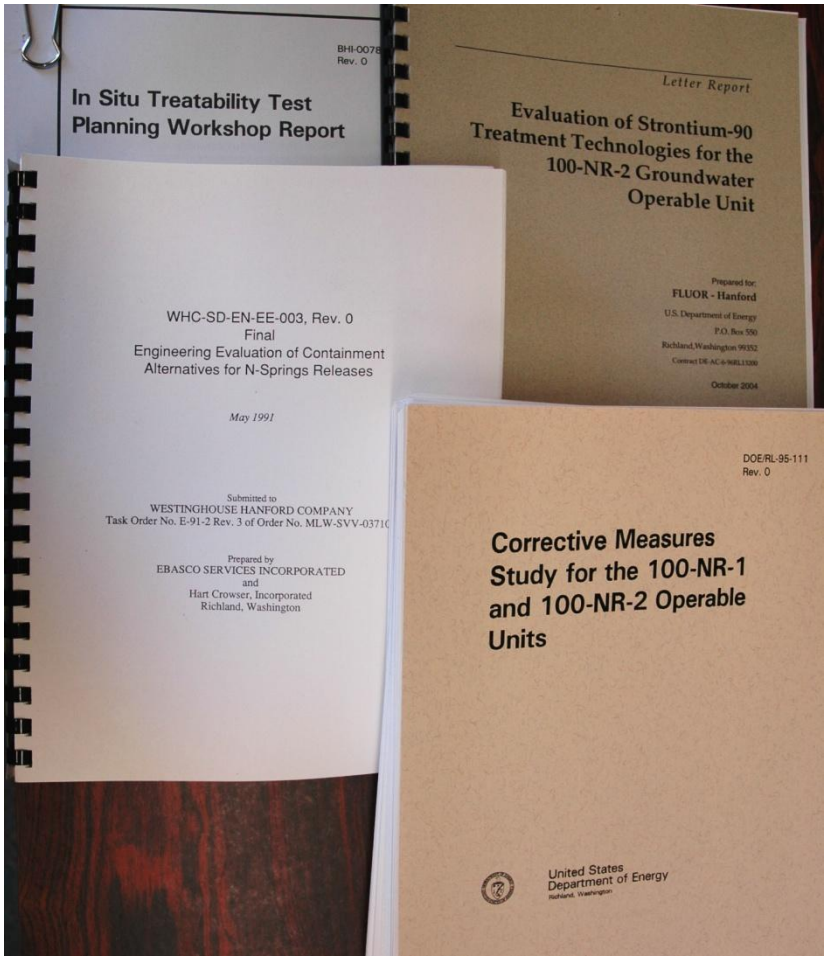
100-N Technology Evaluations Available to Support the FS Report/Proposed Plan



Engineering Evaluation of Containment Alternatives for N-Springs Releases
May 1991

- Prepared for WHC by Ebasco Environmental (WHC-SD-EN-EE-003)
- Analysis was not required by the TriParty Agreement
- Evaluation of alternatives to restrict N-Springs releases to below DCG in DOE Order 5400.5 (1,000 pCi/L)
- Considered
  - Pump-and-Treat – Evaluated in detail
  - Freeze Wall– Evaluated in detail
  - Slurry Wall– Evaluated in detail
  - In Situ Chemical Precipitation– Evaluated in detail
  - Surface Sealing and Capping – Screened out in initial evaluation
  - Hydraulic Barrier using a carbonate solution – Screened out in initial evaluation
- Slurry Wall and Freeze Wall received similar score and outranked pump-and-treat
- No action was implemented

Engineering Evaluation/Cost Analysis
January 1994

- Four Alternatives Determined to be appropriate for consideration
  - No Action (Required for baseline comparisons)
  - Pump-and-Treat
  - Slurry-Wall Barrier
  - Hydraulic Control

- DOE concluded that no single alternative could be recommended above the others to meet the 90% reduction of Sr-90 concentrations in the groundwater flowing from N-Springs into the Columbia River
- DOE convened an independent expert panel to review the findings.
- Ecology and EPA did not concur with the findings of the report (or the findings of the expert panel) – Ecology directed DOE, through an Action Memorandum in September 1994, to install a pump-and-treat system enhanced with a temporary sheet pile barrier.

Independent Technical Review of N-Springs Expedited Response Action Proposal Hanford Site February 1994

- Prepared by Advanced Sciences Inc for WHC
- Review of "N-Springs Expedited Response Action Proposal, DOE/RL-93-23, Rev 0, January 1993" and supporting documents.
- Review Board of nationally recognized experts
- Board consensus and recommendations included the following:
  - The goal of significant reduction of Sr-90 flux to the Columbia River by separation of Sr-90 from pumped groundwater during the [proposed] 10 year ERA duration would result in insignificant total mass removal due to the natural immobility of Sr-90.
  - The most cost-effective alternative appears to be a vertical barrier with monitoring at the ends of the barrier. The Panel stated that a vertical barrier using a slurry wall could have been selected and this option has the least technological and cost uncertainty (The WHC report did not recommend a preferred alternative).

