An Initial Evaluation of Characterization and Closure Options for Underground Pipelines within a Hanford Site Single-Shell Tank Farm – 13210

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ABSTRACT

The Hanford Site includes 149 single-shell tanks, organized in 12 "tank farms," with contents managed as high-level mixed waste. The *Hanford Federal Facility Agreement and Consent Order* requires that one tank farm, the Waste Management Area C, be closed by June 30, 2019. A challenge to this project is the disposition and closure of Waste Management Area C underground pipelines. Waste Management Area C contains nearly seven miles of pipelines and 200 separate pipe segments. The pipelines were taken out of service decades ago and contain unknown volumes and concentrations of tank waste residuals from past operations. To understand the scope of activities that may be required for these pipelines, an evaluation was performed. The purpose of the evaluation was to identify what, if any, characterization methods and/or closure actions may be implemented at Waste Management Area C for closure of Waste Management Area C by 2019. Physical and analytical data do not exist for Waste Management Area C pipeline waste residuals. To develop estimates of residual volumes and inventories of contamination, an extensive search of available information on pipelines was conducted. The search included evaluating historical operation and occurrence records, physical attributes, schematics and drawings, and contaminant inventories associated with the process history of plutonium separations facilities and waste separations and stabilization operations. Scoping analyses of impacts to human health and the environment using three separate methodologies were then developed based on the waste residual estimates. All analyses resulted in preliminary assessments, indicating that pipeline waste residuals presented a comparably low long-term impact to groundwater with respect to soil, tank and other ancillary equipment residuals, but exceeded Washington State cleanup requirement values. In addition to performing the impact analyses, the assessment evaluated available sampling technologies and pipeline removal or treatment technologies. The evaluation accounted for the potential high worker risk, high cost, and schedule impacts associated with characterization, removal, or treatment of pipelines within Waste Management Area C for closure. This assessment was compared to the unknown, but estimated low, long-term impacts to groundwater associated with remaining waste residuals should the pipelines be left "as is" and an engineered surface barrier or landfill cap be placed. This study also recommended that no characterization or closure actions be assumed or started for the pipelines within Waste Management Area C, likewise with the premise that a surface barrier or landfill cap be placed over the pipelines.

INTRODUCTION

Closure of Waste Management Area (WMA) C is required by the year 2019 in accordance with *Hanford Federal Facility Agreement and Consent Order* (HFFACO) Milestone M-045-83. Nearly seven miles and 200 separate underground pipelines will be required to undergo closure actions as part of WMA C closure. To begin scoping pipeline closure actions, the U.S. Department of Energy (DOE) and its tank farm contractor evaluated options for both characterization and closure activities associated with underground piping. The document *Single-Shell Tank Waste Management Area C Pipeline Feasibility Evaluation*, RPP-PLAN-47599, Rev. 1 contains DOE's recommendations for closure of WMA C pipelines.[1]

RPP-PLAN-47599 was a collaborative effort between DOE, its tank farm contractor, and the Washington State Department of Ecology (Ecology), lead regulator for WMA C closure. However, Ecology has made it clear that this evaluation does not constitute a closure decision. Ecology will make pipeline closure decisions in the Hanford Dangerous Waste Permit[2] under its State-designated *Resource Conservation and Recovery Act of 1976* (RCRA, 42 USC 6901, et seq.) authority (*Washington Administrative Code* [WAC] Chapter 173-303, "Dangerous Waste Regulations") and via a process in the HFFACO with DOE and the U.S. Environmental Protection Agency (with Ecology, the Tri-Parties). Ecology will require DOE to complete a risk assessment (RA) for WMA C and all of its attributes. The Tri-Parties will require DOE to also complete a performance assessment (PA) for WMA C and all of its attributes. The RA and PA will be developed from a series of collaborative working sessions prior to making any decisions on closure activities associated with WMA C pipelines. The results of the RA and PA will be used by Ecology to make final closure decisions under the Hanford Site-Wide Permit.[2]

DISCUSSION

Pipeline Residual Volume Estimate, Inventory Calculations, and Uncertainty Assessment

To determine estimated waste residuals in pipelines, an exhaustive search of drawings and other records was performed to determine their physical attributes. Pipeline construction followed five operational phases. These phases and the pipelines constructed for their service are depicted in Figures 1 and 2.

