CHAPTER 1.0

COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

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TABLE OF CONTENTS

TABLES

1.0 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

This section presents the rationale and results of a comparison of remedial alternatives for the 100-NR-1 source operable unit (OU) and the 100-NR-2 groundwater OU. This comparison is based on five of the nine Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) evaluation criteria (EPA 1988) and National Environmental Policy Act (NEPA) values as discussed in DOE/RL-95-111, Rev. 0, Section 6.0. Source-site comparisons were done according to waste group types.

Key discriminators were selected within the evaluation criteria to compare the applicable remedial alternatives within each exposure scenario (i.e., rural-residential and modified Columbia River Comprehensive Impact Assessment [CRCIA] ranger/industrial) and are identified in Section 7.1. Based on key discriminators, this comparative analysis identifies the relative advantages and disadvantages of each alternative and provides a basis for selecting a remedial alternative for each exposure scenario.

1.1 Evaluation Criteria and Key Discriminators

To facilitate the evaluation of remedial alternatives, CERCLA prescribes nine specific evaluation criteria:

1. Overall protection of human health and the environment.
2. Compliance with Applicable or Relevant and Appropriate Requirements (ARAR).
3. Long-term effectiveness and permanence.
4. Reduction of toxicity, mobility, and volume through treatment.
5. Short-term effectiveness.
6. Implementability.
7. Cost.
8. State acceptance.
9. Community acceptance.

The first two criteria, overall protection of human health and the environment and compliance with ARARs, are considered threshold criteria that, if not met, would eliminate an alternative from consideration. Though it fails to meet the threshold criteria, the No-Action Alternative is retained in this comparative analysis for the purposes of providing a baseline assessment. The Institutional Controls Alternative for the 100-NR-1 OU (source sites) also fails the first criterion for the waste site groups, and it is inconsistent with unrestricted land use. Both the Institutional Controls and No-Action Alternatives, by definition in DOE/RL-95-111, Rev. 0, Section 5.0, may become part of other alternatives should site-specific soils data dictate that these alternatives are appropriate for individual sites.

The Institutional Controls Alternative is retained as a viable option for the 100-NR-2 OU (groundwater) remedial actions.

The overall protection and ARAR compliance criteria are not included in the comparative analysis presented in this section because all alternatives retained meet these threshold criteria. In addition, certain key discriminators within the overall protection criterion (e.g., impacts to natural and cultural resources, and residual risk) are inherent to other evaluation criteria such as long-term effectiveness and permanence and short-term effectiveness.

The last two criteria, state and community acceptance, will not be evaluated until after the proposed plan has been issued; therefore, they are not part of the comparative analysis presented below. This leaves five CERCLA evaluation criteria that are addressed in this Comparative Analysis:

- Long-term effectiveness and permanence.
- Reduction of toxicity, mobility, and volume through treatment.
- Short-term effectiveness.
- Implementability.
- Cost.

An evaluation of NEPA values also has been added so as to comply with the policy requiring integration of NEPA values into the CERCLA process.

Sections 7.1.1 through 7.1.6 discuss the five evaluation criteria and NEPA values, as well as the associated key discriminators used to compare alternatives.

1.1.1 Long-Term Effectiveness and Permanence

This criterion is concerned with the long-term consequences of the Remedial Alternative. Key discriminators for this criterion include the following:

- Residual risk (e.g., removal of the source contaminants eliminates site risk while the capping of wastes in place results in residual risk that limits land use and requires monitoring).
- Adequacy and reliability of controls (e.g., the Containment Alternative needs to address the reliability of the containment barrier, and the Remove/Dispose Alternative needs to address the reliability of the engineered disposal site).
- Long-term natural resource and environmental consequences (e.g., ability to manage residual risks, potential for habitat restoration, and influence on biodiversity).

1.1.2 Reduction of Toxicity, Mobility, or Volume through Treatment

The key discriminator for this criterion is the ability of the remedial alternative to reduce the mobility, toxicity, or volume of contaminants. Most alternatives considered would decrease contaminant mobility using containment or treatment technologies, but the effectiveness of the alternatives differs. Some remedial alternatives may also reduce waste volume (e.g., soil washing by using physical separation processes to segregate clean material from contaminated material). In situ and ex situ bioremediation are expected to reduce toxicity.

1.1.3 Short-Term Effectiveness

The EPA (1988) includes several discriminators (risk to the community, the worker, and the environment) in the short-term effectiveness criterion. This criterion also considers the time required to achieve protectiveness. Several NEPA values also relate to short-term effectiveness, including potential impacts to cultural resources, natural resources, socioeconomics, and transportation. The health risk to the community is considered insignificant for this evaluation because of the remote location of the 100-N Area. Socioeconomics was not considered a key discriminator because impacts of the remedial alternatives being considered probably would not make much difference on a regional level. Risk to the environment varies at each waste site. The impacts to vegetation and natural habitats would be minor as most of the waste sites have been previously disturbed. However, the capability to revegetate and restore wildlife habitats has been considered. Also, impacts to protected or sensitive species may be critical. The key discriminators for this criterion follow:

- Risk to workers.
- Transportation impacts.
- Risks to natural and cultural resources.

1.1.4 Implementability

Technical feasibility, administrative feasibility, and availability of services and materials are discriminators for implementability. Technical feasibility is important because it takes into account the technical aspects of implementing a remedial action.

Administrative feasibility considers how consistent the remedial action is with the future land-use options. Administrative feasibility is also significant because it includes coordination with other agencies and parties (agencies, trustees, and tribes) that have regulatory responsibility or stakeholder interests. Availability of services and materials is significant when considering waste removal and disposal, in situ treatment, capping, subsurface barriers, hydraulic controls, and sources of fill material. The key discriminators follow:

- Technical feasibility
- Administrative feasibility
- Availability of services and materials.

1.1.5 Cost

The estimated cost of each alternative is considered in all evaluations. The estimated costs available at this time should only be used to compare relative differences between remedial alternatives. These costs are not intended to be accurate estimates of total costs to remediate the sites.

1.1.6 NEPA Values

Key discriminators under this criterion include irreversible and irretrievable commitment of natural and cultural resources, cumulative impacts from implementation of the alternative, and environmental justice issues as they relate to Native American use of the land.

1.2 Comparison of Remedial Alternatives for Source Waste Sites

Comparative analyses were performed for the following four alternatives for both the rural- residential and modified CRCIA ranger/industrial exposure scenarios:

- No action (all waste groups types).
- Remove/dispose (all waste groups types).
- Remove/ex situ bioremediation/dispose (petroleum waste group).
- In situ bioremediation (petroleum waste group).

Comparative analyses of the following two alternatives were performed only for the modified CRCIA ranger/industrial exposure scenario:

- Containment (radioactive waste group).
- Solidification (radioactive waste group).

As discussed in DOE/RL-95-111, Rev. 0, Section 5.3, due to the lack of data on the extent of contamination in soil, all alternatives may potentially result in implementing no action or institutional controls upon obtaining further characterization data at a specific site within the 100-NR-1 OU.

Table 7.1 presents the remedial alternatives discussed in DOE/RL-95-111, Rev. 0, Sections 5.3, and 6.2.2 that are applicable to the rural-residential exposure scenario. If the rural-residential exposure scenario is selected, the remedial alternatives to meet unrestricted use are as shown in Table 7.1.

Table 7.2 presents the remedial alternatives considered to be applicable to the modified CRCIA ranger/industrial exposure scenario. In this case, land-use restrictions are appropriate and allow more options for remedial action.

The No-Action Alternative has been retained in this comparative analysis for both exposure scenarios as a basis for comparison with the other alternatives. However, as described in the detailed analysis presented in DOE/RL-95-111, Rev. 0, Section 6.0, the No-Action Alternative does not satisfy evaluation criteria for overall protection; long-term effectiveness and permanence; reduction of toxicity, mobility, and volume; or implementability. Therefore, the No-Action Alternative is not considered a viable alternative for the remediation of source sites at the 100-N Area.

Remedial alternatives compared under a rural-residential exposure scenario for all waste groups (Table 7.1) include the No-Action Alternative and the Remove/Dispose Alternative. The Remove/Dispose Alternative encompasses treatment that may be required for the Resource Conservation and Recovery Act (RCRA) Land Disposal Restrictions (LDR) compliance or for meeting waste acceptance criteria for disposal; however, the need to treat for land-disposal-restriction compliance and waste acceptance is not anticipated. The Remove/Dispose Alternative assumes that no contamination above cleanup levels will be encountered at depths below 4.6m (15 feet). However, should contamination be found below 4.6m (15 ft), a site specific determination will be required to define the appropriate remedial action options may include leaving some contamination in place. An evaluation will be conducted during the remedial action activities that will balance the extent of deep excavation with the following: protection of human health and the environment; disturbance of ecological and cultural resources; worker health and safety; remediation costs; operation and maintenance (O&M) costs; radioactive decay of short-lived radionuclides; the use of institutional controls; and long-term monitoring costs.

Specific information on ex situ bioremediation that is pertinent to a comparison of alternatives has been outlined in the comparative analyses in Sections 7.2.1 and 7.2.2. It must be emphasized that ex situ bioremediation is dependent upon detailed, site-specific information to determine if it is a cost-effective remedy. Because this information is not available, the comparative analysis cannot definitively assess the appropriateness of this technology for individual sites relative to other technologies. In addition, the petroleum waste group includes the In Situ Bioremediation Alternative, which is considered appropriate for two TPH-contaminated sites where TPH contaminants were detected in the groundwater. DOE/RL-95-111, Rev. 0, Section 6.0 provides detailed information on ex situ bioremediation, in situ bioremediation, and a no-treatment option that supports the comparative analysis.

Remedial alternatives compared for the modified CRCIA ranger/industrial scenario (Table 7.2) include the No-Action Alternative and the Remove/Dispose Alternative for all waste groups. In addition, the radioactive waste group includes the Containment Alternative, applicable to 16 sites, and the Solidification Alternative, which is applicable to 21 sites. Similarly to the rural-residential exposure scenario, the petroleum waste group includes the In Situ Bioremediation Alternative and the Ex Situ Bioremediation Alternative.