In Situ Treatability Test Planning Workshop
April – May 1996

- Evaluation of In Situ Treatability Test Plan, DOE/RL-95-107, Rev. 0
- Proposed an In Situ Treatment Zone (ISTZ) test
  - 100 ft test Trench, 3 ft wide, 30 ft deep parallel to the river
  - Trench would be backfilled with clinoptilolite (Same zeolite as used in P&T system) to form a permeable reactive barrier
  - Test trench would be removed if test failed to perform
- Stakeholder response resulted in termination of the proposal
  - Perception of large accumulation of Sr-90 on Columbia River shoreline
  - Cultural resource concerns
  - Stakeholders desire to remove Sr-90 vs. containment
  - Perceptions concerning riverbank stability
  - Complexity of the river/groundwater interactions
  - Constructability and cost concerns

In Situ Treatability Test Planning Workshop April – May 1996

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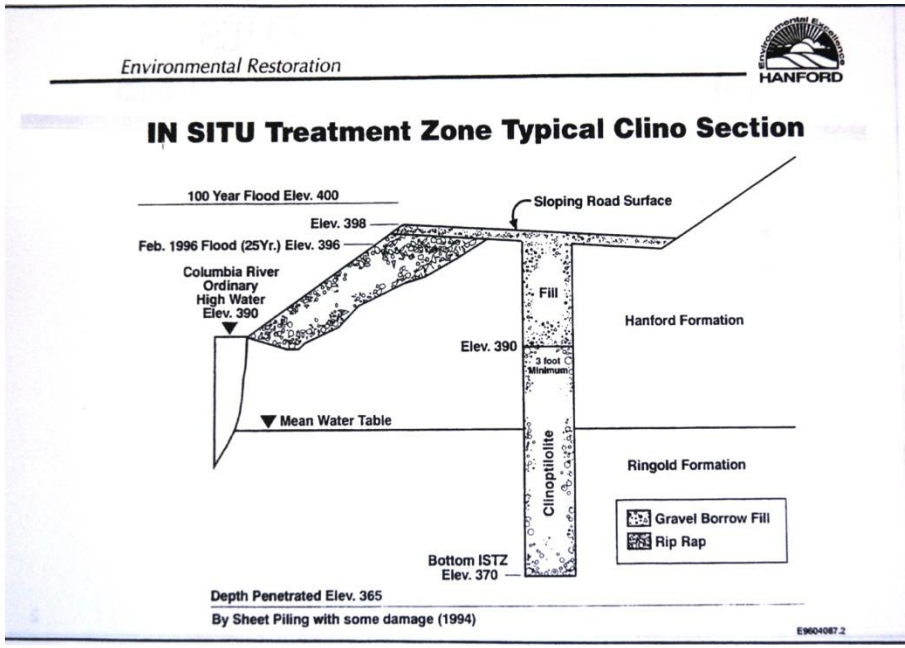


Corrective Measures Study for the 100-NR-01 and 100-NR-02 Operable Units
July 1997

- Groundwater & Columbia River protection RAO's
  - Protection of Columbia River from Sr-90
  - Protection of Columbia River from tritium
  - Removal of Sr-90 from the aquifer
  - Removal of chromium VI, nitrate, manganese, sulfate and petroleum hydrocarbons from aquifer
- Remedial technologies evaluated included
  - No action
  - Institutional controls
  - Hydraulic controls
  - Permeable and impermeable barriers (Sheet Pile & Cryogenic)
  - Pump-and-Treat
  - Soil Flushing

Corrective Measures Study for the 100-NR-01 and 100-NR-02 Operable Units
July 1997

- CMS Recommendations
  - Final remedy could not be selected with data available at that time
  - Interim Measures recommended
    - Continue operation of pump-and-treat system required by the 1994 Action Memorandum
    - Propose additional actions in the 5-yr period if P&T system is shown to have no beneficial effect on discharges to the river
    - Remediate the floating petroleum hydrocarbon
    - Evaluate Sr-90 remediation technologies excluding P&T as a sole long-term remediation option
    - Continue monitoring the groundwater for all contaminants of concern

The Innovative Treatment and Remediation Demonstration for Hanford's 100-N Area

100-N Area ITRD Project History

March 1998	• Kick-off Meeting and identification of technologies for in-depth evaluation
Sept 1998 - February 2000	• Phase I (groundwater modeling, soil flushing, stabilization, bank stability, phytoremediation, and treatment walls
March – Sept 2000	• Phase II (groundwater modeling, design/cost estimate for soil flushing, and design/cost estimate, soil stabilization)
December 2001	• Treatment Scenarios and cost estimates • Draft Final Report