According to historical process operation records, pipelines were to be flushed following a waste transfer, and at times prior to a waste transfer. However, historical process operations records are not complete and do not document all of the waste transfers and associated flushing events from the 1940s through the 1980s. Waste transfers were conducted under pressure and the original pipelines were constructed with a 1% slope which would allow waste to drain into their receiving vessels. The combination of pressurized transfers, flushing and drainage promoted cleared pipelines with little waste left in the pipeline. Later pipelines were constructed and pressurized as waste was removed from tanks with jet pumps and vacuum pumps. Nevertheless, lines were still designed to drain back into the tank after pumping was completed. As a result of the design and operational features of the waste transfer pipelines it is anticipated that the volume of residual wastes remaining is not significant. However, it is reported that a limited number of pipelines plugged, and little to no characterization is available on the tank farm lines to prove or disprove the amount of residual wastes present within the lines.

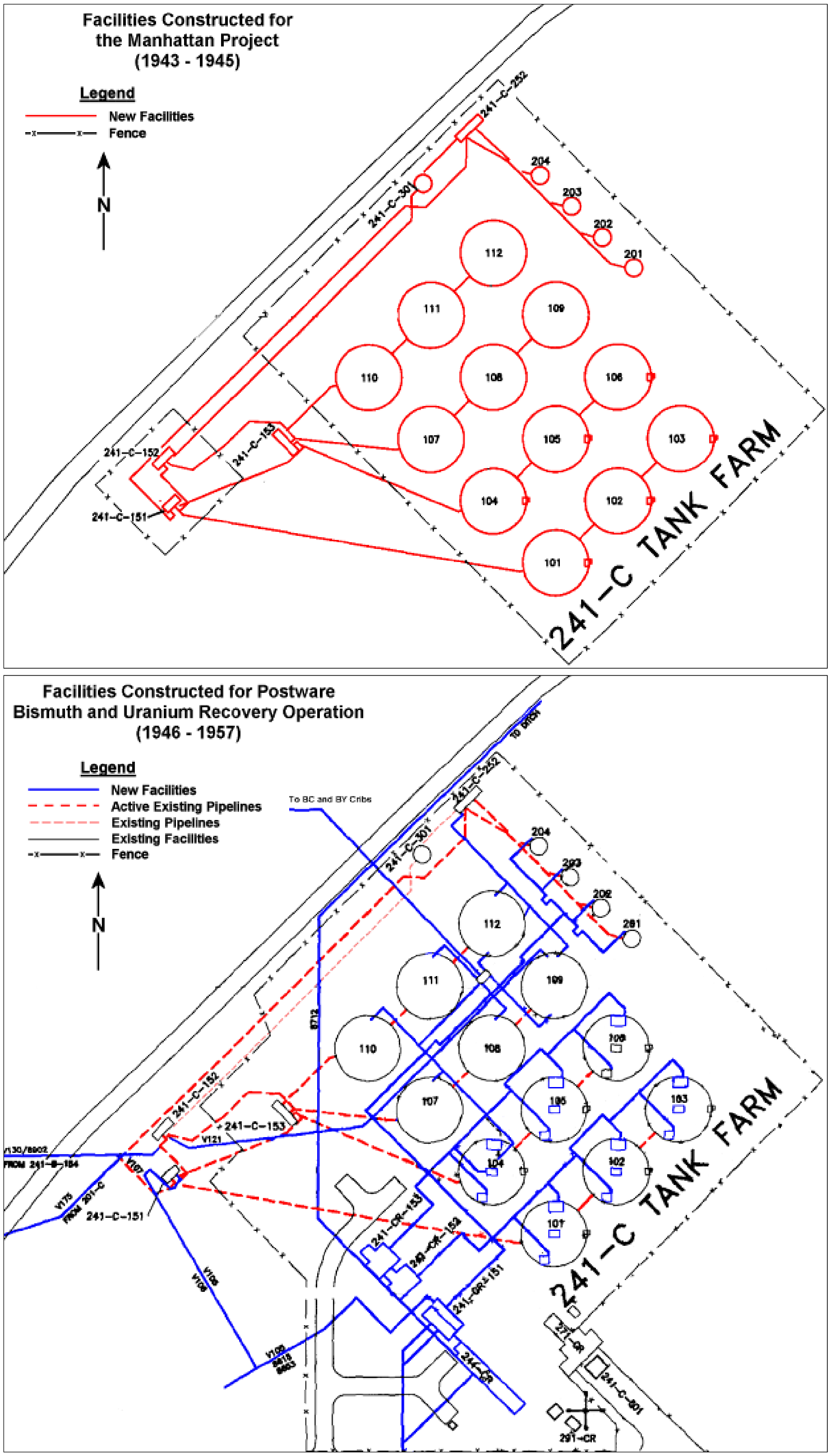

Fig. 1. Waste Management Area C Components Constructed for the Manhattan Project (1943 to 1945) and Bismuth and Uranium Recovery Operation (1946 to 1957)