The comparative analysis of alternatives for source sites is presented in two subsections, Section 7.2.1 for the rural-residential exposure scenario, and Section 7.2.2 for the modified CRCIA ranger/industrial exposure scenario. The reader should note the following organization in reading the comparative analysis for source sites:

- In the comparative analysis, no distinction is made among the five waste groups. During the detailed analysis process, it was determined that the responses to the CERCLA and NEPA evaluation criteria depended primarily on the type of remedial action to be taken rather than on the type of contaminant present at the site.
- No direct comparison is made in the modified CRCIA ranger/industrial scenario between in situ bioremediation and containment (or solidification) because these alternatives do not apply to the same sites. In situ bioremediation is presented as an alternative to remediate petroleum spills at two sites where petroleum was observed in the groundwater; containment and solidification are presented as alternatives to remediate certain sites within the radioactive waste group.

1.2.1 Rural-Residential Exposure Scenario

1.2.1.1 Long-Term Effectiveness and Permanence

The Remove/Dispose Alternative provides a high degree of long-term effectiveness and permanence. No sources of risk above approved cleanup levels would remain at the site. All removed soils would be treated, if needed and as appropriate, with treatment residuals being disposed at the Environmental Restoration and Disposal Facility (ERDF).

No additional long-term restrictions for residential use at the waste site would be required following remediation with this alternative, unless it is determined that wastes that could pose a direct exposure hazard may be left below 4.6 m (15 ft). In this case, restrictions on excavation below 4.6 m (15 ft) would be required. If appropriate, revegetation and restoration efforts could be implemented that have the potential to more rapidly restore ecological habitats to healthy, sustainable conditions than is currently possible through natural succession.

The Remove/Ex Situ Bioremediation/Dispose Alternative would compare similarly to the Remove/Dispose Alternative, but it would have the added advantage of returning all, or a significant part of the soil, to the site rather than sending it to the ERDF.

The In Situ Bioremediation Alternative would also provide a high degree of long-term effectiveness and permanence. No risks from TPH contamination would remain because the contaminants would be destroyed, assuming complete treatment. However, it may be impossible to determine whether the treatment reaches all of the contamination. Post-remediation monitoring would be required.

The No-Action Alternative does not offer long-term effectiveness and permanence. Contaminants would remain in near-surface and subsurface soils above levels protective of human health and the environment. Sources of contamination that could contribute to groundwater contamination would remain. No revegetation or restoration efforts would be performed with this alternative.

1.2.1.2 Reduction in Toxicity, Mobility, or Volume

The Remove/Dispose Alternative would potentially provide reduced toxicity, mobility, or volume through application of treatment technologies, as appropriate for LDR compliance and ERDF waste acceptance. This alternative would remove wastes from the site, thereby reducing waste volume there. The Remove/Ex Situ Bioremediation Dispose Alternative might be employed for TPH where soil characteristics are amenable to the success of such a treatment technology. Ex situ and in situ bioremediation would reduce or destroy the toxicity of petroleum constituents through destruction. The reliability of technology and controls for ensuring complete treatment is less certain for in situ bioremediation. The No-Action Alternative would not reduce toxicity, mobility, or volume of contaminants in soils.

1.2.1.3 Short-Term Effectiveness

For the Remove/Dispose Alternative, a large volume of contaminated soils would be generated relative to the other alternatives. As this would require handling through excavation, treatment, and transportation, it would have the potential for inherently greater short-term impacts. Petroleum sites, as well as others, may have contamination at depth. Excavation to greater depths may increase short-term impacts to natural resources. During implementation, risks to workers from exposure to contaminated soils and fugitive dust or from accidents may increase; however, these risks can be effectively minimized through appropriate engineering controls and through health and safety procedures. Certain types of treatment may generate residuals that will require further management to meet LDR or ERDF waste acceptance criteria and, thus, would increase short-term risks to workers. Short-term impacts to vegetation and wildlife may be greatest with this alternative because it would disturb the largest land area. These impacts could be reduced through proper scheduling and implementation of the alternative. This alternative has the highest probability of impacting cultural resources in the short-term, simply due to the large land area impacted. Cultural resource locations are not precisely known; however, identification and mitigation of potential impacts would be addressed through the cultural resources mitigation plan.

Excavation impacts from the Remove/Ex Situ Bioremediation/Dispose Alternative would be similar to those of the Remove/Dispose Alternative. This alternative would take longer to be fully effective if determined to be appropriate. Therefore, at sites where treatment may be required, there may be more short-term disruption to the environment during this period. Transportation of wastes to ex situ bioremediation facilities may increase short-term impacts relative to the in situ treatment. Ex situ bioremediation, however, is expected to provide clean fill material to offset use of borrow material.

The In Situ Bioremediation Alternative is anticipated to require 5 to 25 years to complete at the two petroleum sites where it is applicable. Risks to workers from exposure to vented gases and fugitive dust or from accidents may be present during this time. However, these risks can be effectively minimized through appropriate engineering controls and through health and safety procedures. The potential for worker exposure to contaminated soils would be minimal during in situ treatment in contrast to the ex situ bioremediation option. Because little or no waste would be generated by in situ treatment, few transportation impacts are anticipated. Only equipment would be transported to and from the site. Risks to natural and cultural resources would be minimized. Short-term impacts to vegetation and wildlife may occur but could be avoided or reduced through appropriate design and implementation of the alternative. Cultural resources, if present, should not be impacted. If potential impacts are identified, they would be addressed through the cultural resources mitigation plan.

The No-Action Alternative would not involve any remedial actions; therefore, risks to workers, transportation impacts, and short-term risks to natural and cultural resources would not be increased nor decreased.

1.2.1.4 Implementability

The Remove/Dispose Alternative performs most favorably for technical and administrative feasibility and the availability of services and materials. Technical problems in implementing excavation and disposal activities within this alternative are not expected.

Ex situ bioremediation implementability is dependent upon site specific information, much of which could be obtained using the observational approach during excavation. Equipment required for implementation is readily available. However, should contamination be found at great depths, it may become less feasible to excavate. Due to the lack of soil characterization data, this potential would have to be evaluated during the design phase of this alternative. It might also be necessary to treat soil constituents to meet LDRs for which there is no immediately available treatment technology. Should it be found upon characterization that petroleum contamination exists at depth or that radionuclide or inorganic contaminants are present, this alternative would not be considered readily implementable.

There is less certainty regarding reliable implementation of in situ bioremediation because completeness of treatment cannot be accurately monitored. Characterization to better determine the extent of remediation may be required. Equipment required for implementation is readily available.

The No-Action Alternative would be easy to implement but would not be consistent with the Department of Energy's (DOE) long-range objective.

1.2.1.5 Cost

Cost estimates for the source sites in DOE/RL-95-111, Rev. 0 were developed using either the Micro Computer Aided Cost Estimating System (MCACES) or the Remedial Action Cost Engineering and Requirements (RACER) package. Total costs presented in this section do not include a 3 percent design cost and a 3 percent cost data collection cost that applies to all estimates. Details of the cost estimates are presented in Permit Attachment 47, Appendix G. It needs to be kept in mind that the quality of a cost estimate is directly related to the quality of the input data used in the models. As has been noted earlier in this report, data on site-specific contamination, site locations, and site dimensions were limited, and this introduces uncertainty in the cost estimates. Despite this uncertainty, it is believed that the cost estimates are of sufficient quality to fulfill the primary objective, which is to aid in selecting preferred remedial alternatives. How representative these estimates might be of actual remediation costs is more difficult to answer and will not be resolved until the uncertainties in the data are resolved.

The No-Action Alternative would require no additional cost and is not considered further in this comparative analysis.

Individual cost estimates for each waste site, exposure scenario, and remedial alternative are presented in Table 6.2. Three alternatives (Remove/Dispose, Remove/Ex situ Bioremediation/Dispose, and In Situ Bioremediation) are proposed for petroleum-contaminated sites under both exposure scenarios.

Ex situ bioremediation is proposed for 14 sites that have near-surface contamination, and in situ bioremediation is proposed for two sites with deep contamination. Because all of the petroleum contamination will be removed, there is no cost difference between the two exposure scenarios for this alternative. The cost comparison in Table 7.3 shows that in situ bioremediation is 65 percent less expensive than the Remove/Dispose Alternative. The cost comparison in Table 7.4 shows that ex situ bioremediation is 12 percent more expensive than the Remove/Dispose Alternative. Because of the uncertainty in the data used to develop these estimates, cost should not be used as a factor in deciding between these two alternatives. This 12 percent difference is not considered significant.

A summary of these results is presented in Table 7.5. The least cost alternative for the rural-residential scenarios is to select the Remove/Disposal Alternative for all sites except the two deep petroleum sites. This produces a cost saving of 7 percent over the using the Remove/Dispose Alternative for all sites.

1.2.1.6 NEPA Values

Irreversible and irretrievable commitment of a significant number of natural resources would not occur with the Remove/Dispose Alternative. Contaminated soils would be removed from a site and transported to the ERDF; therefore, there would be a commitment to use portions of that disposal unit for long-term waste management. Excavated material would be replaced with clean fill and topsoil, then revegetated to mirror more closely the native plant community. (This may be an interim benefit should future rural-residential use of the land dictate another vegetative regime.) Future use of the river and adjacent lands would allow Native American use in concert with a modified CRCIA ranger/industrial exposure scenario in a relatively short time frame. Excavation could disturb cultural resources contained at a site, and careful adherence to cultural resource mitigation planning would be required. Cumulative impacts may occur at borrow sites and transportation routes.

