million)*	Recommended peer review
Implement/Consider		
Uranium in the 300 Area		
In situ polyphosphate treatment tests	$1.6	expedited
Strontium in the 100 N Area		
Apatite sequestration	$0.8	expedited
Phytoextraction along river	$0.4	full
Chromium in the 100 Areas		
Refine source location	$0.8	full
Mend ISRM Barrier	$0.9	expedited
Electrocoagulation Treatment (phases 1&2)	$2.2	full
In situ calcium polysulfide (reduced scope)	$1.0	expedited
Technetium in the 200 Area		
Nanoparticle treatment tests (phases 1&2)	$0.7	full
Carbon Tetrachloride in the 200 Areas		
Abiotic degradation process study	$0.3	full
Supplement Alternative Project (conceptual model)	$0.8	expedited