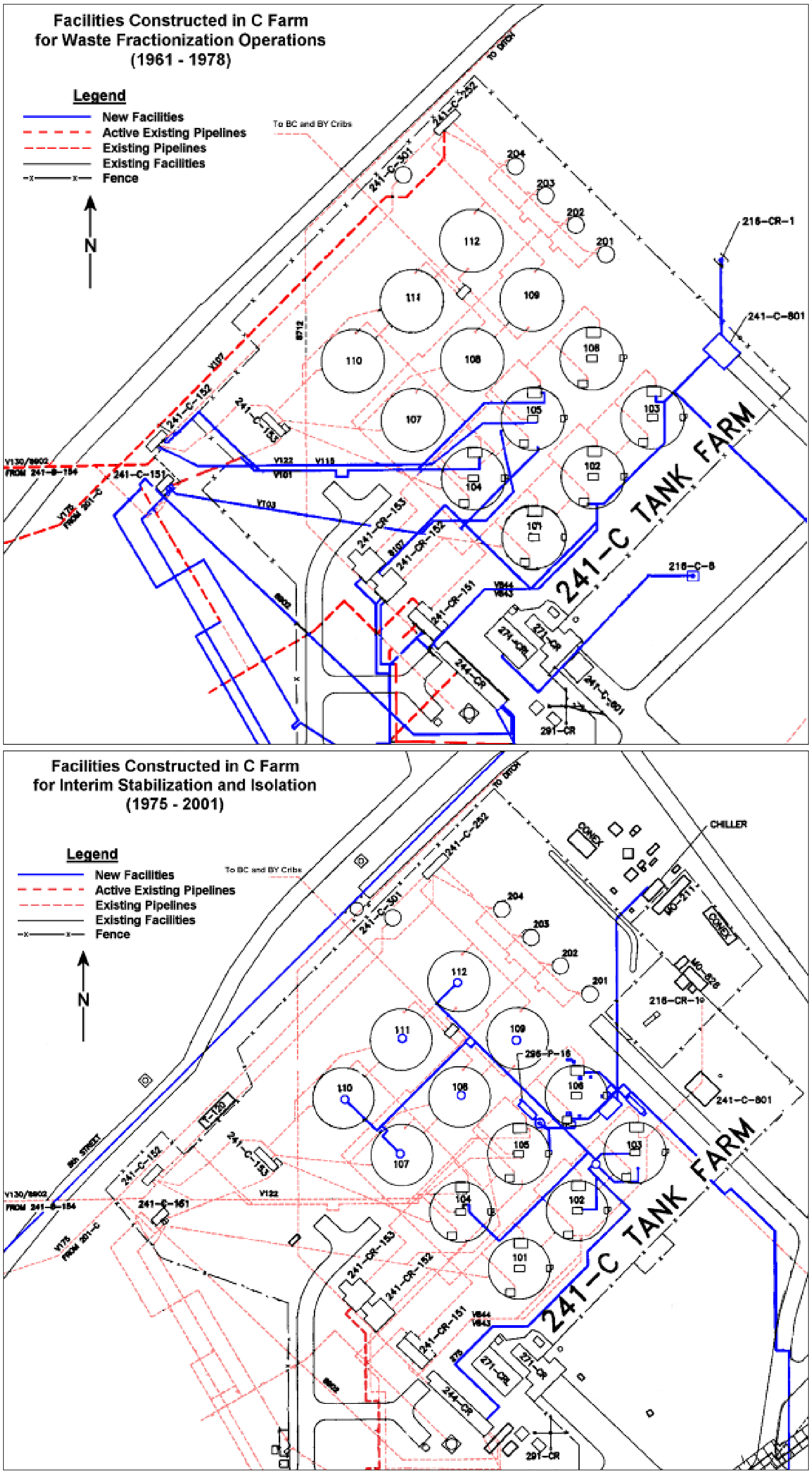

Fig 2. Waste Management Area C Components Constructed for Waste Fractionization Operations (1961 to 1978) and Interim Stabilization and Isolation (1975 to 2001)

Historical records contained previous attempts to estimate pipeline residual waste volumes. However, these previous estimates contained assumptions regarding lengths and percent of residuals in the pipelines that were not supportable after the historical record search. For the purposes of revising the WMA C pipeline residual estimate(s), a conservative percent volume of residual for each of the two main types of pipelines present in WMA C were established.

1. WMA C gravity-fed pipelines: WMA C gravity-fed pipelines include the cascade lines between the 100-series single-shell tanks which were prone to plugging. These pipelines as well as another plugged pipeline (V122) were assumed to be 100% filled with residual waste for their entire length.

2. WMA C pressurized pipelines: the remaining pipelines in WMA C were pressurized and assumed to be 5% filled throughout the pipe as an average. It is acknowledged that long, straight runs of pipe may have less than 5% by volume while pipe bends and elbows most likely have more than 5% by volume waste within them. This assumption is based conservatively on observations from the residuals found in other tank waste transfer pipelines, as documented in RPP-PLAN-47559.

These revised assumptions result in a residual pipeline volume of 5,962 liters (1,575 gallons). A graphical representation of residual calculations for pressurized pipelines is contained in Figure 3.