Final List of Technologies

- Groundwater Modeling
  Models fate and transport of ^{90}Sr in groundwater
- Bank Stability
  Stability study of 100-N Area Columbia River bank
- Clinoptilolite Treatment Wall
  Permeable barrier for ^{90}Sr adsorption
- Natural Attenuation
  Natural process that leads to reduction of contaminants (EPA requires monitoring ~250 yrs)
- Sheet pile/Cryobarrier
  Controls contaminant flux to river
- Soil Flushing
  Lixiviant removes exchangeable ^{90}Sr
- Soil Stabilization
  Immobilize ^{90}Sr in stable, insoluble PO_4 minerals
- Phytoremediation
  Uptake of ^{90}Sr by plants

Results: Groundwater Modeling

- Model inflow and outflow ^{90}Sr transport at river for 50 years
- Determine if the constant flushing of the ^{90}Sr contaminated sediments with uncontaminated river water introduce ^{90}Sr into the Columbia River.
- Sr plume will not move downgradient if sorption occurs (K_d = 15 ml/g)
- 0.14 - 0.19 Ci over one year is released along length of contaminated zone (400-500 meters)

Results: Bank Stability

- The bank has been stable for thousands of years
- Erosion of subsurface barrier elements would be negligible
- Erosion potential associated with construction of the proposed barriers is also considered negligible
- Limiting access to the roadway and minimizing vibrations during barrier installation activities would significantly reduce the potential damage to the environment that could be caused during construction

Results: Clinoptilolite Treatment Wall

- Would prevent migration of upgradient ^{90}Sr to the Columbia River
- Low maintenance
- Low disturbance of hydrologic regime or spread of contaminants
- No radioactivity brought to surface after installation
- It is a relatively intrusive technology, especially near the river
- It does not address the contamination found in the near-river environment between the proposed permeable barrier and the Columbia River

Results: Monitored Natural Attenuation

- The site meets the criteria established by DOE for MNA
  - –Short half-life and strong sorption of ^{90}Sr make this an attractive option
- Long-term monitoring strategies are needed; these may emerge as protocols for Long–Term Stewardship (LTS) are established
- Recommendation: examine option in more detail when LTS protocols are established.
- Perform risk analysis in collaboration with Regulators to determine if level of release (4.92 to 6.15 Ci over 60 years) is acceptable

Results: Impermeable Barrier

- Combination sheet pile wall and cryogenic barrier to form an impermeable barrier in the river bank area to control contaminant flux to the river
- Could be used in combination with soil flushing or stabilization
- Sheet pile wall: 1 m (4 ft) above land surface and 8m (25 ft) into the subsurface.
- Cryogenic barrier - from land surface to a depth of 15 m (50 ft) (to the Ringold Formation).

Results: Soil Flushing

- Likely to be effective in removing both radioactive and non radioactive Sr from the site in the least amount of time.
- Modeling calculations indicate that it is possible to build a wellfield and to detect and control potential excursions.
- Long term monitoring may still be required after the flushing is nominally completed
- Recommend that this issue be examined in more detail in consultation with regulators

Results: Soil Stabilization

- It is well-known that phosphate solid injection and coprecipitation removes Sr
- It may be possible to create a long-term barrier in some areas of the plume using stabilization by liquid phosphate injections
- A stabilization system was not designed, so there are no data to support recommendation of this option

Conclusions: Phytoremediation

- A possible option for controlling current releases of Sr at the river
- Leaf litter control may be an issue
- May be suitable for a 30-yr period to control the riparian zone while MNA or stabilization is used to control the portions of the plume that are further from the river
- Additional work - literature review, greenhouse hydroponics studies, field study using existing trees, and food chain studies (tree to insect, insect to bird transfer)

