**Preliminary Siting Activities
For New Waste Handling Facilities
at the
Idaho National Engineering Laboratory**

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ABSTRACT

The Idaho Waste Processing Facility, the Mixed and Low-Level Waste Treatment Facility, and the Mixed and Low-Level Waste Disposal Facility are new waste treatment, storage, and disposal facilities that have been proposed at the Idaho National Engineering Laboratory (INEL). A prime consideration in planning for such facilities is the selection of a site. Since spring of 1992, waste management personnel at the INEL have been involved in activities directed to this end. These activities have resulted in the (a) identification of generic siting criteria, considered applicable to either treatment or disposal facilities for the purpose of preliminary site evaluations and comparisons, (b) selection of six candidate locations for siting, and (c) site-specific characterization of candidate sites relative to selected siting criteria. This report describes the information gathered in the above three categories for the six candidate sites. However, a single, preferred site has not yet been identified. Such a determination requires an overall, composite ranking of the candidate sites, which accounts for the fact that the sites under consideration have different advantages and disadvantages, that no single site is superior to *all* the others in *all* the siting criteria, and that the criteria should be assigned different weighting factors depending on whether a site is to host a treatment or a disposal facility. Stakeholder input should now be solicited to help guide the final selection. This input will include (a) siting issues not already identified in the siting work to date, and (b) relative importances of the individual siting criteria. Final site selection will not be completed until stakeholder input (from the State of Idaho, regulatory agencies, the public, etc.) in the above areas has been obtained and a strategy has been developed to make a composite ranking of all candidate sites that accounts for all the siting criteria.

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SUMMARY

The Idaho Waste Processing Facility, the Mixed and Low-Level Waste Treatment Facility, and the Mixed and Low-Level Waste Disposal Facility are new waste treatment, storage, and disposal facilities that have been proposed at the Idaho National Engineering Laboratory (INEL). Among the first steps in planning for such facilities is the selection of a site. Although sites for the new facilities have not yet been selected, waste management personnel at the INEL have been obtaining information since spring of 1992 that can be used for site selection. This information includes the following three categories:

- Developing site-selection criteria which are generally applicable to both treatment and disposal facilities
- Selecting suitable candidate locations to consider in light of the selection criteria
- Obtaining characterization data, specific to the identified candidate locations, that can be used to make an objective comparison of these locations to identify and select a suitable site for the new facility (or facilities).

To obtain information in the first of the above categories, a review was performed of existing federal and state statutes and relevant U.S. Department of Energy (DOE) orders. This review was published as an informal report and was used as a starting point by an advisory committee (consisting primarily of managerial personnel at the INEL), which was appointed to select a set of site-screening criteria. These criteria were to be used to screen all available land on the INEL and identify suitable candidate locations for the new facilities. The criteria selected by the committee encompassed issues of waste transportation, environmental impacts, public/worker health and safety, archaeological resources, geology/seismology, and service/support requirements.

The second category of information listed above, selecting candidate locations, was accomplished by a field committee comprising technical personnel with specific areas of expertise. Members of this committee were assigned the task of identifying preferred and nonpreferred areas of the INEL from the standpoint of each siting criterion, using only information which existed at the time. Once these areas were identified and mapped, the field committee selected eight candidate areas of 3-8 mi² and performed site inspections (referred to as "site walkovers"; a site walkover was a visit to a candidate site by personnel qualified to inspect and evaluate the site against specific siting criteria. Such criteria included the presence of archeological artifacts, presence of wetlands or habitat for threatened or endangered species, topographic and geological hazards and impediments to construction, soil types and estimated depths, evidence of past flooding, etc.) to further evaluate these areas as viable sites for the proposed new facilities.

Following a review of the observations and comments made during these inspections, the committee chose three sites from among the original eight candidate areas. Selection of these three sites was based on the relative advantages and disadvantages of each of the eight areas, compiled from the written comments of the participants in the site walkovers. Some time after this selection was made, three additional sites were added for consideration, on the recommendations of waste management and geosciences personnel. This recommendation was based partly on previous siting work, and partly on the premise that development and operational costs for the facilities could be

minimized if a suitable site could be found close to the Radioactive Waste Management Complex, where many of the wastes to be treated are currently stored.

Information in the third category, of those above, was obtained after an action plan had been formulated for further site-specific characterization of the six candidate sites. This action plan targeted issues of seismic hazard, flooding potential, probable impacts to archaeological resources, possible adverse ecological effects, airborne pollutant transport, subsurface contaminant migration, buried utilities, and soil types. Portions of this plan were funded and completed during late fiscal year 1993 and early fiscal year 1994. As a result of these activities, site-specific information was obtained to perform objective (and, where possible, quantitative) comparisons of the six candidate sites.

This report describes the information gathered in the above three categories for the six candidate sites. **However, a single, preferred site has not yet been identified. Such a determination requires an overall, composite ranking of the candidate sites, which accounts for the fact that the sites under consideration have different advantages and disadvantages, that no single site is superior to *all* the others in *all* the siting criteria, and that the criteria should be assigned different weighting factors depending on whether a site is to host a treatment or a disposal facility.** The work completed to date and documented here provides a technical basis for site evaluation and a starting point for discussions among stakeholders. Specifically, stakeholders internal to DOE and external stakeholders (the State of Idaho, regulatory agencies, special interest groups, and the public) will be asked to provide their input in identifying siting issues that have not been addressed by the effort thus far. (Note that this report only addresses regulatory and programmatic requirements identified to date; other technical and nontechnical issues may be identified by stakeholders and could affect final site selection.) A final set of site-selection criteria will be formulated after stakeholder input is obtained.

In addition to guiding the choice of the final siting criteria, the stakeholders will be invited to participate in ranking the criteria in order of importance for both treatment facility sites and disposal sites, and in determining how the site rankings based on individual criteria will be combined into a single composite ranking, thus leading to the final site selection.

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ACRONYMS AND ABBREVIATIONS

ACHP	Advisory Council on Historic Preservation
ARLFRD	Air Resources Lab Field Research Division in Idaho Falls
CFA	Central Facilities Area
CIET	Center for Integrated Environmental Technologies
CRM	Cultural Resources Management
DOE	U.S. Department of Energy
DOE-ID	DOE Idaho Operations Office
FEMA	Federal Emergency Management Agency
FFA/CO	Federal Facilities Agreement/Consent Order
FY	fiscal year
GIS	geographic information system
GPS	Global Positioning System
INEL	Idaho National Engineering Laboratory
IWPF	Idaho Waste Processing Facility
MLLW DF	Mixed and Low-Level Waste Disposal Facility
MLLW TF	Mixed and Low-Level Waste Treatment Facility
MTRU	Mixed transuranic wastes
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act of 1966 (P.L. 89-665)
NPR	New Production Reactor
NOAA	U.S. National Oceanic and Atmospheric Administration
NR	National Register of Historic Places
RESL	Radiological and Environmental Sciences Laboratory
RWMC	Radioactive Waste Management Complex
SCS	U.S. Soil Conservation Service
SHPO	State Historic Preservation Office
TAN	Test Area North
TRA	Test Reactor Area
TRU	transuranic
TSD	treatment, storage, and disposal
α -LLW	alpha-contaminated low-level waste
α -MLLW	alpha-contaminated mixed low-level wastes

Preliminary Siting Activities For New Waste Handling Facilities at the Idaho National Engineering Laboratory

1. INTRODUCTION

A major part of the planning process for new facilities is site selection. This report, prepared by the Environmental Restoration & Waste Management Department at EG&G Idaho, provides a summary description of activities, preparatory to site selection, which have been performed for new waste handling facilities at the Idaho National Engineering Laboratory (INEL). Details of major tasks completed to date are provided in the appendices.

1.1 Background

The Idaho Waste Processing Facility (IWPF), the Mixed and Low-Level Waste Treatment Facility (MLLW TF), and the Mixed and Low-Level Waste Disposal Facility (MLLW DF) are new waste treatment, storage, and disposal (TSD) facilities currently under consideration for the INEL. The IWPF would be designed to treat stored and newly-generated inventories of mixed transuranic (MTRU) and alpha-contaminated mixed low-level wastes (α -MLLW) for which the U.S. Department of Energy (DOE) is responsible. The MLLW TF would treat mixed and low-level waste streams generated by ongoing activities, and possibly wastes generated by decommissioning and decontamination, and remediation activities within the DOE complex. The MLLW DF would be a disposal site for treated mixed, low-level, and low-level alpha-contaminated wastes. A more detailed description of each of these facilities is provided in Section 1 of Appendix A.

At the inception of siting activities for these facilities during fiscal year (FY) 1992, all three of the above facilities were in the early planning stages. However, since that time, funding has been curtailed for all but the IWPF. Therefore, while many of the early activities described in this report and its appendices were performed with the intent to support all three facilities, characterization activities performed during the fourth quarter of FY 1993 and the first quarter of FY 1994 were primarily directed at obtaining data for those siting criteria which are most important from the standpoint of the IWPF. Though these criteria were also deemed relevant to the MLLW DF, they are likely to be of lesser importance in siting a disposal facility than other criteria.

1.2 Objectives

The preliminary siting activities performed to date are preparatory to, but do not constitute, final site selection for any of the facilities described above. These preparatory activities have been structured to maintain maximum flexibility, up to final site selection, given current uncertainty regarding which of the above waste handling facilities will actually be constructed on the INEL, and given the nature of the operations to be performed there. Thus, the objectives of these actions have been as follows:

- (a) **Identify criteria that relate to candidate sites for the types of facilities described in Section 1.1.** These criteria should address the full range of *potential* operations (i.e., treatment, storage, and disposal of waste) that could be performed at the facility, recognizing that the type of facility to be constructed has not yet been decided. Thus, the objective was to identify all site characteristics that could be important and applicable for a facility that either treats, stores, or disposes the above described wastes.
- (b) **Limit the field of candidate sites to be considered.** There are approximately 890 mi² on the INEL, and *most* of this area is available for siting of new facilities. The objective here was to identify (on the basis of currently available information) a tractable number of smaller areas within the boundaries of the INEL, which represent a geographic cross section of the site, and which are desirable on the basis of at least one (and preferably, many) of the criteria identified in (a)
- (c) **Obtain additional information about candidate sites.** In an effort to contain costs, a graded approach has been applied in which detailed, site-specific characterization activities have been limited to the sites identified under (b). It is emphasized that these sites were chosen on the basis of then-current knowledge of the general siting criteria described under (a), and that any or all of these sites could be eliminated from further consideration, should they prove unacceptable on the basis of new information, or on the basis of additional siting criteria suggested by future stakeholder involvement in the siting process.
- (d) **Set the stage for stakeholder involvement, prior to site selection.** The work completed to date and documented here provides a starting point for discussions among stakeholders (i.e., DOE, the State of Idaho, regulatory agencies, special interest groups, and the public), who will be asked to provide input in identifying siting issues that may not have been addressed by activities, thus far. This activities documented herein only address regulatory and programmatic requirements identified to date. Other technical and nontechnical issues may be identified by stakeholders and may alter the choice of candidate sites. In addition, given that no single site on the INEL has been identified, which is superior to *all* other sites in *all* the siting criteria, it will be necessary to devise a scheme to rank candidate sites in a composite, or overall sense. This scheme must take account of *all* the siting criteria, together with differing relative importances (or "weights") of individual criteria. These criteria weights, will also depend on the *type* of facility (treatment, storage, or disposal) that is ultimately constructed.

In summary, the activities performed to date have identified a set of generic siting criteria which are deemed relevant to any waste handling facility. Also, a pool of candidate sites has been identified, and preliminary rankings of these sites have been performed relative to **individual** criteria (but not in an **overall** sense). These criteria and the pool of sites provide a starting point for soliciting stakeholder input, refining (if necessary) the criteria and the list of candidate sites, defining an overall ranking scheme, and selecting a site for a new facility.

1.3 Site Selection Overview

The subject activities of this report consisted of a series of steps, each with specific, minor objectives supporting the overall objectives described in Section 1.2. The remaining chapters provide summary descriptions of the activities in each of the categories described in Sections 1.3.1 through 1.3.4. Details of the work performed in each of these categories are not provided within the body of this report, but are referenced and provided in the appendices. The appendices were produced as various phases of the siting effort were completed.

1.3.1 Siting Criteria

The first step in the site-selection process was to determine the criteria by which candidate locations for the facilities would be evaluated and compared. The manner in which this was done is discussed in Section 2. This section also summarizes the discussions and decisions regarding the manner in which the siting criteria were to be applied to site screening.

1.3.2 Candidate Sites

After the siting criteria were determined, the next step in the process was to select a pool of candidate sites using a graded approach. This approach involved several screenings of the available locations on the INEL. Each successive screening involved data gathering (i.e., characterization) on progressively smaller and fewer parcels of land, thereby reducing program costs. The first of these screenings involved most of the land on the INEL, and resulted in the selection of eight areas, each roughly 3-8 mi² in extent. The second screening reduced the number of candidate locations to six, with a total combined area of about 1.1 mi². These locations were targeted for additional site characterization efforts, with the intent of providing sufficient information to determine which (if any) of these sites would most likely be acceptable from a regulatory standpoint, and also to compare the sites on the basis of the "want" criteria (i.e., desirable, but not mandatory, characteristics) that were identified. These efforts have provided data on which a further screening may be based, and one or two preferred sites can be selected for final, detailed characterization, barring possible changes to the pool of candidate sites to be considered, as a result of stakeholder involvement (see Section 1.2).

1.3.3 Site Characterization

As noted in Section 1.3.2, above, the first and second screenings of candidate locations were made without characterization data beyond what was already available at the time. Therefore, it was necessary to identify possible deficiencies in the data and formulate an action plan to obtain additional site-specific data for each of the candidate sites, to provide the basis for an objective selection of one or two preferred candidate sites. This action plan, and the data generated from its execution, are discussed in Section 4.

1.3.4 Conclusions

The implications of the site-specific characterization data discussed in Section 3 are addressed in Section 5. This section discusses the question criteria weighting in order to rank the candidate sites described in Section 3 in an overall sense.

2. SITING CRITERIA

2.1 Review of Regulatory Siting Criteria

Objective selection of a site for any new facility begins with identification of selection criteria. The first criteria that were considered in performing this identification were those mandated by Federal and State law. The second criteria were U.S. Department of Energy (DOE) policy recommendations as described in DOE orders. A comprehensive review was performed to identify these criteria (see Appendix B). From this review, a preliminary set of siting criteria were developed, based on waste transportation costs, the environment, health and safety, archaeological resources, geology, and service and support requirements.

2.2 Siting Criteria Selection

The information compiled in Appendix B provided a starting point for assembling a list of siting criteria for the new facilities. Shortly after the Appendix B report was released, an advisory committee was assembled to review the report and to consider other criteria that might be relevant. This committee was composed of people within the INEL community familiar with statutory requirements and waste management operations (for a complete list of committee members, see Table 2-1 of Appendix A).

2.2.1 "Must" and "Want" Criteria for Site Screening Maps

The advisory committee's work resulted in a list of criteria to be used and a set of recommendations on how to apply each criterion in the list. In general, the criteria were divided into two categories: "must" criteria and "want" criteria. The "must" criteria were those that were deemed essential, while "want" criteria were considered nonessential but desirable. The deliberations of the committee in regard to "must" and "want" criteria are given in Section 3.2 of Appendix A. From these deliberations evolved the siting criteria that were actually used in the preliminary site screening process described in Section 3.1. The following are summary descriptions of the criteria used to generate the siting maps described in Sections 3.1.1 and 3.1.2.

2.2.1.1 U.S. Highway 20/26 (want). The site should be on the same side of all public highways as the Radioactive Waste Management Complex (RWMC). (See Section 5.1.1 of Appendix A.)

2.2.1.2 100-Year Flooding Elevation (must). The site must be above the 100-year flooding elevation. (See Section 5.1.2 of Appendix A.)

An issue related to flooding that must be addressed is storm water protection and erosion. While site selection is clearly related to this issue, it was not explicitly addressed in the choice of siting criteria, on the strength of the following assumptions: (a) This issue can be addressed during design of the facility, (b) The only impact of siting would be on the cost of design and construction of a system to handle storm water discharge and erosion, and (c) This impact is more manageable than possible impacts of other siting criteria.

2.2.1.3 Fine-Grained Sediments (want). The site should be located on significant deposits of fine-grained sediments. (See Section 5.1.3 of Appendix A.)

2.2.1.4 Transport of Airborne Contamination (want). The site should be in a location where the potential for airborne contamination of the public is minimal. (See Section 5.1.4 of Appendix A.)

It should be noted that, while this criterion has been treated as a "want" to this point in the siting process, it is possible that in today's evolving regulatory environment, constraints on air quality impacts could effectively transform this criterion into a "must". For example, due to diurnal wind patterns over the INEL, it is conceivable that for some sites (or possibly even *all* sites) on the INEL, it would be infeasible to control air emissions sources to the extent necessary to achieve prescribed levels of air quality at all locations to which the public has access.

2.2.1.5 FFA/CO Sites and Environmentally Controlled Areas (must). The site must not incorporate any Federal Facilities Agreement/Consent Order (FFA/CO) sites or environmentally controlled areas. (See Section 5.1.5 of Appendix A.)

2.2.1.6 Category I Facilities (must). The site must not be closer than one mile to high-hazard (Category I) facilities. (See Section 5.1.6 of Appendix A.)

2.2.1.7 Wind Corridors of Existing INEL Facilities (want). The site should not lie within the wind corridors (i.e., immediately upwind or downwind) of existing INEL facilities. (See Section 5.1.7 of Appendix A.)

Note that the caveat mentioned under Section 2.2.1.4 may also apply here; i.e., siting outside existing wind corridors could become a "must" criterion at a later time.

2.2.1.8 Lava Flows (want). The site should not lie within areas of the INEL most vulnerable to lava flows. (See Section 5.1.8 of Appendix A.)

2.2.1.9 Volcanic Fissuring (want). The site should not lie within areas of the INEL most vulnerable to volcanic fissuring. (See Section 5.1.9 of Appendix A.)

2.2.1.10 Capable Faults (want). The site should be located to be maximally distant from all identified capable faults. (See Section 5.1.10 of Appendix A.)

2.2.1.11 Other Future INEL Projects (want). The site should not lie on land selected for siting other projects proposed for the INEL. (See Section 5.1.11 of Appendix A.)

2.2.1.12 Snake River Plain Aquifer (want). The site should not lie directly above the Snake River Plain Aquifer. (See Section 5.1.12 of Appendix A.)

2.2.1.13 Wetlands (must). Because of regulatory constraints on disturbance or displacement of wetlands, the advisory committee decided that a candidate site must not contain a wetland or a portion of a wetland (see Section 3.2.1.5 of Appendix A.) However, due to regulatory

uncertainty over what areas on the INEL actually constituted wetlands, this criterion was not used in generating the siting maps. Rather, it was considered during "site walkovers," as described in Section 2.2.2.8.

2.2.2 Criteria for Field Evaluation During "Site Walkovers"

A number of criteria were evaluated at each site during the "site walkovers" described in Section 3.1.4. (A "site walkover" involved visiting candidate sites by personnel qualified to inspect the site and evaluate it against specific criteria. These criteria included presence of archeological artifacts, presence of wetlands or habitat for threatened/endangered species, and other impediments to construction.) Some of these criteria were among those that had been selected by the advisory committee to be used for preliminary site screening, while others had been rejected for various reasons. Those in the latter group were considered during site walkovers with the hope of early elimination of sites that were likely to be problematic later in the site selection process [i.e., during the National Environmental Policy Act (NEPA) review of siting alternatives]. The list of criteria evaluated during the site walkovers is given below. All were considered want criteria at this stage because insufficient data would be collected during the surveys to actually qualify or disqualify any given site.

2.2.2.1 Estimated Soil Depth. The finer-grained sediments and deeper surficial deposits were considered advantages. (See Sections 3.2.2.13, 3.2.2.23, and 5.4.2.1 of Appendix A.)

2.2.2.2 Seismic Potential. The greater the estimated distance from the nearest capable fault, the more favorably a site was considered. (See Section 5.4.2.2 of Appendix A.)

2.2.2.3 Critical Habitat for Endangered Species. Possible evidences were sought that would likely disqualify sites during the NEPA-review stage. (See Sections 3.2.1.2 and 5.4.2.3 of Appendix A.)

2.2.2.4 Cultural Resources. Preliminary archaeological screening was performed as required by law. (See Sections 3.2.1.6, 3.2.2.30.1, and 5.4.2.4 of Appendix A.)

2.2.2.5 General Topography. Features were sought that might be problematic at a later time. (See Sections 3.2.2.13, 3.2.2.17, and 5.4.2.5 of Appendix A.)

2.2.2.6 Likelihood of Lava Inundation. (See Section 5.4.2.6 of Appendix A.)

2.2.2.7 Evidence of Surface Flooding. (See Sections 5.1.2 and 5.4.2.7 of Appendix A.)

2.2.2.8 Wetlands. In an attempt to avoid potential conflict with regulatory restraints on disturbing wetlands, sites containing areas that had been designated as wetlands by the U.S. Fish and Wildlife Service were given a low ranking. They were not formally excluded, however, on the assumption that site boundaries could be slightly realigned to avoid incorporation of such areas. (See Section 2.2.1.13, above, and Sections 3.2.1.5 and 5.4.2.8 of Appendix A.)

2.2.2.9 Proximity to Existing Utilities. (See Sections 3.2.2.4, 3.2.2.8, 3.2.2.29, and 5.4.2.9 of Appendix A.)

2.2.2.10 Miscellaneous Factors. Any factor deemed relevant by any member of the site inspection team (see Section 3.1.4) was considered during site walkovers.

2.2.3 Reconciliation with Advisory Committee's Siting Criteria

Comparison of the criteria listed in Sections 2.2.1 and 2.2.2 with those discussed in Section 3.2 of Appendix A indicates a considerable condensation of the latter list. The justification for this condensation was that there was insufficient data at the time of the preliminary siting process to evaluate sites against some of the criteria. Moreover, many of the siting criteria considered by the advisory committee were stated in terms of facility performance requirements. For example, Section 3.2.1.10 of Appendix A states the "Facility shall be located such that the . . . annual dose equivalent to . . . the public . . . shall not exceed 25 millirems . . ." Requirements such as these could not be formally imposed per se on the site selection process in the absence of facility design information (which was not available). Therefore, these criteria were either excluded or reformulated and combined with other similar criteria. The result of this process was the criteria list above and in Section 2.2.1. (For a complete description of the reasoning used, see Sections 5.1 and 5.4 of Appendix A.)

3. CANDIDATE SITES

Once the criteria for site screening were established, the next step was to examine the available land on the INEL and choose locations with a high likelihood of being acceptable in light of all the siting criteria. This choice was to be based on existing data available at the time. For this reason, the possibility was recognized that any of the sites selected at this stage could be excluded later after additional site-specific data was collected. Similarly, it was possible that additional sites would be considered after preliminary site screening on the assumption that new, site-specific data might indicate acceptability of such sites.

The outcome of the site-screening process was the selection of the three candidate sites described in Section 3.1. Following the preliminary screening, three additional sites were added for consideration, as described in Section 3.2.

3.1 Preliminary Site Screening

The following subsections summarize the procedure used for preliminary site screening.

3.1.1 Siting Maps for Individual Criteria

For each of the siting criteria listed in Section 2.2.1, a map of the INEL was generated showing either excluded and nonexcluded areas (for "must" criteria) or more-preferred and less-preferred areas (for "want" criteria). These maps were prepared with the input of the field committee members (see Section 2.1) and are shown as Figures A-1 through A-12 in Appendix A.

3.1.2 Composite Siting Map

Once the above maps were produced, they were compiled into a single siting map showing all the preferred and excluded areas together. This composite siting map is shown as Figure A-13 in Appendix A.

3.1.3 Candidate Areas

On the basis of the composite siting map which was generated, eight candidate areas were screened from all available land on the INEL for further consideration. Each of these areas comprises a 3 mi² to 8 mi² contiguous surface area within the INEL that was judged by the field committee to satisfy the siting criteria. The rationale for the selection of these areas is described in Section 5.2.1 of Appendix A. The locations of the selected areas are shown (shaded) in Figure A-13 of Appendix A, and below in Figure 3-1.

3.1.4 "Site Walkovers" of Candidate Areas

A site-inspection team was assembled from among the advisory and field committee members to do field inspections of each of the eight candidate areas and evaluate them from the standpoint of one or more of the siting criteria listed in Section 2.2.2.

3.1.5 Candidate Sites—1, 3, and 5

On the basis of the assessments of the site inspection team, the field committee chose three candidate sites within the candidate areas. (A candidate site is an area of roughly 200 ac identified within a candidate area.) These sites comprise a preliminary siting recommendation^a to DOE, and are shown (solid) as sites 1, 3, and 5 in Figure 3-1. The rationale for the selection of these sites is given in Section 5.5 of Appendix A.

3.2 Supplementary Site Recommendations

Some time after the preliminary site recommendation above was made, waste management personnel requested that three additional sites be considered. The areas in which these sites are located had been excluded during the preliminary site screening process described in Section 3.1.3. However, as noted above, this did not preclude the consideration of other sites, provided additional characterization data was obtained to support their inclusion among the candidate sites. The three additional sites are shown in Figure 3-1 as sites 9, 14, and 18.

3.2.1 Site 9

As discussed in Section 3.2.2.20 of Appendix A, transportation of wastes to and from the new facilities was a major issue in selection of the siting criteria for preliminary site screening. This issue led to the choice of site 9, which is located close to the RWMC where most of the wastes are currently stored that will be treated by the IWPF. While this site was initially excluded during the preliminary screening on the basis of possible flooding concerns, it was added for renewed consideration on the assumption that additional flooding analysis would put to rest these concerns.

3.2.2 Site 14

A siting requirements review³ for the MLLW DF, which was parallel to that described in Section 2.1, was completed in May 1992. The summary and conclusions section of that review cites specific requirements for chemical waste landfills relating to soil depth and permeability (see 40 CFR 761.75). Because of these additional regulatory requirements, the priorities of the siting criteria for the disposal facility (MLLW DF) were somewhat different from those for the treatment facilities (MLLW TF and IWPF). This difference led to consideration of additional sites for the disposal facility beyond those that were chosen during the initial screening for the treatment facilities.

a. Letter from J.L. McAnally, EG&G Idaho, to W.N. Sato, DOE Idaho Operations Office, October 7, 1992, JLM-691-92, Subject: "Siting of the Idaho Waste Processing Facility and Mixed/Low-Level Waste Treatment Facility on the INEL."

Figure 3-1. Candidate Areas and Candidate Sites for New Waste Handling Facilities at the INEL

In choosing other sites, the recommendations from earlier siting efforts were considered. In particular, a recommendation published in 1969^b was examined and formed the basis for the addition of site 14 to the list of candidate sites to be considered (see Figure 3-1; this site is near the U.S. Geological Survey well site with the same identifying number). This site was chosen because of the abundance of fine-grained surficial sediments in the area.

3.2.3 Site 18

Site 18, approximately two miles north of site 14, was added on the basis of field surveys and discussions^c with INEL personnel having expertise in geology and seismology. Both sites 14 and 18 lie in an area of the INEL that was excluded from consideration during the preliminary site screening described in Section 3.1. The reason for the earlier exclusion of these sites was that they failed to satisfy the criteria initially used to assess vulnerability to flooding (see Section 5.1.2 of Appendix A). The flooding potential at these sites, therefore, required further study in order to justify their inclusion as candidate sites (see Sections 4.1.2 and 4.2.2).

b. Memorandum from J.T. Barraclough, Research Projects Chief, U.S. Geological Survey, WRD, National Reactor Testing Station, to Dr. C.A. Pelletier, Chief, Environmental Branch, Atomic Energy Commission, National Reactor Testing Station, November 26, 1969, Subject: "Preliminary Appraisal of Sites at the National Reactor Testing Station for a Proposed New Solid Radioactive Waste Burial Ground." (This letter cited an earlier, unpublished report, U.S. Geological Survey report ID-02219, by M. Deutsch and S.W. West, 1952.)

c. An example includes a handwritten memorandum from J.T. Barraclough to J. Tullis, September 8 1990, currently in the project file for the Mixed Low-Level Waste Disposal Facility, Waste Management Facility Projects Unit, EG&G Idaho, Subject: "Proposed Locations for Sites for New Locations to Store or Dispose of Solid, Radioactive Waste."

4. SITE CHARACTERIZATION

After assembling the list of candidate sites described in Section 3, an assessment was performed to determine what additional site-specific information should be obtained to facilitate an objective comparison of the candidate sites and to support the recommendation of a specific site. In addition, an action plan was drafted for obtaining the required information. Section 4.1 summarizes the siting issues addressed by the plan and references the sections of Appendix C where the detailed recommendations are given. Section 4.2 provides the status of the action items from the action plan and summarizes the results of those items that have been completed to date.

4.1 Action Plan

The following subsections briefly describe the criteria recommended for additional characterization in the action plan (Appendix C). The objective of the action plan was not a complete characterization of the candidate sites. (Exhaustive characterization activities will be performed later to support the Environmental Impact Statement, Performance Assessment, etc.) Rather, the data obtained through the action plan was to augment the existing data and provide a defensible basis for quantitative comparison of the candidate sites based on specific siting criteria discussed in Section 2.

4.1.1 Seismicity

Because all six candidate sites are in Butte County, there are no Federal or state regulatory requirements for seismic concerns in site selection (see Section 2.1 of Appendix C). However, DOE orders mandate consideration of seismicity in siting new facilities (for example, the cost of construction for seismic conditions could be significant, depending on the design requirement). The current guidelines for determining such design requirements are summarized in Table 4-1, which specifies the ground-motion factors to be used for various locations on the INEL, for performance categories 3 and 4 (previously known as moderate and high hazard facilities). The table indicates significantly higher factors for the Test Area North (TAN) area, suggesting that on the basis of these guidelines, sites 5, 14, and 18 should be given a lower ranking than sites 1, 3, and 9.

DOE guidelines note, however, that site-specific probabilistic hazard curves are planned for each facility area. In anticipation of this, Appendix C lists recommendations that certain site-specific data be collected/analyzed that might shed light on possible changes to the current guidelines. These recommendations are given in Section 2.3 of Appendix C.

Table 4-1. Design ground motions for performance categories 3, 4 at various INEL locations

Area	Performance category 3 ^a	Performance category 4 ^a
Idaho Chemical Processing Plant	0.18 g	0.24 g
TAN	0.26 g	0.35 g
Power Burst Facility	0.17 g	0.22 g
RWMC	0.16 g	0.21 g
TRA	0.18 g	0.24 g

a. DOE-ID Architectural Engineering Standards, U.S. Department of Energy Idaho Operations Office, Revision No. 14, September 1993.

4.1.2 Flooding

As noted in Section 2.2.1.2, vulnerability to flooding was a major criterion used in screening areas for candidate sites. To ensure that candidate sites comply with applicable flooding regulations, each site was analyzed to determine what portions are below the 100-year flooding elevation or within the 100-year floodplain. The action plan addressing this task is contained in Section 3.3 of Appendix C.

In considering this issue, two sources of flooding must ultimately be considered. The first of these is generalized flooding along the normal channels of established streams. The second flooding source is localized flooding due to runoff and ponding from immediately adjacent watersheds. Both sources were considered; however, only localized flooding potential has been analyzed to date.

4.1.3 Cultural Resources

Section 3.3 of Appendix B discusses preservation of historical artifacts and/or sites that may be present on the INEL. The National Historic Preservation Act of 1966 requires that mitigating measures be adopted to minimize adverse effects on properties listed or eligible for listing on the National Register of Historical Places. [Appendix B erroneously implies that a formal license is to be issued, prior to proceeding with projects that will affect undisturbed areas. The actual requirement is that any Federal agency head with jurisdiction over an undertaking on properties eligible for listing on the National Register of Historical Places follow a prescribed procedure, prior to approving the expenditure of any Federal funds *or* (if appropriate) prior to the issuance any applicable license or permit. The required procedure is to afford certain entities (e.g., the Advisory Council on Historic Preservation, the State Historic Preservation Officer, Indian tribal officials, etc.) a reasonable opportunity to comment on the undertaking.] Other regulations require that a formal archaeological survey be performed on all sites considered to be candidates for development in order to assess the likelihood of finding historic or prehistoric artifacts. An action plan for addressing requirements relating to these cultural artifacts is contained in Section 4 of Appendix C.

Several of the Federal laws described in Section 4 of Appendix C require the protection of cultural resources during all preproject activities. The cultural resources must also be given proper consideration in the preparation of environmental assessments and environmental impact statements.

Additional requirements pertain to areas of Native American significance. If, during any phase of archeological field work or INEL construction activities, human burials are encountered, all work must stop and the Idaho State Historic Preservation Office (SHPO) must be consulted immediately for advice.

Neither the INEL Cultural Resources Management (CRM) office nor the DOE Idaho Operations Office (DOE-ID) can grant the archeological clearance necessary to allow the project to proceed. The SHPO approves the survey adequacy, reports, recommendations, and mitigation plans in consultation with other groups such as tribal governments and the national Advisory Council on Historic Preservation (ACHP).

All cultural resources will be registered through the state historic archival system. Artifacts collected during the survey will also be submitted for permanent curation according to SHPO recommendations and will be prepared according to the specific guidelines of the Southeastern Idaho Regional Archeological Center at the Idaho Museum of Natural History.

If any properties identified within the bounds of the project area are potentially eligible for inclusion on the National Register of Historic Places, DOE-ID is required to determine if the project will have any effect on the properties. DOE-ID also is required to provide the ACHP with an opportunity to comment on the project. DOE-ID is directed by the National Historic Preservation Act of 1966 (NHPA) (P.L. 89-665) to make a good faith effort to preserve and protect any such properties.

4.1.4 Ecology

The purpose of the ecological survey is to comply with several Federal laws and executive orders to identify and evaluate potential environmental impacts as a result of the project. The action plan addressing this task is contained in Section 5 of Appendix C.

The Federal laws and executive orders discussed in Section 5 of Appendix C establish national policies and goals for the protection of the environment. In particular, all Federal agencies are required to give appropriate consideration to the environmental effects of their proposed actions in their decision making. Those actions must not jeopardize the continued existence of any endangered or threatened species or adversely affect their critical habitat. Each agency must take action to minimize the destruction, loss, or degradation of wetlands wherever there is a practicable alternative.

The field surveys of the locations were conducted to observe vegetation (especially species of concern), animal species present, presence of any critical habitat for rare or endangered species, general soil characteristics, wetlands, and any relationship of the candidate sites to other ongoing ecological studies.

4.1.5 Air Pollution

Section 6.1 of Appendix C discusses a number of regulatory issues dealing with air pollution from the new facilities. These regulatory issues formed the justification for a number of recommended actions. These actions were intended to further characterize the candidate sites based on impacts to the public from air emissions and subsequent atmospheric transport of hazardous pollutants. One of the recommended actions was to model atmospheric transport of a generic air pollutant from each of three regions considered representative of the six candidate sites. Such modeling would provide a quantitative basis for comparing sites from the standpoint of the "want" criterion which states that the new facility should be located so as to minimize public exposure to airborne pollutants (see Section 2.2.1.4). Other actions recommended in Appendix C dealt with collection of meteorological and background air quality data, which will be required for permitting purposes, prior to construction.

4.1.6 Contaminant Migration

Section 7.1 of Appendix C describes performance requirements that are likely to be applied to any new disposal facility at the INEL. (Such requirements, however, may not be applicable to new treatment facilities.) Demonstration of a site's ability to satisfy such requirements necessitates the acquisition of a considerable body of subsurface data. This data, in turn, is used to provide the modeling parameters used in performance assessments. A list of such parameters is provided in Section 7.2 of Appendix C. This list includes moisture potential, hydraulic conductivity, porosity, geometries and boundary conditions, hydraulic head, ion-exchange capacity and organic content (of soils), Eh-pH, soil mineralogy, and others.