Average concentrations for WMA C solids were calculated using the Hanford Site Best Basis Inventory (BBI) concentrations and the volume of residual waste extrapolated for this feasibility evaluation (1,575 gallons). The BBI is the best estimate of the waste composition in each Hanford Site tank. This estimate is based on the waste transfer history associated with each tank, modified by sample analysis results. Using the average BBI volumetric concentrations and multiplying by the total assumed volume of contamination provides an estimate of the inventory in the pipelines.

Uncertainties in the estimates of pipeline residual inventories were determined to be low for the purposes of closure decision-making. The following uncertainties in inventory estimates are summarized.

- Length and number of pipelines – An exhaustive review of design drawings produced revisions to the length and number of pipelines in WMA C. These revisions are considered to have a very small level of uncertainty.

- Residual waste volume estimates – By applying operational history for WMA C and the revised length of pipelines and extrapolating the results of previous characterization studies, the uncertainty of the volume of residual waste in WMA C pipelines was reduced. The volume estimate of 5,960 liters (1,575 gallons) is considered to maintain an appropriate degree of conservatism for making closure decisions.

- Residual waste composition – The chemical and radionuclide composition of pipeline residuals can be estimated based on the BBI information on tank wastes. The BBI is considered a reasonable estimate which has been validated based on past tank waste residual sampling estimates that have compared favorably to that of the BBI. Therefore, current uncertainties in the composition of pipeline residuals are considered low.