The In Situ Bioremediation Alternative would not irreversibly or irretrievably commit significant amounts of natural resources. Using ERDF resources would not be required under this alternative in comparison to the Remove/Dispose Alternative. Potential impacts on future land use would be comparable to the Remove/Dispose Alternative. Disturbance of cultural resources could occur with this alternative, but not to the degree that would be required with the Remove/Dispose Alternative. Irreversible and irretrievable commitment of natural resources would occur with the No-Action Alternative because contaminants would remain on site, so human and ecological receptors would continue to be exposed. For radiological constituents, this exposure will remain until decay results in contaminant levels below concern. For nonradiological constituents, exposure may be very long term. There may be an impact on Native Americans because they are potentially more likely than other groups to use the area. No direct impacts would result from implementing this alternative.

1.2.2 Modified CRCIA Ranger/Industrial Exposure Scenario

1.2.2.1 Long-Term Effectiveness and Permanence

The Remove/Dispose Alternative provides a high degree of long-term effectiveness and permanence. No sources of risk above approved cleanup levels would remain at the site. All removed soils would be treated, if needed and if appropriate, with treatment residuals being disposed at the ERDF. No additional long-term restrictions for residential use at the waste site would be required following remediation with this alternative unless it is determined that wastes that could pose a direct exposure hazard may be left below 4.6 m (15 ft). In this case, restrictions on excavation below 4.6 m (15 ft) would be required. If appropriate, revegetation and restoration efforts could be implemented that have the potential to more rapidly restore ecological habitats to healthy, sustainable conditions than is currently possible through natural succession.

The Remove/Ex Situ Bioremediation/Dispose Alternative would compare similarly to the Remove/Dispose Alternative, but it would have the added advantage of returning all, or a significant part of the soil, to the site rather than sending it to the ERDF.

The In Situ Bioremediation Alternative would also provide a high degree of long-term effectiveness and permanence. No risks from TPH contamination would remain because the contaminants would be destroyed, assuming complete treatment. However, it may be impossible to determine whether the treatment reaches all of the contamination. Post-remediation monitoring would be required.

The Containment and In Situ Solidification Alternatives perform relatively equally on long-term effectiveness and permanence, but neither performs as well as the Remove/ Dispose Alternative. While contaminants are left in place under both alternatives, for the near term, human health and the environment are considered protected. Both alternatives have the potential for long-term failure (i.e., containment through failure of the barrier and in situ solidification through incomplete treatment or deterioration of the solidified matrix). Long-term post-closure monitoring, including maintenance of barriers, would be required with these alternatives. Revegetation is considered to have a good probability for success with these alternatives, but wastes would be left in place and would limit complete restoration.

The No-Action Alternative does not offer long-term effectiveness and permanence. Contaminants would remain in near-surface and subsurface soils above levels protective of human health and the environment. Sources of contamination that could contribute to groundwater contamination would remain. No revegetation or restoration efforts would be included with this alternative.

1.2.2.2 Reduction in Toxicity, Mobility, or Volume

The Remove/Dispose Alternative would potentially provide reduced toxicity, mobility, or volume through application of treatment technologies, as appropriate for LDR compliance and ERDF waste acceptance. This alternative would remove wastes from the site, thereby reducing waste volume at the site. The Remove/ Ex Situ Bioremediation/Dispose Alternative might be employed for TPH where soil characteristics are amenable to the success of such a treatment technology. Ex situ and in situ bioremediation would reduce or destroy the toxicity of petroleum constituents through destruction. The reliability of technology and controls for ensuring complete treatment is less certain for in situ bioremediation.

Containment does not include a treatment option; however, a properly constructed engineered barrier would reduce the mobility of contaminants by reducing infiltration. Neither a reduction in toxicity nor volume is provided by this alternative.

The in situ solidification would reduce mobility through stabilization in the near term but would not reduce toxicity or volume of contaminants. Remobilization of contaminants could occur if the stabilized media degraded through time. Incomplete mixing of contaminants with the stabilization media could interfere with reduction in contaminant mobility, and some contaminants might not be stabilized to the same degree as others.

The No-Action Alternative would not reduce toxicity, mobility, or volume of contaminants in soils.

1.2.2.3 Short-Term Effectiveness

For the Remove/Dispose Alternative, a larger volume of contaminated soils would be generated relative to the other alternatives. This would require handling through excavation, treatment, and transportation, which would have the potential for inherently greater short-term impacts. Petroleum sites, as well as others, may have contamination at depth. Excavation to greater depths may increase short-term impacts to natural resources. During implementation, risks to workers from exposure to contaminated soils and fugitive dust or from accidents may increase; however, these risks can be effectively minimized through appropriate engineering controls and through health and safety procedures. Short-term impacts to vegetation and wildlife may be greatest with this alternative because it would disturb the largest land area. These impacts could be reduced through proper scheduling and implementation of the alternative. This alternative has the highest probability of impacting cultural resources in the short term simply due to the large land area impacted. Cultural resource locations are not precisely known; however, identification and mitigation of potential impacts would be addressed through the cultural resources mitigation plan.

Excavation impacts from the Remove/Ex Situ Bioremediation/Dispose Alternative would be similar to that of the Remove/Dispose Alternative. This alternative would take longer to be fully effective if determined to be appropriate. Therefore, at sites where treatment may be required, there may be more short-term disruption to the environment during this period. Transportation of wastes to ex situ bioremediation facilities may increase short-term impacts relative to the in situ treatment. Ex situ bioremediation, however, is expected to provide clean fill material to offset the use of borrow material.

The In Situ Bioremediation Alternative is anticipated to require 5 to 25 years to complete at the two petroleum sites where it is applicable. Risks to workers from exposure to vented gases and fugitive dust or from accidents may be present during this time. However, these risks can be effectively minimized through appropriate engineering controls and through health and safety procedures. The potential for worker exposure to contaminated soils would be minimal during in situ treatment in contrast to the ex situ bioremediation option. Because little or no waste would be generated by in situ treatment, few transportation impacts are anticipated. Only equipment would be transported to and from the site. Risks to natural and cultural resources would be minimized. Short-term impacts to vegetation and wildlife may occur but could be avoided or reduced through appropriate design and implementation of the alternative. Cultural resources, if present, should not be impacted. If potential impacts are identified, they would be addressed through the cultural resources mitigation plan.

The Containment and In Situ Solidification Alternatives perform similarly with regard to short-term effectiveness. Both alternatives pose little risk to workers because they would not be exposed to contaminants during implementation. No contaminated soils would be transported. Transportation of materials and equipment for containment or solidification, and transportation of clean fill after containment, would increase traffic on haul roads. Short-term impacts to vegetation and wildlife could occur during the estimated 2- to 5-year restoration time frame, but these could be avoided or reduced through proper implementation of the alternative. Cultural resources, if present, should not be impacted. Identification and mitigation of these impacts would be addressed through the cultural resources mitigation plan.

The No-Action Alternative would not involve any remedial actions; therefore, risks to workers, transportation impacts, and short-term risks to natural and cultural resources would not occur.

1.2.2.4 Implementability

The Remove/Dispose Alternative performs most favorably for technical and administrative feasibility and the availability of services and materials. Technical problems in implementing excavation and disposal activities within this alternative are not expected.

Ex situ bioremediation implementability is dependent upon site-specific information, much of which could be obtained using the observational approach during excavation. Equipment required for implementation is readily available. However, should contamination be found at great depths, it may become less feasible to excavate. Due to the lack of soil characterization data, this potential would have to be evaluated during the design phase of this alternative. It might also be necessary to treat soil constituents to meet LDRs for which there is no immediately available treatment technology. Should it be found upon characterization that petroleum contamination exists at depth or that radionuclide or inorganic contaminants are present, this alternative would not be considered readily implementable.

There is less certainty regarding reliable implementation of in situ bioremediation because completeness of treatment cannot be accurately monitored. Characterization to determine the extent of remediation may be required. Equipment required for implementation is readily available.

Containment will be easy to implement; however, characterization of the extent of contamination will be required in order to properly locate the barrier. Technical problems causing delays are not anticipated. Large quantities of soil and rock material will be required for construction of the barrier; however, this material is considered available from sources within or near Hanford.

The In Situ Solidification Alternative is considered less implementable than the Containment Alternative because of the potential for incomplete mixing of the treatment zone. Contaminants may be encountered that are not effectively treated through this technology. Problems in ensuring complete treatment could result in remediation delays. As with containment, further characterization of the extent of contamination will be required to determine proper treatment. Materials needed for implementation are considered readily available.

The No-Action Alternative would be easy to implement, but would not be consistent with DOE's long-range objective.

1.2.2.5 Cost

Cost estimates for the source sites in DOE/RL-95-111, Rev. 0 were, in general, developed using either the MCACES or the RACER package. Total costs presented in this section include neither a 3 percent design cost nor a 3 percent data collection cost. Details of the cost estimates are presented in Permit Attachment 47, Appendix G.

As has been noted earlier in this report, data on site-specific contamination, site locations, and site dimensions were limited, and this introduces uncertainty in the cost estimates. The quality of a cost estimate is directly related to the quality of the input data used in the models. Despite this uncertainty it is believed that the cost estimates are of sufficient quality to fulfill the primary objective, which is to aid in selecting preferred remedial alternatives. How representative these estimates might be of actual remediation costs is more difficult to answer and will not be resolved until the uncertainties in the data are resolved.

The No-Action Alternative would require no additional cost and is not considered further in this comparative analysis.

Individual cost estimates for each waste site, exposure scenario, and remedial alternative are presented in Table 6.2. Five remedial alternatives (Remove/Dispose, Remove/Ex Situ Bioremediation/Dispose, In Situ Bioremediation, Capping, and In Situ Solidification) have been proposed for the modified CRCIA ranger/industrial exposure scenario. The evaluation of alternatives for the sites with petroleum contamination is the same as just presented for the rural-residential scenario and concludes that in situ bioremediation is the least expensive alternative for the two deep petroleum sites and remove/dispose for the near-surface petroleum sites.