Section 7.3 of Appendix C describes the types of data and measurements that can provide the above parameters, and Section 7.4 provides a detailed list of tasks to be performed in order to obtain this data. These tasks include review of lithologic and geophysical log of existing wells in the INEL [task 7.4.1(a)], drilling of additional bore holes [where required by gaps in existing data, task 7.4.1(b)], additional geophysical measurements [task 7.4.1(c)], infiltration measurements [tasks 7.4.1(d) and 7.4.1(e)], measurement of retardation coefficients [task 7.4.1(f)], and modeling of contaminant migration using the above site-specific data [task 7.4.1(g)].

4.1.7 Buried Utilities

In order to comply with DOE Order 6430.1A, General Design Criteria, it was necessary to review the location of any buried pipe utilities in the areas in and near this project. Section 0285-2.2.5., Sites Traversed by Utilities, requires that sites traversed by buried pipe utilities not be used for TSD facilities unless the relocation of the utilities is economically feasible.

The Planning and Inspection Unit in the Facility Engineering Group is responsible for the maps of underground power utilities on the INEL. The Telecommunications Systems Unit in the Information Systems Group has the information on any buried telecommunications services on the INEL.

4.1.8 Soils

The purpose of the soil-cover study for areas involved in this project is to comply with DOE Order 6430.1A, General Design Criteria, Section 0285-2.2.6. This section, Characteristics and Availability of Soil Cover, requires that the characteristics and availability of on-site soil cover be considered with respect to site operation and performance requirements, including vehicle maneuverability, as part of the site-selection criteria for TSD solid waste systems.

For each of the candidate sites, a soil map will be developed showing the distribution of soil types and the relationship of soils to geologic features, groundwater, vegetation, and site physiography. Interpretations will be provided for each soil type addressing site suitability, potential for contaminant migration, and erosive and hydrologic properties. In addition, laboratory analyses will be performed that will greatly enhance soil interpretations and provide quantitative information for determining site suitability.

Soil mapping will include identification and complete descriptions of the soil types. Field observations for soil mapping will take into account soil features that determine the suitability of the site for the proposed facilities.

Soil samples will be collected for alpha and gamma spectral analyses to establish baseline levels for radionuclides. These values are needed for the determination of radiological impact from the future facility. The portion of the sample collected that has not been used for analysis will be archived for future reference and analyses, and for potential use in establishing *de minimus* values.

4.2 Characterization Activities

The following subsections provide status of all characterization activities recommended in the action plan (Appendix C). The results are summarized for the activities that were funded and completed during the fourth quarter of FY 1993 and the first quarter of FY 1994, and each of the six candidate sites is assigned a rank between 1 and 10 (with 1 indicating best on the basis of the criterion under consideration). The rankings are provided in tabular form at the end of each subsection.

4.2.1 Seismicity

A portion of the recommended activities mentioned in Section 4.1.1 (specifically, tasks 2.3.1(a)(1), (2), and (3)) were conducted during the first quarter of FY 1994. Completion of these tasks generated the following results:

- A sensitivity analysis to identify the most important factors determining ground motions at specific locations on the INEL. This study included estimates of the ranges of ground motions associated with the ranges in the uncertainties of quantitative estimates of the important determining factors (e.g., locations of fault terminations, magnitude of the assumed random earthquake on the Eastern Snake River, Plain, etc.).
- A review of data that were generated by the New Production Reactor (NPR) program that might aid in reducing the uncertainties of the important determining factors for seismic

hazard. This data included geophysical data directed at identifying the terminating points of known faults on the INEL. It also included review of recently obtained data about geologic features (e.g., the Kath fissure, the LaPoint Monocline, and the linear magnetic anomaly that runs parallel to the Howe-East Butte volcanic rift zone) that could influence estimates of the level of seismic hazard.

- Recommendations of additional field work that could be done to reduce the uncertainties in estimates of ground motions at the candidate sites.

The results of the all the activities described above are documented in Appendix D.

4.2.1.1 Seismic Hazard Definition. The seismic hazard is defined as the likelihood of exceeding various levels of ground motion at a site during a specified time period. It is determined from a seismic hazard assessment model^d that incorporates ranges of uncertainties for all known seismic sources and several ground motion attenuation relationships. In applying the model, a hazard analyst weights each of the seismic sources and attenuation relationships in a manner consistent with the seismic and tectonic setting of the specific site. The resulting model output is an ensemble of ground motions corresponding to the range of uncertainties in the parameters encompassed by the model.

The ground motion sensitivity analysis for the current site screening study was subcontracted to Woodward-Clyde Federal Services.² Because of the proximity of sites 9, 14, and 18 to sites 1, 3, or 5, only the latter three were considered in the analysis. Application of the hazard assessment model to these three locations produced exceedance values for ground motion at the 15th, 50th, and 85th percentiles. In addition, the arithmetic mean of the calculated ground motions for each recurrence interval was provided. The results are summarized in Table 4-2 (taken from Table 1 of Appendix D).

4.2.1.2 Major Factors Influencing Ground Motion. In addition to the results in Table 4-2, the output from the model was used to determine the most influential uncertainties in determining ground motions at the candidate sites. The following factors were determined:

d. The model includes several elements that together constitute a probabilistic seismic hazard methodology. The elements of this methodology are as follows:

- (1) Characterization of seismic sources and uncertainties.
- (2) Characterization of seismic wave transmission characteristics and uncertainties.
- (3) Development of a logic tree reflecting current understanding of seismic sources and paths of seismic energy. Uncertainties are accounted for by incorporating all possibilities in different branches of the logic tree and assigning weighting factors to each branch.
- (4) Computer codes that calculate ground motion for each branch of the logic tree. Two types of code are used: stochastic (band limited white noise/random vibration theory requiring site-specific path parameters, with code developed by Walt Silva at Woodward-Clyde Federal Services) and empirical (depending only on measured ground motions at seismic stations for specific historical earthquakes, with code developed by Geomatrix Consultants).
- (5) A computer code that calculates hazard curves which reflect the uncertainties. (This code was developed and adapted by many people involved in probabilistic seismic hazard assessment.)

Table 4-2. Calculated horizontal ground motions at candidate sites

S I T E	Calculated Ground Motion (g)											
	PC1 ^a 500-yr				PC2, PC3 1000-yr				PC4 5000-yr			
	15th %ile	50th %ile	85th %ile	Mean	15th %ile	50th %ile	85th %ile	Mean	15th %ile	50th %ile	85th %ile	Mean
1 ^b	- ^c	.061	.085	.069	.069	.089	.131	.096	.140	.190	.260	.210
3 ^c	-	-	.076	.057	.051	.072	.100	.084	.110	.140	.210	.170
5 ^d	-	.066	.100	.080	.074	.093	.150	.110	.150	.180	.300	.230

a. PC1 = Performance Category 1 (and hazard recurrence interval) as defined by DOE Order 5480.28, PC2 = Performance Category 2, etc.

b. Dominant contributors to ground motion at site 1 were location of Lost River Fault termination, random earthquake magnitude, and choice of seismic attenuation relationships

c. Dominant contributors to ground motion at site 3 were location of Lemhi Fault termination, and choice of seismic attenuation relationships

d. Dominant contributors to ground motion at site 5 were location of Lemhi and Beaverhead Fault terminations, and choice seismic attenuation relationships

e. Where no number is given, the value is less than 0.05 g.

- The locations of the termination points of major Basin and Range normal faults on and near the INEL.
- The assumed recurrence interval and magnitude of a random earthquake on the Eastern Snake River Plain (in the seismic analysis, the random earthquake is considered an event that is separate and distinct from seismic activity associated with any of the identified seismic sources).
- The relation used (band limited white noise with random vibration theory, or empirical) to quantify the seismic attenuation. Depending on which relation is more heavily weighted at a given location, the stratigraphy of the near surface geology beneath each site can also be a significant factor in determining the ground motion.

Uncertainty in the seismic attenuation at site 5 is particularly problematic since there is no deep borehole stratigraphic data (i.e., 3,000 ft depth or greater) within approximately 19 km of the site. The ground motion analyses assumed the stratigraphy is similar to that at the Idaho Chemical Processing Plant (roughly 46 km away), based on similar surface geology. However, the uncertainty associated with this assumption is not reflected in the sensitivity study. Thus, the range of probable ground motions calculated for site 5 may overestimate or underestimate the ground motion uncertainty that would be calculated if better stratigraphic data were available.

4.2.1.3 Site-Specific Ground Motions vs Current DOE Standards. The mean ground motion values for performance categories 3 and 4 for the RWMC in Table 4-2 do not exceed those in Table 4-1. The difference suggests that the DOE-ID Architectural Engineering Standards may be

conservative and acknowledges the differences in how the latter values were determined relative to the values in Table 4-2. Further comparison of the tables indicates agreement that site 5 is the least desirable of the three from the standpoint of minimizing potential ground motion (assuming that the TAN values from Table 4-1 are applicable to site 5). However, if one assumes the TRA and ICPP values from Table 4-1 are representative of site 3, the two tables provide different conclusions about the relative desirabilities of sites 1 and 3.

For the purposes of the present site screening exercise, the site-specific data in Table 4-2 were presumed to provide a more accurate comparison of the sites' potential ground motion.

4.2.1.4 Comparison of Candidate Sites on Basis of Seismicity. DOE Order 5480.28 states that for sites containing facilities in performance category 3 or 4 (moderate to high hazard facilities), a site-specific probabilistic natural phenomena hazard assessment is to be conducted, while for sites containing facilities in performance category 1 or 2 (low hazard facilities), it is sufficient to use natural phenomena hazard maps from building codes or national consensus standards. Since the Uniform Building Code (1991 Uniform Building Code, Figure 23-2 and Table 23-I) apparently places all the INEL in seismic zone 2B (with 0.20 g nominal ground acceleration), all candidate sites would be considered equally desirable from the standpoint of seismicity if the facility that is ultimately constructed is considered to be a low-hazard facility (i.e., performance category 1 or 2).

For the present site comparison, it is conservatively assumed that the facility will be considered moderate to high hazard. In addition, it is assumed that by the time the facility is designed and constructed, the site-specific data from Table 4-2 will be factored into the DOE Architectural Engineering standards. With these premises, the six candidate sites are ranked in Table 4-3 according to the 85th percentile ground motions listed in Table 4-2. The ranking also assumes that due to their geographical proximities to one another, sites 1 and 9 are seismically equivalent, and sites 14 and 18 are equivalent to site 3. The low ranking of site 5 reflects higher anticipated ground motion due to its proximity to the Lemhi Fault and the uncertainty associated with the subsurface stratigraphy (see Section 4.2.1.2).

Table 4-3. Ranking of candidate sites—seismicity

Site	Rank ^a
3, 14, 18	1
1, 9	2
5	3
a. Rankings are from 1 to 10; 1 indicates best.	

Notwithstanding the site ranking in Table 4-2, it has been pointed out that differences between seismic ground motions at sites 1, 3, and 5 increase or decrease the overall cost of construction by a

relatively small amount^e. This suggests that seismicity may not be an overriding concern in the selection of one of the candidate sites. That is, if weighting factors were assigned to the siting criteria discussed herein, seismicity should be assigned a relatively low weight. Stated another way, all sites on the INEL can probably be considered equally good from a seismic standpoint. Nonetheless, the seismic information that has been generated will eventually be utilized in the design of the facility (assuming the facility is authorized, and funds are provided for design and construction), since all design loads must be justified.

4.2.2 Flooding

The activities described in Section 3.3 of Appendix C were performed during the summer and fall of 1993 for the six candidate sites. A complete description, together with the results obtained, are provided in Appendix E. As a result of these activities, inundation areas for 100-year and 500-year hydrological events were defined in accordance with the guidelines of the Federal Emergency Management Agency (FEMA) guidelines¹ for sites 1, 3, and 9. At site 5, an assessment of the potential flooding hazard was made. However, a FEMA-compliant determination of the areas of inundation could not be made without a two-dimensional flow-spreading analysis, which was beyond the scope of the effort. In addition, probable inundation areas for the above events were defined for sites 14 and 18. However, due to funding constraints, a full FEMA-compliant study was also not performed for these areas. The results of these activities are summarized below.

4.2.2.1 Candidate Site Assessments. None of the six candidate sites (as currently defined) is wholly above the 100-year flooding elevation. In addition:

- Sites 14 and 18 are both susceptible to major flooding during both 100-year and 500-year events.
- Site 5 appears to be immune from *natural* flooding, but could possibly be inundated from overflows of the *manmade* Birch Creek Return Channel, which routes flooding flows toward the site that would otherwise go elsewhere. However, two-dimensional analysis of flood flows may negate this conclusion.
- Approximately 36 ac (27%) of site 3 is inundated by both the 100-year and 500-year events. The uniform distribution of the inundation areas throughout the site tends to make it impractical to refine site boundaries to exclude the areas prone to flooding.
- About 7.2 ac (12%) of site 9 are flooded from ephemeral streams during the 100-year event, but there are no ponding areas on the site. The 500-year inundation area differs only slightly from the 100-year area.
- Site 1 contains both ponding areas and ephemeral streams, resulting in inundation of approximately 52 ac (27%) of the site. The 500-year inundation area differs only slightly from the 100-year area.

e. From conversations with R. C. Guenzler, unit manager for Applied Mechanics (B460), EG&G Idaho, Inc. on 1/18/94 and 5/11/94.

4.2.2.2 Comparison of Candidate Sites on Basis of Flooding Potential. The implications of the above results are as follows:

- The issue of flooding at sites 9 and 1 could probably be adequately addressed without rendering the sites unusable by redefining the site boundaries to exclude flooded areas. For this reason, sites 1 and 9 are judged to be superior to the other candidate sites from the standpoint of flooding potential.
- Site 3 contains several significant ponding areas and is less desirable than sites 9 and 1. However, depending on the actual area requirement for the new facility, the site may still be usable if sites 9 and 1 are rejected for other reasons.
- In the absence of a two-dimensional spreading analysis of flooding overflows from the Birch Creek Return Channel, flooding potential at site 5 considered indeterminate at this stage of the siting process, and no ranking is assigned at this time.
- Sites 14 and 18 are considered unacceptable on the basis of significant flooding potential. However, flooding potential at site 18 might be eliminated by diking at one key location.

On the basis of flooding potential, the six sites are ranked as shown in Table 4-4.

Table 4-4. Ranking of candidate sites—flooding potential

Site	Rank ^a
1	1
9	2
3	5
5	?
18	9
14	10

a. Rankings are from 1 to 10; 1 indicates best.

Site 1 is ranked slightly higher than site 9 because redefining the site boundaries could eliminate all land subject to inundation without fragmenting the site into multiple small parcels. Site 9 is only one-third the size of site 1, and the ephemeral streams divide site 9 into roughly equivalent pieces. Hence, realignment of site boundaries to eliminate flood-prone areas along the streams would yield a considerably smaller contiguous site.

4.2.3 Cultural Resources

4.2.3.1 Candidate Site Assessments. The archeological surveys of the candidate sites were conducted during the summer of 1993, under the direction of Ms. Brenda L. Ringe. Ms. Ringe's qualifications to perform these surveys and interpret the results are as follows:

- Bachelor of Arts degree in Anthropology (1986), Idaho State University
- Master of Arts degree in Anthropology (1994), Idaho State University
- 10 yrs experience in archeological research and cultural resource management on the INEL
- Currently employed by EG&G Idaho, responsible for project-specific compliance with cultural resource legislation, and long term management of INEL cultural resources.

The report, detailing the results of the archeological surveys, comprises two volumes. Volume I is included as Appendix F. It discusses the legal mandate for the archeological surveys, describes the areas and the survey methods, and reports the survey results. Guidelines to protect the archeological resources are also discussed if further work is done at any of the locations.

Volume II of the report contains the appendices detailing the location of the individual finds, and the detailed completed forms for the finds. Volume II is for official use only and must not be released without the approval of the INEL Cultural Resource Management Office.

A total of 82 cultural resources were reported from the candidate sites. These resources were individually evaluated, and the majority were classified as isolates, which are not likely to yield any additional information. These can be removed from management consideration and will require no further work. However, 30 prehistoric sites and a single historic rock feature were evaluated as being likely to contain subsurface cultural remains. Current policy of the Idaho SHPO is to consider all such archeological sites to be significant or potentially eligible for the National Register of Historic Places (NR) until proven ineligible. This determination is generally based upon completion of shovel testing of subsurface sediments associated with the sites. If shovel testing yields no subsurface deposits, then the initial recordation of the site in conjunction with the completed shovel testing may fulfill NHPA mitigation requirements. However, if subsurface deposits yield cultural resource materials, additional data recovery may be required. At this point in time, no shovel testing has been completed at any of the sites under consideration.

4.2.3.2 Comparison of Candidate Sites on Basis of Cultural Resources. There are no significant cultural resources located within site 5. Therefore, construction in this site would require no shovel testing for subsurface materials unless cultural materials are discovered during construction.

The remaining candidate locations contain the 30+ cultural resources that have been determined to be significant^f, as described above. These will require shovel testing before construction to determine the need for full-scale archeological excavation and mitigation. The cost of testing in each candidate location is a function of the number of potentially significant resources. The

f. Letter to Brenda Ringe, Chemical Services Unit, EG&G Idaho, from Robert M. Yohe II, State Archaeologist and Deputy SHPO, Idaho State Historical Society, dated January 5, 1993.

cost of full-scale archeological excavation and mitigation at the sites that contain subsurface cultural materials will be determined on a site-by-site basis.

Rankings of the candidate sites, based on the *number* of significant resources found on each site, are given in Table 4-5. It should be noted that this ranking is subject to change after additional data (e.g., from shovel testing) is obtained. In addition, even if shovel testing provides no evidence of cultural resources at a given site, established mitigation procedures must be followed, should any significant cultural resource be unearthed during excavation at that site.

Table 4-5. Ranking of candidate sites—cultural resources

Site	Rank ^a
5	1
18	3
14	5
9	6
3	7
1	9

a. Rankings are from 1 to 10; 1 indicates best.

4.2.4 Ecology

4.2.4.1 Candidate Site Assessments. Ecological field surveys were conducted in late fall of 1992 and spring and summer of 1993. The results for the MLLW TF and the IWPF are reported in Appendix G. The results for the MLLW DF are reported in Appendix H.

In October 1992, three of the locations were staked out with blaze-orange lath survey marker stakes. In spring and summer of 1993, the other candidate sites were also staked out.

Site 5, at the north end of the INEL, was staked in October 1992 in four corners approximating the square mile under consideration. In April 1993, site 5 was restaked to define the northern half as the area under consideration.

Field surveys of sites 1 and 3 were conducted in late fall of 1992 by representatives of the project and the Center for Integrated Environmental Technologies (CIET) and a representative from DOE-ID Radiological and Environmental Sciences Laboratory (RESL). Field surveys of sites 9, 14, and 18 were conducted with RESL in the spring of 1993.

Additional field surveys have been conducted by CIET while marking the candidate sites and while recording global positioning system (GPS) measurements of the boundaries. Observations were made of soils, vegetation types, animals, and animal signs such as tracks, droppings, dens, burrows, nests, and perches.

GPS locations of the boundary marker stakes for all the candidate sites were collected. The field GPS location data were later corrected against the surveyed community base station data. The location data for all candidate sites were input to the Arc/Info Geographic Information System (GIS), and overlaid onto the CIET vegetation map of the INEL. The results of these vegetation analyses are included as tables following the maps in Appendices G and H.

Results of the field surveys indicate use of site 1 by pygmy rabbits (*Sylvilagus idahoensis*) and expected use by them in sites 3 and 9. Pygmy rabbits are categorized a C2 species by the U.S. Fish and Wildlife Service. Two other C2 species, the ferruginous hawk (*Buteo regalis*) and the loggerhead shrike (*Lanius ludovicianus*) would also be expected to frequent the candidate sites. A C2 species is a species for which information indicates proposing to list as endangered or threatened is possibly appropriate, but for which conclusive data are lacking to support a final decision. Site 5 is in the winter range of a large number of pronghorn antelope (*Antilocapra americana*). Two species of rare vascular plants have previously been reported to occur in the vicinity of the sites 14 and 18. Site 18 is about 500 m from the Cinder Butte hibernacula, which is a winter den in which about 750 snakes hibernate, of which about 500 are rattlesnakes. None of the candidate sites are in other environmental study areas.

4.2.4.2 Comparison of Candidate Sites on Basis of Ecology. Based on field surveys of the candidate locations, site 9 is recommended when considering the ecological concerns for siting.

From an ecological and environmental viewpoint, site 9 has the least drawbacks, and its proximity to the RWMC would minimize any disturbances. If the facility were constructed at site 9 and fenced to be included as part of RWMC, the fence could be animal-proof without disturbing animal movements and migrations.

Site 1 has relatively few drawbacks. One concern with site 1 would be the disturbing of animal movements and migrations if the facility at site 1 were enclosed by a fence all the way to and around RWMC.

Rankings of the candidate sites, based on presently available information, are given in Table 4-6. These rankings are based, most importantly, on potential disturbance to animal movements and migrations, and on fragmentation of significant areas of undisturbed habitat.

Table 4-6. Ranking of candidate sites—ecology

Site	Rank ^a
9	1
1	3
3, 14	6
18	8
5	9

a. Rankings are from 1 to 10; 1 indicates best.

4.2.5 Air Pollution

A portion of the activities described in Section 4.1.5 were completed during the fourth quarter of FY 1993 and first quarter of FY 1994. Specifically, tasks 6.3.1(a)(1) and (2) of Appendix C were performed by the Air Resources Lab Field Research Division (ARLFRD) of the National Oceanic & Atmospheric Administration (NOAA) in Idaho Falls. The first of these tasks involved modeling air dispersion of a generic pollutant from sites 1, 3, and 5, using the MESODIF computer software model. The second of the two tasks involved performing a sensitivity study to determine whether uncertainties in current meteorological data warrant the collection of additional data from site 5, prior to comparing the sites on the basis of air pollution issues. Results from completion of these tasks are documented in Appendix I and are summarized in the subsections that follow. (Note that Appendix I also contains the wind roses that were the basis for the siting maps described in Section 3.1.1 for the criteria in Sections 2.2.1.4 and 2.2.1.7.)

4.2.5.1 Air Pollutant Dispersion Modeling of Selected Sites. Only sites 1, 3, and 5 were evaluated by dispersion modeling. Sites 9, 14, and 18 were not formally evaluated on the assumption that their dispersion characteristics are similar to those of sites 1, 3, or 5. This assumption is based on the close proximity of site 9 to site 1 and sites 14 and 18 to site 3.

Dispersion modeling of sites 1, 3, and 5 was performed using the MESODIF computer program. MESODIF (Mesoscale Diffusion) was developed by NOAA at the ARLFRD in Idaho Falls, Idaho. It is a forward time marching Gaussian plume model in which successive small plume elements (pollutant "puffs") are advected horizontally on the basis of data collected from existing meteorological stations on and around the INEL. The model simulates the dispersion of the pollutant puffs to calculate time-dependent concentrations of a generic air pollutant at designated receptor locations. The calculated concentrations are indicative of the dose that an individual would experience at any of the designated locations.

For this modeling effort, receptor locations were selected at bearings every 5 degrees surrounding each of the candidate sites, beginning with due north. The radial distance to each receptor is the distance to the nearest site boundary or place of public access on the bearing to the receptor. Simulated puffs were released every 20 minutes from each of the sites for a period of one

year, assuming a source strength of 1 unit per hour. (The units of the release are arbitrary, since the principal objective of the study was to compare the concentrations at the site boundary from the respective sites. However, an estimate of the actual pollutant concentrations could be obtained by simple linear scaling of the assumed source strength.)

4.2.5.2 Modeling Results. For each receptor at each site, time average concentrations were calculated for consecutive 1-, 3-, 6-, 12-, and 24-hour time intervals. From these calculations, a 95% concentration and a 100% concentration were calculated at each receptor at each site (95% concentration means that 95% of the time the pollutant concentration was calculated to be below that value, and 5% of the time it was above it. A 100% concentration is the maximum calculated concentration at a given location). These values were used to compare the potential impact to the public of facilities located at the three sites. The 95% concentration is probably a more meaningful value for comparisons because it tends to discount the effects of extremely rare meteorological events that result in large calculated pollutant concentrations at specific receptors and that have little statistical significance in assessment of public risk. However, for information purposes, the 1-, 3-, 6-, 12-, and 24-hour 100% concentrations were also included in Appendix I.

The 95% and 100% concentrations at all receptors are shown for each site, and for each of the above time intervals in Figures 1-10 in Appendix I. The values at the most impacted receptors for each site are listed in Tables 1 through 5 in Appendix I. The results consistently show that a facility at site 5 would generate the highest pollutant concentration at a site boundary for all five time intervals considered. Site 1 gives the next highest concentration, and site 3 gives the lowest. Table 4-7 shows the concentrations for sites 1, 3, and 5, normalized by the concentration at site 3, for easy comparison of the three sites. The table indicates that the 95% concentration of a generic pollutant at the site boundary for site 1 is 2.7-4.4 times that for site 3. The corresponding concentration for site 5 is 5.4-7.8 times that for site 3.

4.2.5.3 Site 5 Sensitivity Study. Because site 5 is comparatively distant from any NOAA meteorological station, an attempt was made to estimate the uncertainty of the above MESODIF calculations due to interpolation of data from the NOAA grid. To this end, MESODIF calculations were made for site 5 with the wind information from the TAN meteorological station omitted. (TAN is the closest wind station to site 5.) The results for the 1- and 24-hour concentration averages are shown in Figures 11 and 12 of Appendix I. The figures suggest a maximum uncertainty of about 25% in the computed results for site 5. Applying this uncertainty to the values in Table 4-7, the 95% concentration of a generic pollutant at the site boundary for site 5 would be 4.0-5.8 times than for site 3. Thus, the ranking of the sites in Section 4.2.5.2 is not altered by the uncertainty, and it was concluded that acquisition of additional site-5-specific meteorological data is not necessary for site ranking from the standpoint of minimization of public exposure to airborne pollutants.

Table 4-7. Normalized pollutant concentrations at Site boundary for sites 1, 3, and 5

Time interval	95% Concentration			100% Concentration		
	Site 1	Site 3	Site 5	Site 1	Site 3	Site 5
1 hr	4.4	1.0	5.4	1.7	1.0	7.9
3 hr	4.1	1.0	7.8	1.9	1.0	6.7
6 hr	3.4	1.0	7.7	1.2	1.0	5.0
12 hr	2.8	1.0	7.2	1.2	1.0	5.8
24 hr	2.7	1.0	7.0	1.3	1.0	5.7

4.2.5.4 Comparison of Candidate Sites on Basis of Air Pollution. On the basis of the modeling studies, the most favorable of the six candidate sites, from the standpoint of air pollution, is site 3. Because sites 14 and 18 are in close proximity to site 3, they are considered equally favorable. Sites 1 and 9 (which is close to site 1) are the second most favorable locations, and site 5 is least favorable with respect to public risk due to airborne contaminants. Based on the most impacted receptors for the three sites analyzed in the study, the six sites are ranked as shown in Table 4-8. The ranking is based on a comparison of the mean 95% concentrations in Table 4-7.

Table 4-8. Ranking of candidate sites—airborne pollutant concentration

Site	Rank ^a
3, 14, 18	1
1, 9	3
5	7

a. Rankings are from 1 to 10; 1 indicates best.

4.2.6 Contaminant Migration

4.2.6.1 Status of Action Plan Tasks. The cost of the activities described in Section 7 of Appendix C was estimated to be approximately \$1.5 million. The fact that subsurface characterization requirements are likely to be less stringent for a treatment facility (IWPF or MLLW TF), with a zero discharge design criterion, than for a disposal facility (MLLW DF), together with curtailment of funding for the disposal facility, led to the decision not to fund these activities for the current site screening effort. Performance of these activities may be completed at a later date, depending on decisions regarding continued funding of siting activities for the MLLW DF at the INEL.

4.2.6.2 Comparison of Sites on Basis of Contaminant Migration. Since no additional site-specific data was collected (beyond the initial site screening described in Section 3.1), the site rankings with regard to the criterion described in Section 2.2.1.3 are as indicated on the siting map for this criterion (see Section 3.1.1 and Figure A-5 in Appendix A). The ranking is shown in Table 4-9.

Table 4-9. Ranking of candidate sites—contaminant migration

Site	Rank ^a
14, 18	1
1, 3, 5, 9	10

a. Rankings are from 1 to 10; 1 indicates best.

4.2.7 Buried Utilities

4.2.7.1 Candidate Site Assessments. A survey of the locations was conducted by contacting the Planning and Inspection Unit in the Facility Engineering Group, and the Telecommunications Systems Unit in the Information Systems Group, to obtain their description of any buried utilities in the candidate sites. There are no buried utilities in any of the candidate sites.

As reported by the Planning and Inspection Unit, there are no identified buried utilities outside fenced areas enclosing the controlled-access facilities on the INEL site. At the Central Facilities Area (CFA) all identified buried utilities are within the region of the buildings.

A buried telecommunications line runs from the CFA to the RWMC and crosses Farragut Road north of site 1. This phone line location is indicated on EG&G Idaho drawings 426645 and 426647. Consideration of the line should be made if road construction to the IWPF and MLLWTF would impact the line.

Also, a buried fiber-optic telecommunications cable runs along the east side of Lincoln Boulevard from CFA to TAN. If candidate site 3, 14, or 18 is selected, consideration for the fiber-optic line should also be made prior to road construction from Lincoln Boulevard east to the facility.

4.2.7.2 Comparison of Candidate Sites on Basis of Buried Utilities. There are no differences in the candidate sites with respect to buried utilities. Buried utilities should not be a factor in the siting decision, and no site rankings are provided, based on this criterion.

4.2.8 Soils

4.2.8.1 Candidate Site Assessments. No detailed soil studies have been conducted at the candidate sites. Only the basic surficial examinations described in the ecological surveys (Appendices G and H) have been done.

4.2.8.2 Comparison of Candidate Sites on Basis of Soils. No comparison of the candidate locations based on soils can be made at this time. Consequently, no site rankings are provided, based on soil characteristics.

5. CONCLUSIONS

Table 5-1 summarizes the evaluations of all sites considered to date, including candidate areas 1-8 and candidate sites 9, 14, and 18, against all siting criteria that have been applied. (See Section 3.1 for the distinction between candidate *areas* and candidate *sites*; candidate *sites* 1, 3, and 5 are within candidate *areas* 1, 3, and 5, respectively). The table distinguishes the following three categories of rankings:

- (1) Rankings done during the preliminary screening of the entire INEL, described in Section 3.1.3. This ranking resulted in the selection of eight candidate areas, on which site walkovers were performed to further assess the sites;
- (2) Rankings done during site walkovers, described in Section 3.1.4. These rankings were done subsequent to those in category (1), and resulted the selection of three candidate sites from among the eight candidate areas. These three sites formed the basis for a preliminary recommendation⁴ to DOE-ID;
- (3) Rankings done subsequent to the activities described in Section 4. These rankings were based on site-specific characterization efforts performed on the three candidate sites (sites 1, 3, and 5), mentioned in (2), above, and on the three *additional* sites (sites 9, 14, and 18) which were added for consideration *after* the rankings in categories (1) and (2), were completed (see Section 3.2).

Note that in some cases the early site rankings were changed, after additional site specific data were collected (e.g., 100-yr flooding potential at site 9). Such cases are identified in Table 5-1 with parentheses enclosing early rankings which were subsequently altered. Also, sites 9, 14, and 18 were not among the preferred areas during the preliminary screening of the entire INEL. For this reason, site walkovers of these sites were not performed, and no rankings are provided for them within category (2), in Table 5-1. Likewise, since areas 2, 4, 6, 7, and 8 were eliminated from further consideration prior to the start of site-specific characterization efforts, no rankings are given for these locations under category (3).

The comparisons in Table 5-1 have been made on the basis of only *one* criterion at a time; i.e., each criterion was considered separately from all other criteria. Since no single site was ranked number 1 in *all* individual criteria, selection of a single site on the basis of the table rankings cannot be done without ordering the criteria according to their importance. This step has not yet been taken. Moreover, its completion will await the input from all stakeholders in the site-selection process. The stakeholders include those internal to DOE and those which are external to the agency (the State of Idaho, regulatory agencies, special interest groups, and the general public).

Stakeholder input will be sought in two general areas. The first of these is the choice of final site-selection criteria. The criteria identified within this report (and its appendices) address only technical issues stemming from regulatory and programmatic requirements. Additional concerns of the stakeholders beyond these technical issues must now be identified and added to the list of criteria by which candidate sites will be evaluated.

The second area in which stakeholder input will be solicited is in determining how a composite ranking of candidate sites should be effected, accounting for all the siting criteria as a whole. This determination will, of necessity, involve ordering the selection criteria by importance, as discussed above. It will also involve some type of weighting of the criteria beyond a simple ordering in order to determine how tradeoffs between conflicting criteria should be viewed.

In summary, the site screening activities described in this report for new waste handling facilities at the INEL have generated technical information from which objective comparisons have been made of six candidate sites. While these comparisons suggest preferred sites on the basis of individual siting criteria, no final site recommendation has been attempted. Rather, the stage has been set to solicit the input of all stakeholders (internal and external to DOE) in identifying additional siting issues beyond those already addressed and to incorporate all the issues in a composite ranking of the candidate sites. Once the latter step is completed, a single, preferred site can be identified.

Table 5-1. Summary of rankings of all candidate sites against siting criteria applied to date.

CRITERION	SITES										
	1	2	3	4	5	6	7	8	9	14	18
	RANKINGS ^a										

Category (1): Rankings Done During Preliminary Screening:

MUSTS

Above 100-yr flood elevation	1	1	1	1	1	1	1	1	(2)	2	2
Excludes FFA/CO sites, ECAs	1	1	1	1	1	1	1	1	1	1	1
Minimum of 1 mi to Cat I facilities	1	1	1	1	1	1	1	1	1	1	1
Minimum of 200 ft from capable fault	1	1	1	1	1	1	1	1	1	1	1

WANTS

Below US Hwy 20/26	1	1	2	2	2	2	2	2	1	2	2
Fine-grained sediments present	2	2	2	2	2	2	2	2	2	1	1
Minimizes public air pollution impacts	1	1	1	1	3	1	3	2	1	1	1
Outside wind corridors of existing facilities	3	1	1	1	2	1	1	3	3	3	3

(Table 5-1, cont'd)

CRITERION	SITES										
	1	2	3	4	5	6	7	8	9	14	18
RANKINGS ^a											
Minimizes vulnerability to lava flows	2	1	1	2	1	1	1	1	1	1	1
Minimizes vulnerability to volcanic fissuring	1	1	1	3	1	2	1	1	1	2	3
At least 1 mi from fault	1	1	1	1	1	1	2	1	1	1	1
Excludes areas chosen for other INEL projects	1	1	1	1	1	2	1	2	1	1	1
Not directly above Aquifer	2	2	2	2	2	2	1	2	2	2	2
<u>Category (2): Rankings Done During Site Walkovers:</u>											
MUSTS											
Evidence of wetlands	1	2	1	2	1	1	1	2	-	-	-
WANTS											
Estimated soil depth	1	1	2	2	1	2	1	2	-	-	-
Estimated seismic potential	2	3	3	1	3	2	3	2	-	-	-
15 km or more from capable fault	1	2	2	1	2	2	2	1	-	-	-
Critical habitat for endangered species	2	2	2	2	1	3	3	3	-	-	-
Evidence of cultural resources	(2)	2	(2)	2	1	(2)	(2)	(2)	-	-	-
General topography	1	1	2	2	1	2	2	2	-	-	-
Vulnerable to lava flows	2	1	1	2	1	1	1	1	-	-	-
Evidence of surface flooding	1	1	1	1	1	1	2	1	-	-	-
Proximity of utilities	1	2	2	2	2	2	2	2	-	-	-

(Table 5-1, cont'd)

CRITERION	SITES										
	1	2	3	4	5	6	7	8	9	14	18
	RANKINGS ^a										
Near developed roads	1	1	2	6	1	3	1	2	-	-	-
Rail spur adjacent	1	2	2	2	2	2	2	2	-	-	-
No ponding areas	2	2	2	1	1	2	1	2	-	-	-
Site is central to INEL	2	2	1	2	2	1	2	2	-	-	-
Close to waste feedstocks	1	2	3	4	6	3	5	2	-	-	-
Miscellaneous criteria ^b	1	5	6	6	2	6	9	9	-	-	-
<u>Category (3): Rankings Subsequent to Site Specific Characterization Activities:</u>											
MUSTS											
Flooding potential	1	-	5	-	(d)	-	-	-	1	6	7
WANTS											
Seismic hazard	1	-	5	-	10	-	-	-	1	6	7
Cultural resources	9	-	7	-	1	-	-	-	6	5	3
Ecology	3	-	6	-	9	-	-	-	1	6	8
Air pollution	3	-	1	-	7	-	-	-	3	1	1
Contaminant migration ^c	10	10	10	10	10	10	10	10	10	1	1
Buried utilities	1	-	1	-	1	-	-	-	1	1	1

a. Ranking from 1 to 10; 1 indicates best.

b. See Table 5-1 of Appendix A for specific comments made about each site. Ranking is based on the number of specific advantages mentioned during site walkovers minus the number of disadvantages.

c. Contaminant migration characteristics based solely on estimated depth of fine-grained sediments from preliminary site screening.

d. Flooding assessment at Site 5 was inconclusive (see Appendix E).