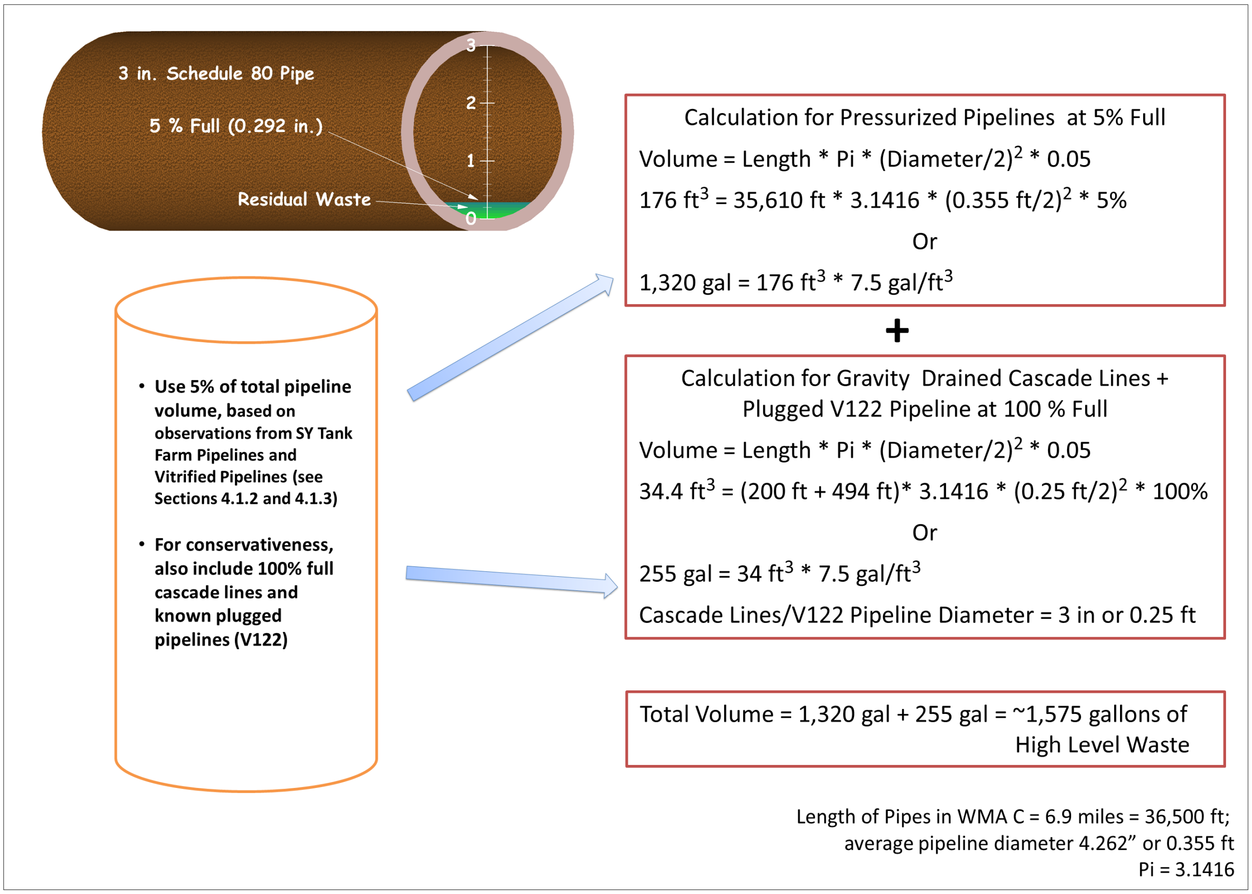

Fig. 3. Revised Technical Basis Residual Volume in Pressurized Pipelines at Waste Management Area C.

Preliminary Assessment of Impacts to Human Health and the Environment Associated with Estimated Pipeline Residuals

Initial scoping analyses utilized three different methodologies to evaluate potential long-term impacts to human health and the environment from estimated pipeline residual inventories. The results of these assessments are summarized below.