Capping is considered for 5 clusters of waste sites to cover a total of 16 sites. As shown in Table 7.6, the cost of remediating 16 sites by capping is about $65,000,000 versus $2,400,000 for the Remove/Dispose Alternative for 20 sites. This is 27 times the cost of the Remove/Dispose Alternative. Additionally, the Remove/Dispose Alternative is less expensive than capping at all five cap sites. Although it may appear that some sites could be capped at less cost than the Remove/Dispose Alternative, this is deceptive. These costs reflect the cost of capping a cluster of sites and must be evaluated as a group because the costs are shared among the several sites within the cluster. When evaluating capping costs it is necessary to keep in mind that this cost estimate is based upon using a specific barrier, the Modified RCRA Subtitle C barrier. This is perhaps one of the most expensive barrier options. It was selected for use in DOE/RL-95-111, Rev. 0, because there was limited site-specific data with which to make a decision. As additional data is collected during the design process, other, less expensive cap designs may be appropriate.

In situ solidification is considered for the 16 capping sites and 4 additional ones. As shown in Table 7.6, the cost of remediating 20 sites by in situ solidification is about $6,600,000 as opposed to $3,100,000 for the Remove/Dispose Alternative. This is over two times the cost of the Remove/Dispose Alternative. Additionally, the In Situ Solidification Alternative was more expensive than the Remove/Dispose Alternative at all 20 sites.

A summary of these results is presented in Table 7.7. The least cost alternative for the modified CRCIA ranger/industrial scenario is to select the Remove/Disposal Alternative for all sites except the two deep petroleum sites. This produces a cost saving of 7 percent over using the Remove/Dispose Alternative for all sites.

There are many uncertainties dealing with developing cost estimate for sites with limited site-specific information. As already noted, for example, limited data lead to the selection of an expensive cap design.

1.2.2.6 NEPA Values

By definition, the modified CRCIA ranger/industrial scenario requires more of a commitment of onsite resources than does the residential exposure scenario. At the same time, there would be less commitment of ERDF resources because less soil may require excavation and disposal. There would also be less impact on cultural resources, and fewer cumulative impacts under a modified CRCIA ranger/industrial exposure scenario because of this. Restrictions on hunting and gathering are also inherent in the modified CRCIA ranger/industrial scenario defined in DOE/RL-95-111, Rev. 0.

An irreversible and irretrievable commitment of natural resources would occur with the Remove/Dispose Alternative. Contaminated soils would be removed and transported to the ERDF; therefore, there would be a commitment to use portions of that disposal unit for long-term waste management and the associated borrow pit commitment for ERDF cover. Excavated material would be replaced with clean fill topsoil (from the borrow pits), then revegetated to mirror more closely the native plant community existing prior to disturbance from 100-N Area activities. Future use of the river and adjacent lands would allow Native American use in concert with a modified CRCIA ranger/industrial exposure scenario in a relatively short time frame. Excavation could disturb cultural resources existing at a site, and careful adherence to cultural resource mitigation planning would be required. Cumulative impacts may occur at borrow sites and transportation routes.

The In Situ Bioremediation, Containment, and In Situ Solidification Alternatives perform similarly to the Remove/Dispose Alternative for key discriminators under this criterion with the exception that fewer ERDF resources would be utilized under these alternatives.

Irreversible and irretrievable commitment of natural resources would occur with the No-Action Alternative because contaminants would remain on site, and human and ecological receptors would continue to be exposed. For radiological constituents, this exposure would remain until decay results in contaminant levels below concern. For nonradiological constituents, exposure may be very long term. There may be an impact on Native Americans because they are potentially more likely to use the area than are other groups. No cumulative impacts would result from implementing this alternative.

1.3 Comparison of Remedial Alternatives for Groundwater

Table 7.8 presents the seven alternatives described in DOE/RL-95-111, Rev. 0, Section 5.0 for the remediation of groundwater underlying the 100-N Area and for protection of the Columbia River. It indicates which technologies are used within each remedial alternative to address the four issues considered to be critical for remediating the contaminated groundwater system at the 100-N Area. These four issues follow:

- Protection of the river from tritium.
- Protection of the river from Sr-90.
- Reduction of Sr-90 in the aquifer.
- Reduction of other contaminants in the aquifer.

In the comparative analysis of groundwater alternatives, no distinction is made between the rural-residential and modified CRCIA ranger/industrial exposure scenarios. No distinction is necessary because, under either exposure scenario, the existing beneficial uses of the Columbia River must be protected. The existing beneficial uses of the river include water supply, recreation, fish and wildlife habitat, hydroelectric power production, transportation, and agriculture.

The remedial alternatives must meet the appropriate ARARs for these beneficial uses, regardless of whether the exposure scenario is rural-residential or modified CRCIA ranger/industrial. Also, under both scenarios, it is assumed that the goal is to restore groundwater for beneficial uses. Therefore, no distinction is required with respect to aquifer remediation.

The No-Action Alternative is not considered a viable alternative because it does not meet overall protectiveness or compliance with ARARs. The No-Action Alternative is retained as the baseline case for comparison with the other alternatives that incorporate some active response action.

1.3.1 Long-Term Effectiveness and Permanence

1.3.1.1 Protection of the River from Tritium

Alternative 5 and Alternative 7 (Table 7.8) describe technologies to reduce tritium flux to the river (hydraulic controls or barrier with hydraulic controls) and therefore are equally effective in preventing the tritium from entering the river at concentrations above the MCL for tritium. The added impermeable barrier in Alternative 7 may provide some degree of protection above hydraulic controls alone for tritium, but the differences are considered neither quantifiable nor great because tritium is easily controlled hydraulically. Both are considered comparable in their reliability of controls, as well. The other alternatives do not include any action to prevent tritium from entering the river except through decay (although Alternative 4 might coincidentally prevent tritium discharge through hydraulic controls placed on the Sr-90 plume). For alternatives 1, 2, 3, and 6, the tritium reaching the river will exceed Maximum Containment Levels (MCL) for approximately 15 years.

1.3.1.2 Protection of the River from Sr-90

Alternatives 1 and 2 do not include any action to prevent Sr-90 from entering the river; therefore, they provide a basis for comparison to the other alternatives. Taking no physical action, the Sr-90 concentrations in the groundwater/river interface will decay to concentrations below MCLs over a 300-year period. The remaining five alternatives use three different technologies to reduce the Sr-90 flux to the river: a permeable barrier (Alternative 3), hydraulic controls (Alternatives 4 and 5), and impermeable barriers (Alternatives 6 and 7). These three technologies for reducing flux may be interchanged within the three alternatives to accomplish this objective.

Although these technologies reduce flux of Sr-90 discharging to the Columbia River (i.e., mass of Sr-90 per unit time moving through the aquifer into the river), none of the alternatives are expected to significantly reduce Sr-90 concentrations entering the river above MCLs because a section of aquifer next to the river would be essentially unaffected by the technologies, and the slow release of the Sr-90 adsorbed onto the aquifer soils in this section would continue. This is true with all alternatives because a section of land remains between the river and the barrier in all cases--either by a physical barrier (impermeable or permeable) or a hydraulic barrier. This phenomenon is due to the sorbing ability of Sr-90 on soils, which retard dissolution in the groundwater, as described in DOE/RL-95-111, Rev. 0, Sections 3.0, and 5.0. The impact of this Sr-90-contaminated area adjacent to the river on concentrations at the groundwater/river interface is not anticipated to decrease significantly faster than the decease that will occur solely because of natural decay. However, comparatively, hydraulic controls contained in Alternatives 4 and 5 may potentially reduce concentrations at the groundwater/river interface more effectively than the other alternatives, although not significantly, because of the net gradient effect. For example, the net groundwater flow in the aquifer immediately adjacent to the river is inland, with hydraulic controls in place, while the net groundwater flow with the barriers is toward the river. A permeable barrier (Alternative 3) is expected to be the next best alternative for reducing Sr-90 concentrations in the groundwater/river interface, with the impermeable barrier (Alternatives 6 and 7) being the least effective in reducing concentrations of Sr-90.

All alternatives (except 1 and 2) are expected to reduce flux of Sr-90 to the river by more than 90 percent. The Hydraulic Control Alternatives, because they reverse the groundwater flow near the river shoreline, are probably more effective than the other alternatives for reducing flux, and might be more effective in reducing concentrations of Sr-90. However, this increase in effectiveness has not been quantified. The Impermeable Barrier Alternatives would rank next in ability to reduce Sr-90 flux, with the Permeable Barrier Alternative ranking the least effective among Alternatives 3 through 7.

Relative to risk, reducing the flux of Sr-90 to the river may not be of great importance. Currently, the most stringent ARAR for Sr-90 is based on an MCL, which is established for the purposes of achieving human health protection from the use of surface or groundwater as a drinking water source. Decreasing the flux of Sr-90-contaminated waters to the river is inconsequential with respect to using the river as a drinking water supply, because of the near instantaneous reduction of Sr-90 concentrations that occurs near the groundwater/river interface. DOE/RL-95-111, Rev. 0, Section 3.3.5 describes Columbia River water quality relative to Sr-90, and it concludes that concentrations in the river are consistently below MCLs for Sr-90. However, the seeps located at N-Springs on the river bank adjacent to the 116-N-1 Crib do exceed MCLs, and institutional controls would be required to restrict this area of the river from use as a drinking water source.

With the exception of N-Springs, Sr-90 does not threaten the Columbia River as a drinking water source. In contrast, however, concentrations of Sr-90 in the sediments at the groundwater/river interface may be harming aquatic organisms. Site-specific data related to ecological effects may not be complete, and in any case, no alternatives are capable of substantially decreasing these concentrations or significantly reducing the time frame for achieving a protective concentration.

1.3.1.3 Reduction of Sr-90 in the Aquifer

Alternatives 1, 2, and 3 do not include any action to reduce the Sr-90 contamination in the groundwater, but Alternatives 2 and 3 include institutional controls to prevent exposure to humans from use of the groundwater until Sr-90 decays to acceptable levels, thereby providing a measure of long-term protectiveness. Alternative 3 does, however, immobilize large quantities of Sr-90 through capture in the permeable barrier. This capture does not change concentrations of Sr-90 in the groundwater upgradient of the barrier due to the equilibrium that will occur between soil and groundwater, but it will immobilize a large mass of Sr-90 from the aquifer. This immobilization action may not contribute much to reducing Sr-90 concentrations at the groundwater/river interface as described above.