6. REFERENCES

1. Federal Emergency Management Agency, Federal Insurance Administration, *Flood Insurance Study Guidelines and Specifications for Study Contractors*, FEMA 37, March 1991.
2. I. Wong, et al., *Site-Specific Probabilistic Seismic Hazard Analyses for the Idaho National Engineering Laboratory*, Draft Final Report prepared for EG&G Idaho, Inc. by Woodward-Clyde Federal Services, Geomatrix Consultants, and Pacific Engineering and Analysis, June 1993.
3. J. M. Hillary, *Regulatory Siting Requirements for the Proposed Mixed and Low-Level Waste Disposal Facility at the INEL*, EGG-WMO-10250, May 1992.
4. J. L. McAnally, *Siting of the Idaho Waste Processing Facility and Mixed/Low Level Waste Treatment Facility on the INEL*, Letter to W. N. Sato, Idaho Field Office, U.S. Department of Energy, JLM-691-92, October 7, 1992.

Appendix A

Preliminary Site Selection for the Idaho Waste Processing Facility and the Mixed & Low-Level Waste Treatment Facility at the Idaho National Engineering Laboratory

**Preliminary Site Selection for the Idaho
Waste Processing Facility and the Mixed &
Low-Level Waste Treatment Facility at the
Idaho National Engineering Laboratory**

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February 1993

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ABSTRACT

The Idaho Waste Processing Facility (IWPF), the Mixed and Low-Level Waste (MLLW) Treatment Facility, and the MLLW Disposal Facility are currently in the planning stages by the Environmental Restoration & Waste Management Department at EG&G Idaho, Inc. The IWPF will be designed to treat stored and newly-generated inventories of transuranic and alpha-contaminated, low-level waste for which the Department of Energy (DOE) is responsible. The MLLW Treatment Facility will treat mixed and low-level wastestreams generated by ongoing DOE activities at the Idaho National Engineering Laboratory (INEL) and possibly elsewhere in the DOE complex. The MLLW Disposal Facility will be a disposal site for treated mixed, low-level, and alpha-contaminated, low-level wastes. One of the steps in the planning process for these facilities is the selection of siting locations. A preliminary site selection process has recently been completed, resulting in the recommendation of three acceptable sites for a co-located IWPF/MLLW Treatment Facility. The preferred site lies roughly two miles east of the RWMC. Siting of the MLLW Disposal Facility has not been explicitly addressed in this process and will be performed at a later date.

SUMMARY

The Idaho Waste Processing Facility (IWPF), the Mixed and Low-Level Waste (MLLW) Treatment Facility, and the MLLW Disposal Facility are three waste treatment, storage, and disposal (TSD) facilities that are currently in the planning stages at the Idaho National Engineering Laboratory (INEL). The treatment facilities are being designed to handle stored, mixed transuranic and alpha-contaminated mixed low-level wastes, as well as mixed, low-level wastes generated by ongoing operations, decommissioning and decontamination of facilities, and possibly environmental remediation activities in the Department of Energy complex. The disposal facility will receive the treated wastes from these facilities, with the exception of the transuranic wastes, which will be transported to the Waste Isolation Pilot Plant in New Mexico for placement.

Siting is an important step in the current phase of development of these facilities. This report describes the details of a recently completed siting study that resulted in the recommendation of three candidate sites for the co-located IWPF and MLLW Treatment Facility. The siting effort began with the publication of a siting criteria document that summarized the relevant regulatory and U.S. Department of Energy requirements for siting the IWPF. Similar documents have been published for the MLLW Treatment Facility and Disposal Facility. Because the requirements for the two facilities are nearly identical, it was decided that site selection would be performed on the assumption that the two facilities would be built side-by-side (co-located) at a single location.

After the siting document for the IWPF was completed, the work of site selection was divided between two committees: an advisory committee and a field committee. The purpose of the advisory committee was to review the siting criteria that were identified in the above-mentioned document and refine these criteria as necessary to guide the site selection process in a meaningful way. The purpose of the field committee was to select sites from the available land on the INEL on the basis of the advisory committee's siting criteria and then recommend three to seven sites to the Department of Energy, Idaho Field Office (DOE-ID) on the basis of a technical evaluation.

The advisory committee reduced the number of siting criteria substantially from what was proposed in the original siting criteria document. The criteria that ultimately were factors in the selection of candidate areas (defined below) were as follows:

- The facility must be above the floodplain of the probable maximum flood due to postulated failure of MacKay Dam during the most severe flood event reasonably possible.
- The facility must be above the 100-year flooding elevation (which conservatively accounts both for generalized flooding from the Big Lost River on the INEL and local flooding due to ponding from localized runoff).
- The facility must not be located over any site listed in the Federal Facilities Agreement/Consent Order, with the exception of Waste Area Group 10 [i.e., the Snake River Plain Aquifer (SRPA)].
- The facility must not be located on any known wetland.

- The facility should be located where there are known surficial deposits of fine-grained sediments to inhibit downward migration of possible contaminants to the SRPA.
- The facility should be located in the regions of the INEL where airborne releases of hazardous substance would result in the exposure of a minimum number of members of the public.
- The facility should not be located in areas where there would be significant interaction of the new facility with existing facilities in terms of airborne contamination by plumes.
- The facility should be located in regions that are least vulnerable to lava inundation or fissuring due to volcanism in the area of the INEL.
- The facility should not be located within a mile of a capable fault.
- The facility should not be located on portions of the INEL that have been selected for other projects that currently are not funded.
- The facility should be located on portions of the INEL that are not directly above the SRPA.
- The facility should be located south of U.S. Highway 20/26 so that stored wastes at the RWMC can be transported to the IWPF/MLLW Treatment Facility without crossing public highways.

On the basis of the above siting criteria, several maps of the INEL were generated that indicated preferred areas and excluded areas. The former are areas that are desirable on the basis of a specific siting criterion, and the latter are areas that were excluded from further consideration because of a criterion deemed to be mandatory by the advisory committee. Once the mapping was completed, eight candidate areas were selected that were outside all excluded areas and inside as many preferred areas as possible. These candidate areas were generally contiguous tracts of three to eight sections (square miles), each of which was judged to contain land that was acceptable from the standpoint of the siting criteria, even though none of these areas satisfied *all* the siting criteria. (It was determined that *no* sites could be found that satisfied all the above criteria.)

Once the eight candidate areas were selected, a number of candidate sites were identified within the candidate areas (a candidate site was a contiguous tract of 200-acres of federally-owned land on the INEL). These sites were visited by a team of INEL personnel representing several different backgrounds (e.g., project management, regulatory compliance, water quality, surface water flooding, ecology, archaeology & cultural resources, siting of disposal facilities for commercial low-level radioactive waste, architectural engineering, geology, and soil physics) in a series of site walkovers, the purpose of which was to gather additional information on which to base a final recommendation of three to seven specific candidate sites for the IWPF/MLLW Treatment Facility. The type of information gleaned from these surveys was as follows:

- Soil type and estimated depth

- Evidence of habitat for sensitive plant and animal species
- Evidence of historical and/or archeological resources
- Topographic features
- Surficial geologic features
- Proximity to utilities and services
- Evidence of past surface flooding
- Potential impact to or by neighboring facilities
- Miscellaneous characteristics that could impact siting.

On the basis of the evaluations performed by the members of the site inspection team during the site walkovers, the siting coordinator recommended three sites to DOE-ID for the IWPF/MLLW Treatment Facility. The three sites are as follows:

Preferred site: Site 1, located in Township T2N, R29E Section 15 (roughly two miles east of the RWMC)

First alternative site: Site 5, located in Township T7N, R31E Sections 1 and 2 (roughly eight miles north of Test Area North)

Second alternative site: Site 3, located in Township T4N, R31E Section 8 [roughly seven miles east-northeast of the Naval Reactor Facility (NRF)].

The table below summarizes the evaluations for each of the above sites. The table indicates for each of the siting criteria whether the site was considered preferred ("X"), or not preferred (" ") (i.e., "X" indicates the site was judged as satisfying the criterion on the basis of information available at the time, while " " indicates the contrary). Both the criteria used in generating the siting maps, and factors discussed during site walkover evaluations are included.

SITING CRITERIA	SITE		
	1	5	3
(criteria used to generate siting maps--basis for selection of eight candidate areas)			
Below U.S. Highway 20/26 (Certified shipping containers not required)	X		
Above 100-year flooding elevations	X	X	X
Contains fine-grained sediments			
Minimum potential for airborne contamination of public	X		X

Does not contain FFA/CO sites or Environmentally Controlled Areas	X	X	X
Not within one mile of a category I facility, or existing/proposed reactor	X	X	X
Outside wind corridors of existing INEL facilities		X	X
Least vulnerable to lava flows		X	X
Least vulnerable to volcanic fissuring	X	X	X
One mile or more from a capable fault	X	X	X
Not on land reserved for other INEL projects	X	X	
Not directly above Snake River Plain Aquifer			
(factors mentioned during site walkovers--additional information for site selection)			
No evidence noted of critical habitat for endangered species	X	X	X
More than 15 km (9.3 mi) from capable faults	X		
No surficial evidence of flooding noted	X	X	X
No evidence of wetlands	X	X	X
Access to power lines	X	X	X
Developed roads present	X		X
Rail spur adjacent	X		
Relatively flat topography	X	X	
No ponding areas on site		X	
Estimated depth of surficial sediments probably greater than 3 m (10 ft)		X	
No evidence of historical/archeological resources on site		X	
Located central to the INEL, not visible to public roads			X
Close to waste feedstocks	X		

The procedure used to choose the recommended sites did not attempt to identify the best site from all potential sites on the INEL. Nonetheless, after the initial screening of all available INEL sites on the basis of objective siting criteria, in which eight candidate sites were identified, an attempt was made to select the best site from among those eight on the basis of the judgments of the siting committees, and of the siting coordinator, in weighing the relative advantages and disadvantages of the eight candidate sites.

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ABBREVIATIONS & ACRONYMS

alpha-LLW	alpha-contaminated, low-level waste
AIRFA	American Indian Religious Freedom Act
ANL	Argonne National Laboratory
ARA	Auxiliary Reactor Area
BLM	Bureau of Land Management
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area
CFR	Code of Federal Regulations
cfs	cubic feet per second
COCA	Consent Order and Compliance Agreement
D&D	decommissioning and decontamination
DOE	United States Department of Energy
DOE-ID	United States Department of Energy-Idaho Operations Field Office
DOT	Department of Transportation
EBR-I	Experimental Breeder Reactor I
ECA	environmentally controlled area
EPA	United States Environmental Protection Agency
ER&WM	Environmental Restoration & Waste Management
ES&Q	Environmental Safety and Quality Department
FFA/CO	Federal Facilities Agreement/Consent Order
FY	Fiscal Year
GPS	Geodetic Positioning System
ICPP	Idaho Chemical Processing Plant

IDHW	State of Idaho Department of Health and Welfare
INEL	Idaho National Engineering Laboratory
IWPF	Idaho Waste Processing Facility
K-T	Kepner-Tregoe Decision Analysis
LANDSAT	Land-Scanning Satellite, or Earth Resources Technology Satellite
LDR	land disposal restriction
LOFT	Loss of Fluid Test
mrem	milliroentgen equivalent man
MLLW	Mixed and Low-level Waste
MTRU	Mixed Transuranic Waste
NEPA	National Environmental Protection Act
NOAA	National Oceanic and Atmospheric Administration
NPR	New Production Reactor
NRF	Naval Reactors Facility
NWCR	Nuclear Weapons Complex Reconfiguration
OEL	Occupational Exposure Limit
PBF	Power Burst Facility
PCB	Polychlorinated Biphenyl
PTI	Protection Technology Idaho
RCRA	Resource Conservation and Recovery Act
rem	roentgen equivalent man
RWMC	Radioactive Waste Management Complex
SPERT	Special Power Excursion Reactor Test
SRPA	Snake River Plain Aquifer

TCLP	toxicity characteristic leaching procedure
TRA	Test Reactor Area
TRU	transuranic
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
UPRR	Union Pacific Rail Road
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WERF	Waste Experimental Reduction Facility
WIPP	Waste Isolation Pilot Plant

GLOSSARY OF TERMS

Advisory committee: A committee of individuals from the INEL community who represented management and legal concerns in selecting and defining the criteria in Section 5.5 used in the site selection for the IWPF/MLLW Treatment Facility (see Section 2.1).

Candidate area: An area of three to eight mi² within the INEL that was judged to satisfy the siting criteria described in Section 3 on the basis of the preferred areas and excluded areas that were identified by the field committee (see Sections 1.3.3 and 5.2).

Candidate site: An area of roughly 200 acres that was identified within a candidate area to be potentially desirable for siting the IWPF/MLLW Treatment Facility, and merited further characterization by a site walkover (see Sections 1.3.4 and 5.3).

Excluded area: An area of the INEL that had to be excluded in siting the IWPF/MLLW Treatment Facility from the standpoint of at least one mandatory siting criterion (see Sections 1.3.2 and 5.1).

Field committee: A committee of individuals from the INEL community who evaluated various sites on the INEL according to their technical experience and/or expertise in the areas addressed by the siting criteria in Section 5.5 (see Section 2.2).

Must criterion: A siting criterion that was deemed by the advisory committee to be mandatory. If a site did not satisfy any "must" criterion then it was not considered further for siting the IWPF/MLLW Treatment Facility.

Preferred area: An area of the INEL that was considered desirable for siting the IWPF/MLLW Treatment Facility from the standpoint of a single siting criterion (see Sections 1.3.2 and 5.1).

Recommended site: One of the three candidate sites that were ultimately recommended to DOE-ID for siting the IWPF/MLLW Treatment Facility (see Sections 1.3.6 and 5.5).

Site walkover: A visit to a candidate site by personnel qualified to inspect the site and evaluate it against specific siting criteria. Such criteria included presence of archeological artifacts, presence of wetlands or habitat for threatened/endangered species, impediments to construction, etc. (see Section 5.4.1).

Want criterion: A siting criterion that was deemed by the advisory committee to be desirable but not mandatory. Sites that satisfied all "must" criteria were compared on the basis of how many and to what extent they satisfied the various "want" criteria.

Preliminary Site Selection for the Idaho Waste Processing Facility and the Mixed & Low-Level Waste Treatment Facility at the Idaho National Engineering Laboratory

1. INTRODUCTION

This report documents the procedures and policies which were used to generate the siting recommendations (previously released)^a for the Idaho Waste Processing Facility (IWPF) and the Mixed and Low-Level Waste (MLLW) Treatment Facility at the Idaho National Engineering Laboratory (INEL). The preliminary work of identifying relevant siting criteria and of recommending a procedure for site selection was completed and documented during June 1992.¹ That work is summarized in Section 1.2, following a brief background description of the subject facilities in Section 1.1. In Section 1.3, a quick overview of the site selection process is provided.

1.1 Background

The facilities that are the subject of the siting task described in this report have been previously described.¹⁻⁴ They constitute a portion of an INEL Waste Management Complex, currently envisioned by the Environmental Restoration & Waste Management Department (ER&WM) at EG&G Idaho, Inc. The complex comprises the IWPF, the MLLW Treatment Facility, and the MLLW Disposal Facility. Brief descriptions of these facilities taken from the above references are provided below.

1.1.1 Idaho Waste Processing Facility

The IWPF is a treatment facility whose mission is to treat (a) alpha-contaminated, mixed low-level waste (alpha-MLLW), which is composed of stored defense wastes containing 10-100 η Ci/g of alpha contamination, and one or more hazardous components, for disposal at a Resource Conservation & Recovery Act (RCRA)-permitted facility in compliance with the land disposal restrictions (LDRs) contained in Code of Federal Regulations (CFR) 40 CFR 268⁵, and (b) mixed transuranic (MTRU) waste, which comprises stored defense wastes containing $>100 \eta$ Ci/g of TRU contamination, and one or more hazardous components, for shipment to and disposal at the Waste Isolation Pilot Plant (WIPP) in New Mexico. In addition, the IWPF mission may expand to include treatment of alpha-LLW and TRU waste from environmental restoration activities at the Radioactive Waste Management Complex (RWMC) at the INEL. The mentioned waste treatments could include thermal treatment, repackaging, immobilization, removal of liquids, or neutralization of hazardous components of the wastes. Any TRU or alpha-LLW that does not meet the waste acceptance criteria for the final repository or the transportation requirements for that waste will be processed within the scope of the IWPF project.

a. Letter from J. L. McAnally, EG&G Idaho, Inc., to W. N. Sato, DOE Idaho Field Office, "Siting of the Idaho Waste Processing Facility and Mixed/Low-Level Waste Treatment Facility on the INEL," JLM-691-92, October 7, 1992.

Alpha-emitting wastes to be handled by the IWPF constitute roughly 65,000 m³ (2.2 x 10⁶ ft³) of stored material, of which approximately 25,000 m³ (8.8 x 10⁵ ft³) are alpha-LLW and 40,000 m³ (1.4 x 10⁶ ft³) are TRU waste. It is estimated that 95% of these wastes contain RCRA-prohibited constituents and are thus considered mixed waste. Though a portion of the alpha-LLW is well-characterized, a significant fraction is uncharacterized. The current strategy of the IWPF project is to design, construct, and operate a treatment facility that will initially treat only the characterized alpha-LLW. Subsequent expansions and additions will be made to the facility to allow processing of stored contact- and remote-handled TRU waste.

1.1.2 Mixed and Low-Level Waste Treatment Facility

The mission of the MLLW Treatment Facility is to treat conventional INEL low-level and mixed LLWs for cost-effective and LDR-compliant disposal at a RCRA-permitted facility. The MLLW Treatment Facility feedstocks include only INEL-generated mixed and low-level waste from ongoing operations and from decommissioning and decontamination (D&D) *after* Fiscal Year (FY) 2000. The feedstocks do not include the current INEL backlog of mixed and low-level waste, nor that which may be accumulated between now and FY 2000. The MLLW Treatment Facility is intended to treat, process, and package waste contaminated with hazardous constituents or low-level beta-gamma radionuclides to meet disposal site waste acceptance criteria. Treatment objectives will include volume reduction, stabilization, and satisfaction of waste acceptance criteria of any disposal facility to which the waste will be sent.

It is here noted, however, that the MLLW Treatment Facility project is currently unfunded, and may not be constructed. This project is on indefinite hold, pending evaluation of the IWPF.

1.1.3 Mixed and Low-Level Waste Disposal Facility

The mission of the MLLW Disposal Facility is to provide an engineered disposal facility for conventional INEL-generated low-level waste, and treated mixed low-level waste from the MLLW Treatment Facility that is cost-effective, LDR-compliant, and RCRA-permitted. In short, the MLLW Disposal Facility is to replace the RWMC. The mission of the MLLW Disposal Facility is also to include treated alpha-LLW from the IWPF.

The feedstocks for the facility are as follows:

- Mixed waste residues from treated low-level waste (including alpha-LLW) with a radioactive alpha content of less than 100 nCi/g
- Radioactive residues from treated hazardous waste, including those containing polychlorinated biphenyls (PCBs)
- Solidified products from treatment of wastes containing heavy metals satisfying toxicity characterization leaching procedure (TCLP) requirements

- Fifty-five-gallon drums, bins, and slabs containing iron-enriched basalt satisfying TCLP requirements
- Miscellaneous low-level refuse, including radioactive equipment, maintenance residues, protective clothing, hardware, and sized metal pieces
- Radioactively contaminated soils
- LLW repackaged in "high integrity containers"
- Sulfur polymer cemented waste containing lead or mercury
- Radioactively-contaminated asbestos.

The MLLW Disposal Facility will not accept for disposal TRU wastes, high-level radioactive wastes, solidified wastes that do not satisfy TCLP requirements, volatile wastes, untreated PCBs, liquids, contained gases, untreated hazardous wastes, or strictly hazardous nonradioactive wastes.

1.2 Prior Work

1.2.1 Preliminary Definition of Siting Criteria

As a first step in the site selection process, a list of siting criteria was assembled. These criteria were based on the laws and regulations that address the treatment, storage, and disposal (TSD) of hazardous, radioactive, and mixed wastes in effect as of June, 1993. References 1, 3, and 4 summarize Environmental Protection Agency (EPA) regulations and Department of Energy (DOE) orders that specifically address facility siting for the IWPF, the MLLW Treatment Facility, and the MLLW Disposal Facility. However, the site selection activities described in this report were specifically directed toward choosing a single location for the IWPF and the MLLW Treatment Facility. This was done for the following reasons. First, the siting criteria relevant to the IWPF and the MLLW Treatment Facility are almost identical. Second, it was assumed early in the siting procedure (see Section 3.1) that the two facilities could be co-located (for economy of operations). Thus, the site selection was conducted for the IWPF and the MLLW Treatment Facility, jointly.

Since some of the siting criteria for the MLLW Disposal Facility differ from those for the IWPF/MLLW Treatment Facility, the siting of the disposal facility will be performed separately at a later date. The MLLW Disposal Facility was a factor in the current site selection only to the extent that some consideration was given to the availability of land adjacent to candidate sites where the disposal facility might be located, provided the site satisfied the disposal facility siting criteria.

1.2.2 Recommended Site Selection Procedure

Section 2 of Reference 1 described a recommended procedure for site selection. This procedure was based on Kepner-Tregoe Decision Analysis (K-T), and it was proposed that K-T be applied in a similar manner to what was performed for the Advanced Liquid Metal Reactor and New Production Reactor site selections. Briefly summarized, this approach distinguishes two types of siting criteria: musts and wants. A must criterion is one that is deemed essential, while a want criterion is one that

is deemed desirable (but not essential). To apply the procedure and select candidate sites the following steps must be performed:

1. All potential siting criteria are identified.
2. All criteria are discussed, refined, and reworded (as appropriate) to ensure that they are understood by all participants in the siting process and that they are measurable. Mandatory siting criteria are identified as musts, and remaining criteria are considered as wants. Each must criterion is assessed to determine whether it should be considered as both a must and as a want. (e.g., a must criterion might be "a site be at least five miles from a capable fault." It may be desirable to cast this criterion also as a want criterion, worded as follows: "A site should be maximally distant from a capable fault.")
3. Weighting factors are assigned to the want criteria to provide a quantitative measure of their relative importance.
4. All potential sites are identified and evaluated against the must criteria. Any site that does not satisfy *all* the must criteria is excluded from further consideration. A refined list of potential sites is then generated consisting of all the original sites which satisfy all the must criteria.
5. Each potential site from the refined list is assigned a score (between fixed limits, such as 1-10) for each want criterion, according to how well the site compares with other candidate sites when judged against this single criterion.
6. For each site, a single numerical score is computed by summing the products of the "want" weighting factors with the respective scores for that site.
7. The site with the highest numerical score is selected, subject to final approval by a panel of informed personnel.

It should be noted that Step 5 in the above procedure was to be accomplished using only existing data, that is, no further site characterization work was to be done before scoring candidate locations.

1.2.3 Responsibilities

It was further recommended in Reference 1 that the tasks outlined above be accomplished by two committees. The first committee (the advisory committee) was to perform Steps 2, 3, and 4. The second committee (the field committee) was to perform Step 5. Step 1 was done when Reference 1 was completed, and Step 6 was to be completed by the siting coordinator. Step 7 was then to be completed by assembling both committees and all personnel who participated in the site selection process.

1.3 Overview of Site Selection Process

The first step in the site selection process was the selection of a siting coordinator (the author of this report) to oversee the performance of the tasks required prior to site selection. Following this

appointment, an advisory and a field committee were formed per recommendation in Reference 1. An organizational meeting was held on July 7, 1992, to provide an overview of the siting task and to brief the members of the committees on their respective responsibilities.

1.3.1 Siting Criteria Selection

Following the organizational meeting on July 7, the first advisory committee meeting was held on July 17, 1992, to begin to identify and clarify the must criteria. In a subsequent meeting on July 27, the want criteria were selected and clarified. Having established the criteria to be used in site selection, the advisory committee then considered the task of weighting the wants. After some discussion, the committee elected to depart from the recommended K-T process and refrain from weighting the want criteria. Details of the rationale for this decision and the site selection procedure that was chosen in place of K-T are discussed in Section 4.

1.3.2 Identification of Preferred Areas of the INEL

Having decided not to weight the wants, the work of the advisory committee was completed, and the field committee began the task of evaluating all potential sites on the INEL against the siting criteria. On August 4, 1992, the first field committee meeting was held. The must and want criteria defined by the advisory committee were discussed, and action items were assigned to individual committee members to evaluate all areas of the INEL against individual siting criteria. From these actions, a composite map of the INEL was constructed showing areas that were desirable from the standpoint of individual siting criteria. The map also shows areas that were not considered for siting because they failed to satisfy at least one of the must criteria. The former areas are referred to in the report as preferred areas, and the latter as excluded areas. Details of these area evaluations are provided in Section 5.1.

1.3.3 Selection of Candidate Areas

After studying the composite siting map and after consultation with the project managers and unit manager from the Waste Management Facility Projects Unit, the siting coordinator selected seven areas of the INEL. These areas were roughly 3-8 mi² tracts that were entirely outside excluded areas of the INEL and inside enough of the preferred areas to be deemed acceptable from the standpoint of the siting criteria that had been established. The seven areas were presented for discussion and approval/modification at the next field committee meeting on September 4, 1992. After discussing the rationale for the selection of these sites, the members of the field committee approved the selection and added one additional area for consideration. The areas selected by the siting coordinator and field committee at this stage are referred to herein as candidate areas. Details of this area screening step are in Section 5.2.

1.3.4 Selection of Candidate Sites

The next task in the site selection process was to scrutinize each of the candidate areas and select specific sites to be further evaluated. This was accomplished by reviewing stereo aerial photographs and LANDSAT pictures of the candidate areas and on this basis choosing what appeared to be the most desirable locations. The sites selected from within the candidate areas by this process are referred to as candidate sites within the report.

1.3.5 Site walkovers of Candidate Sites

Once the candidate sites were selected, onsite inspections of these sites were performed to obtain first-hand visual data to aid the final evaluation and selection of sites. These site visits were called site walkovers and their purpose was to identify any surface features or visually obvious characteristics that might be relevant to the selection process. Several people participated in the surveys (see Section 2.4), and each was requested to complete an evaluation form summarizing their observations. A detailed discussion of the results of the site walkovers is provided in Section 5.4.

1.3.6 Selection of Recommended Sites

Finally, on the basis of the site walkover evaluations, the siting coordinator chose three sites for the IWPF/MLLW Treatment Facility. These sites were presented before a joint meeting of the advisory and field committees on September 29, 1992, for their review and approval. A review of the comments from this meeting is provided in Section 5.5.4. Finally, on September 30, an EG&G Idaho, Inc. internal letter was drafted from the siting coordinator to the unit manager of Waste Management Facilities Projects summarizing the siting recommendations.^b These recommendations were subsequently reviewed by upper management within the ER&WM Department of EG&G Idaho, Inc. and forwarded to W. N. Sato of DOE-ID.^c

1.4 Overview of Report

The remainder of this report provides details for each of the steps in the site selection process mentioned above. The order of presentation is as follows:

- Selection of siting committees
- Refinement of siting criteria
- Modification to the recommended site selection procedure
- Actual site selection procedure
- Conclusion.

b. Letter from D. D. Taylor to M. R. Martin and L. W. Ball, EG&G Idaho, Inc., "Siting of Idaho Waste Processing Facility and Mixed/Low-Level Waste Treatment Facility on the INEL," DDT-12-92, September 30, 1992.

c. Letter from J. L. McAnally, EG&G Idaho Inc., to W. N. Sato, DOE Idaho Field Office, "Siting of the Idaho Waste Processing Facility and Mixed/Low-Level Waste Treatment Facility on the INEL," JLM-691-92, October 7, 1992.

2. SITING COMMITTEES

As indicated in Section 1.2, the site selection procedure called for the formation of two committees to perform the steps outlined in the K-T process that was originally proposed. Members of the first of these committees (the advisory committee) were selected per the recommendations of the EG&G Idaho Waste Management Facility Projects Unit. Members of the second committee (the field committee) were selected by the principal author of Reference 1 on the basis of their experience with other siting activities [e.g., New Production Reactor (NPR)]. The final makeup of the two committees reflected the choices of the above individuals, though in some instances the persons selected were unable to participate due to other commitments. In those situations the original designees selected qualified alternates.

2.1 Advisory Committee

The nature of the tasks assigned to the advisory committee required some familiarity with statutory requirements and guidelines, INEL operations, the EG&G Idaho waste management organization and procedures, regulatory practices and philosophies, and public opinion regarding the INEL and its operations. Therefore, the members of this committee were selected from among relatively senior EG&G Idaho management and legal personnel. The advisory committee was composed of the people listed in Table 2-1.

2.2 Field Committee

The nature of the tasks assigned to the field committee required technical expertise and some familiarity with the physical features of the INEL. The members of this committee were thus selected from among the technical staff of EG&G Idaho and the National Oceanic and Atmospheric Administration (NOAA). The field committee was composed of the people listed in Table 2-2.

2.3 Project Managers

The project managers for the three waste facilities and their unit manager also served in an advisory capacity for the work of both committees. The project managers were L. W. Ball (IWPF), D. E. Sheldon (MLLW Treatment Facility), and M. J. Sherick (MLLW Disposal Facility), and their unit manager is M. R. Martin.

2.4 Site Inspection Team

In addition to the above groups, which were formally chartered at the beginning of the site selection process, a team of INEL personnel representing several different backgrounds (e.g., project management, regulatory compliance, water quality, surface water flooding, ecology, archeology & cultural resources, siting of disposal facilities for commercial low-level radioactive waste, architectural engineering, geology, and soil physics) was assembled midway through the process to conduct site walkovers and to provide specific site evaluations as input for the final site selection. The members of this group were chosen from the three groups described above and from other EG&G Idaho organizations with expertise in areas not represented by these groups. This group of

people is hereafter referred to as the site inspection team. It included the individuals listed in Table 2-3.

Table 2-1. Advisory committee members.

Designee (title)	Delegate	Organization
Scientific specialist	J. T. Barraclough	Applied Geosciences [formerly U.S. Geological Survey (USGS)]
Principal program/project manager	A. L. Bowman	Environmental Regulatory Group (formerly with NPR Regulatory Compliance Group)
Manager, Level 2	T. L. Clements	Transuranic Waste Program
Principal program/project manager	D. G. Pound	Transuranic Waste Program
Manager, Level 1	D. L. French	RWMC Operations
Senior operations specialist	R. S. Monson	RWMC Operations
Attorney	L. A. Guinn	EG&G Idaho Legal Office
Manager, Level 2	M. R. Martin	Waste Management Facility Projects
Principal program/project manager	R. Y. Maughan	Waste Experimental Reduction Facility (WERF) Project
Principal program/project manager	T. A. Kerr	National Low-Level Waste Program

Table 2-2. Field committee members.

Designee (title)	Delegate	Organization
Principal administrator	J. W. Love	Physical Security
Senior engineering specialist	W. R. Horne	Radiological Engineering
Engineer	D. R. Lipp	Radiological Engineering
Manager, Level 2	T. R. Wood	Applied Geosciences
Senior scientist	I. Porro	Applied Geosciences
Scientific specialist	R. P. Smith	Geology and Seismology
Engineering specialist	G. A. Leuzinger	Facilities Planning and Inspection
Senior program/project engineer	L. D. Smith	Facilities Planning and Inspection
Research meteorologist	K. Clausen	NOAA
Research meteorologist	J. Sagendorf	NOAA
Manager, Level 2	D. Hutchinson	Environmental Technical Support
Senior scientist	M. Gilmore	Environmental Technical Support
Manager, Level 2	B. O. Reyes	Cost Estimating
Senior engineer	B. W. Wilcox	Cost Estimating
Principal program/project engineer	S. R. Withers	Major Projects
Engineering specialist	J. F. Zukauskas	Environmental Engineering
Business systems specialist	K. L. Nelson	Traffic Management

Table 2-3. Site walkover team members.

Designee (title)	Delegate	Organization
Engineering specialist	L. W. Ball	Waste Management Facility Projects
Principal program /project engineer	D. E. Sheldon	Waste Management Facility Projects
Program/project engineer	M. J. Sherick	Waste Management Facility Projects
Senior program/project engineer	M. Jorgenson-Waters	Environmental Engineering
Engineering specialist	J. F. Zukauskas	Environmental Engineering
Senior engineering specialist	D. D. Taylor	Environmental Engineering
Senior Scientist	R. C. Rope	Centers for Bioprocessing and Environmental Assessment
Scientist	B. L. Ringe	Cultural Resources Management
Principal program/project manager	T. A. Kerr	National Low-Level Waste Program
Principal program/project manager	S. R. Withers	Major Projects
Scientific specialist	R. P. Smith	Geology and Seismology
Taxonomist	J. Glennon	Centers for Bioprocessing and Environmental Assessment (subcontracted consultant)
Associate scientist	N. Hampton	Centers for Bioprocessing and Environmental assessment
Senior scientist	I. Porro	Applied Geosciences

3. SITING CRITERIA

This section discusses the work of the advisory committee in developing the siting criteria, and in addressing the other tasks that were initially outlined as described above in Section 1.2.2.

3.1 Definition of Candidate Site

The first meeting of the advisory committee was held on July 16, 1992. A facilitator from EG&G Idaho Human Resources was employed to assist in directing the efforts. The first item of discussion in the meeting was the overall objective of the siting effort, which at the start was to select three to seven candidate sites for locating the IWPf and the MLLW Treatment Facility waste treatment facility for the INEL.

Initially, it was not presumed that the two facilities would be co-located. However, after some discussion, the members of the committee agreed that because the siting requirements were nearly identical for both facilities and because of the complications involved in selection of two potentially separate sites, it would be assumed that the IWPf and the MLLW Treatment Facility could be co-located at the same site. Thus, the objective was modified to select three to seven candidate sites for co-locating the IWPf and MLLW Treatment Facility waste treatment facilities for the INEL.

The next item on the meeting agenda was to define more precisely what was meant by a candidate site. The definition that was adopted was "any parcel of federally-owned land on the INEL containing at least 200 contiguous acres." In making this definition it was agreed by the members of the committee that a 200-acre tract would provide sufficient area to accommodate the needs of both the IWPf and the MLLW Treatment Facility.

3.2 Refinement of Siting Criteria

The next task addressed by the advisory committee was to review the siting criteria in Reference 1, and to refine them as appropriate for the purpose of preliminary site screening. This task also involved consideration of any additional criteria deemed appropriate by the committee members. To this end the committee discussed a list of suggested must criteria, which had been prepared from the information in Reference 1 by the siting coordinator before the committee met. Some of the criteria were reworded to make their meaning and application clearer and also to make them measurable. Others were deleted as being nonapplicable to early site selection. In addition, the desirability of casting some of the must criteria as both musts and wants was discussed.