1. Ratio of estimated pipeline waste residual inventory to total WMA C residual inventory – this assessment resulted in an estimated percent contribution of less than 1 percent for both total radionuclide and chemical contaminants that will remain in WMA C after retrieval of waste residuals in the 100- and 200-series tanks.

2. A comparison of concentrations of nonradionuclides in estimated pipeline waste residuals to Washington State cleanup standards (WAC Chapter 173-340, "Model Toxics Control Act – Cleanup") resulted in a determination that:

- Estimated pipeline residuals are well above unrestricted land use cleanup standards for direct exposure to human and ecological receptors under the assumption that no remedial actions are performed, and

- Estimated pipeline residuals are well above the concentrations protective of groundwater using the WAC 173-340 fixed parameter three-phase partitioning model and again, assuming that no remedial actions are performed.

3. A set of scoping calculations were performed using the ECOLEGO toolbox[1] based on the evaluation of two exposure scenarios that included: (1) an acute human exposure to waste residuals through an inadvertent drilling intrusion into residual wastes in pipelines at WMA C, and (2) a chronic exposure of a member of the public to water pumped from a well completed immediately down gradient from WMA C that receives releases for residual wastes in pipelines. Note that fate and transport assumptions and the scenarios used to perform the calculations have not been accepted by Ecology. These will only be approved after the WMA C RA is approved by Ecology in the Site-Wide Permit[2]. Results of the analysis indicate the following.

   - For the inadvertent drilling intrusion scenario, results of the analysis showed a total acute dose to the intruding receptor to be less than 0.1 millirem per year after an assumed loss of institutional controls at 150 years and to be less than 0.0001 millirem per year after 500 years. These doses are well below the generally accepted performance objective for inadvertent intrusion (500 millirems per year for acute exposure) at closed low-level waste facilities under DOE Order 435.1, *Radioactive Waste Management*.

   - For the groundwater use scenario, the analysis results indicated a peak chronic total dose to the receptor using groundwater at WMA C to be less than 0.1 millirem per year. This peak dose is also well below the generally accepted performance objective of 4 millirems per year for a receptor using groundwater at closed low-level waste facilities under DOE Order 435.1.

   - The key non-radiological contaminants using the same groundwater use scenario are well below groundwater cleanup levels which are shown in parentheses:

     - Nitrate – 31.9 micrograms per liter (groundwater cleanup level is 45,000 micrograms per liter [as NO_3])

[1] ECOLEGO is a MATLAB® toolbox for modeling dynamic systems and performing risk assessments using model simulations. The ECOLEGO toolbox is a set of compartmentalized software tools developed by Robert Broed and Shulan Xu of Facilia Consulting (Sweden) that has been successfully applied in the field of radionuclide/contaminant fate and transport modeling and risk assessment at a variety of high-level waste repositories and low-level waste sites in Europe and South Africa.

- Chromium – 0.57 micrograms per liter [groundwater cleanup level is 100 micrograms per liter for total chromium and 48 micrograms per liter for chromium (VI)].

Pipeline Characterization Technologies

There is a range of technologies that are potential candidates for characterizing pipelines. These technologies have been developed for a variety of applications, from assessing the integrity of a pipeline to cleaning and repairing. These technologies operate in a range of pipeline operating conditions. The specific application and operating environment contribute to the implementation constraints of each of the technologies. The WMA C pipeline attributes must be considered when evaluating characterization technologies for WMA C pipelines including:

- the physical condition of the pipe
- whether it is encased or direct buried
- the degree to which corrosion has compromised the integrity of the pipe and the friction coefficient of the interior pipe surface
- size
- slope
- number of bends and types of bends
- accessibility to the pipeline (the depth it is buried, access points such as valve boxes or diversion boxes), and
- the potential physical and chemical characteristics of any residual wastes in the pipeline (scale, solid, liquid, plugs).