Alternatives 4, 5, and 6 are more effective in reducing Sr-90 in the aquifer than the first three alternatives because these alternatives include pump-and-treat systems. They do not, however, have a significant increase in effectiveness because the alternatives only achieve a 10 percent reduction in the time to attain the remediation goal – 270 years versus 300 years. Alternative 7 (soil flushing) has the potential to be more effective and result in a shorter restoration time frame than any of the other alternatives. However, at this stage, it is considered an innovative technology for Sr-90 in the aquifer and for the site-specific conditions of the 100-NR-2 OU. A series of laboratory, bench, and field-scale tests would be required before a decision on the feasibility of soil flushing could be made. Because of this requirement, no objective comparison of soil flushing can be made against the other alternatives in DOE/RL-95-111, Rev. 0.

1.3.1.4 Reduction of Other Contaminants in the Aquifer

Alternatives 1 through 4 include no action to reduce the contamination in the aquifer from other contaminants; therefore, they are not compared against each other for long-term effectiveness and permanence. The other contaminants include nitrate, sulfate, manganese, chromium IV, and TPH. Some migration of those contaminants will occur over time. Utilizing travel-time predictions contained in DOE/RL-95-111, Rev. 0, Appendix D, gross predictions of natural migration can be made. These predictions are based on modeling assumptions that may not account for the heterogeneity inherent in the groundwater/river system over time.

However, since groundwater at the 100-N Area flows into the river, the travel time for peak concentrations to reach the river roughly equates to the time required for natural migration of the contaminant from the aquifer (DOE/RL-95-111, Rev. 0, Appendix D).

Nitrate may migrate from groundwater to the river within 10 to 20 years. Sulfate may migrate from groundwater to the river in 5 to 15 years. Chromium VI may migrate to the river in 15 to 25 years. Manganese may take over 3,000 years to migrate from groundwater to the river. Migration times for TPH cannot be estimated because the product will continue to float on top of the aquifer for an indeterminate, but probably long, period of time.

It should be noted that chromium VI concentrations are based on data from a small number of wells and that there is no discernible plume. Also, since manganese and sulfate Primary Remediation Goals (PRG) are based on secondary MCLs, the need for remediating these two contaminants may not be as critical as for the other contaminants.

Alternatives 5, 6, and 7 all rely upon the same pump-and-treat technology for remediation of the other contaminants. Pump-and-treat technologies can be effective in the long term because they permanently remove contaminants from the environment. It is anticipated that pump-and-treat technologies will decrease restoration time frames for groundwater protection as follows: nitrates, 5 years; sulfates, 5 years; chromium VI, 1 year; manganese, 88 years; and TPH, 5 years.

Given these estimates, long-term effectiveness can be achieved earlier with pump-and-treat technology than with natural migration:

- Nitrates may be remediated in the aquifer 5 to 15 years earlier.
- Sulfates may not be remediated in the groundwater at a significantly faster rate than could be achieved by natural migration.
- Chromium VI may be remediated 15 to 25 years earlier.

Manganese may be remediated over 3,000 years earlier.

- TPH may be remediated many years earlier, but time frames cannot be estimated.

Groundwater monitoring after cleanup would be required for a time to ensure that all of the plumes have been captured.

1.3.1.5 Summary

Seven alternatives have been compared that meet (except for no action) all or part of the needs for long-term effectiveness and permanence. For tritium river protection, Alternatives 5 and 7 are anticipated to provide, most effectively, long-term protection. Other than the No-Action Alternative, all of the alternatives that could be implemented are comparable for long-term effectiveness and permanence for addressing the Sr-90 releases to the river. An estimated 90 percent reduction in the mass of Sr-90 entering the river will result through utilization of Alternatives 3, 4, 5, 6, or 7 as opposed to an Institutional Controls Alternative. However, reduction in mass is anticipated to have little human health or environmental benefit. Reduction in the restoration time of Sr-90 concentrations is not anticipated to be significantly different for any of the alternatives with the possible exception of Alternatives 4 and 5 due to the net gradient effect of bringing clean river water inland.

For Sr-90 reduction in the aquifer, no alternative will resulting in remediation of Sr-90 to groundwater protection standards more rapidly than will natural attenuation, with the possible exception of soil flushing. Alternative 7 has the potential to improve the long-term effectiveness by shortening the time to meet remedial goals, but it is an innovative technology for Sr-90-contaminated soils at Hanford, and it must be the subject of further testing and evaluation before a decision on its use can be made. Alternative 7 has the potential for risks to natural resources by expansion of the Sr-90 plume, potentially to the river, if soil flushing is not carefully implemented. Given the uncertainties at this time relative to safe implementation of this option, these risks remain unknown.

Alternatives with pump and treat will reduce nitrate, chromium VI, and manganese (the latter two if proven to be a contaminant of concern (COC) upon further results of monitoring) at a faster rate than would be achieved through natural migration of contaminants in the aquifer. However, this improvement may not be significant when it is considered that a significant portion of the aquifer will remain unusable during the period of Sr-90 contamination.

1.3.2 Reduction in Toxicity, Mobility, or Volume through Treatment

For protection of the river from tritium, Alternatives 1 through 4 contain no treatment element and therefore would not reduce toxicity, mobility, or volume (i.e., mass) of tritium. Alternatives 5 and 7 reduce the mobility of the tritium to the river by establishing barriers to the flow to the river.

For protection of the river from Sr-90, Alternatives 1 and 2 contain no treatment element for Sr-90 and therefore would not reduce toxicity, mobility, or volume (i.e., mass) of Sr-90. Alternatives 3 through 7 would decrease the flux of Sr-90 entering the river by around 90 percent. Differences between these alternatives (permeable barrier, impermeable barrier, and hydraulic controls) are considered neither quantifiable nor great.

Alternatives 1 through 3 do not contain a treatment element for Sr-90 reduction in the aquifer. Alternatives 4 through 6, which have barriers to the river and pump-and-treat systems, compare favorably with respect to Sr-90 reduction in the groundwater; however, reductions in mobility, and/or volume are neither quantifiable nor great. Alternative 7 has the greatest potential for mass reduction, but will require that a test program be implemented before this alternative could be adequately compared with other alternatives.

For reducing other constituents in the aquifer, Alternatives 5 through 7, which have pump-and-treat systems, will reduce contaminant toxicity, mobility, and/or volume, dependent upon the specific constituent, to a higher degree than Alternatives 1 through 4.

1.3.3 Short-Term Effectiveness

None of the alternatives is expected to have significant short-term impacts on the community during implementation. No alternative will remediate the river or aquifer for Sr-90 within 270 years. Alternative 1, followed by Alternative 2, has the lowest short-term impacts associated with worker risk, as well as the lowest ecological, cultural, and transportation impacts from system installation. The greatest potential impacts to natural and cultural resources are from installation of barriers. Alternatives 4 and 5, which use wells rather than barrier, have less short-term impact than the barrier alternatives (Alternatives 3, 6, and 7) that use excavation techniques or cryogenics. Alternative 7 has the potential for risks to natural resources by expansion of the Sr-90 plume, potentially to the river, if soil flushing is not carefully implemented. Given the uncertainties at this time relative to safe implementation of soil flushing, these risks remain unknown.

1.3.4 Implementability

All alternatives, with the exception of the No-Action Alternative, will require institutional controls that will require some maintenance for close to 300 years. The technical and administrative feasibility of maintaining these controls is uncertain, but it is a comparable implementability issue for every alternative.

All three barriers are expected to be implementable, but each presents a concern because they represent a new application at Hanford. A treatability test plan is being considered for evaluation of the construction of the permeable wall in Alternative 3. This would help to refine this determination. Alternative 6 introduces some concerns because of the need to freeze the ground near the river and because of the need to maintain its integrity over 300 years. Alternative 7 presents implementability concerns regarding sheet pile installation because of past problems in installing a sheet pile barrier at Hanford. However, the alternative sheet pile installation method proposed in Alternative 7 is expected to resolve past concerns. There is little basis to distinguish between these alternatives with respect to barrier construction; however, all of the construction alternatives will require collection of additional information at the design stage.

Alternatives 4, 5, and 7 are less implementable than institutional controls because they involve installation of a complicated hydraulic control system. Hydraulic controls are subject to breakdown, and, as such, would not be effective 100 percent of the time. However, these alternatives are still technically and administratively feasible. Hydraulic control systems like the one contemplated in these alternatives would be similar to a system already in place at Hanford; therefore, these alternatives are considered more implementable than barrier construction alternatives.

The soil flush portion of Alternative 7 is not considered implementable without first successfully completing a series of laboratory, bench-scale, and field tests.

Alternatives that involve pump-and-treat systems for Sr-90 and/or other contaminants are considered less implementable than Alternatives 1 or 2.

In all of the alternatives, there is a strip of land along the river shoreline that is contaminated with Sr-90. The soil in this strip does not meet PRG levels for the rural-residential scenario and may not meet them for the modified CRCIA ranger/industrial exposure scenario. Remediation of the shoreline area would be difficult. The remove and dispose remedial alternative proposed for source waste sites could be implemented along the river shoreline, but would require excavation and backfilling to 4.6 m (15 ft) or 3 m (10 ft) for the rural-residential and modified CRCIA ranger/industrial scenarios, respectively. Such remedial actions would destroy the ecology of this riparian zone and possibly undercut the bluff along the shore, causing further destruction. Such actions may only provide temporary relief because there will likely be recontamination from upgradient groundwater. Additionally, the area appears to be within the Columbia River flood plain and residential construction may be limited or prohibited. Institutional Controls has been recommended in all of the alternatives (except No-Action) to ensure limited access to this area.