Each of the criteria discussed in the following section was either taken from Reference 1 or evolved from the discussions of siting criteria by the advisory committee. It should be noted that many of the criteria were refined and altered from their original form as the work of the advisory and field committees progressed. Thus, the criteria on which subsequent siting maps were based (see Section 5.1) evolved from the criteria presented below, but are (in most cases) worded differently. The connection between the criteria considered below, and those used in actual site evaluations is discussed in Section 5.1.

3.2.1 Must Criteria

As previously indicated, before the first meeting of the committee, the coordinator extracted from Reference 1 a tentative list of must criteria. The criteria in this list were paraphrased from the original reference for ease of discussion. Each criterion in the list was discussed in turn by the committee, and adopted, modified, and/or deleted as described in the following sections.

3.2.1.1 RCRA and CERCLA Sites. The criterion as proposed to the committee was "the locations of existing RCRA and/or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites shall be avoided in siting the IWP/MLLW Treatment Facility."

This criterion was retained as a must criterion after being revised and was clarified as follows: "A candidate site must not contain any portion of a site designated under the Federal Facilities Agreement/Consent Order (FFA/CO) with the exception of Waste Area Group 10, unless the site has been released for use under the FFA/CO."

3.2.1.2 Endangered Species and Critical Habitat. The criterion as proposed to the committee was: "the IWP/MLLW Treatment Facility cannot be located within an endangered or threatened species critical habitat."

This criterion was deleted by the advisory committee on the basis that it would be addressed during the National Environmental Protection Act (NEPA) site selection process after sufficient data were available to confirm the presence or absence of threatened or endangered species and critical habitat on a site. Therefore, the presence of critical habitat did not influence the site selection process through the selection of candidate sites. However, during the site walkovers and subsequent evaluations (Sections 1.3.5 and 1.3.6) the probability of potential conflicts with this issue was a factor (see Section 5.4.2.3).

3.2.1.3 Seismicity. The criterion as proposed to the committee was "If the IWP/MLLW Treatment Facility is located in Bingham, Bonneville, Clark, or Jefferson Counties, portions of the facility where treatment, storage, or disposal of hazardous waste will be conducted cannot be located within 61 m (200 ft) of a fault that has displaced during the last 10,000 years."

This criterion was revised as follows: "If located in Bingham, Bonneville, Clark, or Jefferson Counties, a candidate site must be a minimum of 61 m (200 ft) from any fault that has been displaced during the last 10,000 years."

The criterion was retained by the advisory committee as a must criterion. However, it was later pointed out by a member of the field committee that there are no known faults of the type mentioned anywhere on the INEL, and the above criterion was deleted from further consideration during the siting procedure. However, the same individual added that there are "capable" faults (i.e., faults that have moved either during the last 35,000 years or multiple times during the last 500,000 years) on or near the INEL. The locations of these faults were identified but were not considered a siting criterion during the selection of candidate areas (Section 1.3.2). However, proximity to capable faults was a factor considered during the site walkovers and subsequent evaluations (Sections 1.3.5 and 1.3.6). For further discussion of the impact of seismic zones on the siting process, see Section 3.2.2.14.

3.2.1.4 100-Year Flooding Elevation. The criterion as proposed to the committee was "The IWPF/MLLW Treatment Facility cannot be located at a site below the 100-year flood water elevation if the facility contains PCBs or PCB items with concentrations of 50 ppm or greater."

Since it was presumed that the facility will be handling PCB-contaminated wastes and the concentrations of PCBs in these wastes are unknown, the advisory committee had to assume that the facility would contain PCBs above the specified de minimus limit. Thus, the criterion was reworded with the contingency removed and it was retained as a "must" criterion as follows: "The candidate site must not be located at a site below the 100-year flood water elevation."

There was a considerable amount of discussion about the meaning of the phrase "below the 100-year flood water elevation." The statute on which the above criterion is based is the Toxic Substances Control Act (TSCA) [40 CFR 761.65(b)(1)]⁶. However, it contains no precise definition for the phrase "100-year flood water elevation." Some advisory committee members were of the opinion that "100-year flood water elevation" is synonymous with "100-year floodplain." The statutory definition for floodplain is as follows:

The term "floodplain" shall mean the lowland and relatively flat areas adjoining inland and coastal waters...including...that area subject to a one percent or greater chance of flooding in any given year (Executive Order 11988, May 24, 1977).

while the definition provided for 100-year floodplain is as follows:

"100-year floodplain" means any land area which is subject to a one percent or greater chance of flooding in any given year from any source [40 CFR 264.18(b)(2)(i)]⁷.

The former definition implies that a floodplain must adjoin a waterway of some kind, while the latter does not.

Because of the uncertainty of the legal interpretation of "below the 100-year flood water elevation" the committee conservatively assumed the more restrictive definition from 40 CFR 264.18(b)(2)(i). Thus, the must criterion that was adopted precluded the choice of any site that was subject to a one percent or greater chance of flooding of any kind, irrespective of the site's proximity to a waterway.

Also in connection with this criterion, the question was raised whether engineered barriers to flooding could be considered to influence the definition of the 100-year flooding elevation, and the EG&G Idaho Legal Office was asked to comment. The response was that legal precedents are lacking and that the committee should assume that artificial elevation of a site is not acceptable for satisfying this criterion. Legal counsel suggested that a more exhaustive look at legal ramifications could be done later if necessary.

[NOTE: It was pointed out in subsequent discussions with the field committee that the issue of engineered barriers is very relevant, because the MacKay Dam is an engineered barrier, as are the many irrigation canals and diversions upstream of the INEL. If these structures are not considered in defining the flooding elevation then many existing facilities on the INEL must be viewed as being in jeopardy of flooding events.

One approach that is currently being used in dealing with flooding concerns at the RWMC in the construction of new waste storage modules is to artificially raise the elevation of these facilities above the expected 100-year flood water elevation. A similar approach has been used at the ICPP where all new facilities have been constructed above the predicted flooding elevation assuming a failure of the MacKay Dam with the reservoir filled to capacity. Both approaches have thus far been accepted by the State of Idaho in its construction permitting process.

Nonetheless, for purposes of the current siting task, the above legal counsel was accepted and the conservative assumption was made that the IWP/MLLW Treatment Facility must not be located in areas subject to flooding with an expected frequency exceeding once every hundred years.]

3.2.1.5 Wetlands. Two criteria were cited in Reference 1 that dealt with siting on wetlands. Neither of these criteria categorically prohibits siting on wetlands, though both contain language that discourages such. The language was sufficiently similar that the siting coordinator combined the two criteria into a single criterion as follows: "The IWP/MLLW Treatment Facility shall not be located on federally-owned wetlands unless there is no other practical alternative."

As in the case of the 100-year flooding elevation, there was some question and discussion of what constitutes a wetland. It was mentioned that the U.S. Fish and Wildlife Service (USFWS) has established a tentative list of more than 300 wetland areas on the INEL. This being the case, the committee again decided to take the conservative approach and retain the above wetlands criterion as a must with the following rewording: "A candidate site must not include any portion of a known wetland." It was decided to assume that any area that had been designated by USFWS would be regarded as a "known wetland" for the purposes of the siting process, notwithstanding that current USFWS designations are neither authoritative nor final.

3.2.1.6 Cultural Resources. The criterion as initially proposed to the committee was "The IWP/MLLW Treatment Facility cannot have any direct adverse impacts on sites listed or eligible for listing on the National Register of Historic Places." This criterion is not a regulatory requirement; i.e., impacts to sites listed or eligible for listing on the National Register of Historic Places are not prohibited, provided certain procedures are followed. The *initial* preference expressed by the advisory committee, however, was to avoid potential conflict and expense associated with impacts to historical sites by adopting this siting criterion.

In discussing the criterion, one of the committee members brought up the issue of religious shrines of the Shoshone-Bannock Indian Tribes on the INEL and potential conflicts if such locations were disturbed. For this reason, the committee reworded the criterion as follows: "A candidate site must not include any portion of a property already listed on the National Register of Historic Places or a known site designated under American Indian Religious Freedom Act (AIRFA)."

During subsequent discussions, it was pointed out that the only property on the INEL that is currently listed on the National Register of Historic Places is Experimental Breeder Reactor I (EBR-I). It was further pointed out that there are also no designated AIRFA sites. Thus, though not formally deleted by the committee, the above criterion was not used as a site screening criterion during the selection of preferred areas (Section 1.3.2). However, as in the case of critical habitat,

during the site walkovers and subsequent evaluations (Sections 1.3.5 and 1.3.6), the probability of potential conflicts with this issue was considered and site preferences were determined accordingly (see Section 5.4.2.4). In short, the criterion was deleted as a "must", but was later considered as a "want".

3.2.1.7 Wells in Contaminated Groundwater. The criterion as proposed to the committee was "groundwater must not be drawn from locations at which contaminated groundwater plumes are known to exist or are anticipated to exist."

This criterion was deleted as a siting criterion on the basis that if a site were chosen that was desirable from the standpoints of other criteria then the above criterion could be treated as a facility design constraint rather than as a siting issue.

3.2.1.8 Impairment of Class I Air Quality Areas. The criterion as proposed to the committee was "the IWPF/MLLW Treatment Facility cannot be located in a site such that air emissions from the facility will visibly impair any Class I air quality area."

This criterion was also deleted as a must criterion because it was viewed as a design issue. It was suggested that the committee consider incorporating it later as a want. However, subsequent discussion suggested that this would be counterproductive because of the lack of a conceptual design at the current time. Therefore, the criterion was not considered in the site selection process.

3.2.1.9 Storage of RCRA Hazardous or Mixed Waste. The criterion as proposed to the committee was "if the IWPF/MLLW Treatment Facility does not store PCBs or PCB items but stores RCRA hazardous or mixed waste, it cannot be located in the 100-year floodplain unless it meets one of the following three conditions:

- (a) The facility is protected, via dikes or other equivalent measures, from washout during a 100-year flood
- (b) All hazardous materials can be moved to safe ground prior to flooding
- (c) It can be demonstrated that no adverse effects to human health and the environment will occur should flood waters reach the waste."

This criterion was deleted because it was assumed that the IWPF/MLLW Treatment Facility will store PCBs/PCB items (Section 3.2.1.4). This assumption invokes the requirement of siting above the 100-year flooding elevation.

3.2.1.10 Operational Releases of Radioactive Material. The criterion as proposed to the committee was "the IWPF/MLLW Treatment Facility shall be located such that the combined annual dose equivalent to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation from such management and storage shall not exceed 25 millirems to the whole body and 75 millirems to any critical organ."

This criterion is based on the radiation protection standards in 40 CFR 191⁸, which are applicable to public radiation doses due to spent nuclear fuel, high-level, or transuranic wastes at any disposal

facility that is operated by DOE and that is not regulated by the U.S. Nuclear Regulatory Commission. It has been pointed out^d that, for the wastes to which it is applicable, the above standard is more stringent than the current⁹ DOE standard of 100 mrem/yr effective dose equivalent to members of the public from normal operations of DOE facilities. However, since the IWPF/MLLW TF will be handling low-level alpha-contaminated wastes, the 40 CFR 191 standard is assumed to apply.

(Disposition of this criterion by the advisory committee is discussed below in Section 3.2.1.13.)

3.2.1.11 Airborne Releases of Radioactive Material. The criterion as proposed to the committee was "the IWPF/MLLW Treatment Facility must be sited such that emissions of radionuclides to the air shall not exceed those amounts that would cause any member of the public to receive an effective dose equivalent of 10 mrem/yr."

(Disposition of this criterion by the advisory committee is discussed below in Section 3.2.1.13.)

3.2.1.12 Releases of State-Listed Toxic Air Pollutants. Reference 1 contained no mention of the Idaho Air Toxics Regulations. Because it also imposes restrictions on potential exposure of the public to hazardous substances, it was also considered by the advisory committee. The criterion as proposed to the committee was "the IWPF must be sited such that at site boundaries or public roads emissions of state-listed toxic air pollutants do not cause pollutant concentrations that exceed 1% of the Occupational Exposure Limit (OEL)."

(Disposition of this criterion by the advisory committee is discussed below in Section 3.2.1.13.)

3.2.1.13 Accidental/Providential Releases of Radioactive Material. The criterion as proposed to the committee was based on DOE Order 6430.1A¹⁰ Section 0200-1.3. The IWPF/MLLW Treatment Facility must be sited such that potential accidents attributable to both operational and natural phenomena do not result in doses to offsite individuals that exceed a 50-year committed dose equivalent of 25 rem to the whole body, 300 rem to the thyroid, 300 rem to the bone surface, 75 rem to the lung, or 150 rem to any other organ. If multiple organs receive doses from the same exposure, the effective dose equivalent from all sources shall not exceed 25 rem when calculated using the weighting factors defined by the International Commission on Radiological Protection, Report No. 26.

In considering this criterion, together with similar criteria listed in Sections 3.2.1.10, 3.2.1.11, and 3.2.1.12 relating to exposure of the public to hazardous/radioactive substances, the committee recognized that it would be impossible to treat these criteria as musts at this stage in the development of the facilities. The reason for this is that the facility-specific design data that would be needed to determine whether the criteria are satisfied at specific locations are not yet available. It was further recognized that the above criteria would be satisfied by design constraints regardless of the site that is ultimately selected. Therefore, the committee elected to delete these four criteria from the site selection process as musts.

d. Private communication with E. W. Chew, DOE Idaho Field Office, of the Radiological and Environmental Sciences Laboratory at the INEL, January 6, 1993.

However, the committee recognized that the presence or absence of certain physical site characteristics can influence the difficulty of satisfying the above criteria by design constraints. In addition, it was anticipated that the public might be highly skeptical of any siting procedure that did not account in some way for these criteria. Therefore, it was decided to reflect the criteria listed in Sections 3.2.1.10, 3.2.1.11, 3.2.1.12, and 3.2.1.13 as the single "want" criterion described in Section 3.2.2.1.

3.2.1.14 Other "Must" Criteria (Not Found in Reference 1). In addition to the musts extracted from Reference 1, the advisory committee suggested and discussed other potential siting criteria that some committee members brought up during the meetings. These criteria and their disposition by the committee are discussed below.

3.2.1.14.1 Volcanic Rift Zones—Presumably because of the INEL's history of volcanism, Reference 1 suggested the following siting criterion: "The distance from volcanic exclusion zones shall be considered."

From this suggestion and on the basis of prior experience of some committee members with siting of the NPR, it was suggested that distances from volcanic rift zones, vents, and fissures be considered in site ranking. Subsequently, the following criteria were both suggested as musts:

- A candidate site for the IWPF/MLLW Treatment Facility must be a minimum distance of x from vents inside/outside a rift zone (x to be defined from consultation with appropriate members of the field committee).
- A candidate site for the IWPF/MLLW Treatment Facility must not include a volcanic vent that has been active within the past 10,000 years.

After discussion with geologists from EG&G Idaho, it was decided that because of the comparatively low probability of volcanic events, application of the above criteria as musts was not warranted. Instead, it was recommended that they be incorporated as a single want, with an appropriate weighting factor. This recommendation was ultimately adopted (though a weighting factor was never formally assigned; see Sections 4.1 and 3.2.2.16).

3.2.1.14.2 Distance from Public Roads—On the basis of public safety considerations, it was proposed that a must criterion of the following form be adopted: "A candidate site for the IWPF/MLLW Treatment Facility must be a minimum of x distance from a public road (x to be defined after consultation with appropriate site safety personnel)."

(Disposition of this criterion by the advisory committee is discussed below in Section 3.2.1.14.3.)

3.2.1.14.3 Distance from Site Boundaries—The following criterion was also suggested as a "must" on the basis of public safety considerations: "The candidate site must be a minimum of x distance from the site boundary (x to be defined after consultation with appropriate site safety personnel)."

Some in the committee felt that minimum distances should be specified between a candidate site and public roads and site boundaries. An action item by the committee to the siting coordinator was given to consult with nuclear facility safety personnel to obtain a recommendation on what this minimum should be. Pursuant to this assignment, a representative the EG&G Idaho Department of Environmental Safety and Quality (ES&Q) was asked to address this issue at the next advisory committee meeting. He pointed out that there are no minimum required distances from site boundaries or public roads, except as dictated by performance assessments of public exposure to radiation, toxic air pollutants, etc., at specific facilities. Likewise, he added, minimum distances between adjacent facilities are not prescribed but rather are based on facility-specific evaluations of the potential for adverse effects between facilities such as "rolling" power failures, explosions, or any other event that would result in a synergistic effect at adjacent facilities because of their proximity to one another.

On the basis of the above the advisory committee elected to delete the two distance criteria from this and the preceding sections on the following assumptions:

- Public safety considerations could be adequately addressed by suitable facility design requirements
- The impact of site selection on these design requirements would be small.

However, it was decided as a matter of practicality that a minimum distance of one mile would be set for locating the IWP/MLLW Treatment Facility from Category I facilities and from operating or planned reactors (Section 3.2.1.14.4). In addition, want criteria would be developed to maximize distance upwind and downwind from existing facilities (Section 3.2.2.22) and to minimize impact of release of contaminants to populated areas (Section 3.2.2.1).

3.2.1.14.4 Distance from Reactors and Category I Facilities—For the reason discussed in the preceding section, the following criterion was adopted as a must: "The candidate site must be a minimum of one mile from all Category I facilities and from operating or planned reactors."

3.2.1.14.5 Sites Designated for Other Uses—The following criterion was suggested as a must by a member of the committee: "The candidate site must not include any portion of a site that has been selected for another future facility or that is designated for other uses in the INEL Site Development Plan."

The pros and cons of employing this criterion in the site selection process were discussed. The committee ultimately decided that it was not necessary and could be counterproductive to exclude such areas. However, again as a matter of practicality, it was recommended that the criterion be reflected as a want. This was done, as discussed in Section 3.2.2.2.

3.2.2 Want Criteria

The second meeting of the advisory committee took place on July 27, 1992. At this meeting, a tentative list of must criteria was agreed to, based on the committee's work during the previous meeting and the actions that had been assigned. The remaining criteria from Reference 1 were then

discussed and clarified. As in the case of the musts, many of the remaining want criteria were reworded or deleted, again because they were not applicable during preliminary siting activities. Each criterion was discussed and disposed by the committee as described in the following sections.

[NOTE: It should be recognized in what follows that the K-T process for site selection was ultimately not used (see Section 4). This fact is relevant to understanding the discussion of want criteria in the sections below. Had K-T been utilized, then each want criterion would have been worded in such a manner as to make it objectively measurable for each site considered. At the time the wants were first discussed by the advisory committee, the decision not to use K-T had not yet been made. Thus, many of the want criteria reflect this measurability characteristic. However, in describing the disposition of the want criteria, the author has included a discussion of the evolution of each criterion beyond the advisory committee meetings. Thus, some of the want criteria are not strictly measurable (e.g., "distance from x should be minimized" is a measurable criterion. "x should be considered" and "site location should be chosen so as to minimize public exposure" are not measurable criteria, because, in the former, there is no objective parameter mentioned, and in the latter, is unclear how public exposure should be measured. However, in both these cases the lack of a measurable parameter does not preclude thoughtful consideration of these issues as siting criteria.]

3.2.2.1 Public Exposure to Hazardous/Radioactive Substances. As previously discussed (see Sections 3.2.1.10, 3.2.1.11, 3.2.1.12, and 3.2.1.13) a want criterion was fashioned from the originally proposed musts dealing with limiting potential exposure of the public to hazardous substances due to operational and/or accidental releases. This want criterion was worded by the advisory committee as follows:

The site location should be chosen so as to minimize public exposure to radiation and toxic air pollutants (resulting from accidental and operational discharges of radioactive and/or hazardous materials and direct radiation from management and storage) on the basis of existing site information that could be used to estimate annual dose equivalent and/or pollutant concentrations at site boundaries and public roads (i.e., distance from site boundaries and roads, mean annual wind speed and direction, subsurface hydraulic permeability).

The manner in which this want criterion was applied to the site selection is discussed in Sections 5.1.3 and 5.1.4.

3.2.2.2 Sites Designated for Other Uses. As mentioned in Section 3.2.1.14.4, a want criterion was defined dealing with the selection of sites that have set aside either for other projects (such as NPR and the Nuclear Weapons Complex Reconfiguration (NWCR), which are *not* currently line items in any fiscal year budget), for other planned facilities as defined in the INEL Site Development Plan, or for other current uses [such as grazing under agreement between DOE and the Bureau of Land Management (BLM)]. In the interest of flexibility in the current site selection process and in the interest of not foreclosing other programmatic options unnecessarily, the following want criterion was adopted:

At least half of the locations that are ultimately proposed for the IWPF/MLLW Treatment Facility must not lie on land that has been selected for other projects or that is subject to "land

use planning and land withdrawal provisions," as currently defined by Department of Energy, Idaho Field Office (DOE-ID).

3.2.2.3 Remoteness from Site Boundaries. The criterion from Reference 1 was as follows: "The remoteness from site boundaries shall be considered when siting the IWPF/MLLW Treatment Facility."

After discussion by the committee, it was decided that the above criterion should not be used. The basis for this conclusion is partly the fact that the end objective of the current siting process is to select three to seven candidate sites for the IWPF/MLLW Treatment Facility. Thus, if remoteness is a strong consideration in the choice of a site, it could be considered when making a final choice from among the recommended sites.

3.2.2.4 Length of Required Power Lines. The criterion from Reference 1 was as follows: "Minimize the length of new power lines to the IWPF/MLLW Treatment Facility from existing power distribution lines."

(The disposition of this criterion is discussed in Section 3.2.2.10.)

3.2.2.5 Site Reclamation Costs. In Reference 1 the following imperative was given in regard to site reclamation costs: "Life-cycle cost analysis shall be performed during site selection for TSD facilities and shall include site reclamation costs."

From this statement, the following want criterion was inferred: "Minimize site reclamation costs."

(The disposition of this criterion is discussed in Section 3.2.2.10.)

3.2.2.6 Use of Existing Security Fence. The criterion from Reference 1 was as follows: "If possible, the IWPF should be sited within the fence line of an existing secure facility or located close enough to the fenceline of an existing secure facility to permit the extension of the existing fenceline to enclose the IWPF/MLLW Treatment Facility."

(The disposition of this criterion is discussed in Section 3.2.2.10.)

3.2.2.7 Use of Existing Supplies of Potable Water. The criterion from Reference 1 was as follows: "Existing supplies of potable water should be identified and considered in siting the IWPF/MLLW Treatment Facility."

(The disposition of this criterion is discussed in Section 3.2.2.10.)

3.2.2.8 Use of Existing Sewer Facilities. The criterion from Reference 1 was as follows: "Maximize the use of existing sewer service facilities."

(The disposition of this criterion is discussed in Section 3.2.2.10.)

3.2.2.9 Impact on Current Traffic Control Facilities. The criterion from Reference 1 was as follows: "Minimize the negative impacts on existing traffic control facilities."

(The disposition of this criterion is discussed in Section 3.2.2.10.)

3.2.2.10 Use of Existing Traffic Control Facilities. The criterion from Reference 1 was as follows: "Maximize the utilization of existing traffic control facilities."

The advisory committee made the judgment that all the criteria in Sections 3.2.2.4 through 3.2.2.10 may be considered cost minimization criteria. It was indicated by one of the committee members that costs would be considered during activities mandated by NEPA, and on this basis, the current siting procedure should be considered as site screening before final site selection by the NEPA process and cost considerations should be deleted during the current (preliminary) site selection. The committee agreed, and it was decided to exclude the above criteria from further consideration during the current siting activities.

3.2.2.11 Colocation of IWP/MLLW Treatment Facility and MLLW Disposal Facility. The discussion of colocation of the IWP/MLLW Treatment Facility led to a discussion of the desirability of defining a want criterion that would reflect a site's capability to accommodate the MLLW Disposal Facility together with the IWP/MLLW Treatment Facility. As noted in Section 1.2.1, the siting criteria for the IWP/MLLW Treatment Facility were identical. However, it is likely that there are some differences between the siting criteria for treatment/storage facilities and those for disposal facilities. Therefore, it was decided by the committee that the above criterion would not be applied during site selection for the IWP/MLLW Treatment Facility.

3.2.2.12 Presence of Buried Utilities. The criterion from Reference 1 was as follows: "Sites traversed by buried pipe utilities shall not be used for TSD facilities unless the relocation or protection of these utilities is economically feasible."

(The disposition of this criterion is discussed in Section 3.2.2.13.)

3.2.2.13 Site Characterizability. The criterion from Reference 1 was as follows: "The ability of the site to be fully characterized (i.e., not a complex geological location) shall be considered."

This criterion and that of Section 3.2.2.12 were deleted from further consideration on the basis that insufficient data are available (without further site characterization activities) to adequately evaluate candidate sites in reference to them.

3.2.2.14 Fault Zones and Karst Terrain. The criterion from Reference 1 was as follows: "Fault zones and karst terrain shall be avoided or receive the lowest siting priority."

Since the INEL contains no karst terrain, the second portion of the criterion is not applicable. Fault zones are discussed in Section 3.2.1.3. While the location of fault zones was not a factor in the selection of candidate areas (Section 1.3.2), the proximity of candidate sites to faults was a factor in the final recommendations (Section 1.3.6), as discussed in Section 5.4.2.2.

3.2.2.15 500-Year Floodplain. The criterion from Reference 1 was as follows: "500-year floodplains shall be avoided or receive the lowest siting priority for TSD of hazardous, nonhazardous, and radioactive solid waste."

This criterion was deleted from formal consideration due to uncertainty about how engineered flood control barriers should be accommodated in the definition of the 100-year and 500-year floodplains for the INEL. However, the criterion was considered indirectly, in that the conservatism that was applied in consideration of the 100-year flooding elevation (Section 3.2.1.4) was such that the 500-year floodplain was probably avoided in the site selection process (See Section 5.1.2). Nonetheless, verification of this will have to await the formal delineation of the 500-year floodplain.

3.2.2.16 Volcanic Hazard Zones. The consideration of volcanism on the INEL in siting the facilities was discussed previously in Section 3.2.1.14.1. The want criterion that was proposed at the second meeting of the advisory committee was as follows:

Maximize the distance of a candidate site from all regions that would be inundated with lava and/or penetrated by fissures associated with diking from vents and rift zones that have been active in the last 10,000 years. Regions of inundation and fissuring will be established by generating probability distributions based on topography, probability of eruptions of specific vents based on age, and existing data on extent of recent lava flows on the INEL.

The manner in which the above criterion was applied to site selection is described in Sections 5.1.8 and 5.1.9.

3.2.2.17 Slope of the Land Surface. The criterion from Reference 1 was as follows: "The slope of the land surface and corresponding energy available for erosion shall be considered."

The above criterion was retained and applied as described in Section 5.4.2.5.

3.2.2.18 Transportation Distance of Waste Feedstocks. The criterion from Reference 1 was as follows: "Minimize transportation distance of waste to facility."

(The disposition of this criterion is discussed in Section 3.2.2.20.)

3.2.2.19 DOE Control of Roads Used To Transport Waste. The criterion from Reference 1 was as follows: "Minimize utilization of roads that are not DOE access controlled for transporting hazardous waste to the IWPF/MLLW Treatment Facility."

The above criterion as formally stated was deleted as a factor in site selection, though during its discussion the accessibility of a DOE-approved transportation system was considered as a siting criterion. However, the criterion was not adopted on the assumption that DOE-ID would probably not favor it.

3.2.2.20 Department of Transportation Regulations. The criterion from Reference 1 was as follows: "The effects of U.S. Department of Transportation (DOT) regulations on the transportation of waste to and from the IWPF shall be considered:"

Transportation of waste feedstocks from the point of generation/storage to the IWPF/MLLW Treatment Facility and the impacts of DOT regulations were discussed at length by the committee. As previously mentioned, at one point it was proposed that a must criterion be added requiring a site to have access to a DOE-approved waste transportation system. Though this

suggestion was not adopted, it catalyzed discussion of the fact that DOE requires compliance with DOT regulations when hazardous materials are transported outside of any facility fence. Such regulations mandate the use of certified shipping containers. However, a significant fraction of the TRU and alpha-LLW in storage at the RWMC and destined for treatment in the IWPF/MLLW Treatment Facility is not certified. For this reason, such waste could not be transported in any existing certified container (e.g., Transuranic Package Transporter-II) and would thus require that a new container be designed, built, tested, and certified. However, this would be extremely costly (in both time and dollar amounts) due to the fact that maximum radiation levels of some of the mentioned stored wastes are not known and would have to be determined before design of a new, certified container could begin.

The issue of transportation distance of waste feedstocks was also discussed. The point was raised that most of the anticipated feedstocks for the IWPF are stored wastes at the RWMC, while the feedstocks for the MLLW Treatment Facility will originate from several locations throughout the INEL. Thus, from the standpoint of transportation distance of feedstocks to the MLLW Treatment Facility, there is not a compelling reason to locate the IWPF/MLLW Treatment Facility at any one specific location. However, most of the feedstocks which will go to the IWPF are located at the RWMC. It follows that from the standpoint of transportation distance of feedstocks (Section 3.2.2.18), location of the facility near the RWMC would be preferred.

The argument for the above approach was reinforced by the issue of DOT compliance. The reasoning was that by locating the facility on the same side of U.S. Highway 20/26 as the RWMC, the strict regulatory requirement for use of DOT-compliant, certified, shipping containers would be eliminated. [It was later pointed out by a member of the field committee that this idea is not totally correct due to the DOE policy that requires shipping compliance with DOT regulations except in the following cases: (a) when the shipment stays entirely within a facility fence, (b) when the shipment falls under a DOE-approved transport plan, and (c) when the shipment is made "out of commerce" by DOE itself with government-owned and government-operated vehicles. See Section 5.2.3.4.3.]

The outcome of the above considerations was that two want criteria were suggested that addressed, respectively, the cost of shipping in DOT-compliant containers and the cost of actual over-the-road transport. After discussions both inside and outside the committee, the siting coordinator decided (with approval of the IWPF/MLLW Treatment Facility project managers) that the cost and schedule impacts of using DOT-compliant containers were significantly greater than those of direct over-the-road transportation of the wastes. Therefore, a single want criterion was formulated to address the concerns of the criteria in Sections 3.2.2.18 and 3.2.2.20 as follows: "If possible, the IWPF/MLLW Treatment Facility should be sited on the south side of U.S. Highway 20/26 and as close as possible to the RWMC (subject to other siting constraints)."

Application of this criterion to the site selection procedure is discussed in Section 5.2.1.

3.2.2.21 Adverse Effects on Existing Facilities. The criterion from Reference 1 was as follows: "Sites that would adversely affect operation of other facilities shall be avoided."

The above criterion was considered in establishing the must criterion in Section 3.2.1.14.4 and the want criterion in Section 3.2.2.22, below.

3.2.2.22 Downwind Effects Between Facilities. As mentioned in Section 3.2.1.14.3, consideration of adverse effects of locating the IWPF/MLLW Treatment Facility near an existing facility led a discussion by the advisory committee of windborne transport of hazardous substances between facilities. Following the discussion, the following was adopted as a want criterion: "In selecting sites for the IWPF/MLLW Treatment Facility, the distance from adjacent facilities in a perpendicular direction to the prevailing (most probable) wind direction should be maximized."

In applying the above criterion, it was recognized that dispersion reduces the concentration of airborne pollutants, and thus rigid application of the criterion (as stated above) becomes less and less important the further downwind a candidate site is located. The manner in which the criterion was applied is discussed in detail in Section 5.1.7.

3.2.2.23 Watersheds for Domestic Water Supply. The criterion from Reference 1 was as follows: "Watersheds for domestic water supply shall be avoided or receive the lowest siting priority for TSD of hazardous, nonhazardous, and radioactive solid waste."

This criterion was deleted based on two considerations. First, it was assumed that the criterion applies primarily to watersheds feeding surface impoundments (reservoirs). Since there are no such impoundments on the INEL used for domestic water supplies, the criterion was deemed nonapplicable. Second, in the event that the above assumption is incorrect and the Snake River Plain Aquifer (SRPA) is considered to be a domestic water supply, then the criterion is not applicable because the entire INEL may be considered a recharge zone for the aquifer. Thus, all sites under consideration are considered equal from the standpoint of this criterion, and its inclusion among the site selection criteria would have no effect.

3.2.2.24 Recharge Zones for Sole Source Aquifers. The criterion from Reference 1 was as follows: "Recharge zones for sole source aquifers shall be avoided or receive the lowest priority rating for TSD of hazardous, nonhazardous, and radioactive solid waste."

The above criterion was included indirectly by virtue of a DOE-ID suggestion that at least one site be considered that is not directly over the SRPA (see Section 5.1.2).

3.2.2.25 Unexploded Ordnance. The criterion from Reference 1 was as follows: "The location of unexploded ordnance shall be considered."

The above criterion was deleted from further consideration. The committee believed that unexploded ordnance could be located later during site characterization and subsequently removed without difficulty. It was therefore concluded that the presence of ordnance should not prejudice the selection of an otherwise acceptable site.

3.2.2.26 Availability of Fire Department Facilities. The criterion from Reference 1 was as follows: "Minimize the travel time from an existing fire fighting facility to the IWPF/MLLW Treatment Facility."

(The disposition of this criterion is discussed in Section 3.2.2.27.)

3.2.2.27 Availability of Medical Facilities. The criterion from Reference 1 was as follows: "Minimize the response time from the IWP/MLLW Treatment Facility to the existing medical facilities at Central Facilities Area (CFA) and Naval Reactor Facilities (NRF)."

The criteria in Sections 3.2.2.26 and 3.2.2.27 were deleted from consideration on the basis that any prescribed response time may be achieved by suitable facility design. The criteria were therefore viewed as cost issues and were excluded from site selection considerations (see Section 3.2.2.10).

3.2.2.28 Commuting Distance of IWP/MLLW Treatment Facility Personnel. The criterion from Reference 1 was as follows: "The commuting distance to the IWP/MLLW Treatment Facility shall be considered."

The committee felt that the above criterion is not sufficiently compelling to be considered alongside the other siting criteria. It was therefore deleted from further consideration in siting.

3.2.2.29 Site Accessibility to Service Vehicles. The criterion from Reference 1 was as follows: "Sites must be accessible to service and refuse collection vehicles by all weather road extensions."

The criterion was viewed as a design consideration rather than a siting issue and was deleted from further consideration.

3.2.2.30 Other Information. The following information was included in Reference 1 as "Environmental Siting Guidelines Applicable to the IWP/MLLW."

3.2.2.30.1 Archeological Survey—"An archeological survey will need to be performed on all candidate sites."

The above is not a siting criterion. However, it was a factor in the site selection process, as discussed in Section 5.4.2.4.

3.2.2.30.2 Pre-Operational Environmental Monitoring—"An environmental study shall be conducted prior to startup of a new site that has the potential for adverse environmental impact."

The above is also not a siting criterion but a requirement of DOE 5400.1¹¹, which deals with the DOE's General Environmental Protection Program. It was not considered in discussions of siting criteria, nor was it a factor in site selection.

4. SITE SELECTION PROCEDURE

The final action of the advisory committee at the second committee meeting on July 27 was to revise the site selection procedure in a manner that eliminated the use of weighting factors for want criteria. In so doing, the committee effectively rejected the use of the K-T process for site selection. The rationale for this decision together with the procedure that was eventually used for site selection are described in the following sections.

4.1 Review of the K-T Process

One of the advisory committee members represented the National Low-Level Waste Program and brought to the committee first-hand experience in siting a commercial low-level waste disposal facility in the state of Illinois. When the subject of assigning weighting factors to the want criteria came up in the committee meetings, he pointed out that the use of weighting factors and scoring of sites could have several undesirable repercussions. The first of these is that criteria weighting factors are subjective and thus vulnerable to challenge by critics, interveners, etc. Consequently, no matter how the weighting factors are assigned, they could be subject to question by individuals and/or organizations who may disagree with the outcome of a site selection based on them.