Understanding the attributes of the pipelines helps in evaluating the applicability of a technology to the specific pipes in the system. The limiting constraint is if the technology is deployable in the tank farm environment and if the technology can actually be used to characterize the waste form likely to be encountered in the pipeline.

In October 2006 the DOE Office of River Protection received support from the DOE Headquarters Office of Environmental Management which convened an expert panel on pipeline characterization technologies. The expert panel reviewed a range of characterization technologies for potential applicability to assist with the determination of remedial and closure actions for the pipeline system.[3] While the expert panel did not provide specific recommendations for the use of a particular technology at Hanford, they did stress that ALARA (As Low As Reasonably Achievable) practices must be a primary focus for characterization activities.

Characterization technologies for waste residuals in pipelines included the following categories:

- Removal and analysis of piping and residual wastes
- In situ visual analysis and radiological screening
- In situ sampling and analysis
- Modeling.

Characterization of pipelines is not limited to the deployment of a single technology. Characterization activities can include evaluation of the interior of pipelines and adjacent vadose zone soil. There are extensive pre-deployment activities that also must be completed, which can involve various technologies for screening and accessing the pipes and adjacent soils for defining worker exposure and risks. Surface geophysical and radiation surveys must be conducted at all sample locations. The surface geophysical surveys will need to be conducted using ground-penetrating radar and/or electromagnetic induction. This will aid in verifying buried pipeline locations, other buried utilities, and subsurface anomalies. Surface radiation surveys will identify areas of surface contamination that might impact intrusive activities and health and safety requirements.

Actual pipeline characterization experiences at Hanford were described, including cost and schedule information.

Pipeline Closure Technologies

The following four classes of technologies for closing pipelines were identified.

- **Removal**. This category of technologies includes the physical excavation of the pipelines, or potentially segments of pipelines, that are considered hot spots that have an unacceptable risk. Implementation of removal technologies would require subsequent stabilization of the removed pipeline as needed, backfilling of the excavation and disposal at the Environmental Restoration Disposal Facility (ERDF).

- **Grout filling inside of the pipeline**. This technology involves the placement of any variety of materials such as grout, polymers, or scale coatings inside of the pipeline (as opposed to the encasements as identified in next bullet).

- **In situ encapsulation.** This technology includes placement of grout into the pipeline or pipeline encasement with the objective of filling the pipeline or the void space inside of the encasement and encapsulating the pipe and the residual waste inside of the pipe.
  A variation of this technology would be to encapsulate the entire trench or pipeline through vitrification of the soil surrounding the trench.

- **Pipeline residual extraction.** This category of technologies includes flushing and hydraulically activated pipeline pigging. It involves the introduction of various media which would push the residual waste through the pipe by purging the pipeline of the waste. The mobilization of the residual waste could be accomplished with water, acids or abrasive materials.

Rough order of magnitude estimates for a WMA C encased and direct buried pipeline were developed for removal of a 25-foot segment and presented in the document.

CONCLUSIONS

Recommendations for WMA C Pipeline Characterization to Support Closure

The findings in this report support the recommendation that sampling of WMA C pipelines is not required to support closure decisions, assuming that the closure decision(s) include installation of a surface barrier or landfill cap that adequately is constructed and monitored to protect human health and the environment. This recommendation will be revisited upon completion of the WMA C RA and PA. This is based on the following conclusions.

1. Obtaining representative samples of in-pipeline residuals in a highly radioactive and congested environment such as WMA C would increase potential worker exposure, would be costly, and would result in significant schedule impacts to closure of the WMA.

2. Process knowledge for WMA C provides sufficient information to make closure decisions for pipelines based on long-term impacts (note that other closure actions may be necessary for the purposes of ensuring optimal performance of a landfill cap).

3. A technically sound and conservative WMA C pipeline residual inventory has been developed.

4. This inventory does not significantly contribute to potential long-term impacts to human health and the environment for either the groundwater or DOE Order 435.1 inadvertent intruder pathway based on a scoping analysis using conservative assumptions.