1.3.5 Cost

A summary of the cost estimates for each groundwater remedial alternative is presented in Table 7.9, and information that is more detailed is presented in Permit Attachment 47, Appendix G2. A simple quantitative comparison, as shown in Table 7.9 is not sufficient for evaluating the alternatives, since the alternatives represent different levels of remediation. An incremental analysis would be more appropriate. In this type of analysis, each alternative (or each group of alternatives with a similar level of remediation) is compared to the alternative with the next lowest level of remediation.

Alternative 1 includes no remediation because it proposes to do nothing and it costs nothing. Alternative 2 is similar to Alternative 1 in that it includes no remediation, but it proposes institutional controls such as warning signs and land-use restrictions. The total cost of institutional controls is $762,826.

Alternative 3 includes a remedial technology to prevent Sr-90 from entering the river. Constructing a clinoptilolite barrier will not prevent all Sr-90 from entering the river, but it will substantially reduce the amount. Strontium-90 will decay to an acceptable level in about 300 years. This degree of remediation will cost $8,499,399 more than Alternative 2, for a total cost of about $9,262,125. The objectives of Alternative 3 could also be met by using the hydraulic controls technology from Alternative 4 or the impermeable barrier technology from Alternatives 6 or 7.

In Alternative 4, the clinoptilolite barrier is replaced by hydraulic controls, which further reduces the amount of Sr-90 that will reach the river (although with less certainty). Additional remediation is provided by Alternative 4 in that a pump-and-treat system is used to remediate the Sr-90 that is present in the groundwater. The pump-and-treat system will extract Sr-90 from the aquifer and thereby reduce the mass of the contaminant. Operating the pump-and-treat system will reduce the time it takes to remediate the groundwater by about 10 percent, from 300 to 270 years. The cost of shortening this period by 30 years is about $4,983,489 more than Alternative 3, for a total of about $14,245,714.

Alternative 5 provides additional remediation by extending the hydraulic controls to protect the river from tritium, as well as Sr-90, and by to remediating the other contaminants (nitrate, iron, sulfate, manganese, TPH, and chromium VI) in the groundwater.

Meeting this last objective is accomplished by operating a pump-and-treat system for the other contaminants. This pump and treat would shorten the time for the concentrations of these contaminants to reach acceptable levels in the groundwater, but it would not shorten the time until the groundwater would be available for use. The concentrations of these contaminants would be at acceptable levels (with no action) well before the Sr-90 concentration reached an acceptable level. The cost of the additional remediation is about $24,920,116 more than Alternative 4, for a total cost of about $39,165,605.

Alternative 6 actually results in less remediation than Alternative 5 because it replaces the hydraulic controls for protecting the river from Sr-90 with a cryogenic barrier that will not provide total protection from tritium. This alternative is not as effective as hydraulic controls used in preventing the Sr-90 from reaching the river. In this alternative, the protection of the river from tritium is not included as it was in Alternative 5. These changes in remediation reduce the cost of Alternative 6 compared to Alternative 5 by about $17,492,921 to $56,658,526.

Alternative 7 has the potential to provide a greater degree of remediation than any of the other alternatives because it proposes to significantly shorten the time it will take for the Sr-90 concentration in the groundwater to reach acceptable levels. Because this alternative is still in the development and evaluation stage, a reliable estimate of what this reduction in time might be cannot be made. This alternative costs $79,872,099 more than Alternative 6, for a cost of $136,530,625. This alternative is in the development stage, and this cost estimate is not as reliable as the estimates for the other alternatives.

1.3.6 NEPA Values

An interim (270 to 300 years) irreversible and irretrievable commitment of the unconfined aquifer and river shoreline would result with all alternatives because none would effectively reduce Sr-90 concentrations in the aquifer or river bank seeps within a shorter time. Also, none are effective in reducing Sr-90 concentrations at the groundwater/river interface. Aquatic resources at the groundwater/river interface may be impacted; however, more information must be acquired before impacts can be quantified. Restrictions on the use of the shoreline by humans may be required for a long period of time, regardless of the alternative chosen. Use of the river as a downstream drinking water supply or for other uses such as fishing will not be impacted by implementation of any alternative. Restrictions on the use of the groundwater will be required for 300 years under Alternatives 1 through 3 and for 270 years under Alternatives 4 through 6. Alternative 7 may result in use of the groundwater in a shorter time frame if soil flushing can be successfully implemented, but reduction in years cannot be quantified at this time. Alternative 6 may require a large expenditure of energy in order to initially implement the cryogenic barrier. There may be an impact on Native Americans because they are potentially more likely than other groups to use the area.

1.4 Interim Action for Remediation of Groundwater

1.4.1 Potential for Implementing an Interim Action

An interim action for the 100-NR-2 groundwater OU may be warranted. Within the detailed and comparative analyses of alternatives for remediation of the groundwater, certain analyses have been complicated by a lack of information in two critical areas: confirmation that an alternative can or cannot significantly shorten restoration time frames from that of natural attenuation (300 years), and quantification of current and future risk to aquatic receptors living in the river and in river bottom substrate. A summary of these information needs and their significance in making a remedy decision is presented below.

1.4.1.1 Groundwater Remediation for Sr-90

No Sr-90 groundwater remedial alternative has been identified in DOE/RL-95-111, Rev. 0 that would provide a significantly shorter restoration period than the estimated natural attenuation period of 300 years. Soil flushing was identified as an innovative technology that could potentially shorten groundwater remediation. However, the lack of information regarding its implementability, safety, and cost raises doubts as to its technical feasibility.

State and public acceptance of a 300-year groundwater remedial action may be very difficult to obtain. Maintenance of a long-term remedy and its associated institutional controls would also be difficult over such an extended time frame. Because of the problems inherent with a long-term remedy and because of the lack of information supporting innovative technologies such as soil flushing, an interim action on groundwater remediation may be warranted.

River Protection from Sr-90. Data on Sr-90 impacts to aquatic resources are incomplete. Should it be concluded that there are no impacts to aquatic resources from Sr-90 contamination, no remediation for protection of the river would be necessary. Conversely, should it be concluded that substantial impacts exist, actions that are more aggressive may be warranted.

The existing alternatives may remove or prevent 90 percent or more of the Sr-90 mass within the aquifer from entering the river. However, the fate of approximately 5 Ci of Sr-90 in the soil (aquifer sediments) in the strip of land adjacent to the river is not well understood. The ability of any of the selected technologies to remove the Sr-90 from the aquifer sediments adjacent to the river is unknown. As detailed in Section 7.3.1.2, it is the persistent Sr-90 concentrations in this area that will cause long restoration time frames for protection of the river even if the movement of contaminated groundwater to the river is significantly reduced. Further evaluation of these technologies and their capabilities in this area may be warranted.

The lack of information on technologies and receptors may be deemed by the regulatory agencies, DOE, and the public to be of critical importance to the determination of a final remedy for the 100-NR-2 OU. Because of this, an interim action may be necessary in order to provide adequate time for investigations designed to support the selection of a final remedy. The length of the interim action will depend upon the type and scope of interim investigations needed. However, it is anticipated that an interim action would be planned and executed for approximately a 5-year period. At the conclusion of this period, the need to continue the interim action would be evaluated.

1.4.2 Remedial Action Objective for a Groundwater Interim Action

No alternative has been identified that can remediate the groundwater or protect the river in less than 270 years. The purpose for an interim action at this OU would be to:

- Prevent exposure to contaminated groundwater
- Provide protection of the river by limiting the Sr-90 movement to the river
- Obtain information to allow selection of a final remedial action
- Take action consistent with the likely final remedies.

Remedial alternatives would be chosen that would act in concert with these objectives and be capable of providing further information for use in making a final alternative determination. Because of the uncertainties associated with ecological risk in the area along the river, and in the river bottom substrate, an alternative that controls the movement of Sr-90 to the groundwater-river interface would be an added objective of the interim action.

1.4.3 Remedial Technology Descriptions for an Interim Action

Viable remedial alternatives to achieve the interim remedial action objective should provide the most efficient use of budgetary resources and be consistent with any potential final remedy. It is evident using this basis that none of the final action alternatives presented in Section 7.3 that include long-term physical barriers would be appropriate for an interim action. Construction costs for these barriers are estimated at $8,200,000 for a permeable barrier (Alternative 3), $16,500,000 for a cryogenic barrier (Alternative 6), and $8,600,000 for a soil flush system that incorporates a sheet pile barrier (Alternative 7). The soil flush system associated with Alternative 7 is considered to be too speculative and costly at this time to be considered for an interim use.

The physical barriers could potentially preclude the implementation of final remedies that do not incorporate the chosen barrier in the final action, or conversely would require removal costs to implement a different final remedy. Therefore, all alternatives associated with these physical barriers have been screened from consideration as viable interim actions.

The objectives of the interim action could be met by implementing hydraulic controls using a pump-and-treat system such as described in Alternative 4, or just by implementing the hydraulic control portion of such a system. Since this is for an interim action, the full system described as Alternative 4 would not be needed. The existing N-Springs Expedited Response Action (ERA) (as modified to optimize costs) could be used to fulfill the interim action objectives, operated as either a hydraulic control or a pump-and-treat operation.

The remedial alternatives that would remain as possible interim actions are: No-Action; Institutional Controls; Hydraulic Controls; and, Pump and Treat. These alternatives are compared below against applicable interim action CERCLA criteria. This comparison has been performed for the purpose of supporting the selection of a remedial alternative should an interim action be recommended.

1.4.3.1 No-Action and Institutional Controls

Descriptions of the technologies included in these alternatives are contained in DOE/RL-95-111, Rev. 0, Sections 5.4.1 and 5.4.2, respectively. Components of the Institutional Controls Alternative specific to Sr-90 would apply during an interim action.