The second possible repercussion is that the scoring/ranking process can preclude the consideration of factors that are relevant to the siting process. For example, this can occur if a siting factor is overlooked during the stage at which the criteria are initially defined and weighted. While the formal K-T process allows for a final review and approval of a decision, the addition of new criteria after weighting factors are assigned casts a pall of doubt on the objectivity of the process.

Another possible repercussions of the use of the K-T process is related to public perception of the expected outcome. Since the process is based on numerical comparisons, it is presumed to be fully objective. Thus, any decision that is reached is supposed to be "optimal." If a site is selected using K-T and is later rejected (for whatever reason), then any alternate site subsequently chosen is often viewed by the public as being a poor choice because it was not selected by the "objective" process on the first pass.

Finally, the scoring of sites against the siting criteria is often based on incomplete or nonexistent data and thus relies on judgement or intuition. If intuition or judgement happens to be incorrect, then a site's score may be unrealistically high or low, which can result in either the exclusion of a good site or the selection of a poor site. If the latter turns out to be the case and the site is later (during characterization) deemed to be poor or unacceptable, the selection of an alternative site becomes difficult to justify to the public for the reasons cited above.

For the above reasons it was decided by the advisory committee that the K-T process would not be used during the selection of candidate areas but that it might be used later to rank candidate sites relative to one another.

NOTE: Ultimately, the formal K-T process was never used. In its place a revised procedure was developed that incorporated the concepts of musts and wants but stopped short of defining formal weighting factors for the wants. Thus, the site selection was not done based on a

single figure of merit (or score) presumed to represent the relative goodness of candidate sites.

4.2 Revised Siting Procedure

In discussing possible procedures for screening the entire INEL to locate candidate areas, the problem of choosing specific sites from among more than 2,000 potential sites on the INEL was discussed. The infeasibility of scoring all these sites being apparent, so the committee initially decided to defer the application of the formal K-T process until the following two steps had been accomplished:

1. A map had been generated showing all land remaining after application of the exclusion (i.e., must) criteria.
2. The remaining land had been divided into zones of equal preference from the standpoint of each of the remaining want criteria, and the zones were so marked. (e.g., zones would be marked as "1st preference/SEISMIC", "2nd preference/SEISMIC", "3rd preference/SEISMIC", and similarly for the other want criteria.)

Once the above steps were accomplished, it was to be determined whether K-T scoring would be necessary or whether the most desirable sites would be apparent (from overlapping zones on the "preference" maps) as well as the rationale for their selection.

After the above decision by the advisory committee was made, the mechanics of performing the above steps were contemplated. After discussions between some of the field committee members and the siting coordinator, it became evident that available data was insufficient to objectively divide the entire INEL into zones of equal preference to the degree recommended by the advisory committee. Thus, the coordinator (with the approval of the facility project managers) further modified the selection procedure to the following.

First, a set of maps would be prepared showing the entire INEL. On each of these maps would be shown the preferred, avoided, or excluded areas from the standpoint of one of the siting criteria that were to be applied from Section 3. Each map would be marked by a member of the field committee qualified to evaluate the different areas of the INEL against one of these criteria. The maps would then be consolidated into a single map and areas of the INEL would be identified from among the preferred areas that lay outside of all excluded areas and outside as many of the avoided areas as possible. The manner in which these areas were selected using the composite map is discussed in Section 5.2.1.

It was anticipated that the candidate areas selected by the foregoing procedure would comprise several sections (one section = one square mile). The final choice of 200-acre tracts for siting the waste treatment facilities would then be made after a series of site walkovers had been completed. These surveys amounted to site inspections and evaluations by various individuals (discussed in detail in Section 5.4). On the basis of the conclusions from the site walkovers, a list of three to seven recommended sites would be assembled, ranked (possibly utilizing the K-T procedure), and sent to DOE-ID for review and final approval.

5. SITE SELECTION

As briefly described in Section 1.3.2, once the siting criteria had been defined by the advisory committee, the field committee's task of applying these criteria to actual site selection began. Because the INEL is comprised of about 2,300 km² (890 mi²), the selection process was divided into four steps. The first step was to screen the entire area of the INEL by identifying on a single map the preferred and excluded areas from the standpoint of each of the siting criteria. The second step was to choose candidate areas from among the preferred areas identified in the first step. These candidate areas defined the areas of the INEL from which specific 200-acre tracts (candidate sites) for the IWPF/MLLW Treatment Facility were chosen in the third step. These candidate sites were then evaluated from information gleaned from the site walkovers, performance of which constituted the fourth step. The fifth and final step in the process was to compare the candidate sites on the basis of the site walkovers and select three sites to recommend for construction of the IWPF/MLLW Treatment Facility. The details of each of these steps are described in the following sections.

5.1 Identification of Preferred Areas of the INEL

The first meeting of the field committee was held on August 4, 1992. At this meeting, the work and recommendations of the advisory committee were presented and briefly discussed. Then, based on the siting criteria that had been defined, individual committee members were assigned to identify on E-size (44 x 34 in.) maps of the INEL the preferred and excluded areas, as previously described. The areas so marked are shown in Figure A-1 through Figure A-12. Each marked area is discussed in the following sections.

5.1.1 Below U.S. Highway 20/26

The shaded area in Figure A-1 is the preferred area from the standpoint of the want criterion discussed in Section 3.2.2.20. The objective in defining this area was to identify the region of the INEL within which wastes stored at the RWMC could be transported without crossing any public highway (assuming a suitable road or other means of transportation were constructed). (The road from U.S. Highway 20/26 to EBR-I is a public road as well as the highway.)

5.1.2 Above 100-Year Flooding Elevations

The delineation of this area on the map represents the field committee's efforts to address the criterion in Section 3.2.1.4. It also represents their efforts to address the criteria in Sections 3.2.1.5 and 3.2.1.15. The preferred areas marked reflect the committee's determination of those areas of the INEL that are least likely to be flooded. In marking these areas the following flooding sources were considered:

- (a) A flood wave moving down the channel of the Big Lost River
- (b) Accumulation of localized runoff (ponding).

Flooding from Source (a) along the channel of the Big Lost River was analyzed in a prior study¹² in connection with the siting of the NPR. In that study, the consequence of a failure of the Mackay Dam was analyzed. The hypothesized cause of the failure was an event termed the probable maximum flood (PMF), which was described in the report as follows:

The PMF represents the hypothetical flood that is considered to be the most severe flood event reasonably possible, based on hydrometeorological application of maximum precipitation and other hydrologic factors. The general storm PMF for the drainage basin above Mackay Dam resulted from a 48-hr general storm in June, preceded three days in time by an antecedent storm with a magnitude of 40% of the 48-hr storm. The peak flow for this PMF is 82,100 cfs, occurring 154 hr after the beginning of the storm. . . . This PMF estimate falls within the 50,000 - 200,000 cfs Myers envelope curve used by the U.S. Army Corps of Engineers. The PMF peak flow is almost 20 times higher than the highest flow, 4,420 cfs, recorded at Howell Ranch, a USGS gaging station located approximately 17 mi northwest of the dam. The PMF is based on the maximum potential for critical hydrometeorological conditions to occur, not on probabilities or historical flood frequencies. The semiarid climate provides little opportunity to observe large storms over the Big Lost River drainage, but the potential for these storms does exist.

The cited study contains a map of the PMF inundation area based on the model prediction. The authors provide some discussion of sensitivities of the calculated high-water elevations to potential errors in three specific model inputs (time of dam failure, breach width, and flow losses). Their discussion suggests a maximum possible uncertainty of roughly ± 1 ft in peak flooding elevation due to possible error in the flow loss input. Though they provide no specific quantitative estimate of the impact of the one-dimensional fluid flow assumption of their model, they cite a prior ad hoc study of the Teton Dam failure where the same flood routing model gave calculated flooding elevations within ± 1.5 ft of observed values. In the absence of the authors' synthesis of an overall estimate of error in their calculated flooding elevations one must assume additive contributions from the two sources identified above; i.e., a possible error of at least 2.5 ft in the flooding elevations. The impact of this uncertainty on the flooding boundaries could be substantial, given the relatively flat topography of the INEL.

In light of the above uncertainties, it was decided to provide a measure of conservatism in mapping the areas of the INEL thought to be immune from flooding. The manner in which this was done is as follows.^e

e. Personal memorandum from J. F. Zukauskas to D. D. Taylor, EG&G Idaho, Inc., "Technical Basis for Preferred MLLWTF Site Locations With Regard to Surface Water Hydrology," October 2, 1992.

The potential for flooding from Source (a) was evaluated for each section (square mile) of the INEL by comparing the minimum elevation within the section with the elevation of the hydraulically nearest point on the perimeter of the estimated PMF inundation area boundary^f for the Big Lost River. A second criterion for the flooding potential due to Source (a) was the hydraulic distance (i.e., the distance the water would travel) of the section from the estimated PMF floodplain. Potential for flooding from Source (b) was evaluated for each section by assessing the amount of upland drainage area, patterns of branching of intermittent stream networks, and the area-averaged slope of the land surface.

Based on the above criteria, the areas marked in Figure A-2 are believed to be above the 100-year flooding elevation as defined in Section 3.2.1.4. Owing to the conservatism of the conditions placed on the areas marked, it is highly likely that they are also above the 500-year floodplain. The shaded areas are thus preferred from the standpoint of the above-cited criteria.

5.1.3 Fine Grained Sediments

The delineation of this area on the map represents a portion of the field committee's efforts to address the criterion in Section 3.2.2.1. As suggested in the referenced section, the potential of a site to minimize public exposure to radiation and hazardous chemicals was evaluated by considering the air and groundwater pathways. The shaded area in Figure A-3 is preferred from the standpoint of the groundwater pathway.^g

Since advection is the primary transport mechanism for contaminants through the vadose (unsaturated) zone to the SRPA, low hydraulic conductivities that slow the percolation of water also restrict the migration of contaminants. In addition, the presence of sorptive chemical species in the subsurface medium also retards the downward movement of contaminants. Finally, vapor contaminant migration is inhibited by tight pore structures. Low hydraulic conductivity, highly sorptive species, and tight pore structure are all typical characteristics of fine-grained clay sediments. Therefore, in the absence of engineered barriers or manmade structures to contain the downward migration of accidental and operational discharges of radioactive and/or hazardous materials, the

f. The estimated PMF inundation area boundary that was used currently resides in the AUTOCAD database of the EG&G Idaho Graphic Arts Unit. This boundary does not align perfectly with that of the flood routing study referenced in the text. As of this writing, the author has been unable to establish the precise connection between the two maps. Based on private communications with the authors of the referenced report, it appears that the inundation boundary in the AUTOCAD data base was derived from that in the report, with some modifications. However, comparison of the AUTOCAD boundary with that in the report reveals that the latter indicates no flooding in the spreading areas near the RWMC while the former indicates such flooding. In keeping with the conservatism exercised in interpreting the regulatory requirements, and in the absence of any clear legal statement regarding how the spreading areas should be treated, it was decided to utilize the map showing the larger flooding area.

It was presumed by the siting coordinator that for the purposes of the present preliminary siting study this approach is justified. It was further presumed that its validity must await the formal definition of the 100-year flooding elevation and its approval by the appropriate agency (i.e., EPA and/or the State of Idaho).

g. Interoffice correspondence memorandum from I. Porro to D. D. Taylor EGG Idaho, Inc., dated "Documentation for Siting Map," October 20, 1992.

primary factor determining the rate of contaminant migration to the aquifer is the thickness of the fine-grained sediment layers below the contaminant source. For this reason available information about sediment types and thicknesses from ground surface to the SRPA were used to delineate preferred areas for siting the IWPF/MLLW Treatment Facility.

The marking of these areas Figure A-3 was mostly based on the surficial geologic map produced by W. E. Scott.¹³ This map provides broad depth estimates for the various mapping units; however, it does not provide hydraulic, chemical, or sorption properties for any materials.

It should be noted that the preferred areas indicated in the map do not reflect the influence of sedimentary interbeds among the various basalt flows that comprise the vadose zone on the INEL. It is known from various well drilling activities that such interbeds exist and can contain fine-grained and/or compacted sediments, which retard contaminant migration. The presence of these interbeds could be taken into account, if necessary, prior to the finalization of the site selection for the IWPF/MLLW Treatment Facility. Since completion of the work described herein, a contour map has been generated indicating total sediment thickness based on drilling data.

5.1.4 Minimum Potential for Airborne Contamination of Public

The delineation of this area in Figure A-4 represents the field committee's efforts to address the criterion in Section 3.2.2.1 from the standpoint of the air pathway. The shaded areas are preferred because the prevailing winds are least likely to advect plumes from these regions into inhabited areas such as Atomic City and the Mud Lake-Terretton areas. The marking of these areas was based on wind rose plots from the past five years (1987-1991) for the Grid III, Loss of Fluid Test Facility (LOFT), Argonne National Laboratory (ANL), CFA, NRF, and Power Burst Facility (PBF) areas of the INEL.^h

5.1.5 FFA/CO Sites and Environmentally Controlled Areas

The delineation of FFA/CO sites and environmentally controlled areas (ECAs) in Figure A-5 represents the field committee's efforts to address the criterion in Section 3.2.1.1. The FFA/CO is an agreement between the EPA, the State of Idaho Department of Health and Welfare (IDHW), and the DOE. The purpose of the agreement is to ensure that the environmental impacts associated with the release of hazardous substances at the INEL are dealt with to the satisfaction of the above parties. The agreement was executed in November 1991, and supercedes a similar prior agreement, called the Consent Order and Compliance Agreement (COCA) which was executed in July 1987. The indicated regions within the boundaries of the INEL are considered to be excluded areas. They were mapped as follows.ⁱ

The FFA/CO sites and ECAs referred to above are identified and listed in the agreement. The FFA/CO sites are waste management units that had been identified under the previous COCA as

h. Personal letter from Jerry Sagendorf (NOAA) to Dean Taylor, "Documentation for Siting Map," October 13, 1992.

i. Interoffice correspondence memorandum from M. C. Gilmore to D. D. Taylor, "Field Committee on Waste Treatment Facility Siting COCA Site Mapping Assignment," October 15, 1992.

potentially hazardous locations. The ECAs are synonymous with the COCA sites but also include a buffer zone to protect the sites from disturbance. The information for the map was available through the existing ARC/INFO geological graphing system at EG&G Idaho. This information was transferred electronically from the Environmental and Waste Management Computing Unit to the AUTOCAD system within the Graphic Arts Unit, where the map overlays for the current siting study were being prepared.

The COCA site location information was originally obtained from the installation assessments performed by INEL contractors in 1987. This effort established, as accurately as possible, the location of each site for the FFA/CO. It was assumed that the information from the ARC/INFO system is identical to that provided in the FFA/CO. The proper translation of the data between the ARC/INFO and AUTOCAD systems was verified by comparison of key locations from the ARC/INFO data to corresponding locations within the AUTOCAD data base. The agreement was deemed to be more than adequate for the purposes of the current siting exercise.

It will be noted that all mapping features have been omitted from Figure A-5 except for the FFA/CO sites and environmentally controlled areas. The reason is that these areas are generally close to existing facilities and are relatively small. Consequently, they would be difficult to see on the map if the other features were shown.

Most of these excluded areas are within those described in Section 5.1.6 below. Since the latter areas and existing facilities (with the exception of the RWMC) were generally avoided in siting the IWPF/MLLW Treatment Facility for other reasons, this criterion did not strongly influence the selection of candidate areas. For this reason, the FFA/CO sites and ECSs were not shown on the composite siting map in Figure A-13.

5.1.6 Within One Mile of Category I Facilities or Existing/Proposed Reactors

The delineation of these areas on the map represents the field committee's efforts to address the criterion in Section 3.2.1.14.4. Figure A-6 was generated by construction of circles of one-mile radius around the center of all the facilities on the INEL that were Category I. A Category I facility is defined in DOE Order 5480.23 as any nuclear facility whose hazard analysis shows the potential for significant offsite consequences. In addition to these facilities, the locations of existing or proposed reactors were similarly marked as excluded areas. The excluded areas are indicated in black in Figure A-13.

5.1.7 Outside Wind Corridors of Existing Facilities

The delineation of these areas on the map represents the field committee's efforts to address the criterion in Section 3.2.2.22. Using the same wind data as was discussed in Section 5.1.4, the prevailing wind directions at the INEL were identified. These directions are generally from the southwest during the day and from the northeast at night. Using this information, wind corridors were drawn where plumes from existing facilities are likely to be located.^j These wind corridors were regarded as areas in which existing facilities are likely to impact the new facilities and vice

j. See footnote h, page 5-4.

versa. The areas of the INEL outside the wind corridors are therefore preferred and are shown shaded in Figure A-7 and Figure A-13.

5.1.8 Least Vulnerable to Lava Flows

The delineation of these areas on the map represents a portion of the field committee's efforts to address the criterion in Section 3.2.2.16. The marking of areas on the basis of volcanic hazards was performed by taking into account the following considerations.^k

Assessment of volcanic hazards was based on the geologic record of past volcanism at the INEL on the assumption that "the past is the key to the future." Thus, information was compiled on time (geochronology), nature (eruption styles), and locations of past volcanism as evidenced by volcanic vents and surface deformations. Topography of the land surface on the INEL is also important due to the fact lava flow effusion is the predominant volcanic process. The relevant information is compiled in a volcanic risk assessment for the NPR,¹⁴ and in recent geologic maps and reports.^{15,16} The areas of the INEL determined to be most vulnerable to lava flows were determined after taking into account the following three criteria:

- The average size of geologically recent (mostly Holocene) lava fields on the ESRP
- Locations and ages of volcanic vents in the area of the INEL
- Topographic gradients of the INEL that would determine the directions of lava flow.

The boundaries of the areas considered to be most vulnerable to lava inundation are based on eruption of lava fields of reasonable size from the areas where northwest-trending, volcanic rift zones (i.e., the Arco and the Lava Ridge-Hell's Half Acre zones discussed in Section 5.1.9) intersect the Axial Volcanic Zone of the INEL. These areas of intersection are assumed to be the most likely effusion points for lava flows based on the most recent volcanic activity in the area.

An indication of the level of volcanic risk from lava inundation was provided in Reference 14. It was estimated that the probability of such an occurrence impacting the NPR site (i.e., the south-central part of the INEL) is about 10^{-5} per year (yielding a recurrence interval of 100,000 years). All other volcanic phenomena are expected to have even lower probabilities of impacting the NPR site. The shaded areas in Figure A-8 are the portions of the INEL that are outside the areas of comparatively high risk of volcanic events and are thus the preferred areas from the standpoint of this criterion.

k. Interoffice correspondence memorandum from Bill Hackett and Dick Smith to D. D. Taylor, EG&G Idaho, Inc. "INEL Map of Volcanic-Hazard Zones and Capable Faults, for use in Waste-Treatment Facility Siting," September 4, 1992.

5.1.9 Least Vulnerable to Volcanic Fissuring

The shaded areas in Figure A-9 represent the remainder of the field committee's efforts¹ to address the criterion in Section 3.2.2.16. They represent regions of the INEL with the lowest potential for ground deformation associated with subsurface magma movement (fissuring, minor faulting, and uplift) near volcanic vents along volcanic rift zones. These phenomena are more likely to affect the southern INEL because the most recent and most voluminous volcanism has occurred from vents to the south of the INEL along the Axial Volcanic Zone. It is noted that the lines in Figure A-9 separating the high and low risk zones for volcanic fissuring should not be interpreted as rigid boundaries but rather as the estimated midpoints between zones of greater and lesser risk. The unshaded areas represent Quaternary (less than 2 million year old) volcanic rift zones, that is, northwest-trending regions of volcanic vents and associated fissure swarms, formed by ascending magma.

The probability of lava inundation events occurring within the boundaries of the INEL is discussed in Section 5.1.8. The shaded areas are the preferred areas from the standpoint of possible site damage due to volcanic fissuring.

5.1.10 One Mile or More from a Capable Fault

The delineation of this area on the map represents the field committee's efforts^k to address the criterion in Section 3.2.2.14. There is no simple consensus or definition of what constitutes an active fault in regulations governing the siting of nuclear power plants in the United States.¹⁷ Capable faults, on the other hand, exhibit one or more of the follow characteristics:

- (a) Movement within the past 35,000 years or recurrent movement within the past 500,000 years
- (b) Instrumentation-determined macroseismicity demonstrating a direct relationship with the fault in question,
- (c) Structural relationship of the fault in question to a known capable fault (according to a or b, above) such that movement on one could reasonably be expected to be accompanied by movement on the other.

The determination of the seismic region for Figure A-10 is based on several sets of criteria. Fault locations were taken from the INEL geologic map¹⁶, and capability is evaluated on the results of recent INEL paleoseismic investigations by EG&G Idaho and its subcontractors.¹⁸ The shaded region represents the areas of the INEL that are at least 1.6 km (1 mi) from a capable fault and is thus considered the preferred area from the standpoint of the seismic siting criterion.

1. See footnote j on page 5-4.

5.1.11 Not Reserved for Other INEL Projects

The delineation of the shaded area in Figure A-11 represents the field committee's efforts to address the criterion in Section 3.2.2.2. The map was supplied by the Planning and Inspection - Unit^m of EG&G Idaho, Inc. and shows the areas of the INEL that have not been selected for other proposed projects at the INEL. These projects include NPR, the Advanced Liquid Metal Reactor, and the Nuclear Weapons Complex Reconfiguration. The locations for these projects were chosen through siting studies and were published in new programs development and proposal documents which were provided to Planning and Inspection by the EG&G Idaho, Inc. Business Technology Center of the Engineering Research and Applications Department.

The preferred area for siting the IWP/MLLW Treatment Facility from the point of view of this criterion is shown shaded in the figure.

5.1.12 Not Above Aquifer

The delineation of this area on the map represents the field committee's efforts to address the suggestion from DOE-ID that at least one location be considered that is not directly above the SRPA. There appears to be one relatively small area on the INEL at the southern tip of the Lemhi Mountains that does not lie directly over the aquifer. The marked area in Figure A-12 was based on an EPA document.¹⁹ This document provides a map of the sole source aquifer boundary and also states: "Generally, the aquifer boundary is the contact between Quaternary sedimentary and volcanic rocks and the surrounding Tertiary and older rocks."

The descriptors used in the above quotation are based on Reference 19. The marked area in the figure was regarded as a preferred area from the standpoint of the criterion in Section 3.2.2.24.

5.2 Selection of Candidate Areas

Once the mapping activities described in Section 5.1 were completed, the siting coordinator requested that the mapped areas be entered into the AUTOCAD map data base maintained by the Graphic Arts Unit of EG&G Idaho, Inc. This allowed all the preferred and excluded areas to be displayed together on a single composite map of the INEL. When this was done it was discovered that there is *no* area of the INEL that lies in the preferred regions for *all* the criteria. Thus, the choice of candidate areas for siting the IWP/MLLW Treatment Facility necessarily involved choosing a compromise among the criteria. The starting point for selection of these candidate areas was the above-mentioned composite map. The details of the selection process are described below.

5.2.1 Rationale for Selection

The next step in the siting process was to choose candidate areas as briefly discussed in Section 1.3.3. The methodology that was employed in choosing the candidate areas was discussed at length by the siting coordinator and the members of the Waste Management Facilities Projects Unit.

m. Interoffice correspondence memorandum from M. G. Koll to D. D. Taylor, EG&G Idaho, Inc., "Documentation for Siting Map," October 19, 1992.

After considering several possible approaches, it was decided to make a preliminary selection (subject to later discussion and modification by the field committee) of seven areas based on the following requirements:

- (a) The candidate areas must not contain any portion of an excluded area (i.e., an FFA/CO site, an ECA, or land within one mile of a Category I facility or existing/proposed reactor as shown on the siting maps in Figure A-5 and Figure A-6).
- (b) The candidate areas must represent a reasonable geographic cross-section of the entire INEL.
- (c) All candidate areas must lie within the preferred area above the 100-year flooding elevations shown on siting map in Figure A-2.
- (d) Each candidate area selected must lie within the preferred area for at least one of the remaining want criteria in the legend of the siting map and preferably in as many as possible.
- (e) For each want criterion in the siting map legend, at least one of the candidate areas must lie in the preferred area for that criterion.
- (f) At least half the candidate areas must be outside areas marked "Reserved for Other INEL Projects."

5.2.2 Candidate Areas Selected

The candidate areas selected by the siting coordinator on the basis of the above requirements are indicated as Areas 1 through 7 in Figure A-13. Outlines of the preferred areas shown in Figure A-1 through Figure A-12 have been retained for ease of comparison with the maps for the individual siting criteria. Conformity of the selected areas with the above requirements is discussed below.

5.2.2.1 Area 1. This area satisfies requirements 5.2.1(a) and 5.2.1(c). It also lies within the following preferred areas:

- Least vulnerable to volcanic fissuring
- One mile or more from a capable fault
- Not reserved for other INEL projects.

5.2.2.2 Area 2. This area satisfies requirements 5.2.1(a) and 5.2.1(c). It also lies within the following preferred areas:

- Minimum potential for airborne contamination of public
- Outside wind corridors of existing facilities

- Least vulnerable to lava flows
- Least vulnerable to volcanic fissuring
- One mile or more from a capable fault
- Not reserved for other INEL projects.

5.2.2.3 Area 3. This area satisfies requirements 5.2.1(a) and 5.2.1(c), and lies within the following preferred areas:

- Minimum potential for airborne contamination of public
- Outside wind corridors of existing facilities
- Least vulnerable to lava flows
- Least vulnerable to volcanic fissuring
- One mile or more from a capable fault.

5.2.2.4 Area 4. This area satisfies requirements 5.2.1(a) and 5.2.1(c), and lies within the following preferred areas:

- Minimum potential for airborne contamination of public
- Outside wind corridors of existing facilities
- One mile or more from a capable fault
- Not reserved for other INEL projects.

5.2.2.5 Area 5. This area satisfies requirements 5.2.1(a) and 5.2.1(c), and lies within the following preferred areas:

- Outside wind corridors of existing facilities
- Least vulnerable to lava flows
- Least vulnerable to volcanic fissuring
- One mile or more from a capable fault
- Not reserved for other INEL projects.

5.2.2.6 Area 6. This area satisfies requirements 5.2.1(a) and 5.2.1(c). It lies within the following preferred areas:

- Minimum potential for airborne contamination of public
- Least vulnerable to lava flows
- Least vulnerable to volcanic fissuring
- One mile or more from a capable fault.

5.2.2.7 Area 7. This area satisfies requirements 5.2.1(a). It lies within the following preferred areas:

- Outside wind corridors of existing facilities
- Least vulnerable to lava flows
- Least vulnerable to volcanic fissuring
- Not reserved for other INEL projects
- Not above aquifer.

5.2.2.8 Conformity of Candidate Areas with Section 5.2.1. The above selections fulfill most, but not all, of the requirements listed in Section 5.2.1. First, none of the selected areas lie in the preferred area for the fine-grained sediments criterion. In this regard, it is noted that the original choice for Area 3 was the four-square-mile area two miles north of that indicated in Figure A-13 and this area incorporated roughly 1.5 mi² of the fine-grained sediments area. In addition, a small portion of Area 4 was noted to lie in this area. However, it was later discovered that neither the portion of the original Area 3 in the fine-grained sediments area nor the portion of Area 4 in this area actually satisfies requirement 5.2.1(c). In fact, it was reasoned that the two site objectives of having significant deposits of fine-grained sediments and of being above 100-year flooding elevations may be mutually exclusive. This conclusion is reasonable, based on the assumption that all the thick, surficial fine-grained sediment units on the INEL were deposited by alluvial or lacustrine processes. (Loess deposits, also considered fine grained, are present in many areas of the INEL that do not appear to be subject to flooding. However, such deposits are wind-generated and their thicknesses are comparatively small and nonuniform.)

Also, Area 7 fails to satisfy requirement 5.2.1(c). (The reason it fails is that the area contains many intermittent drainage channels due to its close proximity to the Lemhi Mountains.) As previously noted (see Section 5.1.12), the consideration of this area was suggested by DOE-ID and was thus included for consideration.

Subject to the above exceptions, one can verify from the siting maps in Figure A-1 to Figure A-12 that the chosen candidate areas satisfy requirements 5.2.1(a) through 5.2.1(f).

5.2.3 Field Committee Review of Candidate Areas

The field committee met on September 4, 1992, to review the seven areas that were selected. The outcome of the meeting was that the committee approved the selection of all seven areas initially chosen, without changes. As a result of the meeting, however, one area was added to the list of candidate areas (see Figure A-13 and rationale in Section 5.2.3.12). Though there was no alteration of the seven selected areas, the issues that were raised by the committee are discussed briefly in the following sections.

5.2.3.1 Flooding Versus Fine-Grained Sediments Criteria. The reasons for the apparent mutual exclusivity of the fine-grained sediments and above 100-year flooding elevations criteria were discussed (see Section 5.2.2.8).

5.2.3.2 Subsurface Contaminant Plume Intrusion. The areas south of U.S. Highway 20/26 may be subject to intrusion by subsurface contaminant plumes (e.g., tritium, chromium, nitrate, chloride, ^{129}I , ^{137}Cs , and ^{90}Sr) migrating southward from the Test Reactor Area (TRA) and the Idaho Chemical Processing Plant (ICPP) facilities. However, the contaminant concentrations within the plumes still meet federal drinking water standards. Moreover, these concentrations are decreasing due to the termination of the disposal practices that led to their formation.

5.2.3.3 Time Invariance of Wind Corridors. One of the geologists present observed that there is evidence that the wind corridors that were mapped (Figure A-7) have existed for a considerable length of time on a geologic timescale.

5.2.3.4 Compliance with DOT Regulations. Options for dealing with the DOE policy of compliance with DOT shipping regulations were discussed. These options were as follows.

5.2.3.4.1 New Shipping Containers Available—A current project at the INEL (the Remote-Handled Drum Venting Facility) is developing a container for moving radioactive materials within the RWMC. The container might be considered for moving stored wastes at the RWMC to the IWPF/MLLW Treatment Facility, provided the RWMC fence can be extended to include the IWPF/MLLW Treatment Facility.

5.2.3.4.2 ATMX Railcars—The possibility of using certified ATMX railcars for shipping the waste on government-controlled rail spurs was mentioned by the committee member from the EG&G Idaho Transportation Department.

5.2.3.4.3 DOE-Sanctioned Exemption from DOT Regulations—The three options for exemption from DOT compliance in transporting wastes were reviewed. The first of these options would be to site the facility in a location on the same side of all public roads as the RWMC and then extend the RWMC fence to include the IWPF/MLLW Treatment Facility and a DOE-controlled transportation "portal" (a fenced road) connecting the two facilities. Thus, for the purposes of DOT compliance, the RWMC and the IWPF/MLLW Treatment Facility would be considered a single fenced facility and the DOE policy of compliance with DOT regulations would not apply.

The second option would again require siting the facility on the same side of the public roads as the RWMC. However, in place of constructing a fenced portal between the RWMC and the IWPF/MLLW Treatment Facility, a DOE-approved transport plan would be obtained. A transport plan is a DOE-approved document that permits shipment of hazardous material on the INEL without formal compliance with DOT packaging regulations. It requires that administrative controls be imposed (e.g., maximum speed limits, and escorts) that ensure the achievement of a level of safety that is equivalent to that of DOT-compliant transport of the material.

The third option would be to ship the wastes "out of commerce." This option refers to the right of the federal government to transport material of any kind to any location in the country without complying with DOT regulations, provided it is considered to be in the national interest to do so. However, this option is rarely used by DOE, and the possibility of its being approved for transporting waste feedstocks across public roads on the INEL was presumed to be remote.

5.2.3.4.4 Lobbying Effort for DOT Exemption—It was suggested that a lobbying effort for DOT exemption for transport of waste within the boundaries of the INEL be considered. Committee members from the EG&G Idaho Transportation and ES&Q Departments both expressed doubt that such an effort would be successful.

5.2.3.4.5 Relocation of Public Highway—It was stated that it may be less expensive to relocate the public highway around the INEL boundaries than to comply with DOT shipping requirements in transporting the waste. In response to this suggestion, it was pointed out that the INEL is probably powerless to dictate such an action. However, it was suggested that the State of Idaho be queried to determine whether or not such an action may already be in the planning stage.

5.2.3.5 Prioritization of Siting Criteria. The comment was made that siting criteria that are based on catastrophic natural events should be prioritized on the basis of relative probabilities. For example, flooding has a probability of 10^{-2} /year, while the probabilities of seismic and volcanic events are roughly 10^{-3} - 10^{-4} /year and $< 10^{-5}$ /year, respectively. It was further suggested in this regard that site selection should be based solely on considerations of the natural environment and that anthropomorphic criteria (such as the DOT compliance issue) should not influence the choice of a site.

5.2.3.6 Selection of Best Site. It was suggested that the site selection process should yield the best site available on the INEL rather than merely an acceptable site. Discussion of this point led to the assertion that the only way that site selection can be optimized so that the best site is chosen is to employ numerical weighting factors for criteria, together with numerical site scoring, as originally proposed in the K-T process. Reasons for rejection of K-T were briefly reviewed (see Section 4.1).

5.2.3.7 Craters of the Moon Impact. It was pointed out that any site in Area 2 might be challenged by the public on the basis of its potential to impact visibility at the Craters of the Moon National Monument.

5.2.3.8 Bureau of Land Management Concerns. The observation was made that every year BLM requests control of more of the INEL from DOE and that there are already portions of the INEL on which BLM controls grazing rights.

5.2.3.9 Disposition of DOE-Recommended Site. The fact that the DOE-recommended area (Area 7) is within a mile of a capable fault led to the suggestion by one of those present that it be excluded from further consideration. However, it was pointed out by one of the geologists present that unless there is a requirement that ground motion not exceed a specific level, Area 7 need not be rejected on the basis of seismicity (except those portions that lie on a fault).

5.2.3.10 Ground Motion Requirement. Pursuant to the discussion of proximity of Area 7 to a capable fault it was pointed out that, notwithstanding the lack of a specific requirement, the potential for significant ground motion ought to be considered in final site selection. This suggestion was adopted (see Section 5.4.2.2).

5.2.3.11 Visibility from Public Roads. It was suggested that DOE-ID would probably require that the IWP/MLLW Treatment Facility be out of sight from the public road and that this may exclude Area 2 from further consideration.

5.2.3.12 Area 8. As indicated above, following the meeting of the field committee on September 4, another area (Area 8 in Figure A-13) was added for consideration northeast of WERF. The reason that this region was not recommended initially was that it was in the wind corridor of WERF, PBF, Auxiliary Reactor Area (ARA), and Special Power Excursion Reactor Test (SPERT). However, after it was noted that these facilities either have no significant plumes associated with them or will be shut down when the new treatment facilities come on line, it was agreed that there was no reason to exclude Area 8 on the basis of the wind corridors of existing facilities criterion.

Area 8 satisfies requirements 5.2.1(a) and 5.2.1(c) and lies within preferred areas for the following criteria:

- Minimum potential for airborne contamination of public
- Wind corridors of existing facilities
- Most vulnerable to lava flows
- Most vulnerable to volcanic fissuring
- One mile or more from a capable fault.

5.3 Selection of Candidate Sites

The concept of site walkovers was introduced by a member of the advisory committee from the National Low-Level Waste Program who described his previous experience in siting a commercial low-level waste disposal facility. As part of that siting exercise, drive-by inspections (site walkovers) of proposed siting locations were performed for the purpose of identifying obvious physical features (natural or other) that might impact the siting of the facility. That is, the purpose of the surveys was to identify site features that may not be apparent from consideration of published objective data, maps, reports, etc. After discussing this experience, the members of the advisory committee elected to conduct site walkovers on all candidate sites before the final selection of recommended sites.

Each of the eight candidate areas shown in Figure A-13 encompasses between three and eight square miles (1,920 to 5,120 acres). Since a candidate site was only required to include 200 acres and also because of the time required to visit and inspect selected sites, the siting coordinator conducted a preliminary screening of the candidate areas to choose sites that would actually be visited. This screening was based primarily on an inspection of aerial stereo photographs (1:40,000 scale) and LANDSAT 5 thematic mapping images of all the candidate areas. The stereo aerial photos provided a convenient method to quickly identify the most promising parts of each area, from the standpoint of topographic considerations, natural and other structures, barriers, and soil cover. The LANDSAT images provided qualitative information on the types of vegetation that might be present in different areas, together with an indication of presence of potential wetland areas.