5. The concentrations of hazardous waste present in the residual inventory do present a threat to human health direct exposure and ecological receptor pathways. However, further sampling would not change this conclusion. The assumed closure action of placement of an engineered surface barrier will mitigate or prevent risk to these pathways dependent upon its design. Specific design feature(s) of the barrier will be determined as part of the RCRA closure plan and permit modification process.

6. The residual pipeline inventory present after closure actions have taken place does not significantly contribute to potential long-term impacts to human health and the environment for either the groundwater or DOE Order 435.1 inadvertent intruder pathway based on a scoping analysis using conservative assumptions.

7. Where feasible, tank farm pipeline samples should be obtained opportunistically during the course of continued safe storage or closure actions to further clarify residual concentrations and inventory, and if warranted, to reexamine the recommendations provided in this report.

Recommendations for Performance of WMA C Pipeline Closure Activities

The analysis of impacts to human health and the environment concluded that the concentrations of dangerous waste remaining in pipelines would present a threat to human health and the environment because they are well above WAC 173-340 cleanup standards for human and ecological direct contact. The pipeline residuals are also above the soil concentration protective of groundwater per WAC Chapter 173-340-747, "Deriving Soil Concentrations for Groundwater Protection."

However, at closure the WMA C is expected to be protective of human health and the environment because the following is assumed to take place:

1) WMA C is assumed to be closed as a landfill;

2) an engineered surface barrier will be placed over the site which will meet the requirements of landfill closure under WAC 173-303 and DOE Order 435.1;

3) the barrier and the associated post-closure maintenance, monitoring, and institutional controls will ensure that access to the site is restricted; and

4) the engineered barrier is designed to reduce infiltration by a factor of ten or more.

Items 1), 2) and 3) protect human health and the environment from the direct contact pathway considered under WAC 173-340 by limiting access to the contaminated soils. Item 4) would protect the groundwater by limiting infiltration through the pipeline residuals. This closed landfill configuration was evaluated using the scoping calculation completed to meet DOE Order 435.1 requirements. The scoping calculations estimated that the peak concentrations in the groundwater caused by the pipeline residuals would be well below the limits for dangerous waste constituents (set by WAC 173-340) and radionuclides (set by DOE Order 435.1). The scoping analysis was also used to evaluate DOE Order 435.1 requirements for inadvertent intrusion and determined that the impacts to the inadvertent intruder would also be small.

Consequently, the WMA C pipeline feasibility assessment concludes that further pipeline characterization or supplemental closure actions for protection of human health and the environment are not necessary when risks are balanced against the high cost and schedule impacts associated with these actions. Therefore, additional pipeline closure actions would not be recommended for protection of groundwater or direct contact to human and ecological receptors under the assumption of a landfill closure action. Further characterization of pipelines would also not be recommended as this evaluation already concludes that residuals would present a threat without placement of the assumed barrier. Further characterization would not alter these determinations.

Closure actions may be necessary for purposes such as void space removal for engineered surface barrier integrity or for reduction of barrier size. The need for grouting pipeline encasements should be revisited as part of design, construction and maintenance of the WMA C surface barrier.

Washington State Department of Ecology Perspective

Although there is still much work to be done, the WMA C pipeline evaluation was a successful and collaborative effort between DOE, its contractor, and Ecology. The assessment has greatly improved the understanding of the complexities and the relative costs and schedules for performing closure actions. The evaluation has also provided preliminary indications of potential long-term impacts associated with pipeline residual waste. This information will undoubtedly aid the parties in making timely closure decisions for the pipelines within WMA C.

Future modifications to the Hanford Site-Wide Permit[2] may include design features of an engineered surface barrier, if clean closure is impracticable and a landfill closure is authorized. Landfill closure with an engineered surface barrier may influence the need for further pipeline closure actions. Ecology has stated that some characterization of pipelines may be required to verify that the contaminant inventories are within the bounding limits of the modeling results of the RA.

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