1.4.3.2 Pump-and-Treat Alternative

A full description of the pump-and-treat system and operating plan is described in (DOE-RL 1997). This system would consist of four extraction wells, an ion exchange treatment skid, two injection wells, and plant equipment such as piping, electrical equipment, and instrumentation. The extraction well network would include wells N-75, N-103A, N-105A, N-106A (although well N-105A is not being used), located downgradient of the 1301-N Crib. The pump-and-treat system would be operated continuously at a nominal rate of 228 L/min (60 gal/min) with an average removal of 90 percent for the volume of water treated over a given period. Water from the extraction wells would be pumped to a large influent tank located at the treatment facility. The influent tank acts as a surge tank and provides feed water to the treatment system.

The four ion exchange columns would each contain 1.4 m3 (50 ft3) of clinoptilolite (clino), a natural zeolite. Contaminated water would be pumped from the influent tank through the four clino-containing ion exchange columns, where the Sr-90 would be removed from the water. The clino would be changed out on a cycle duration that results in an average removal rate greater than or equal to 90 percent. The treated water would be discharged into a large effluent tank. The effluent tank acts as a surge tank and provides feed water to the injection well network.

The injection well network would include wells N-29 and N-104A, which are located upgradient of the 1301-N Crib. The processed water would be injected into both wells.

1.4.3.3 Hydraulic Controls Alternative

The Hydraulic Controls Alternative would consist of the same extraction and injection systems as in the Pump-and-Treat Alternative described above. The flow of contaminated liquid would bypass the treatment system and be injected without treatment.

1.4.4 Detailed Analysis of Remedial Alternatives for Groundwater Interim Action

Alternatives applicable to an interim action are compared against the CERCLA criteria described in DOE/RL-95-111, Rev. 0, Section 6.0, which for the most part would apply to an interim action. However, the long-term effectiveness criterion would not be applicable to an interim action, and the costs presented in DOE/RL-95-111, Rev. 0, Section 6.0 would not be applicable for the interim period. Interim costs are presented in Table 7.10.

1.4.4.1 No-Action Alternative

The No-Action Alternative (Alternative 1) discussed in DOE/RL-95-111, Rev. 0, Section 6.3.2.1 is retained for interim action as a baseline for comparison. This alternative is, however, not realistic since DOE is maintaining Institutional Controls in this area in connection with other activities. No costs are associated with the No-Action Alternative.

1.4.4.2 Institutional Controls Alternative

The Institutional Controls Alternative (Alternative 2) is discussed in DOE/RL-95-111, Rev. 0, Section 6.3.2.2. The detailed analysis of CERCLA criteria for this alternative as it relates to Sr-90 final remediation would be applicable to an interim action as well, with the following exceptions: (1) the NEPA values define irreversible and irretrievable commitments for the long-term action, which would not be applicable in the short term; (2) impacts on Native American access to cultural resources would not be applicable in the short term; and (3) no additional costs would be associated with the Institutional Controls Interim Alternative because DOE would maintain its present system of site controls during the interim period. Other facilities and circumstances require institutional controls to continue; therefore, additional costs need not be considered for the interim action alternative.

1.4.4.3 Hydraulic Controls Alternative

A hydraulic controls system is discussed in DOE/RL-95-111, Rev. 0, Section 6.3.2.4 as a river protection technology within Alternative 4. The detailed analysis of CERCLA criteria relative to Sr-90 remediation that is presented in DOE/RL-95-111, Rev. 0, Section 6.3.2.4 would be applicable to an interim action, with the following exceptions: (1) the NEPA values define irreversible and irretrievable commitments for the long-term action, and this would not be applicable in the short term; (2) impacts on Native American access to cultural resources would not be applicable in the short term; and (3) a cost-effectiveness study (DOE-RL 1997) of operating the ERA pump-and-treat system at various treatment levels was recently completed. This study noted that no capital cost would be associated with operating this system since it is already in place. A cost analysis (Permit Attachment 47, Appendix G) based on that study shows that the hydraulic control system could operate at $261,900 per year. This cost includes an expanded well monitoring system but no treatment costs.

1.4.4.4 Pump-and-Treat Alternative

A pump-and-treat system is discussed in DOE/RL-95-111, Rev. 0, Section 6.3.2.4 as a groundwater remediation technology within Alternative 4. The detailed analysis of CERCLA criteria relative to Sr-90 remediation that is presented in that section would be applicable to an interim action, with the following exceptions: (1) the NEPA values define irreversible and irretrievable commitments for the long-term action, which would not be applicable in the short term; (2) impacts on Native American access to cultural resources would not be applicable in the short term; and (3) a cost-effectiveness study (DOE/RL-1997) of operating the ERA pump-and-treat system at various treatment levels was recently completed. This study noted that no capital cost would be associated with operating either system since the systems are already in place. A cost analysis (Permit Attachment 47, Appendix G) based on that study shows that the pump-and-treat system could operate at $329,100 per year. This cost includes a reduced well monitoring system and treatment costs.

1.4.5 Comparative Analysis of Remedial Alternatives for Groundwater Interim Action

The following information provides a comparison of the four interim action alternatives utilizing applicable CERCLA criteria. A discussion of how these alternatives compare for final remedy purposes is included in Sections 7.3.1 through 7.3.6. As stated in Section 7.1, the overall protection and ARAR compliance criteria have not been included in this comparative analysis because all alternatives retained (excluding the No-Action Alternative) meet these threshold criteria except for discharge limits for the discharge of groundwater MCLs, which would not be met. This, however, is an interim action. State and community acceptance will not be evaluated until after the proposed plan has been issued; therefore, they also are not part of this comparative analysis.

1.4.5.1 Long-Term Effectiveness and Permanence

This criterion would not apply to interim action.

1.4.5.2 Reduction of Toxicity, Mobility, or Volume through Treatment

Only the Pump-and-Treat Alternative would reduce Sr-90 mass in the groundwater through treatment. However, this reduction is not significant compared to what would occur by natural attenuation, or by implementing one of the other alternatives. The Hydraulic Controls and Pump-and-Treat Alternatives would significantly reduce the flux of Sr-90 towards the river, thus reducing the mobility of the major contaminant in the 100-N Area. None of the alternatives would provide for a shorter restoration time frame because none would remediate the groundwater or protect the river at the conclusion of the interim measure.

1.4.5.3 Short-term Effectiveness

The Pump-and-Treat and Hydraulic Control Alternatives are already in place as a result of the N-Springs ERA (DOE-RL 1996g, 1997). Therefore, short-term impacts from these alternatives would be small and associated primarily with worker risk from continued operation of these systems. Because pump-and-treat contains two operating systems, the hydraulic control system and the ion exchange treatment system, it would have a slightly higher potential for short-term worker risk during O&M than the Hydraulic Control Alternative. However, the short-term impacts would not be significantly different from the other interim action alternatives. Only minor, if any, short-term physical, biological, or cultural impacts would result from any of the alternatives.

1.4.5.4 Implementability

As a short-term action, all four of the alternatives would be considered technically and administratively feasible. Implementability would not be significantly different for any of the alternatives. No action would be the easiest alternative to implement; however, implementation of this alternative would not be viable because the DOE will continue to maintain restrictions and controls over the 100-N Area groundwater for purposes other than 100-NR-2 remediation. Institutional controls are already in place as part of the DOE operation of the Hanford Site. Hydraulic control implementation, required for both the Pump-and-Treat and Hydraulic Controls Alternatives, would be less implementable than the No-Action or Institutional Controls Alternatives due to the continued operation of a complicated hydraulic control system that could be subject to breakdown. Finally, because pump and treat contains another operating system, it would be slightly less implementable compared to hydraulic controls.

1.4.5.5 Cost

The detailed analysis in Section 7.4.4 showed that there were no additional costs associated with the No-Action and Institutional Controls Alternatives, because these interim action alternatives would not require actions beyond what is currently in place. A comparative cost analysis (Table 7-10) for a 5-year period shows that Hydraulic Controls, at a Present Worth cost of $1,153,109 is the second lowest cost alternative, after the No-Action and Institutional Controls Alternatives. The Pump-and-Treat Alternative is the most expensive alternative, at a Present Worth cost of $1,448,981.

1.4.5.6 NEPA Values

None of the alternatives would require construction of new systems. Impacts to wildlife from construction noise, and disturbance of the land area for construction of well systems, would therefore not occur from any alternative. Ecological, cultural, and natural resource reviews would not be required for any alternative. Impacts to aquatic resources are not anticipated to be significantly different for any of the four interim actions, because decreases in river-bottom and shoreline sediment concentrations during the interim period would not be appreciably different with any of the alternatives. Restrictions on the use of groundwater and river water in the vicinity of the 100-N Area would remain in the short-term regardless of which interim alternative is selected, due to continued DOE control over the Hanford Site in the time frame of the interim action.

Table 1.1. Applicable Remedial Alternatives for Source Waste Sites Assuming a Rural Residential Exposure Scenario.

Waste Group	No Action	Remove/ Dispose	In Situ Bioremediation
Radioactive	X	X	
Petroleum	X	X	X[a]
Inorganic	X	X	
Burn Pits	X	X	
Solid Waste	X	X	

[a] This alternative is only applicable to 2 out of 22 sites within the petroleum waste group.

Table 1.2. Applicable Remedial Alternatives for Source Waste Sites Assuming a Modified CRCIA Ranger/Industrial Exposure Scenario

Waste Group	No Action	Remove/Dispose	In Situ Bioremediation	Containment	Solidification
Radioactive	X	X		X[a]	X[b]
Petroleum	X	X	X[c]		
Inorganic	X	X			
Burn Pits	X	X			
Solid Waste	X	X			

[a] This alternative is only applicable to 16 out of 37 sites within the radioactive waste group.
[b] This alternative is only applicable to 20 out of 37 sites within the radioactive waste group.
[c] This alternative is only applicable to 2 out of 22 sites within the petroleum waste group.