Using the information gleaned from inspection of the photos, the siting coordinator selected specific tracts of roughly 200 acres (candidate sites) that he felt would be the best locations within each of the eight candidate areas. These candidate sites were marked on USGS 7-1/2 minute topographic maps so they could be located from four-wheel-drive vehicles or by helicopter. It was decided that land vehicles would be used to visit those sites that were within a few miles of paved roads and that one of the Protection Technology Idaho (PTI) helicopters would be engaged to visit the sites that were relatively inaccessible.

5.4 Evaluation of Candidate Sites

Once candidate sites were identified within the candidate areas, the next step was to obtain further information on which to base a final selection. The site walkovers performed to accomplish this and the evaluations subsequent to them are discussed in the following sections.

5.4.1 Site walkovers

The actual surveys were conducted on September 18, 21, and 23, 1992. On each day a group of ten to twelve members of the site inspection team (Section 2.4) would visit two to four of the candidate sites. Land vehicles were used on September 18 and 21, and the PTI helicopter was used on September 23. Instructions were provided by the siting coordinator on the types of information that were sought on the surveys, and a form was provided to each member of the team to write their comments and observations about each site. The types of information that were mentioned on this form were as follows:

- Soil type and estimated depth
- Evidence of habitat for sensitive plant and animal species
- Evidence of cultural resources and archeological sites
- Topographic features
- Geologic features
- Proximity to utilities and services

- Evidence of surface flooding
- Potential impact to or by neighboring facilities
- Miscellaneous characteristics that could impact siting.

At each of the eight areas visited, the site inspection team spent one to three hours walking over the tracts that had been selected. The site walkovers were documented with both 8-mm video coverage and 35-mm color photographs of each area. The video tape includes aerial coverage of Areas 1, 4, 5, 6, and 7. In particular, it includes a complete aerial view of the final recommended site. (The original 8-mm video tape is in the possession of Ron Rope of EG&G Idaho, Inc., Centers for Bioprocessing & Environmental Assessment. A copy, made on a standard VHS format tape, and the photos are in the IWPF Siting Project File.)

5.4.2 Post-Site walkover Evaluation

After completion of the site walkovers, the siting coordinator requested written comments from the members of the site inspection team. These comments were condensed and summarized in Table 5-1.

Table 5-1. Evaluation of candidate sites from site walkovers.

1	2	3	4	5	6	7	8	9	10	11
Cand. site	Soil depth (+ or -)	Seismic (+ or -)	Crit. habit (+ or -)	Cult. res. (+ or -)	Gen. topog. (+ or -)	Geol. lava (+ or -)	Surf. water (+ or -)	Wetlands (+ or -)	Utilities (+ or -)	Comments (+ = advantage; - = disadvantage)
1	+			-	+	-	+	+	+	<ul style="list-style-type: none"> + Railroad adjacent + South of highway + Road reduces env. impact + >200 acres (est.) flatland + No evidence of flooding - Rocky on ridges
2	+	-		-	+	+	+	-	-	<ul style="list-style-type: none"> + 150 acres (est.) flatland - Presence of unknown lineament
3	-	-		-	-	+	+	+	-	<ul style="list-style-type: none"> - <100 acres (est) flatland
4	-	+		-	-	-	+	-	-	<ul style="list-style-type: none"> + Extremely remote - Runoff drains to wetland area - Unique ecological area
5	+	-	+	+	+	+	+	+	-	<ul style="list-style-type: none"> + Caliche at 3 ft to adsorb + Sediments deep, no basalt + Well-drained, away from sinks + Far from south. INEL boundary + >400 acres (est) flatland - Most sediments very coarse - Adjacent to diversion canal
6	-		-	-	-	+	+	+	-	<ul style="list-style-type: none"> + Remote - Very rocky - Would impact cultural resources
7	+	-	-	-	-	+	-	+	-	<ul style="list-style-type: none"> + Plenty of soil cover - Runoff goes directly to SRPA - Juniper forest unique on the INEL - A lot of wildlife uses the area - Visible from public road - Wind erosion changes soil depth
8	-		-	-	-	+	+	-	-	<ul style="list-style-type: none"> - <60 acres contiguous flatland - 30-40 ft undulating relief - Good-sized cultural site - Rocky

Columns 2-10 in the table represent evaluations of the sites visited from the point of view of seven of the criteria listed in Section 5.4.1, plus two additional criteria that were mentioned by members of the site inspection team in their written comments. These criteria, the manner in which sites were evaluated, and the results of the evaluation are described in the following sections.

5.4.2.1 Soil Depth. A deep layer of soil at the surface was deemed an advantage both from the standpoint of construction costs and also from the standpoint of providing a barrier to percolation of surface water to groundwater. The soil depth was estimated based on cuts, holes, scrapings that may have been encountered, vegetation types, topographic character, development of patterned ground, or other features that might have been correlative with soil depth. No boring was performed to determine soil depth.

5.4.2.2 Seismic. This parameter reflects the potential for ground motion based on the distance from known faults and on the presence of geologic features (e.g., lineaments) that might suggest a history of seismic movement. A threshold distance of 15 km (9.3 mi) from faults was used to identify areas where the risk of seismic ground motion was deemed a disadvantage.

5.4.2.3 Critical Habitat. This criterion reflects the impact that might result to biota in and around a site if the IWPF/MLLW Treatment Facility was located there. The presence of threatened/endangered plant or animal species, the number of animals that appear to frequent a site, and the proximity of a site to other areas known to contain sensitive biological characteristics were used to evaluate sites from the standpoint of this criterion. The site evaluations were based primarily on the observations of the members of the site inspection team from the Centers for Bioprocessing & Environmental Assessment Unit of EG&G Idaho.

5.4.2.4 Cultural Resources. One of the members of the SIT was a trained archeologist from the Cultural Resources Management Unit and searched each of the visited sites for evidences of historical and archeological resources. This search involved identifying tangible artifacts on the surface of the ground as well as generic features of the terrain that would suggest that such artifacts would be encountered if a more exhaustive search were done. The evaluations were based on the amounts of such evidence that were encountered during the site visits. A high positive score indicates that there was no evidence of cultural resources present on site.

5.4.2.5 General Topography. This criterion reflects the total relief found at a site and was intended to represent a site's desirability from the standpoint of how much ground preparation (e.g., blasting of rock, leveling, and excavating) would be required in order to construct the IWPF/MLLW Treatment Facility. The presence of large expanses of flat areas was considered an advantage, and the presence of relatively steep slopes and surficial lava outcrops were considered disadvantages.

5.4.2.6 Geological-Lava. This criterion reflects the relative likelihood of lava inundation at a site.

5.4.2.7 Surface Water. Evidences noted during site visits of significant ponding, runoff, drainage channels, or erosion were the basis of evaluation from the standpoint of this criterion.

5.4.2.8 Wetlands. It was the intention of the advisory committee to avoid any areas of the INEL that might be considered wetlands. Initially, it was concluded that such areas would be based on the current delineations by the USFWS. However, during the site visits, it became evident that there are some areas on the INEL that are not in the current USFWS delineation that possibly should be, based on the criteria used by USFWS. The evaluation of this criterion in Table 1 reflects this judgement. It also reflects the fact that some of the USFWS wetlands were apparently overlooked during the mapping activities described in Section 5.1.

5.4.2.9 Utilities. This criterion was included in the final site evaluation to reflect site development costs for utilities, primarily roads and power. Therefore, the proximity of sites to existing INEL roads and power lines was the basis for the evaluation from the standpoint of this criterion.

5.4.2.10 Evaluation Summary. The entries in each column of the table indicate whether the sites were considered favorable (+) from the standpoint of the criterion in that column, unfavorable (-), or neutral (blank). The siting coordinator assigned a '+', '-', or 'blank' on the basis of the written comments of the members of the site inspection team. Column 11 lists additional factors that were noted in the site walkover evaluations that are considered as either favorable (+) or unfavorable (-) for the sites concerned.

5.5 Selection of Recommended Sites

After the evaluations of eight candidate sites visited during the site walkovers were compiled, the list of candidate sites was narrowed to three: one preferred site plus two alternate sites. The locations of these sites are shown in black in Figure A-14. The rationale used in their selection from among the top eight candidate sites listed in Table 1 is described below, together with the subsequent comments of the siting committees.

5.5.1 Sites Rejected

5.5.1.1 Site 7. As previously indicated, Area 7 failed to satisfy the criterion of Section 3.2.1.4, which deals with flooding issues. This became apparent during the site walkover, when several intermittent streams (erosion channels) were encountered. Nonetheless, it was pointed out by at least one member of the site inspection team that this fact alone should not exclude the site from consideration, since the effects of intermittent streamflow through the site can be mitigated with appropriate facility design. However, it was noted after viewing the course of the water down the erosion channels and onto the plain that most (if not all) the site runoff would eventually find its way into the SRPA, notwithstanding the fact that the site itself may not lie directly over the aquifer. In addition, it was observed that the portions of Area 7 that are not over the SRPA are probably areas where the steep slope of the land surface would make construction of the IWPF/MLLW Treatment Facility infeasible. Thus, any perceived advantage in being not directly over the aquifer is probably not relevant.

In addition to the above considerations, there were other reasons for not recommending the site in Area 7. The area is within a mile of a capable fault. In addition, it lies within the limited portions of the INEL that contain juniper forest. The site walkover revealed many trails criss-crossing the

area, indicating it is used by a variety of animals. The merging of the foothills and the plains at this location provides potential habitat for several sensitive plant species found on the INEL (though none were found during the site walkover).

Finally, the area is adjacent to private land on the INEL boundary that is downgradient with respect to groundwater flow. It was felt that these characteristics, together with the fact that the area is clearly visible from Idaho State Highway 22, would likely provide stumbling blocks for public concerns.

5.5.1.2 Rejection of Sites 2, 4, 6, and 8. Sites 2, 4, 6, and 8 (like all other sites except Area 7) were considered satisfactory from the standpoint of the siting criteria discussed in Section 3. They were rejected from recommendation to DOE-ID solely on the basis of observations made during the site walkovers. These observations are described, site by site, below.

5.5.1.2.1 Site 2—Contained an area considered to be a likely candidate for wetland status (though not currently identified as such by USFWS). In addition, it contained a geological lineament of unknown origin and stability. Finally, in order to benefit from the site's location on the south side of the highway in dealing with DOT regulations, a DOE-controlled road would have to be constructed to cross the Big Lost River channel. It was felt that this could prove to be problematic.

5.5.1.2.2 Site 4—Was bounded on the north by a large playa area of roughly 80–100 acres. The site walkover of the area revealed a large intermittent drainage channel that empties onto the playa. Later investigation indicatedⁿ that the upstream drainage area emptying into this channel is roughly 52 km² (20 mi²). The playa is not currently identified as a wetland by USFWS but it was felt by the site investigation team that it probably will be eventually. It was felt that this consideration was sufficient to rule out Site 4 from recommendation, even though the site itself is on higher ground, above the playa.

In addition to the above consideration, Site 4 is located on a sloping lava deposit and contains many lava outcroppings. This, together with the remoteness of the area from existing utilities and services, tended to reinforce the undesirability of the site.

5.5.1.2.3 Site 6—The site walkover of Site 6 revealed an abandoned raptor nest in a lone juniper. Since the raptor is considered a threatened species, this find could become an environmental issue if the site were selected for the IWPF/MLLW Treatment Facility. In addition, the walkover of the site indicated the likely presence of more cultural resources than at most of the other candidate sites. Finally, the area topography contained comparatively little flat land and many lava ridges.

5.5.1.2.4 Site 8—There were a number of features of this site that are not optimal. First, it was noted by one of the site inspection team members that the site provides good habitat for a sensitive plant species that was identified on the NPR site (immediately adjacent to Site 8). Second, a USFWS delineated wetland was located on the site. Third, an area with significant cultural resources

n. Private communication with R. P. Smith, EG&G Idaho Geology & Seismology Unit, September 24, 1992.

was located on the site. Fourth, the site contains more relief than some of the other sites. Finally, the site is on the preferred site for locating the Advanced Liquid Metal Reactor project.

The first, third, fourth, and fifth undesirable features were not considered sufficient to exclude the site from consideration. However, in keeping with the direction of the advisory committee (see Section 3.2.1.5), the presence of the USFWS-delineated wetland led to the exclusion of Site 8 from the list of sites recommended to DOE-ID.

5.5.2 Site Recommendations

The sites remaining after excluding those discussed in Section 5.5.1 are Sites 1, 3, and 5. Based on the siting criteria described in Section 3, each of these sites is deemed acceptable. They are therefore recommended for siting the IWPf/MLLW Treatment Facility at the INEL in the following order of preference:

Preferred site:	Site 1
First alternate site:	Site 5
Second alternate site:	Site 3

Each of the above sites has advantages and disadvantages, some of which are noted in the following sections.

5.5.2.1 Site 1. The following characteristics of Site 1 are considered to be favorable for siting of the IWPf/MLLW Treatment Facility:

- The site is more than 15 km (9.3 mi) from a known capable fault; therefore the seismic hazard is deemed comparatively low.
- No critical habitat or endangered species were identified on the site during the site walkovers.
- No evidence of flooding or accumulation of surface water was found.
- The site contains no areas currently identified by USFWS as wetlands. In addition, no areas were identified by the site inspection team that would be likely candidates for classification as wetlands.
- There is easy access to a major power line and established roads.
- The site is within 4.8 km (3 mi) of the RWMC. This close proximity would allow construction of a DOE-controlled road to the RWMC and exemption from DOT regulations (as discussed in Section 5.2.3.4.3) requiring transport of waste feedstocks to the IWPf/MLLW Treatment Facility in certified containers.

- The site is bounded on one side by an INEL railroad spur. Though the main railroad to the RWMC is currently owned and maintained by Union Pacific Rail Road (UPRR), DOE could obtain control of all the tracks on the INEL, given that the main line is no longer used by UPRR except to service the needs of the INEL.^o
- The site contains several contiguous expanses of relatively flat land, each of which was estimated to be between 75 and 125 acres in area.

Unfavorable characteristics of Site 1 include the following:

- The site is located in the area identified to be most vulnerable to lava inundation.
- The flat areas on the site are topographical depressions. Hence, any surface water flows would likely be concentrated in the center of the developed area.
- The depth of surface sediments probably does not exceed eight to ten feet, and basalt outcroppings are scattered throughout the area, especially on high points.

Additional considerations in locating the IWP/MLLW Treatment Facility at Site 1 are as follows (1) Site 1 is very near the Naval Ordnance Test Facility site and is in an area that has already experienced some environmental disturbance. The use of this location would therefore obviate the need to disturb other pristine areas on the INEL, (2) Most of Site 1 is more than two miles from U.S. Highway 20/26, and the local topography tends to obscure the selected area from view at the highway. This, however, could change; depending on the height of buildings, stacks, etc. In light of these facts, no relative advantage or disadvantage was assigned to the site from the standpoint of visibility, until additional facility design data are available.

5.5.2.2 Site 5. The following characteristics of Site 5 are considered to be favorable for siting of the IWP/MLLW Treatment Facility:

- The depth of the sediments at this site is considerable, probably 30-91 m (100-300 ft). This would facilitate development and construction at the site. In addition, if well logs at the site should indicate the presence of fine grained sediments at depth, this would provide a more substantial hydrologic barrier to contaminant migration into the SRPA than at the other sites considered. Moreover, siting IWP/MLLW Treatment Facility at this location may permit colocation of the MLLW Disposal Facility because of the thickness of the sediments.
- No evidence was found during the site walkovers of any historical or archeological resources.
- Site topography is nearly ideal: essentially flat but sufficiently sloped in one direction to promote complete drainage without ponding.

o. Private communication with K. L. Nelson of the EG&G Traffic Management Unit, August 25, 1992.

- The area is in a region of the INEL that is relatively unsusceptible to lava inundation and away from the rift zones.
- No critical habitat or endangered species were identified on the site during the site walkovers.
- No evidence of flooding or accumulation of surface water was found.
- The site contains no areas currently identified by USFWS as wetlands. In addition, no areas were identified by the site inspection team that would be likely candidates for classification as wetlands.
- There is easy access to a major power line and established roads.
- The site contains contiguous expanses of relatively flat land estimated to be between 300 and 600 acres in area.

Unfavorable characteristics of Site 5 include the following:

- The site is less than 15 km (9.3 mi) from a known capable fault. Therefore, the seismic hazard is deemed comparatively high.
- The site is maximally distant from all waste feedstocks.
- Site 5 is north of U.S. Highway 20/26. This would probably necessitate compliance with DOT regulations and design and certification of a new container to transport waste feedstocks.
- The entire area around Site 5 is clearly visible from Idaho Highways (28 and 22), one of which serves tourist traffic enroute to and from Salmon, Idaho.

Additional considerations in locating the IWPF/MLLW Treatment Facility at Site 5 are the following:

- The sediments are fairly coarse. Infiltration rates of precipitation would therefore probably be high unless the presence of fine-grained sediments was established at depth.
- Site 5 is on land that is currently leased to the BLM for grazing. The public may object to withdrawal of availability of the land for such use.
- The area at the north end of the INEL in which Site 5 is situated appears to be in the path of migration of game animals such as antelope and possibly elk.
- The area is adjacent to the Birch Creek Diversion Canal from a low-head hydro project to the north. The presence of this canal could constitute an unacceptable flooding hazard.

5.5.2.3 Site 3. The following characteristics of Site 3 are considered to be favorable for siting of the IWPF/MLLW Treatment Facility:

- The site is located central to the INEL, distant from site boundaries, and completely out of sight and away from public roads.
- No critical habitat or endangered species were identified on the site during the site walkovers.
- No evidence of flooding or accumulation of surface water was found.
- The site contains no areas currently identified by USFWS as wetlands. In addition, no areas were identified by the site inspection team that would be likely candidates for classification as wetlands.
- The area is in a region of the INEL that is relatively unsusceptible to lava inundation and away from the rift zones.

Unfavorable characteristics of Site 3 include the following:

- The site is less than 15 km from a known capable fault. Therefore, the seismic hazard is deemed comparatively high.
- Site 3 is north of U.S. Highway 20/26. This would probably necessitate compliance with DOT regulations and design and certification of a new container to transport waste feedstocks.
- The site topography is nonideal: relatively small areas of contiguous flat land surrounded by lava ridges.
- The expected concentration of archeological resources in the area is comparatively high.
- The area currently has no developed roads in service.
- The location on a lava field would entail construction obstacles and higher costs.

Additional considerations in locating the IWPF/MLLW Treatment Facility at Site 3 are the following:

- Because of its comparatively central location within the INEL, Site 3 may be most acceptable to the public on all four sides of the INEL.

- Area 3 is upwind and downwind of existing facilities. Though its distance from these facilities precluded its being contained in the avoided area from the standpoint of the criterion in Section 3.2.2.22 detailed modeling could indicate potential problems.

5.5.3 Review of Recommendation by Advisory and Field Committees

The above recommendation was reviewed at a joint meeting of the advisory and field committees on September 29, 1992. The recommendation was not changed as a result of the meeting. However, the comments made by those in attendance are briefly reviewed below.

5.5.3.1 Effect of Cultural Resources on Siting. It was pointed out that the presence of cultural (historical or archeological) resources on a site do not statutorily preclude the use of the site. Rather, they simply necessitate the application of prescribed measures to assess the importance of the resources and (depending on the outcome of the assessment) to mitigate the loss of cultural information during the site development.

5.5.3.2 Effect of Subsurface Contaminant Plumes on Siting. In response to further comments made regarding the potential impact to the preferred site of subsurface contaminant plumes (see Section 5.2.3.2) from TRA and ICPP, it was reiterated^p that the sources of these plumes have been gone for some time and, consequently, the contaminant concentrations are dropping due to dispersion, adsorption, and decay. In addition, the current concentrations of the plume contaminants are sufficiently low that groundwater samples taken from areas known to be contaminated would pass federal drinking water standards.

5.5.3.3 Deposition of Radionuclides from Wind Eddies. The NOAA representative at the meeting commented on a question that was raised in regard to the patterns of airborne contamination from INEL facilities. He mentioned a NOAA study by their Environmental Monitoring Laboratory that indicated elevated concentrations of radionuclides on the soil surfaces in the areas of the INEL west of Mud Lake and southeast of Howe (near the INEL boundaries). It was concluded that these elevated concentrations result from entrapment of airborne radionuclides in large-scale atmospheric eddies that prevail in these areas of the INEL and subsequent sedimentation of the contaminants to the land surface.

5.5.3.4 Fate of NRF. One of the members of the advisory committee suggested that contaminant plumes from the NRF facility may not be a concern to the IWPF/MLLW Treatment Facility because of possible shutdown in the 1994 timeframe.

5.5.3.5 Effects of Accidents Near Southern INEL Boundary. A concern was raised by one of the advisory committee members regarding impacts to the public of design basis accidents if the facility is located at Site 1 near the south boundary of the INEL. In response to this concern, one of the project support people for the MLLW Treatment Facility indicated that probable source terms for the IWPF/MLLW Treatment Facility are so low that safety issues can easily be addressed by engineered safety systems, many of which will be mandatory regardless of where the facility is sited.

p. Jack T. Barraclough, at the joint meeting of the advisory and field committee meeting, held September 29, 1992.

5.5.3.6 Depth to Water Table at Site 5. The question was raised about the probable depth to the water table at Site 5 in connection with the issue of percolation time of surface water to the SRPA. It was thought that this depth is roughly 46 m (150 ft). However, it was pointed out^q that this number is too low; the depth probably exceeds 137 m (300 ft) in this region of the INEL, based on measurements in the surrounding area.

5.5.3.7 Suggested Alternative for Site 3. In considering Site 3 (second alternate site), it was recommended^p that the section two miles north of Site 3 (refer to Figure A-14) is off the lava and in an area of deep [roughly 137 m (300 ft)], fine-grained sediments and thus is possibly ideal for both the treatment and the disposal facilities. At a minimum, it was suggested that this area would be an improvement on the area that had been selected (i.e., Site 3). The siting coordinator agreed to investigate the feasibility of the recommendation. However, upon further study it was found that the elevation of the recommended area is within a few feet of the top of the conservatively estimated 100-year flooding elevation (see Section 5.1.2). The presence of the fine-grained sediments in this area also attests to its vulnerability to flooding. For these reasons, the above recommendation was not adopted. However, it is here noted that further scrutiny of the area and a less conservative estimate of the 100-year flooding elevation might allow consideration of the recommended area for the IWPF/MLLW Treatment Facility or for the MLLW Disposal Facility, which may have different statutory requirements⁴ with respect to siting in the 100-year flooding elevation.

q. Jack T. Barraclough, at the joint meeting of the advisory and field committee meeting, held September 29, 1992.

6. CONCLUSION

The preliminary site selection for the IWPF/MLLW Treatment Facility has been completed. As a result of the selection process, three sites have been recommended. The preferred site is roughly two miles due east of the RWMC. The first and second alternate sites are located roughly three miles below the northern boundary of the INEL near the intersection of Idaho Highways 22 and 28, and seven miles northeast of NRF, respectively. These sites have been evaluated against a set of regulatory siting criteria and have been judged to be acceptable on the basis of existing data. However, it is emphasized that final determination of regulatory compliance cannot be done until additional data are obtained (e.g., data supporting a formal, legal definition of the 100-year flooding elevation on the INEL; these elevations must take account of the drainages of the Big Lost River, the Little Lost River, and Birch Creek).

It should be emphasized that there is no site on the INEL that lies in the preferred regions for all the want criteria. Therefore, regardless of how sites were chosen, the selection process necessarily involved some compromise among the siting criteria. In addition, it should be recognized that the site selection procedure used did not attempt to select the best site from all potential sites on the INEL. Nonetheless, after the initial screening of all available INEL sites on the basis of objective siting criteria, in which eight candidate sites were identified, an attempt was made to select the best site from among these eight on the basis of the judgments of the siting committees and of the coordinator in weighing the relative advantages and disadvantages of the eight candidate sites.

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Appendix A

Siting Maps

Figure A-1. Below U.S. Highway 20/26.

Figure A-3. Fine-grained sediments.

Figure A-5. FFA/CO sites and environmentally controlled areas.

Figure A-6. Within one mile of Category I facilities and/or existing/proposed reactors.

Figure A-7. Outside wind corridors of existing facilities.

Figure A-8. Least vulnerable to lava flows.

Figure A-10. One mile or more from a capable fault.

Figure A-12. Not above aquifer.

Figure A-14. Recommended sites for the IWP/MLLW Treatment Facility.

Appendix B

Preliminary Site/Service and Support Criteria for the Proposed Idaho Waste Processing Facility at the Idaho National Engineering Laboratory, EGG-WMO-10303

Preliminary Siting/Service and Support Criteria for the Proposed Idaho Waste Processing Facility at the Idaho National Engineering Laboratory

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ABSTRACT

Once completed, the Idaho Waste Processing Facility will be used to process and package low-level and mixed low-level waste, contaminated with transuranic radionuclides, before shipment to a permanent repository. This report identifies the siting requirements imposed on facilities that treat and store alpha low-level and mixed alpha low-level wastes by the Environmental Protection Agency and the Department of Energy. Site selection criteria based on cost, environmental, health and safety, archeological, geological, and service and support requirements are presented. These criteria are a portion of the recommended site selection process that employs Kepner-Tregoe Decision Analysis to select alternative locations for the new facility. The National Environmental Policy Act process should then be invoked to evaluate both alternatives and the alternative sites and make a final site determination. The final step in the site selection process is approval from the cognizant Department of Energy Operations Office.

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ACRONYMS

ALMR	Advanced Liquid Metal Reactor
alpha-LLW	alpha contaminated low-level waste
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area
CFR	Code of Federal Regulations
DOE	Department of Energy
DOT	Department of Transportation
EPA	Environmental Protection Agency
FY	Fiscal Year
INEL	Idaho National Engineering Laboratory
IWPF	Idaho Waste Processing Facility
NEPA	National Environmental Policy Act
NPR	New Production Reactor
NRC	Nuclear Regulatory Commission
NRF	Naval Reactor Facility
PCB	polychlorinated biphenyl
RCRA	Resource Conservation and Recovery Act
TAN	Test Area North
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal

Preliminary Siting/Service and Support Criteria for the Proposed Idaho Waste Processing Facility at the Idaho National Engineering Laboratory

1. INTRODUCTION

The siting requirements for the proposed Idaho Waste Processing Facility (IWPF) at the Idaho National Engineering Laboratory (INEL) are primarily based on the laws and regulations that address the treatment, storage, and disposal (TSD) of hazardous, radioactive, and mixed wastes. The Environmental Protection Agency (EPA) regulations and Department of Energy (DOE) orders that specifically address facility siting are summarized in this report. Additionally, siting criteria have been developed from these requirements and a recommended approach for site selection is discussed.

The scope of the IWPF project is to process and package waste contaminated with transuranic elements, as necessary, before shipping the waste to a permanent repository. The facility is being designed to handle the following wastestreams:

- Stored alpha-contaminated low-level waste (alpha-LLW) and mixed alpha-LLW with 100 nCi/g or less of transuranic elements
- Contact- and remote-handled stored transuranic waste
- Waste buried at the Radioactive Waste Management Complex that includes transuranic waste, alpha-LLW, and mixed waste
- Newly-generated alpha-LLW.

Any transuranic waste or alpha-LLW that does not meet the waste acceptance criteria of the final repository or the transportation requirements for that waste will be processed within the scope of the IWPF project. This could include thermal treatment, repackaging, immobilization, removal of liquids, or neutralization of hazardous components.

The strategy of the IWPF project is to design, construct, and operate a processing facility that will process all four of the above wastestreams. The processing will be done in phases, and initially the facility will process only alpha-LLW that is well characterized. Subsequent expansions and additions of new buildings or processing lines will be made to the initial facility to allow processing of stored contact- and remote-handled transuranic waste. Siting will adhere to the requirements for the final facility. The IWPF is scheduled for construction beginning in Fiscal Year (FY) 2001, with operational startup scheduled for FY 2005 (as planned May 15, 1992).

1.1 Siting Assumptions

DOE's transuranic waste program involves a number of sites in addition to the INEL, and a change in strategy could effect the IWPF mission and requirements. For the purpose of this document it will be assumed that privatization of transuranic waste processing or construction of regional processing facilities will not be implemented, and siting requirements are based on the assumption that the IWPF will be a DOE-owned facility located at the INEL. This report does not consider the siting requirements and impacts of other proposed facilities that could be co-located with the IWPF.

The following set of assumptions were used in developing the siting criteria for the IWPF project.

- The IWPF will be located at the INEL, thus the region of interest is the 890 square miles encompassing the INEL.
- The IWPF will store polychlorinated biphenyls (PCBs) or PCB items with concentrations of 50 ppm or greater, so the requirements of the Toxic Substances Control Act (TSCA) apply.
- The regulatory environment of the future will include the current requirements and the proposed requirements as currently drafted at the time of this printing.
- The IWPF will comply with all currently applicable federal, state, DOE, and EG&G Idaho requirements.
- As a DOE site facility, Nuclear Regulatory Commission (NRC) siting requirements are not applicable to the IWPF.
- National Environmental Policy Act (NEPA) studies will be performed to aid decision makers in selecting the final site for the IWPF, as well as alternatives for offsite options.
- Before the final site selection is approved, a hazard class determination will be performed to evaluate worker hazards and radiation levels at the site boundary.

2. RECOMMENDED APPROACH FOR SITE SELECTION

Three previous siting studies for proposed facilities at the INEL were reviewed to determine if their approaches could be applied to siting the IWPF: the New Production Reactor (NPR), the New Weapons Complex Reconfiguration Site, and the Advanced Liquid Metal Reactor (ALMR). Figure 1 is a map of the INEL showing the locations selected for these proposed facilities. A fourth siting study, conducted for a proposed mixed and low-level waste treatment facility, was conducted concurrently and cooperatively with the present IWPF study. The ALMR and NPR studies employed Kepner-Tregoe Decision Analysis for the site selection process. This process is used to clarify purpose, evaluate alternatives, assess risks, and make decisions.

Decision analysis provides a systematic framework that makes sure all aspects of the decision are considered. The process uses the concepts of "musts" and "wants." "Musts" are those criteria considered to be minimum requirements for site acceptability. Proposed sites that do not meet each and every one of the "musts" requirements are to be eliminated from further consideration. "Wants" are those criteria considered to be desirable for site acceptability. Weighing factors, ranging in value from a low of 1 to a high of 10, are assigned to each of the desirable criteria according to relative importance.

The recommended approach for site selection is shown in Figure 2. This approach identifies the organization of two committees to complete the final site selection process. An advisory committee should be formed to make the final determination of "musts" and "wants" and also assign weights to each of the "wants" criteria based on their probability and seriousness. After this is completed, a field committee, selected before this and comprised of personnel with appropriate technical backgrounds, should use these criteria to select alternate locations for the IWPF. This is accomplished by first reviewing potential sites against the "musts" and making a first-cut reduction to exclude any sites that do not meet all of the mandatory requirements. The "wants" should then be addressed. A system should be used where each site is scored on a scale of 1 to 10 relative to its ability to satisfy each criterion. If a site can not meet a "want" criterion or does not have that specific attribute, the score will be left blank in that area. Each criterion's score will be multiplied by that criterion's weighing factor, and the weighted scores for all criteria added to obtain a total weighted score for each site. Based on total weighted scores, each site will be ranked to determine alternative locations for the facility.

At this point the NEPA process shall be invoked to perform an evaluation of the potential environmental impacts of the site alternatives, as well as other programmatic alternatives. This evaluation will be considered in determining the final location of the IWPF at the INEL. As stated in DOE Order 6430.1A, "General Design Criteria," Section 0285-2.2.9, the final site approval for TSD facilities shall be obtained from the cognizant DOE operations office. Based on this, the DOE counterpart for the IWPF should become involved in the siting process during the early stages.

Figure 1. Map of INEL and immediate vicinity.

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Figure 2. Site selection process.

3. ENVIRONMENTAL REGULATIONS

On December 18, 1978, the EPA proposed standards to control the location of TSD facilities in seismic zones, 100-year floodplains, coastal high hazard areas, 500-year floodplains, wetlands, critical habitats of endangered and threatened species, and recharge zones of sole-source aquifers, as well as specific standards to delimit the location of active portions of facilities with respect to the facilities' property lines. Public comment and additional research regarding the proposed standards were evaluated, and on January 12, 1981, the EPA promulgated two of the eight candidate standards in their Resource Conservation and Recovery Act (RCRA) regulations: the 100-year floodplain and seismic zone restrictions. The 500-year floodplain restriction was rejected as unnecessary to protect human health and the environment, while the other five standards were not promulgated because they were at least partially addressed by other laws. These minimum location standards for hazardous waste TSD facilities are contained in Code of Federal Regulations (CFR) 40 CFR 264.18 and are discussed in Section 3.1 of this report.

Considerations affecting siting are also found in 40 CFR 270.14 (b) and (c), "Contents of Part B: General Requirements." These requirements reflect the standards promulgated in 40 CFR 264.18 and are necessary for the EPA to determine compliance with the Part 264 standards. These requirements are also discussed in Section 3.1 with the Part 264 regulations.

The EPA requires that other Federal laws that affect the location and permitting of TSD facilities be considered (40 CFR 270.3). When any of these laws is applicable, its procedures must be followed. These Federal laws are contained in Sections 3.2 through 3.12 of this report.

The Atomic Energy Act of 1954 (42 U.S.C. 2011 et seq.) authorizes DOE to establish standards to protect human health and minimize dangers to life and property. Through a series of DOE orders, DOE has established an extensive system for standards and requirements to ensure safe operations of its facilities. In accordance with the Energy Reorganization Act of 1974 (Public Law 93-438), only DOE facilities that accept commercial high-level waste are subject to licensing requirements by the U.S. NRC. Based on this requirement, siting of the IWPF is not subject to NRC regulations.

The Federal Register (1991, p. 54,057), contained the EPA's plans to "restrict the siting of hazardous waste treatment, storage, and disposal facilities in environmentally sensitive locations." The EPA designation of environmentally sensitive locations may have a great impact on the siting of the proposed IWPF. The EPA is considering proneness to catastrophic release, ecological sensitivity, and ability to characterize the site. Specific new concerns being considered are ground motion, unstable terrains, and areas over high resource aquifers.

The Notice of Proposed Rulemaking for these location standards is scheduled for July 1992. The final rule is scheduled for March 1994. Since the INEL is located over the Snake River Plain Aquifer, which has been designated a sole source aquifer, these proposed standards could have a large impact on siting and design of the IWPF. This subject will have to be readdressed when the new standards are promulgated.

3.1 Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities

The purpose of 40 CFR 264 Subpart B, "General Facility Standards," is to establish minimum national standards that define the acceptable management of hazardous waste. Location standards for TSD facilities are regulated by the EPA under 40 CFR 264.18. These regulations address seismic considerations, floodplains, salt dome formations, salt bed formations, underground mines, and caves. The applicability of these regulations to the proposed IWPF are discussed in the following subsections.

3.1.1 Seismic Considerations

New treatment, storage, or disposal facilities for hazardous waste must not be located within 61 m (200 ft) of a fault that has had displacement in Holocene time, during the last 10,000 years (see Appendix A). The intent of this standard is to ban new TSD facilities in locations on or near faults that are likely to experience displacement in the future.

In order to demonstrate the applicability of the seismic standard, the owner or operator of a new facility must identify the political jurisdiction in which the proposed facility is to be located (40 CFR 270.14). If the county is not listed in Appendix VI of Part 264, no further requirement is required to demonstrate compliance with 264.18. The Idaho counties listed in Appendix VI are Bannock, Bear Lake, Bingham, Bonneville, Caribou, Cassia, Clark, Franklin, Fremont, Jefferson, Madison, Oneida, Power, and Teton. The counties that compose the INEL are Bingham, Bonneville, Butte, Clark, and Jefferson.