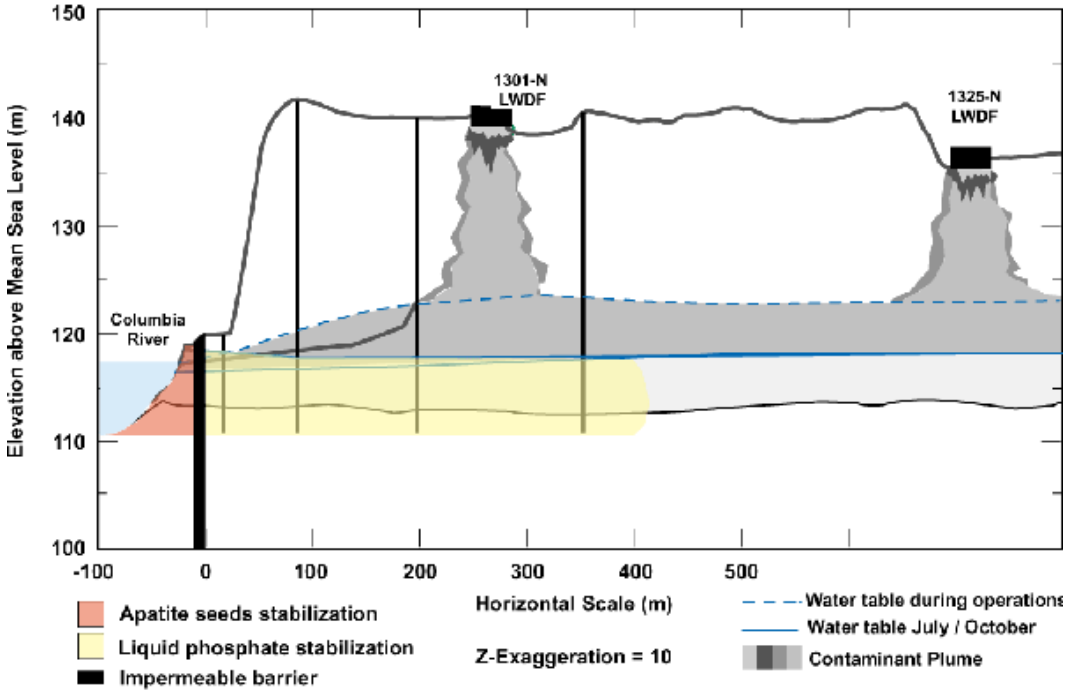
Recommendations for Future Activities

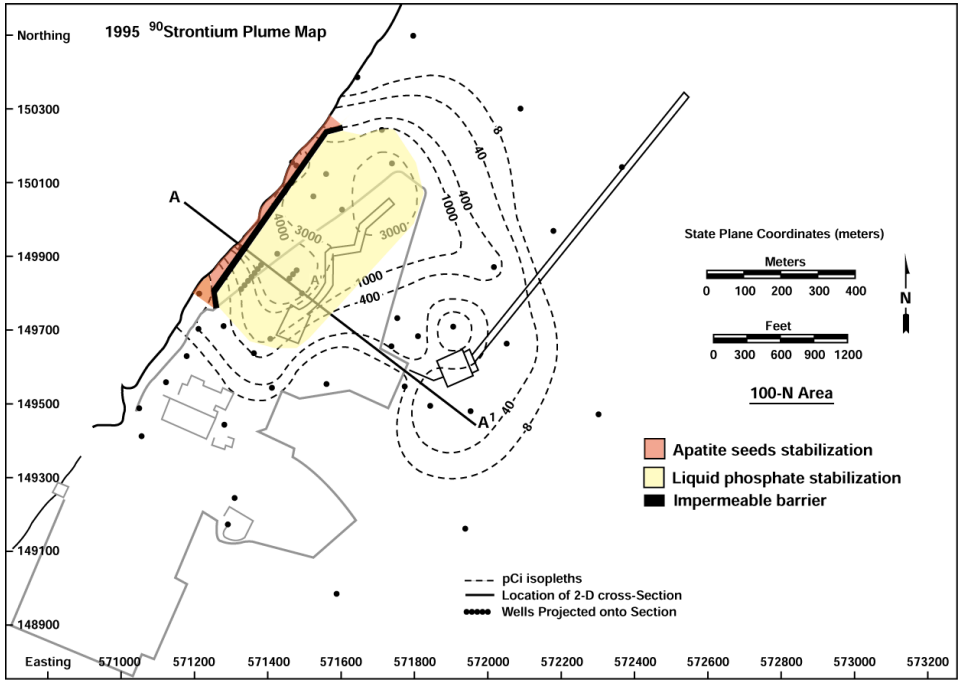
Examine in more detail:

- Monitored Natural Attenuation
- Clinoptilolite Barrier with Monitored Natural Attenuation on river side of barrier
- Clinoptilolite Barrier with Monitored Natural Attenuation and Phytoremediation on the river side of the barrier
- Sheet Pile/Cryogenic Impermeable Barrier with Monitored Natural Attenuation
- Sheet Pile/Cryogenic Impermeable Barrier with phytoremediation on the river side of the barrier and Soil Flushing on the inland side

Remediation Scenario 3:

Apatite Seeds/Liquid Phosphate Stabilization with impermeable barrier; Cross Section and Plan View





Current Technology Evaluations at 100-N

- Apatite sequestration permeable reactive barrier
  - Formation of apatite in GW by injection in wells
  - Formation of apatite in VZ by jet injection
  - Formation of apatite by surface infiltration
  - Phytoextraction
- Petroleum remediation

Systems Approach to Address 100-N ^{90}Sr