Table 1.3. Cost Comparison of Remedial Action Alternatives for Deep Petroleum Source Sites[a]

(Applicable to both the Rural-Residential and Modified CRCIA Ranger/Industrial Exposure Scenarios)

Site	Remove/Dispose	In Situ Bioremediation	Percent Difference from Remove/ Dispose
UPR-100-N-17	$2,409,203	$ 903,509	
UPR-100-N-42	$2,842,571	$ 910,025	
Total Cost	$5,251,774	$1,813,534	-65%

[a] Costs do not include a 3 percent design cost and a 3 percent design data collection cost.
UPR = unplanned release

Table 1.4. Cost Comparison of Remedial Action Alternatives for Near-Surface Petroleum Source Sites[a]

(Applicable to both the Rural-Residential and Modified CRCIA/Ranger Industrial Exposure Scenarios)

Site	Remove/Dispose	Remove/Ex Situ Bioremediation/Dispose	Percent Difference from Remove/Dispose
UPR-100-N-18	$105,000	$107,994	
UPR-100-N-19	$105,944	$112,486	
UPR-100-N-20	$102,056	$105,660	
UPR-100-N-21	$97,168	$100,162	
UPR-100-N-22	$105,092	$108,696	
UPR-100-N-23	$103,593	$104,720	
UPR-100-N-24	$107,499	$121,304	
UPR-100-N-36	$96,816	$97,408	
UPR-100-N-43	$106,574	$116,719	
100-N-3	$254,529	$329,895	
100-N-12	$93,743	$94,334	
100-N-35	$98,242	$99,369	
100-N-36	$94,724	$98,254	
124-N-2	$149,807	$212,349	
Total Cost	$1,620,787	$1,809,350	+12

[a] Costs do not include a 3 percent design cost and a 3 percent design data collection cost.
UPR = unplanned release

Table 1.5. Present Worth Cost Comparison of Remedial Alternatives for Source Waste Sites for the Rural-Residential Exposure Scenario

Remedial Alternative	Number of Sites[a, b]	Remove/ Dispose	Remove/Ex Situ Bioremediation/ Dispose	In Situ Bioremediation	Percent Difference from Remove/ Dispose
Remove/Dispose	80	$52,030,513	N/A	N/A	NA
Remove/Dispose	63	$50,409,726	$50,409,726		
Remove/Ex Situ Bioremediation/ Dispose	17	$ 1,620,787	$1,809,350		+12
Cost	80	$52,030,513	$52,219,056		~ 0
Remove/Dispose	78	$46,777,739		$46,777,739	
In Situ Bioremediation[b]	2	$ 5,251,774	N/A	$ 1,813,350	-65
Cost	80	$52,030,513		$48,592,089	- 7

[a] There are four sites (100-N-28, 116-N-4, 118-N-1, UPR-100-N-35) where all of the waste is below 4.6 m (15 ft), and these sites may not be remediated under this scenario. See DOE/RL-95-111, Rev. 0, Appendix B for information regarding excavation depths.

[b] There are five sites (100-N-46, 100-N-50, 100-N-51a, 100-N-51b, and 100-N-65) for which costs or additional costs will be established during design.

[c] The cost shown in this table does not include a 3 percent design cost and a 3 percent cost for collecting design data in the field.

N/A = not applicable

1 **Table 1.6. Costs for Source Units**

Site Name	Remove/Dispose	Capping	In Situ Solidification
CAP 1-1			
UPR-100-N-10	$95,391	$653,884	$157,016
UPR-100-N-39	$99,297	$3,767,236	$415,600
Subtotal	$194,688	$4,421,120	$572,616
CAP 1-2			
UPR-100-N-29	$100,630	$41,563	$158,467
UPR-100-N-30	$112,776	$4,086,761	$349,849
UPR-100-N-32	$101,908	$389,430	$173,568
Subtotal	$315,314	$4,517,754	$681,884
CAP 4-1			
UPR-100-N-4	$97,464	$83,646	$192,295
UPR-100-N-5	$218,961		$651,238
UPR-100-N-6	$104,056	$190,527	$217,955
UPR-100-N-8	$95,391	$4,647	$157,016
UPR-100-N-25	$97,779	$106,881	$202,532
100-N-26	$101,593	$23,235	$163,047
124-N-4	$766,864	$38,909,260	$1,388,214
Subtotal	$1,482,108	$46,469,916	$2,972,297
CAP 4-2			
UPR-100-N-9	$104,307	$4,672,424	$345,617
UPR-100-N-14	$95,409	$82,740	$158,496
Subtotal	$199,716	$4,755,164	$504,113
CAP 4-3			
UPR-100-N-13	$88,873	$749,331	$181,321
UPR-100-N-26	$99,908	$3,674,112	$252,221
Subtotal	$188,781	$4,423,443	$433,542
Misc In Situ Solidification			
UPR-100-N-1	$150,214	N/A	$386,077
UPR-100-N-11	$95,835	N/A	$345,010
100-N-13	$98,242	N/A	$340,414
100-N-14	$98,242	N/A	$340,414
Subtotal	$442,533	N/A	$1,411,915
Total for Capping and Remove/ Dispose	$2,380,607	$64,587,397	
Total for In Situ Solidification and Remove/Dispose	$2,823,140	N/A	$6,576,367

[a] Costs based on the Modified CRCIA Ranger/Industrial Exposure Scenario.
NA = not applicable

Table 1.7. Present Worth Cost Comparison of Remedial Alternatives for Source Waste Sites for the Modified CRCIA Ranger/Industrial Exposure Scenario [a]

Remedial Alternative	Number of Sites[b,c]	Remove/ Dispose	Remove/ Ex Situ Bioreme-diation/ Dispose	In Situ Bioreme-diation	Contain-ment	In Situ Solidifi-cation	Percent Difference from Remove/ Dispose
Remove/Dispose	80	$49,896,037					
Remove/Dispose	63	$48,275,250	$48,275,250	N/A	N/A	N/A	
Remove/Ex Situ Bioremediation/ Dispose	17	$ 1,620,787	$ 1,809,350	N/A	N/A	N/A	+12
Cost	80	$49,896,037	$50,084,600				0
Remove/Dispose	78	$44,644,263	N/A	$44,644,263	N/A	N/A	
In Situ Bioremediation	2	$ 5,251,774	N/A	$ 1,813,350	N/A	N/A	-65
Cost	80	$49,896,037		$46,457,613			-7
Remove/Dispose	64	$47,515,430	N/A	N/A	$ 47,515,430	N/A	
Containment	16	$2,380,607	N/A	N/A	$64,587,397	N/A	+2703
Cost	80	$49,896,037			$112,102,827		+ 125
Remove/Dispose	60	$46,820,831	N/A	N/A	N/A	$46,820,831	
In Situ Solidification	20	$3,075,206	N/A	N/A	N/A	$6,576,367	+114
Cost	80	$49,896,037				$53,397,198	+7

[a] The cost shown in this table does not include a 3 percent design cost and a 3 percent cost for collecting design data in the field.
[b] There are five sites for which costs or additional costs will be established during design.
[c] There are eleven sites for which all of the waste is below 3 m (10 ft), and these sites may not be remediated under this scenario.

Table 1.8. Remedial Alternatives for Groundwater Contamination at the 100-N Area

Alternative		River Protection Technology		Aquifer Cleanup Technology	
No.	**Title**	**Protection of the River from Tritium**	**Protection of the River from Strontium**	**Reduce Strontium-90 Concentration /Activity in the Aquifer[a]**	**Reduce Concentrations of Other Contaminants in the Aquifer[b]**
1	No Action	No Action	No Action	No Action	No Action
2	Institutional Controls	Institutional Controls	Institutional Controls	Institutional Controls	Institutional Controls
3	Permeable Barrier for River Protection	Institutional Controls	Permeable Barrier Wall	Institutional Controls	Institutional Controls
4	Hydraulic Controls for River Protection and Pump and Treat for Strontium in the Aquifer	Institutional Controls	Hydraulic Control (270 years)	Pump and Treat	Institutional Controls
5	Hydraulic Controls for River Protection and Pump and Treat for Aquifer Remediation	Hydraulic Control (15 years)	Hydraulic Control (270 years)	Pump and Treat	Pump and Treat
6	Cryogenic Barrier for River Protection and Pump and Treat for Aquifer Remediation	Institutional Controls	Impermeable Barrier Wall (cryogenic wall)	Pump and Treat	Pump and Treat
7	Sheet Pile Barrier for River Protection and Soil Flushing/Pump and Treat for Aquifer Remediation	Impermeable Barrier Wall (with hydraulic control for tritium)	Impermeable Barrier Wall (sheet pile wall with pre-excavation)	Soil Flush System	Pump and Treat

[a] Strontium-90 remediated by removing strontium from the aquifer (concentration) and by providing time for natural radioactive decay (activity).
[b] Other contaminants include nitrate, sulfate, hexavalent chromium VI, TPH, and manganese.

Table 1.9. Cost of Remedial Alternatives for Groundwater

No.	Remedial Alternatives	Initial Capital Cost ($)	Present Worth of Future Costs ($)	Total Present Worth Cost ($)
1	No Action	0	0	0
2	Institutional Controls	63,558	699,468	762,826
3	Permeable Barrier for River Protection	8,240,697	1,021,528	9,262,225
4	Hydraulic Controls for River Protection and Pump and Treat for Strontium in the Aquifer	1,754,609	12,491,105	14,245,714
5	Hydraulic Controls for River Protection and Pump and Treat for Aquifer Remediation	4,580,204	34,585,401	39,165,605
6	Cryogenic Barrier for River Protection and Pump and Treat for Aquifer Remediation	20,389,389	36,269,137	56,658,526
7[a]	Sheet Pile Barrier for River Protection and Soil Flushing/ Pump and Treat for Aquifer Remediation	22,416,808	114,113,817	136,530,625

[a] This alternative is in the development and evaluation stage; therefore, a reliable cost estimate cannot be made.

Table 1.10. Comparative Cost Summary of the Interim Groundwater Remedial Alternatives

Alternative	Capital Cost ($)	One Year Operating Cost ($)	Present Worth Cost ($)
No Action	0	0	0
Institutional Controls	0	0	0
Hydraulic Controls	0	$261,900	$1,153,109
Pump and Treat	0	$329,100	$1,448,981

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