If the facility is proposed to be located in an area listed in Appendix VI of Part 264, the owner or operator shall demonstrate compliance with the seismic standard. The major portion of the INEL lies in Butte County, which is not on the list. This means that if the facility were located in Butte County, it is assumed to be in compliance with the seismic requirements. If it turns out that the proposed location of the facility is in a county listed in Appendix VI of Part 264, then this requirement will need to be addressed.

3.1.2 Floodplains

40 CFR 264.10, "Applicability," states that the floodplain restrictions apply only to TSD facilities subject to regulation under Subparts I through O of this part. Subpart I addresses the use and management of containers, and Subpart O addresses incinerators; the IWPF will be subject to these subparts, so floodplain restrictions will apply.

TSD facilities, subject to this regulation, are not permitted in the 100-year floodplain unless one of three conditions are met:

- The facility is protected, using dikes or other equivalent measures, from washout during a 100-year flood
- All hazardous materials can be removed to safe ground before flooding

- It can be demonstrated that no adverse effects to human health and the environment will occur should flood waters reach the waste.

3.1.3 Salt Dome Formations, Salt Bed Formations, Underground Mines, and Caves

40 CFR 264.18(c) states "The placement of any noncontainerized or bulk liquid hazardous waste in any salt dome formation, salt bed formation, underground mine, or cave is prohibited, except for the DOE New Mexico Waste Isolation Pilot Plant." There are caves located at the INEL; however, since they will not be associated with the IWPf, this requirement is not applicable.

3.2 Wild and Scenic Rivers Act (16 U.S.C. 1273 et seq.)

Section 7 of the Wild and Scenic Rivers Act prohibits the regional administrator from assisting, by license or otherwise, the construction of any water resources project that would have a direct, adverse effect on the values for which a national wild and scenic river was established. Generally, the EPA interpretation of this obligation is to discourage the siting of TSD facilities in these riverine areas and adjoining lands to the extent that such facilities may impact these protected areas. The rivers located on the INEL are the Big Lost River, the Little Lost River, and Birch Creek. None of these have been designated as a wild and scenic river, so this requirement is not applicable to the INEL.

3.3 National Historic Preservation Act of 1966 (16 U.S.C. 470 et seq.)

Section 106 of the National Historic Preservation Act and implementing regulations (36 CFR 800) require the regional administrator, before issuing a license, to adopt measures when feasible to mitigate potential adverse effects of the licensed activity and properties listed or eligible for listing in the National Register of Historical Places.

The DOE, the Advisory Council on Historic Preservation, and the Idaho State Historic Preservation Officer require an archeological survey/consultative review of all projects that affect undisturbed areas. This requirement is applicable to the INEL because historic and prehistoric artifacts have been found here in the past. *Archeological Investigations on the Idaho National Engineering Laboratory, 1984-1985*, can be used as a preliminary screening mechanism for sites, but an archeological survey will need to be performed on all candidate sites.

3.4 Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.)

Section 7 of the Endangered Species Act and implementing regulations (50 CFR, Parts 17 and 402) require the regional administrator to ensure that any act authorized by the EPA is not likely to jeopardize the continued existence of any endangered or threatened species or adversely affect its critical habitat. Generally, the EPA interpretation of this obligation is to prohibit the siting of TSD facilities within endangered or threatened species habitat. An ecological survey will need to be performed on candidate sites, and a biological assessment and consultation from the United States Fish and Wildlife Service, the Idaho Fish and Game, and the Bureau of Land Management would be conducted if a critical habitat may exist at a proposed location. Appendix B contains a list of

Federal threatened, endangered, and candidate species and State species of concern that may occur on the INEL.

3.5 Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.)

The Fish and Wildlife Coordination Act requires that the regional administrator, before issuing a permit proposing or authorizing the impoundment, diversion, or other control or modification of any body of water, consult with the appropriate state agency exercising jurisdiction over wildlife resources to conserve those resources. This requirement is applicable if the IWPF project will impound, control, or modify the waters of a stream or other body of water that is greater than or equal to 10 acres in surface area.

3.6 Coastal Zone Management Act (16 U.S.C. 1451 et seq.)

The Coastal Zone Management Act requires that all Federal activities in coastal areas (see definitions in Appendix A) be consistent with approved state coastal zone management programs to the maximum extent possible. The INEL is not a coastal area, so this requirement does not apply.

3.7 Wilderness Protection Act of 1964 (16 U.S.C. 1131 et seq.)

The Wilderness Protection Act designates wilderness areas within public lands that include national parks, national wildlife refuges, national forests, and Bureau of Land Management lands. Designated wilderness areas cannot be used as sites for TSD facilities without congressional approval. The aforementioned areas are not located on the INEL, so this requirement does not apply.

3.8 Toxic Substances Control Act of 1976 (15 U.S.C. 2601 et seq.)

The TSCA contained in 40 CFR Subchapter R is applicable to the IWPF for the storage and treatment of PCBs specifically contained in 40 CFR Part 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions." Location standards apply to the storage for disposal of PCBs and PCB items at concentrations of 50 ppm or greater. These standards are contained in 40 CFR 761.65 (b) (1) (v), "Storage for Disposal," and prohibit locations at sites "below the 100-year flood water elevation."

3.9 Clean Air Act of 1970 (42 U.S.C 7401 et seq.)

The 1977 amendments to this act used EPA's three-class zoning system, Class I, II, and III areas, which provide for certain allowable increments of additional pollution in each. Section 162 defines all national parks and wilderness areas above a certain size (5,000 to 6,000 acres, depending on the type of park) as Class I areas that cannot be redesignated. Section 169A designed a program for "the prevention of any future, and the remedying of any existing, impairment of visibility" in Class I areas from man-made air pollution. In the vicinity of the INEL, Craters of the Moon National Monument, Yellowstone National Park, and Grand Teton National Park are Class I air quality areas. Development that impairs the visibility of these areas will not be eligible for an air quality permit from the State of Idaho. In siting the IWPF, a determination of potential emissions from the facility

must be made and used to site the facility such that there will be no visibility impairment to any Class I area. Class II and III areas will not impact siting at the INEL.

3.10 Wetlands (Executive Order 11990)

Executive Order 11990, "Protection of Wetlands," directs Federal agencies to avoid undertaking or providing assistance for new construction of projects located on federally-owned wetlands (see definitions in Appendix A) unless there is no practical alternative. In cases where there is no alternative site, all measures must be taken to minimize harm to the wetland. The DOE has issued regulations in 10 CFR 1022 that establish procedures for compliance with this order. Wetlands may occur at the INEL during high water stages of the Big Lost River. These areas will need to be identified and eliminated from the siting investigation.

3.11 Floodplains (Executive Order 11988)

Executive Order 11988, "Floodplain Management," requires governmental agencies to avoid to the extent possible impacts associated with the occupancy and modification of floodplains. This order is also implemented in 10 CFR 1022. Since floodplains are more strictly regulated under TSCA and RCRA, this order will have no additional impact on siting the IWPF on the INEL.

3.12 National Environmental Policy Act (42 U.S.C. 4321 et seq.)

All potential projects involving any federal agency must undergo a review pursuant to the NEPA to identify and evaluate potential environmental impacts. NEPA constitutes a national policy to protect the environment and to promote a better understanding of the ecological systems and natural resources that are important to the nation. The Council on Environmental Quality regulations implementing NEPA contain "action-forcing" provisions to ensure that federal agencies consider environmental information before making decisions on proposed actions. The NEPA process includes decision points at which the significance of environmental effects are considered, project alternatives are identified, and appropriate mitigation measures are identified and adopted.

DOE Order 5440.1D, "National Environmental Policy Act Compliance Program," describes the roles of various DOE offices in implementing NEPA. It also states that DOE's policy is to comply fully with the letter and spirit of NEPA. Based on the requirements in 10 CFR 1021, "National Environmental Policy Act Implementing Procedures," the siting of the IWPF will probably involve the preparation of an environmental impact statement. Environmental concerns should be evaluated in the early planning stages, and documentation should begin as soon as possible. The NEPA process should be used to evaluate alternative sites and aid decision makers in selecting the final site for the IWPF.

3.12.1 DOE Order 5400.1, "General Environmental Protection Program"

Chapter IV, Section 3 describes preoperational monitoring of facilities, sites, and operations requirements for an environmental study to be conducted before startup of a new site that has the potential for significant adverse environmental impact. This study should begin not less than one year and preferably two years before startup to evaluate seasonal changes. Details of the requirements

of the study are specified, and, in some cases, documentation for NEPA compliance may suffice to fulfill these requirements.

3.13 National Emission Standards for Hazardous Air Pollutants (40 CFR 61 Subpart H)

Some primary requirements are contained in Subpart H, "National Emissions Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities." Part 61.90 designates that this subpart applies to operations at any DOE facility that emits any radionuclide other than radon-222 and radon-220 into the air. Part 61.92 states that emissions of radionuclides to the air shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem. Methods to determine compliance with this standard and monitoring and sampling requirements are specified in Part 61.93.

4. ADDITIONAL ENVIRONMENTAL SITING REQUIREMENTS

The purpose of DOE Order 6430.1A, "General Design Criteria," is to "provide general design criteria (GDC) for use in the acquisition of the Department's facilities and to establish responsibilities and authorities for the development and maintenance of these criteria." It is DOE policy that the planning, design, and construction of DOE facilities be performed in a manner that will satisfy all applicable executive orders, Federal laws, and regulations. The majority of this order is based on considerations to be observed during siting and not actual requirements. Division 2, Site and Civil Engineering, contains the majority of the requirements applicable to the siting of a new facility. The environmental requirements from this division are discussed in this section of the report, while the service and support requirements from this division and those from Division 1, General Requirements, are discussed in Section 5 of this report. Division 13, Section 1304, "Plutonium Processing and Handling Facilities," although applicable to the IWPF, is not applicable to siting and so will not be discussed in this report.

4.1 Section 0200, Subpart 1, "Facility Siting"

This section contains details relevant to siting the IWPF. The INEL Site Development Plan shall be used to locate new facilities on existing or new sites to ensure effective site utilization and to preclude future conflicts between existing and new facilities. The following conditions and requirements shall be considered during site selection for a new facility:

- Programmatic and operating efficiency
- Natural topographic and geologic conditions
- Existing cultural, historic, and archaeological resources
- Endemic plant and animal species
- Existence of known RCRA or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites
- Special siting requirements for facilities containing, using, or processing hazardous materials
- Health, safety, and environmental protection requirements
- Indoor air quality impacts
- Hazardous operations and consequences of potential accidents in adjacent facilities
- Natural hazards
- Physical protection requirements

- Security and safeguard requirements
- Adequacy of existing or planned support and service facilities, including utilities, roads, and parking areas
- Interrelationships between facilities and aesthetic compatibility
- Energy conservation requirements
- Impact of site selection.

This section states that the above conditions be considered when siting a new facility but does not specifically prohibit any locations.

4.1.1 Section 0200-1.3, "Radiological Siting Guidelines"

For those facilities in which radioactive materials are processed, used, or stored, the acceptability of the site shall be evaluated in terms of potential radiological consequences. The accidents to be considered are those attributable to both operational events and natural phenomena.

The following siting guidelines apply to offsite individuals receiving the maximum dose from exposure to internally-deposited radioactive materials or radiation from external sources. Guidelines are based on a 50-year committed dose equivalent. The maximum calculated dose shall not exceed 25 rem to the whole body, 300 rem to the thyroid, 300 rem to the bone surface, 75 rem to the lung, or 150 rem to any other organ. If multiple organs receive doses from the same exposure, the effective dose equivalent from all sources shall not exceed 25 rem when calculated using the weighting factors defined by the International Commission on Radiological Protection, Report No. 26. These guidelines will be used in siting the IWPF.

4.1.2 Section 0200-2, "Building Location"

This section states that new buildings and building additions shall be located in accordance with the INEL Site Development Plan. Conditions are listed for siting consideration, including those listed in Section 4.1 of this report and also architectural and functional compatibility requirements.

4.1.3 Section 0200-99, "Special Facilities"

This section requires site evaluation and studies necessary to provide the technical basis for location, with appropriate consideration given to the immediate and long-term consequences of releases of radioactive or other hazardous materials to the environment. The potential hazards from other onsite facilities and offsite sources of hazards that could affect the safe operation of the facility shall be considered. Proximity to utilities, the fire department, and other services shall be considered. In addition, meteorological, hydrological, and seismological studies shall be performed in accordance with the requirements in this section.

4.2 Section 0285, Subpart 2, "Site Selection"

Site selection is the most critical step in establishing TSD facilities for hazardous, nonhazardous, and low-level radioactive waste. The following conditions and requirements shall be considered during the selection of solid waste TSD sites:

- Existing groundwater and surface water conditions
- Soil, geologic, and topographic features
- Solid waste types and quantities
- Social, geographic, and economic factors
- Aesthetic and environmental impacts.

This section states that the above conditions be considered during site selection but does not specifically prohibit any locations.

4.2.1 Section 0285-2.2.2, "Environmentally Sensitive Areas"

The following environmentally sensitive areas shall be avoided or receive lowest siting priority for treating, storing, and disposing of hazardous, nonhazardous, and radioactive solid waste:

- Wetlands
- Areas within the 500-year floodplain
- Permafrost areas
- Critical habitats of endangered species
- Recharge zones of sole-source aquifers
- Watersheds for domestic water supply.

Since all but the 500-year floodplain are already restricted by other laws or do not apply to the INEL (i.e., permafrost areas), this section will have little impact on siting of the IWPF. The 500-year floodplain will need to be considered when siting the proposed IWPF.

4.2.2 Section 0285-2.2.3, "Fault Zones and Karst Terrain"

When potential sites are screened for location of new solid waste TSD facilities, seismic zones and karst (limestone formation) terrain shall be avoided unless site-specific evaluations demonstrate minimum potential for contamination of surface water, groundwater, and other environmental resources. The INEL has no karst terrain, but seismic zones will need to be investigated further when siting the proposed IWPF.

4.2.3 Section 0285-2.2.4, "Cost Effectiveness"

Life-cycle cost analysis shall be performed during site selection for TSD facilities and shall include site reclamation costs.

4.2.4 Section 0285-2.2.5, "Sites Traversed by Utilities"

Sites traversed by buried pipe utilities shall not be used for TSD facilities unless the relocation or protection of these utilities is economically feasible. Buried pipe utility trenches can serve as a pathway for the migration of contaminants. This restriction applies to the proposed IWPF.

4.2.5 Section 0285-2.2.6, "Characteristics and Availability of Soil Cover"

The characteristics and availability of onsite soil cover shall be considered with respect to site operation and performance requirements.

4.2.6 Section 0285-2.2.7, "Site Access"

Sites shall be accessible to service and refuse collection vehicles by all-weather road extensions from primary road systems.

4.2.7 Section 0285-2.2.8, "Effects on Other Facilities"

Sites that would adversely affect operation of other facilities shall be avoided. The following effects shall be considered:

- Vehicular traffic
- Noise
- Litter
- Bird strike
- Vectors
- Other nuisance conditions.

This restriction does apply to the proposed IWPF.

4.2.8 Section 0285-2.2.9, "Site Approval"

Final site approval for TSD facilities for hazardous, nonhazardous, and low-level radioactive wastes shall be obtained from the cognizant DOE Field Office.

5. SERVICE AND SUPPORT REQUIREMENTS

The IWPF service and support siting criteria were developed from the requirements contained in DOE orders, CFRs, commercial standards, and executive orders. The following EG&G Idaho departments were also contacted to obtain additional information and verify requirements: Security; Facilities and Maintenance; Environment, Safety, and Quality; Fire Protection; Occupational Medical; and Waste Management Operations.

5.1 DOE Order 6430.1A, "General Design Criteria"

DOE Order 6430.1A is a comprehensive regulation that provides general criteria and requirements for all aspects of DOE construction projects. It contains service and support siting requirements in the following categories:

- Security
- Fire protection
- Occupational medical
- Commercial power
- Water
- Roads
- Traffic control
- Sanitary water treatment

DOE Order 6430.1A, Section 0200-1.1, states "During site selection for new facilities, adequacy of existing or planned support facilities and services including utilities, roads, and parking areas shall be considered." Because all of the above items fall under the category of support facilities and services, their existence shall be considered in the IWPF site selection process. Regulations and requirements for these service and support categories are presented in the following subsections.

5.1.1 Security

40 CFR 264, "General Facility Security," addresses access control for a hazardous waste facility. This document states that the owner or operator of a hazardous waste facility must prevent the unknowing entry and minimize the possibility for the unauthorized entry of persons or livestock onto the active portion of the facility. The IWPF is a RCRA TSD facility, therefore this access control requirement applies.

The following siting criterion follows from the regulations and requirements presented above:

- If possible, the IWPF should be sited within the fence line of an existing secure facility or located close enough to the fence line of an existing secure facility to permit the extension of the existing fence line to enclose to IWPF.

This criterion will minimize the cost of providing security for the IWPF. DOE 6430.1A supports the considerations of existing security services.

5.1.2 Fire Protection

Fire protection is a support function with fire stations at Central Facilities Area (CFA), Test Area North (TAN), and Argonne National Laboratories-West. Best management practice suggests that the IWPF be sited as close to one of these facilities as possible to minimize response time to a fire. Because no specific maximum response time requirement was found in the regulations and DOE Order 6430.1A states that existing fire protection facilities shall be considered in the siting process, the following item shall be considered a criterion for the IWPF:

- Minimize the response time from the IWPF to an existing fire station or stations.
- Maximize the potential use of existing fire protection systems.

5.1.3 Occupational Medical

Occupational medical serves a support function with facilities (i.e., infirmaries) located at CFA, Idaho Chemical Processing Plant, Test Reactor Area, TAN, Naval Reactor Facility (NRF), and Argonne National Laboratories-West. Best management practice suggests that the IWPF be sited as close to one of these facilities as possible to minimize response time to a medical emergency. Because no specific maximum response time requirement was found during this study and DOE Order 6430.1A states existing occupational medical facilities shall be considered, minimizing response time to a medical emergency shall be considered a "want" and weighted accordingly through the site evaluation process.

Based on the above considerations and on DOE 6430.1A, which states that the adequacy of existing or planned service and support facilities be considered in siting a new facility, the following siting criterion is proposed for the IWPF:

- Minimize the response time to an established INEL medical facility.

5.1.4 Commercial Power

Commercial power required for the IWPF can be delivered either by transmission lines that can be run either above or below grade. Due to the widespread occurrence of basalt at or near the ground surface at the INEL and the difficulty and cost of excavating in lava rock, the assumption is made that all power lines shall be placed above grade.

Because a conceptual design has not yet been completed for the IWPF, the total demand for power is an unknown quantity at this time. While the total amount of power that the IWPF will

require for operation is unknown at this time, the following "want" siting criteria is proposed for the IWPF:

- Minimize the length of new power lines to the IWPF from existing power distribution lines.

5.1.5 Potable Water

DOE Order 6430.1A, Section 266.2, states "Domestic water conveyed within distribution systems that serve DOE facilities shall comply with the applicable Safe Drinking Water Act (SDWA), 40 CFR 141 requirements and with all other State, regional, and local requirements." The following requirements for potable water are provided in these documents:

- 40 CFR 141, Section 5, "Siting Requirements." Before a person may enter a financial commitment for or initiate construction of a new public water system or increase the capacity of an existing public water system, he shall notify the state and, to the extent practicable, avoid locating part of or all the new or expanded facility at a site that is subject to a significant risk from earthquakes, floods, fires, or other disasters that could cause a breakdown of the public water system or a portion thereof; or is within the floodplain of a 100-year flood or is lower than any recorded high tide (not applicable for intake structures)
- 40 CFR 264, Subpart C, Section 32, "Required Equipment," provides requirements for such items as pumps, supply lines, valves, and any other equipment needed to supply water to a facility.

A conceptual design has not yet been developed for the IWPF. Processes and facilities that would require water have not been identified, nor has the number of personnel required to operate the facility been established. Therefore, the total demand of the facility for potable water cannot be estimated at this time. The total demand for potable water cannot be stated as a criterion until at least a conceptual design has been completed for the IWPF.

Regardless of the quantity of water required to operate the facility, the quality of the water must meet state and Federal drinking water standards. For this reason, groundwater should not be drawn from locations at which known contaminated groundwater plumes exist or are anticipated to exist based on available groundwater monitoring data and modeling studies. Locations at the INEL where contaminated groundwater plumes exist or are anticipated to exist are summarized in Orr and Cecil (1991), although other sources of information should also be investigated.

DOE Order 6430.1A states that existing water supply facilities capable of providing adequate potable water to the IWPF should be identified and considered in siting the facility. This will help reduce the capital cost of the IWPF.

5.1.6 Roads

Access to the IWPF facility is addressed in DOE Order 6430.1A, Section 0250-3, which states "Geometric design of all roads, streets, access drives, and parking areas shall comply with AASHTO GDHS-84," which provides design requirements for the geometric construction of paved surfaces.

All roads constructed to support the IWPF must meet the above requirements; existing paved roads are assumed to meet these requirements. In keeping with DOE Order 6430.1A, which states "the adequacy of existing or planned support and service facilities including utilities, roads, and parking areas shall be considered," the adequacy of existing or planned roads should be considered in siting the IWPF.

Regulations that address the transportation of hazardous and mixed waste across public accesses (e.g., U.S. Highways 26, 20, 33, and 22) must be considered in siting the IWPF. These regulations are contained in the Department of Transportation (DOT) requirements provided in 49 CFR Subchapter C, "Hazardous Materials Regulations," which states that in order to use a public access to transport hazardous or mixed waste, a licensed cask such as transuranic pack or control access to that road (close the road and prepare a transport plan) must be used. Best management practice to reduce risk of exposing the public to a hazardous or mixed waste spill would be to keep the transportation of waste on public roads to a minimum. Therefore, the requirement shall be to minimize transportation of waste on roads that are not DOE access controlled roads.

The following criterion shall be considered when siting the IWPF:

- Minimize the transportation of waste shipments between facilities.

5.1.7 Traffic Control

Traffic control is addressed in DOE Order 6430.1A, Section 0250-6, which states "Signs, pavement markings, and channelization shall comply with ANSI D6.1." Because traffic patterns for the IWPF have not yet been designed, specific requirements provided in DOE Order 6430.1A, Section 0250-6, cannot be identified at this time. However, traffic control facilities are support facilities; therefore existing traffic control facilities must be considered in siting the IWPF, in keeping with DOE Order 6430.1A.

5.1.8 Sanitary Water Treatment

Wastewater services are addressed in DOE Order 6430.1A, Section 0267-1, which states "complete chemical analyses of potential water source shall be acquired prior to selection of industrial water treatment processes." Section 0270-1, "Sanitary Wastewater Collection System," states "wastewater collection system layouts shall be as simple and direct as possible."

This section provides the following specific requirements for wastewater service, which will be considered essential for siting the IWPF:

- Velocities in gravity sewers and force mains shall not exceed 10 ft/second

- Gravity sewers shall be designed for a minimum velocity of 2 ft/second
- Force mains shall be designed for a minimum velocity of 3.5 ft/second.

The IWPF sewer service must meet all of the above requirements.

Sewer service facilities are support facilities, therefore existing sewer service facilities must be considered in keeping with DOE Order 6430.1A, which states "During site selection for new facilities, adequacy of existing or planned support and service facilities including utilities, roads, and parking areas shall be considered." Use of existing sewer service facilities would lower the capital cost of the IWPF, therefore the following criterion is proposed:

- Maximize the utilization of existing excess sewer service capacity.

5.1.9 General Service and Support

The following requirements are also relevant to siting the IWPF:

- Maximize the distance from public highways.
- Minimize the commuting distance from Idaho Falls, Pocatello, and Blackfoot.
- Minimize the length of new roads.
- Minimize the cost of excavation by avoiding excavation in basalt rock. This requirement is an effort to minimize new construction cost.
- Maximize distance from site boundaries.
- Use of existing service and support facilities to support the IWPF shall have no negative impacts on existing facilities (i.e., increase fire risk to neighboring facility, contamination release down wind of the IWPF, pumping an existing facility's production well dry, overloading existing traffic patterns). Potential negative impacts on planned facilities should be considered on a case-by-case basis.

6. SITE SELECTION CRITERIA

The site selection criteria were developed to identify the requirements of the following siting categories:

- Cost (fixed, maintenance, operational, other)
- Environmental
- Health and safety
- Archeological
- Geological
- Service and support
- Others, as required.

6.1 Cost Criteria

Criteria were developed to minimize costs associated with utilities, roads, construction, and travel (see Table 1). These costs will be driven by whether or not the site has these existing capabilities or they have to be developed. The focus of the criteria based on cost is on minimization of costs associated with each candidate site. Additionally, DOE Order 6430.1A, Section 0285-2.2.4, requires that life-cycle cost analysis, including site reclamation costs, be performed for site selection of TSD facilities.

6.2 Environmental Criteria

Environmental criteria were developed based on environmental requirements identified in Section 3. The most restrictive environmental criterion stems from TSCA and prohibits locations in the 100-year floodplain if the IWPF stores PCBs (Section 3.8). RCRA as implemented in 40 CFR 264.18 restricts locations of TSD facilities based on seismic and floodplain considerations. Additional environmental criteria were developed to include those areas that would have an environmental impact as a result of siting. Table 2 identifies the criteria developed from these regulations and requirements. Siting guidelines, less defined and binding than the criteria, are presented in Table 3.

6.3 Health and Safety Criteria

One criterion was developed based on the health and safety requirements in DOE Order 6430.1A for radiological siting guidelines (see Table 2). The criterion was designed for low risk of public exposure to radiation. Additional health and safety criteria were developed to address distance from site boundaries, interactions with existing facilities, and unexploded ordnance (see Tables 1 and 3).

Table 1. IWPF service and support siting criteria.

Criteria area	Regulations/requirements	Criteria
Security	DOE 6430.1A	If possible, the IWPF should be sited within the fence line of an existing secure facility or located close enough to the fenceline of an existing secure facility to permit the extension of the existing fenceline to enclose the IWPF (Section 5.1.1).
Fire protection	DOE 6430.1A; best management practice	Minimize the response time from an existing fire fighting facility to the IWPF (Section 5.1.2).
Occupational medical	DOE 6430.1A; best management practice	Minimize the response time from the IWPF to the existing medical facilities at CFA and/or NRF (Section 5.1.3).
Commercial power	DOE 6430.1A; best management practice	Minimize the length of new power lines to the IWPF from existing power distribution lines (Section 5.1.4).
Potable water	DOE 6430.1A; best management practice	Existing supplies of potable water should be identified and considered in siting the IWPF. Groundwater must not be drawn from locations at which known contaminated groundwater plumes exist, are known to exist, or are anticipated to exist (Section 5.1.5).
Roads	DOT requirements in 49 CFR Subchapter C	Minimize utilization of roads for transporting hazardous waste to the IWPF, which are not DOE access controlled (Section 5.1.6). Minimize transportation distance of waste to facility.
Traffic control	DOE 6430.1A; best management practice	Maximize the utilization of existing traffic control facilities. Minimize the negative impacts on existing traffic control facilities (Section 5.1.7).

Table 1. (continued).

Criteria area	Regulations/requirements	Criteria
Effects on other facilities	DOE 6430.1A	Sites that would adversely affect operation of other facilities shall be avoided (Section 4.2.7).
Utilities (buried pipe)	DOE 6430.1A	Sites traversed by buried pipe utilities shall not be used for TSD facilities unless the relocation or protection of these utilities is economically feasible (Section 4.2.4).
Sewer services	DOE 6430.1A; best management practice	Maximize the use of existing sewer service facilities (Section 5.1.8).

Table 2. Environmental siting criteria applicable to the IWPF.

Criteria area	Regulations/requirements	Criteria
Air quality	Clean Air Act of 1970 (42 U.S.C. 7401 et seq.)	The IWPF cannot be located in a site such that air emissions from the facility will visibly impair any Class I area (Section 3.9).
Archeological/historical	National Historic Preservation Act of 1966 (16 U.S.C. 470 et seq.)	The IWPF cannot have any direct adverse impacts on sites listed or eligible for listing on the National Register of Historic places (Section 3.3).
CERCLA or RCRA sites	General Design Criteria (DOE Order 6430.1A)	Locations of known RCRA and CERCLA sites shall be avoided in locating the IWPF (Section 4.1).
Endangered or threatened species	Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.)	The IWPF cannot be located within an endangered or threatened species critical habitat (Section 4.4).
Geological features—seismic zones and karst terrain	40 CFR 264.18	The IWPF shall not be located within 61 meters (200 ft) of a fault that has had displacement in Holocene time (i.e., during the last 10,000 years) (Section 3.1.1).
	DOE General Design Criteria (DOE Order 6430.1A)	Fault zones and karst terrain shall be avoided or receive the lowest siting priority (Section 4.2.2).
Radiological	40 CFR 191.03	The IWPF must be sited such that the combined annual dose equivalent to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation from such management and storage shall not exceed 25 millirems to the whole body and 75 millirems to any critical organ.
	40 CFR 61 Subpart H	The IWPF must be sited such that emissions of radionuclides to the air shall not exceed those amounts that would cause any member of the public to receive an effective dose equivalent of 10 mrem/yr.

Table 2. (continued),

Criteria area	Regulations/requirements	Criteria
	DOE General Design Criteria (DOE Order 6430.1A)	The IWPF must be sited such that potential accidents attributable to both operational and natural phenomena do not result in doses to offsite individuals that exceed levels given in Section 4.1.1.
Water, surface—flood plains	40 CFR 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions."	The IWPF cannot be located at a site below the 100-year flood water elevation if the facility contains PCBs or PCB items with concentrations of 50 ppm or greater (Section 3.8).
	40 CFR 264.18	If the IWPF does not store PCBs or PCB items but stores RCRA hazardous or mixed waste, it cannot be located in the 100-year flood plain unless it meets one of three conditions: (a) the facility is protected, via dikes or other equivalent measures, from washout during a 100-year flood, (b) all hazardous materials can be moved to safe ground prior to flooding, and (c) it can be demonstrated that no adverse effects to human health and the environment will occur should flood waters reach the waste (Section 3.1.2).
	DOE General Design Criteria (DOE Order 6430.1A; Section 0285; Subpart 2)	500-year floodplains shall be avoided or receive the lowest siting priority for TSD of hazardous, nonhazardous, and radioactive solid waste (Section 4.2.1).
Water, surface—watersheds for domestic water supply	DOE General Design Criteria (DOE Order 6430.1A)	Watersheds for domestic water supply shall be avoided or receive the lowest siting priority for TSD of hazardous, nonhazardous, and radioactive solid waste (Section 4.2.1).

Table 2. (continued),

Criteria area	Regulations/requirements	Criteria
Water, groundwater	DOE General Design Criteria (DOE Order 6430.1A)	Recharge zones for sole source aquifers shall be avoided or receive the lowest priority rating for TSD of hazardous, nonhazardous, and radioactive solid waste (Section 4.2.1).
Wetlands	"Protection of Wetlands" (Executive Order 11990)	Federal agencies shall avoid undertaking new construction projects located on federally-owned wetlands (Section 3.10).
	DOE General Design Criteria (DOE Order 6430.1A)	Wetlands shall be avoided or given lowest priority when siting the IWPF (Section 4.2.1).

Table 3. Environmental Siting Guidelines Applicable to the IWPF.

Guideline category	Regulations/requirements	Guidelines
Archeological/ historical	DOE Advisory Council on Historic Preservation; Idaho State Historic Officer	An archeological survey will need to be performed on all candidate sites (Section 3.3).
Geological features— geological complexity	Best engineering judgement	The ability of the site to be characterized (i.e., not a complex geological location) shall be considered when siting the IWPF.
Geological features— ground slope	Best engineering judgement	The slope of the land surface and corresponding energy available for erosion shall be considered when siting the IWPF.
Geological features— volcanic exclusion zones	Best engineering judgement	The distance from volcanic exclusion zones shall be considered when siting the IWPF.
Pre-operational monitoring	General Environmental Protection Program (DOE 5400.1)	An environmental study shall be conducted prior to startup of a new site that has the potential for adverse environmental impact (Section 3.12.1).
Remoteness from site boundaries	Best engineering judgement	Remoteness from site boundaries shall be considered when siting the IWPF.

6.4 Archeological Criteria

The National Historic Preservation Act, as implemented in 36 CFR 800, requires the mitigation of potential adverse effects on archeological or historical sites. This was developed into a siting criterion (see Tables 2 and 3).

6.5 Geological Criteria

In addition to the floodplain and seismic criteria stated in Section 6.2, other geological criteria were developed to address seismic and volcanic zones (see Tables 2 and 3). There are no clear definitions of these zones except by the NRC, whose regulations do not govern the IWPF but in this case may be used as a best management practice.

6.6 Service and Support Siting Criteria

Service and support siting criteria and guidelines identified in the Section 5 of this report are summarized in Table 1.

7. SUMMARY AND CONCLUSIONS

The physical location of a TSD facility directly influences the potential for impacting human health and the environment. Physical locations refer to the geologic, hydrologic, and pedologic characteristics of a site as well as adjoining lands, surface water, and groundwater that may be impacted in the event that hazardous and/or radiological constituents are released from the facility. Proper site selection and appropriate hydrologic and geologic conditions are important factors in maintaining long-term protection of the environment.

The first step taken in selecting a site for the proposed IWPF is to assume that the facility would be located at the INEL, thus, the region of interest is the 890 square miles encompassing the INEL. The INEL is located near Idaho Falls in the Eastern Snake River Plain physiographic province. The dominant geologic features of the Snake River plain were formed by volcanism. However, the plain is bordered by basin and range mountains that were created by normal faults.

The siting of the proposed IWPF will be accomplished by excluding all sites on the INEL that do not meet the mandatory requirements. The remaining sites will then be rated according to various differentiating criteria that will impact site selection but are not strict requirements. Risk factors will be assigned to these criteria based on their probability and seriousness and will be used in the final decision-making process.

The following is a list of requirements applicable to the INEL for the location of the proposed IWPF, as determined from EPA regulations and DOE orders.

- The IWPF cannot be located at a site below the 100-year flood water elevation if the facility contains PCBs or PCB items with concentrations of 50 ppm or greater (Section 3.8).
- If the IWPF does not store PCBs or PCB items but stores RCRA hazardous or mixed waste, it cannot be located in the 100-year floodplain unless it meets one of the three conditions discussed in Section 3.1.2.
- If the IWPF is located in Bingham, Bonneville, Clark, or Jefferson Counties, portions of the facility where treatment, storage, or disposal of hazardous waste will be conducted cannot be located within 61 m (200 ft) of a fault that has displaced during the last 10,000 years (Section 3.1.1).
- The IWPF cannot have any direct adverse impacts on sites listed or eligible for listing on the National Register of Historic Places (Section 3.3).
- The IWPF cannot be located within an endangered or threatened species critical habitat (Section 3.4).
- The IWPF cannot be located in a site such that air emissions from the facility will visibly impair any Class I air quality area (Section 3.9).

- The IWPF will be located so that the maximum calculated dose from exposure to internally deposited radioactive materials and/or radiation from external sources to offsite individuals shall not exceed the limits identified in Sections 4.1.1 and 3.13.
- The IWPF cannot be located on a site traversed by buried pipe utilities unless it meets the requirements in Section 4.2.4.
- The IWPF cannot be located on a site that would adversely affect the operation of other facilities (Section 4.2.7).
- The location of existing RCRA and/or CERCLA sites shall be avoided (Section 4.1).
- The adequacy of existing or planned support and service facilities shall be considered (Section 4.1).
- The 500-year floodplain shall be avoided (Section 4.2.1).
- Wetlands shall be avoided (Section 3.10).
- Seismic zones shall be avoided (Section 4.2.2).
- The remoteness from site boundaries shall be considered.
- The impacts of location above a sole-source aquifer shall be considered.
- The effects of DOT regulations on the transport of waste to and from the IWPF shall be considered.
- The slope of the land surface and corresponding energy available for erosion shall be considered.
- The distance from volcanic exclusion zones shall be considered.
- The commuting distance to the IWPF shall be considered.
- The costs of installing new utilities and roads shall be considered.
- The ability of the site to be fully characterized (i.e., not a complex geological location) shall be considered.
- The location of unexploded ordnance shall be considered.
- The co-location of the IWPF with other proposed facilities at the INEL shall be considered.

Siting criteria and guidelines were developed for the IWPF through reviews of pertinent regulations and published guidelines. Environmental siting criteria and guidelines are presented in Tables 2 and 3, and service and support siting criteria and guidelines are presented in Table 1.

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Appendix A

Definitions

Appendix A

Definitions

Alpha low-level waste

Without regard to source or form, waste that is contaminated with alpha-emitting transuranic radionuclides with half-lives greater than 20 years and concentrations greater than 10 nCi/g but less than 100 nCi/g at the time of assay (DOE 5820.2A).

Coastal zone

The coastal waters (including the lands therein and thereunder), strongly influenced by each other and in proximity to the shorelines of the several coastal states; includes islands, transitional and intertidal areas, salt marshes, wetlands, and beaches (16 U.S.C. 1453).

Displacement

The relative movement of any two sides of a fault measured in any direction (40 CFR 264.18).

Fault

A fracture along which rocks on one side have been displaced with respect to those on the other side (40 CFR 264.18).

Holocene

The most recent epoch of the Quaternary period, extending from the end of the Pleistocene to the present, that is, during the last 10,000 years (40 CFR 264.18).

Pleistocene

An epoch of the Quaternary period, beginning two to three million years ago and lasting to the start of the Holocene.

Polychlorinated biphenyl (PCB)

Any chemical substance that is limited to the biphenyl molecule that has been chlorinated to varying degrees, or any combination of substances that contains such substance (40 CFR 761.3).

PCB item

Any PCB article, article container, container, or equipment that deliberately or unintentionally contains or has a part of it any PCB or PCBs (40 CFR 761.3).

Quaternary

The second period of the Cenozoic era, following the Tertiary, beginning two to three million years ago and extending to the present.

Transuranic waste

Without regard to source or form, waste that is contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years and concentrations greater than 100 nCi/g at the time of assay (DOE 5820.2A).

Volcanic Exclusionary Zone

Outside "recent" lava flows, at least three miles from "older" vents, and at least five miles from "recent" vents (Sivill 1990).

Washout

The movement of hazardous waste from the active portion of the facility as a result of flooding (40 CFR 264.18).

Wetland

Land areas where the water table is at, near, or above the land surface long enough to promote the formation of hydric soils and to support the growth of hydrophytes.

100-year flood

A flood that has a one percent chance of being equalled or exceeded in any given year (40 CFR 264.18).

100-year floodplain

Any land area that is subject to a one percent chance of flooding in any given year from any source (40 CFR 264.18).

Appendix B

Federal Threatened, Endangered, and Candidate Species and State Species of Special Concern on the INEL

Appendix B

Federal Threatened, Endangered, and Candidate Species and State Species of Special Concern on the INEL

Common name	Scientific name	Federal status ^a	State status ^a
Plants			
Painted milk-vetch	<i>Astragalus ceramicus</i>	C2	NL
Wooly pod milk-vetch	<i>Astragalus purshii</i>	C2	NL
Oxytheca	<i>Oxytheca dendroidea</i> ^b	NL	SC
Pincushion cactus	<i>Coryphantha missouriensis</i>	NL	SC
Large-flowered gymosteris	<i>Gymosteris nudicaulis</i>	NL	SC
Birds			
Peregrine falcon	<i>Falco peregrinus</i>	E	SC
Merlin	<i>Falco columbarius</i>	NL	SC
Gyr falcon	<i>Falco rusticolus</i>	NL	SC
Osprey	<i>Pandion haliaetus</i>	NL	SC
Bald eagle	<i>Haliaeetus leucocephalus</i>	E	SC
Swainson's hawk	<i>Buteo swainsoni</i>	C2	SC
Ferruginous hawk	<i>Buteo regalis</i> ^b	C2	SC
Burrowing owl	<i>Athene cunicularia</i> ^b	NL	SC
White-faced ibis	<i>Plegadis chihi</i>	NL	SC
Long-billed curlew	<i>Numenius americanus</i>	C2	SC
Mammals			
Townsend's western big-eared bat	<i>Plecotus townsendi</i>	C2	NL
Bobcat	<i>Lynx rufus</i> ^b	NL	SC

a. Status Codes: C2 = Category 2 species; E = endangered species; NL = not listed;
SC = species of special concern; T = threatened species.

b. Known to occur on the NPR site.

Source: DOE 1991.

Appendix C

Action Plan to Characterize Selected Sites for the Idaho Waste Processing Facility and the Mixed and Low-Level Waste Treatment Facility

**ACTION PLAN TO CHARACTERIZE SELECTED SITES
FOR THE IDAHO WASTE PROCESSING FACILITY
AND THE
MIXED AND LOW-LEVEL WASTE TREATMENT FACILITY**

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May 1993

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ACRONYMS

ACHP	Advisory Council on Historic Preservation
AE	adverse effect
AIRFA	American Indian Religious Freedom Act
ARPA	The Archeological and Historic Preservation Act of 1974 (P.L. 93-291)
CEMA	Center for Environmental Monitoring and Assessment
CRM	Cultural Resources Management
DEQ	Idaho State Department of Environmental Quality
DOE	U.S. Department of Energy
DOE-ID	Department of Energy - Idaho Field Office
EA	environmental assessment
EDE	effective dose equivalent
EIS	environmental impact statement
EPA	Environmental Protection Agency
GPS	global positioning system
IAQB	Idaho Air Quality Bureau
INEL	Idaho National Engineering Laboratory
IMACS	Intermountain Antiquities Computer System
INEL	Idaho National Engineering Laboratory
IRC	INEL Research Center
IWPF	Idaho Waste Processing Facility
MLLW TF	Mixed and Low-Level Waste Treatment Facility
NAE	no adverse effect
NAGPRA	Native American Graves Protection and Repatriation Act
NE	no effect
NEPA	The National Environmental Policy Act of 1969 (NEPA) (P.L. 90-190)
NHPA	The National Historic Preservation Act of 1966 (NHPA) (P.L. 89-665)
NRC	U.S. Nuclear Regulatory Commission
NSPS	New Source Performance Standard
PCB	Polychlorinated biphenyl
RWMC	Radioactive Waste Management Complex
RESL	Radiological and Environmental Sciences Laboratory
SHPO	State Historic Preservation Office
SIRAC	Southeastern Idaho Regional Archeological Center
TSCA	Toxic Substances Control Act
TSD	Treatment/Storage/Disposal

ACTION PLAN TO CHARACTERIZE SELECTED SITES FOR THE IDAHO WASTE PROCESSING FACILITY AND THE MIXED AND LOW-LEVEL WASTE TREATMENT FACILITY

1. INTRODUCTION

1.1 Background

During the summer and fall of 1992 a preliminary study¹ was performed to select candidate locations for the Idaho Waste Processing Facility. The result of that study was a recommendation^a of three sites on the Idaho National Engineering Laboratory (INEL) that were judged to be acceptable for locating the combined Idaho Waste Processing Facility and Mixed and Low-Level Waste Treatment Facility (IWPF/MLLW TF). Pursuant to that recommendation the Waste Management Facility Projects unit of the Environmental Restoration and Waste Management Department of EG&G Idaho, Inc. requested that an assessment be performed to determine what site-specific data may be helpful in final site selection. In addition, it was requested that a plan to obtain the data be drafted. This report constitutes the response of unit B610 to those requests.

1.2 Disclaimer (September, 1994)

It is here acknowledged that not all the characterization actions described herein will necessarily be performed. Rather this document was written to provide rough estimates of costs, schedules, and work scopes involved in obtaining site characterization data, beyond what is already available (if necessary), to facilitate the planning and budgeting process for siting the waste management units mentioned above.

It should also be noted that this document was originally generated in May, 1993 for the purposes listed above. It is included as an appendix to EGG-WM-11118 to provide background information for technical site evaluation activities that have taken place since the preliminary study in 1992 (see above). The language of the original report has been preserved so that the activities are described as if they are yet to be done. However, several of the activities have been completed as of the date of publication of EGG-WM-11118. Estimates of cost and schedule (present in the original document) have been removed, since they are no longer useful.

^a Letter from D. D. Taylor to M. R. Martin, Siting of Idaho Waste Processing Facility (IWPF) and Mixed/Low-level Waste Treatment Facility (MLLW TF) on the INEL, Interoffice Correspondence, DDT-12-92, September 30, 1992.

1.3 Assumptions

The following assumptions have been made in assembling the information contained herein:

1.3.1 Licensability of Treatment Facilities

As of this writing, no decision has been made regarding whether or not the subject facilities (i.e., the IWPFF/MLLW TF) will be licensable by the U.S. Nuclear Regulatory Commission (NRC). Therefore, while NRC guidelines have been considered in the definition of site characterization activities, there has been no attempt to address all such guidelines.

1.3.2 Objective of Characterization Activities Described Herein

The objective of the activities described in this report is to obtain site-specific data which can be used to compare the sites previously recommended¹ for the IWPFF/MLLW TF on the basis of the siting criteria² which were used. The intent is not the complete characterization of these sites. It is presumed that exhaustive characterization activities will be performed later in the development of the facilities to support documents such as the Environmental Impact Statement, Performance Assessment, etc. While the data obtained from the activities described in this plan will undoubtedly be used as part of an exhaustive characterization, complete characterization *per se* is beyond the scope of the current effort. Rather, the data to be collected through the activities of this characterization plan should constitute a basis for a more quantitative comparison of the merits/drawbacks of the candidate sites than was possible during the preliminary siting exercise, and thus provide a defensible, objective basis for final site selection.

1.3.3 Locations of Sites

The locations of three of the sites to be characterized under this plan are described in Ref. 1, and are shown below in Figure 1.3.3.1. (e.g., Site #1 is within the blackened square in the cross-hatched region labeled as "Area #1", etc.) The fourth site is one which was not among the recommendations in Ref. 1, but which is likely to be added to the list of recommended sites. It will be in the area adjacent to the east boundary of the Radioactive Waste Management Complex (RWMC).

1.3.4 Use of Existing Information

Efficiency and cost effectiveness are essential considerations in the current siting effort. Therefore, in order to minimize characterization costs, existing information will be utilized to the maximum extent possible, in gathering the data required to address the issues described below in Section 1.4.

Figure 1.2.3.2. Recommended sites for the IWP/MLLW Treatment Facility

1.4 Issues to be Addressed

The preliminary site selection for the IWPF/MLLW TF was performed on the basis of data that was available at the time of the siting study. Such data was available from a number of sources and much of it proved useful for purposes of screening large areas of the INEL and helping to identify sites which would likely be acceptable. However, in some cases there was either no data available, or else the data that was used was only suggestive of how specific sites should be judged against the siting criteria. For example 40 CFR 761, which contains location standards for facilities which store polychlorinated biphenyl (PCB) wastes regulated by the Toxic Substances Control Act (TSCA), explicitly prohibits siting such facilities at locations which are "below the 100-year flood water elevation". There is currently no comprehensive flooding map of the entire INEL which identifies those areas which are below the 100-year flood water elevation. However, for the purposes of the preliminary site selection it was possible to generate a map showing the areas of the INEL thought to be immune from flooding, on the basis of a few objective criteria. The formal, regulatory demonstration that these areas are actually above the 100-year flooding elevation, however, requires additional data.

The siting issues considered by the siting coordinator to be in the above category, requiring additional characterization data, are described briefly below.

1.4.1 Seismic Issues

Section 3.1.1 of Ref. 2 deals with regulatory seismic restrictions in siting of new TSD facilities. While at present it appears that these restrictions are not applicable (See Section 2.1) it has been pointed out^a that the Environmental Protection Agency (EPA) has recently issued regulations concerning groundmotion for design of municipal landfills. It appears likely that such regulations will likely be imposed on siting of new TSD facilities in the near future (See footnote "a" on page 2-3). In addition to likely regulatory concerns in the future, seismic considerations could influence construction costs.

For these reasons it is reasonable to assume that the seismic characteristics of the candidate sites for the IWPF/MLLW TF should be considered in the final selection of a site. The action plan for looking at possible differences in the seismic characteristic of the sites is contained in Section 2.3.

1.4.2 Flooding Issues

Section 3.1.2 of Ref. 2 deals with restrictions on Treatment/Storage/Disposal (TSD) facilities which are located in floodplains, as prescribed in Resource Conservation and Recovery Act (RCRA) regulations in 40 CFR 264.10. Section 3.8 deals with the TSCA restriction that prohibits siting facilities below the 100-year flooding elevation which store (for disposal) PCB-contaminated wastes. In order to demonstrate compliance with these and other flooding regulations it is necessary to formally and authoritatively establish the boundaries of all land on the INEL which is below the 100-

^a Personal communication from R. P. Smith of the Geology & Seismology unit of EG&G Idaho, Inc. to D. D. Taylor on 2/22/93.

year flooding elevation and/or in the 100-year floodplain. The action plan for addressing the flooding issue is contained in Section 3.3.

1.4.3 Cultural Resource Issues

Section 3.3 of Ref. 2 deals with the issue of preservation of historical artifacts and/or sites that may be present on the INEL. The National Historic Preservation Act of 1966 requires that mitigating measures be adopted to minimize adverse effects on properties listed or eligible for listing on the National Register of Historical Places. Other relevant regulations require that a formal archaeological survey be performed on all candidate sites in order to assess the probability of finding historic or prehistoric artifacts. The action plan for addressing requirements relating to these cultural resources is contained in Section 4.2.

1.4.4 Endangered Species

Section 3.4 of Ref. 2 deals with siting requirements related to the preservation of threatened or endangered species as currently identified by the federal government and the state of Idaho. The action plan for complying with these requirements is contained in Section 5.2.

1.4.5 Air Pollution

Section 3.9 of Ref. 2 deals with the prevention of visibility degradation in Class I areas (i.e., national parks and wilderness areas above a certain size). Section 3.13 deals with restrictions on emissions of radionuclides to the ambient air on and near the INEL. In addition to these regulations the Clean Air Act Amendments of 1990 contain new provisions relating to emission of hazardous air pollutants, and the state of Idaho imposes restrictions on facilities which emit pollutants to the air and has formal permitting requirements for such facilities. The ability to comply with these requirements depends both on site characteristics and on facility design. Site-specific data could therefore influence final site selection from the standpoint of air pollution considerations. An action plan to obtain the necessary data is contained in Section 6.3.

1.4.6 Contaminant Migration Issues

Section 4.1.1 of Ref. 2 deals with guidelines contained in U.S. Department of Energy (DOE) Order 6430.1A regarding the maximum allowable dose from exposure to radiation due to accidental and catastrophic natural events. In addition to these guidelines are those contained in DOE Order 5400.5 which deal with the maximum allowable radiation dose to the public from all causes due to DOE operations. Pursuant to these orders are further siting guidelines in DOE Order 6430.1A which require that hydrological studies be performed to investigate the potential for contaminant migration in surface water and ground water.

The action plan for looking at possible differences in the subsurface contaminant migration characteristic of the candidate sites for the IWP/MLLW TF is contained in Section 7.4. (Surface water concerns are addressed in Section 3.3.)

1.4.7 Buried Utilities

Section 4.2.4 of Ref. 2 deals with siting requirements related to the existence of buried utilities. The action plan for complying with these requirements is contained in Section 8.2.

1.4.8 Soils

Section 4.2.5 of Ref. 2 deals with siting requirements related to the types and amounts of soil cover present at prospective sites. The action plan for complying with these requirements is contained in Section 9.2.

1.5 References

1. D. D. Taylor, R. L. Hoskinson, C. O. Kingsford, *Site Screening for New Waste Handling Facilities at the Idaho National Engineering Laboratory*, EGG-WM-11118, September 1994, Appendix A ("Preliminary Site Selection for the Idaho Waste Processing Facility and the Mixed & Low-Level Waste Treatment Facility at the Idaho National Engineering Laboratory").
2. D. J. Kufen, J. F. Zukauskas, M. J. Ancho, L. W. Ball, *Preliminary Siting/Service and Support Criteria for the Proposed Idaho Waste Processing Facility at the Idaho National Engineering Laboratory*, EGG-WMO-10303, June 1992.

2. ACTION PLAN FOR SEISMIC ISSUES

2.1 Purpose

The purpose of this action plan is to obtain information that could impact site selection for the IWPF/MLLW TF on the basis of seismic characteristics of the sites being considered. The seismic location standard for facilities where treatment, storage, or disposal of hazardous waste will be conducted is that such facilities must be at least 61 m (200 ft) from any fault which has had displacement in the Holocene time period^a. However, this standard is only applicable for specific counties listed in Appendix VI of 40 CFR 264. The fact that all the recommended sites for the IWPF/MLLW TF lie within Butte County (which is not among the listed counties where the above seismic standard applies) means that the recommended sites are assumed to be in compliance with the seismic standard for regulatory purposes. Thus, there is no regulatory concern that would dictate a preference for any one of the sites.

Notwithstanding the lack of a regulatory driver for seismic concerns in siting, there may be a basis for preference of one site due to differences in the probable ground motion from seismic events. Peak levels of ground motion, for example, may dictate structural design requirements of facilities on the basis of worker safety concerns. Thus, a plan is outlined in this section to determine whether seismic considerations should be a major factor in final site selection. The following subsections describe seismic data that should be gathered to address this question.

2.2 Required Site-Specific Data

Before funds are committed to seismic characterization of all the recommended sites it should be determined whether such characterization is warranted for the purposes of siting. That is, an assessment should be made of the potential consequence of not addressing differences in seismic characteristics when choosing the final site. As suggested above, the cost of designing and building the facility is directly related to the magnitude of the expected peak ground motion during earthquake excitation. Therefore, the desirability of including seismic characteristics in the final siting decision can be gauged by quantitatively estimating the maximum possible difference in ground motions at the recommended sites.

This estimate could be made on the basis of existing data, assuming such data is representative of the maximum possible variation in seismic parameters that might occur on the INEL. If this variation is not considered significant (in terms of its impact on the predicted range of ground motion) then no further seismic characterization is needed for site selection. Otherwise, additional data should be obtained in order to estimate actual differences in expected ground motions between the sites under consideration. The parameters that have been requested by the U.S. Nuclear Regulatory Commission for seismic characterization of nuclear disposal sites have been summarized in Ref. 1. The key parameters among these for prediction of expected ground motions are described briefly below.

^a 40 CFR 264.18(a)

2.2.1 Historical Earthquakes Within 200 Miles of Sites

Historical data should be researched to list available parameters for earthquakes within 200 miles of the sites in question having a magnitude greater than 3.0. The list should include (where possible) the following;

- Time,
- Focal depth,
- Epicenter coordinates,
- Highest intensity,
- Magnitude,
- Distance from sites being evaluated.

2.2.2 Geologic Structures

All the geologic structures and tectonic provinces within the region that are important in determining the earthquake potential should be identified. When capable faults are identified in the vicinity of the sites a regional map should be provided showing the tectonic provinces, the location of the historical earthquakes with respect to these faults, and the location of geologic structures associated with these faults.

2.2.3 Maximum Earthquake Magnitude

The maximum credible earthquake associated with each geologic structure or maximum historical earthquake associated with each tectonic province should be identified. Frequency content of the earthquake should be discussed, when possible.

2.2.4 Estimate of Site-Specific Ground Motion

The ground motion at the sites under consideration should be estimated using appropriate attenuation models for the area. The maximum earthquakes associated with tectonic provinces should be placed where the tectonic province is closest to the respective sites. For the floating earthquake within the same tectonic province of a site the earthquake should be placed at an appropriate distance from the site.

To estimate ground motion at the candidate sites a knowledge of the seismic wave transmission properties from the sources to the sites is essential. In addition, material overlying the bedrock at the site should be described because this material will amplify or deamplify the upcoming seismic waves. Peak horizontal and vertical accelerations at the site should be estimated by using applicable attenuation relationships. The potential for amplification of vibratory ground motion in the overburden should be addressed. If possible, probabilistic seismic hazard estimates should be provided.

2.2.5 Settling Potential

Deformation and differential settlement of subsurface and fill materials under both static and seismic conditions, analysis for liquefaction potential, and consequences of liquefaction of subsurface soil affecting the stability of the cover material should be analyzed.

2.3 Action Plan

As mentioned in Section 2.2 the first task deemed prudent to perform is to assess whether a comparison of the candidate sites on the basis of seismic difference is warranted. If this assessment indicates that it is desirable to proceed with comparison of site seismic differences, a plan to obtain such a comparison is detailed below.

2.3.1 Task Descriptions.

- (a) Assess need for further seismic characterization of sites. This task is to determine whether or not additional funds should be committed to seismic characterization of the sites, as described above in Section 2.2. It requires completion of the following subtasks:
- (1) Assemble existing geologic, seismologic, geotechnical, and geophysical data for the INEL. Identify the input parameters required for model predictions of local ground acceleration, and locate existing data which would provide conservative (but reasonable) estimates of the probable ranges of these parameters on the INEL.
 - (2) Estimate range of probable ground motions. Calculate the range of ground accelerations corresponding to the range of model input parameters identified in 2.3.1(a)(1) using a computer model developed for this purpose².
 - (3) Evaluate need for site-specific seismic characterization. This task is to determine whether the range of ground accelerations obtained from task 2.3.1(a)(2) indicates that a "best estimate" comparison of seismic characteristics is warranted. This task will involve consultation with the facility designers to estimate the range of design and construction costs associated with the estimated range of ground motions obtained from task 2.3.1(a)(2). It will also involve legal consultations to determine whether seismic evaluation of the sites may be mandatory in the future^a. The result of this

^a While it has already been noted that the location of all candidate sites inside Butte County removes seismic considerations as a regulatory concern, it is likely that at some point in the future, prior to construction of the IWP/MLLW TF, this would not be the case. In a letter from Ms. Felicia Wright of the Environmental Protection Agency to Sandra H. Kent of EG&G Environmental Technical support, dated July 23, 1992, the following statement is found:

"...40 CFR 264.18(a) (seismic considerations) only addresses the risks of earthquake fault rupture in certain areas of the western United States, and does not address seismic ground

task will be a determination whether to proceed with seismic characterization of the recommended sites as described below.

Much of the information described in Sections 2.2.1 through 2.2.5 pertains to the entire INEL and is available from prior studies (e.g., see Ref. 3). In addition to those studies, a comprehensive program of geologic, seismologic, and geotechnical investigations for site characterization at the INEL was initiated under the direction of the U.S. Department of Energy Office of New Production Reactors (DOE-NP) to obtain additional geophysical information necessary for characterization of the INEL. However, only about half the goals of this program had been accomplished at the time when funding for these activities was curtailed. Additional studies required to complete the objectives of the program have been recommended^a. A subset of the recommended studies which is considered necessary to estimate probable peak ground motions at the recommended sites for the IWPF/MLLW TF is given below. These studies, their associated subtasks, and their relationship to the parameters described in Sections 2.2.1 through 2.2.5 are discussed in the task descriptions:

- (b) Obtain site specific geotechnical data. This task is to provide some of the information described in Sections 2.2.4 and 2.2.5, namely, sites' foundation bearing capacities, seismic wave transmission characteristics, and suitability in terms of faulting and ground cracking. This task would involve the following subtasks:
- (1) Perform detailed surface-to-drill-hole seismic surveys (downhole surveys) at candidate sites using knowledge of interbed positions to place geophone strings in the drill holes. Using geophones placed at critical interfaces and shear wave sources at the surface, determine S-wave velocities of the sedimentary interbeds. Combine this information with other data on seismic velocities of basalts at various depths to generate P- and S-wave velocity profiles at the sites selected for the IWPF/MLLW TF.
 - (2) Obtain core samples and undisturbed sediment samples. Depth to which samples will be taken will be determined by subsurface characteristics at each site.
 - (3) Perform laboratory tests to determine static and dynamic mechanical properties of subsurface media from core and sediment samples. These tests will provide:
 - i. Grain size analysis of sediments,
 - ii. Plasticity characteristics,

motion. EPA research indicates that seismic ground motion has the potential to damage or destroy landfill and impoundment berms, dikes, and covers; and to damage or destroy the foundations and piping of tanks and ancillary units and equipment vital to the safe and proper operation of incinerators...For these reasons, EPA is considering development of a location standard, applicable to all of the United States, that would address the risks due to seismic ground motion as well as fault rupture."

^a Copy of proposal by R. P. Smith and W. R. Hackett titled, "Proposal for Completion of the Geological, Seismologic, and Geotechnical (GSG) Investigations for Site Characterization at the INEL", received by D. D. Taylor on 1/20/93.

- iii. Moisture content,
- iv. Dry density,
- v. Specific gravity,
- vi. Consolidated, drained triaxial shear strength,
- vii. Direct shear strength,
- viii. Elastic Modulus,
- ix. Uniaxial compressive strength,
- x. Brazilian tensile strength,
- xi. Point load test data,
- xii. Dynamic elastic properties of undisturbed sediment samples (as determined from cyclic loading tests).

- (c) Determine segmentation characteristics of capable faults. The two major capable faults that have been identified on the INEL (Section 2.2.2) are the Lemhi and the Lost River Faults. Extensive investigations of the Lemhi Fault were conducted for the NPR program and the extent of the fault is fairly well-characterized. Similar investigations were begun, but not completed, on the Lost River Fault. This task is therefore to complete this work in order to provide needed input for the determination of maximum earthquake magnitudes as discussed in Section 2.2.3. The following subtasks will be completed:
- (1) Complete detailed mapping for the Lost River Fault incorporating geologic and geodetic measurements of movements due to fault structures in bedrock.
 - (2) Complete detailed mapping for the northern end of the Arco volcanic rift zone.
- (d) Paleoseismic investigations of nearest capable faults. This task is to generate, for the identified major capable faults on the INEL, the information described in Sections 2.2.1 and 2.2.3. Several excavations that already exist along the Lost River Fault can be used or modified to reveal fault history in the Arco segment. Additional excavations may also be desirable. This task is to complete these investigations for the Lost River Fault in order to determine the recurrence intervals and maximum magnitudes of earthquakes in the region of the INEL.
- (e) Site-specific ground motion assessment. This task is to review information from the other tasks above, make appropriate modification to model inputs generated during task 2.3.1(a)(2), and to re-model the ground motion; i.e., generate the quantitative estimates described in Section 2.2.4. The site-specific ground accelerations predicted by this modeling would provide a quantitative basis for comparison of the sites recommended for the IWP/MLLW TF.

2.4 References for Section 2

1. Site Characterization Handbook for Low-Level Radioactive Waste Disposal Facilities, prepared for the U.S. Department of Energy Office of Environmental Restoration and Waste Management, DOE/LLW-67T, January 1992.
2. Earthquake Strong Ground Motion Estimates for the Idaho National Engineering Laboratory, prepared by Woodward-Clyde Consultants, EGG-BG-9350, November, 1990.
3. A. L. Bowman, W. F. Downs, K. S. Moor, B. F. Russell, INEL Environmental Characterization Report, Appendices D1 through D7, prepared for the U.S. Department of Energy Idaho Operations Office, EGG-NPR-6688, September 1984.

3. ACTION PLAN FOR FLOODING ISSUES

3.1 Purpose

The purpose of this action plan is to obtain information that could impact site selection for the IWPF/MLLW TF on the basis of the ability to demonstrate compliance with regulatory requirements relating to potential flooding at the facility. The requirements which drive the gathering of site-specific data are discussed in the following subsections.

3.1.1 RCRA Requirements Related to Flooding

40 CFR 264.10, "Applicability," states that the floodplain restrictions apply only to TSD facilities subject to regulation under Subparts I through O of this part. Subpart I addresses the use and management of containers, and Subpart O addresses incinerators. Since the IWPF will be subject to these subparts the floodplain restrictions will apply¹.

40 CFR 264.18(b) imposes additional specific requirements on any facility located in a 100-year floodplain to the effect that the facility must be designed and operated so as to prevent washout of any hazardous waste by a 100-year flood, or procedures must be in effect to enable wastes to be relocated before flood waters can reach the facility, or it must be demonstrated that no adverse effects on human health or the environment will result if washout should occur during flooding.

As used above, the term "100-year floodplain" means any land area which is subject to a one percent or greater chance of flooding in a given year from any source, and "100-year flood" means a flood that has a one percent chance of being equalled or exceeded in any given year.²

40 CFR 270.14(b)(11) specifies requirements relating to:

- (a) Providing information about mapping the 100-year floodplain around a facility,
- (b) Required methods for floodplain determination. Specifically, where available, maps prepared by the Federal Insurance Administration (FIA) of the Federal Emergency Management Agency (FEMA) are to be used; otherwise, "equivalent mapping techniques to determine whether the facility is within the 100-year floodplain" are to be used,
- (c) Providing analyses to show fluid dynamic and static forces that might be encountered during flooding, structural studies showing how flood protection devices will prevent washout,
- (d) Describing the procedures to be followed to remove hazardous wastes to secure locations prior to flooding.

² 40 CFR 264.18(b)(2)

3.1.2 TSCA Requirement Related to Flooding

The IWPF/MLLW TF will be subject to the Toxic Substances Control Act if it stores for disposal wastes containing PCBs or PCB items at concentrations of 50 ppm or greater¹. 40 CFR 761.65(b)(v) states that:

"...The facilities shall meet the following criteria...(v) Not located at a site that is below the 100-year flood water elevation."

On the assumption (as stated in Ref. 1) that the IWPF will store PCBs or PCB items with concentrations of 50 ppm or greater, the above requirement applies.

3.1.3 Executive Order 11988

Prior to taking any proposed action, section 2(a)(1) of the order requires a government agency to determine whether the action will occur in a floodplain^a. Moreover, the order recommends that "critical actions" be located outside the 500-year floodplain or protected to the 500-year level^b.

3.1.4 Mapping of Flooding Areas

The flooding regulations cited in Section 3.1 apply to flooding from all sources, including (a) generalized flooding along the normal channels of established streams, and (b) localized flooding due to runoff and ponding. It has been noted^c that it is relatively easy to show that facilities can be sited above the probable maximum flood (PMF) for Big Lost River events. Since the land area within the PMF floodplain exceeds that within the 100-year and 500-year floodplains it follows that the same conclusion is applicable to these latter events. Demonstration that the sites recommended for the IWPF/MLLW TF are not subject to source (a) due to the Big Lost River (BLR), the Little Lost River (LLR), or Birch Creek (BC) (the only major streams on the INEL) is discussed in Sections 3.1.4.1 and 3.2.1.

Flooding from source (b) has occurred on the INEL in the past. Portions of the Radioactive Waste Management Complex (RWMC), for example, were flooded in 1962, 1969, and 1982^d. Methods for assessing the susceptibility of specific locations to such flooding events are discussed in Sections 3.1.4.2, 3.2.2, and 3.3.1.

^a Handout from Gerald Sehlke at meeting to discuss flooding issues relevant to the INEL sitewide Environmental Impact Statement, held December 18, 1992 at EG&G Idaho, Inc., Teton Village Complex.

^b Letter to D. L. Wessman (DOE-ID) from A. L. Bowman (EG&G Idaho, Inc.) dated January 5, 1993. Subject: INFORMATION ON INEL FLOODING POTENTIAL

^c See footnote b, page 3-2.

^d As discussed by R. C. Martineau during his discussion of flooding at the meeting described in footnote a, page 3-2.

Since FIA maps are not available for the INEL (and hence, DOE-ID has not made a floodplain determination for the site)^a the application of equivalent methods mentioned in Section 3.1.1(b) is necessary. Such methods are described in Ref. 2.

3.1.4.1 Mapping of Areas Subject to Generalized Flooding. Mapping of the 100-year and 500-year flooding elevations on the INEL has been cited as a requirement to support several regulatory drivers (including those cited in Section 3.1) and DOE orders applicable to the INEL. In light of this fact, an INEL Floodplain Study has been initiated by the Environmental Assessment and Permitting Department of EG&G Idaho, Inc.^b This study will include development of topographic maps for the BLR, LLR, and BC drainages, as well as other selected RCRA facilities and RCRA/CERCLA corrective action sites which were excluded from previous mapping studies. These maps will provide two-foot contours at a map scale of 1:1200.

The U.S. Geological Survey (USGS) recently completed, as part of this study, a streamflow analysis of gaging data to determine the volume of water associated with the 100-year and 500-year recurrence interval flooding events for each drainage. A floodplain study will be conducted by using cross-sectional survey data together with the information gathered from the streamflow analysis using the USGS Water Surface Profile (WSPRO) model to estimate the boundaries for the 100-year and 500-year floods. The floodplain boundaries will be plotted on the topographic maps per FEMA guidelines.

3.1.4.2 Mapping of Areas Subject to Localized Flooding. Guidelines for mapping of areas susceptible to localized flooding are found in Appendix 2 of Ref. 2 where shallow flooding is discussed. "Shallow flooding" is defined to include "unconfined flows over broad, relatively low relief areas, such as alluvial plains; intermittent flows in arid regions that have not developed a system of well-defined channels; ... ; and flows collecting in depressions to form ponding areas."

The recommended approach to identifying ponding areas is to "determine inflow to, and outflow from, the ponding area and calculate the storage volume and elevations using a simple reservoir routing analysis. Hydrographs, empirical formulas, and design equations for culverts and other manmade structures should be considered. Determination of stage-storage relationships requires some topographic information. Wherever adequate contour interval mapping is available, the study contractor should determine storage volumes directly from those maps. Otherwise, a limited number of cross sections should be surveyed to determine storage volumes. The number of cross sections needed will depend on the size of the ponding area, but usually one along the major axis and two perpendicular to that axis will be sufficient...

"Sheet runoff typically takes place across broad areas of low relief. This situation makes it likely that sheet runoff depths will be less than 1 foot. For flood insurance purposes, once a determination has been made that flooding depths are less than 1 foot, the area should be designated as Zone X and more detailed analysis is not required...

^a See footnote a, page 3-2

^b See footnote a, page 3-2.

"The study contractor should determine the 100-year flood discharge at the head of a sheet flow area by an appropriate method. In the absence of a permanent manmade channel or large-scale topographic features to restrict its flow, this discharge should be routed uniformly across the entire area susceptible to sheet flow. Cross section and slope information must be obtained to determine average flood depths across the area..."

3.2 Required Site-Specific Data

3.2.1 Data for Generalized Flooding Assessment

Owing to the conservatism with which the recommended sites for the IWPF/MLLW TF were chosen with respect to flooding criteria, it is expected that the above floodplain study will clearly indicate that these sites are not within the 100-year or 500-year floodplains for the three streams mentioned. For this reason, it is not anticipated that any site-specific data will be required beyond that which may be collected during the mapping activities discussed in Section 3.1.4.

3.2.2 Data for Localized Flooding Assessment

From the approach described in Section 3.1.4.2, the following data are required to assess the localized flooding susceptibilities of the sites recommended for the IWPF/MLLW TF:

- Topographic contours for the areas surrounding the recommended sites which could provide runoff to them,
- Topographic contours for each of the recommended sites, themselves,
- Precipitation information for the areas which discharge runoff to the recommended sites, and for the sites themselves.

The classical steps in using the above information to obtain a flooding analysis for the areas of interest can be described as follows³:

- Simulate basin hydrology,
- Perform frequency analysis,
- Compute water surface profiles.

The first step provides a conceptual model for determining event hydrographs at accumulation points for the sheet type runoff described in Section 3.1.4.2. The second step provides the expected rates of precipitation for the drainage areas of interest for the 100-year and 500-year events. The third step, using inputs from the first two, provides event hydrographs and estimates for water depths along the runoff route(s) identified in the conceptual model.

3.3 Action Plan

Per the conclusions stated in Section 3.2.1, there are no site-specific site characterization tasks that must be performed by the Waste Management Facilities unit in connection with the assessment of flooding from the major streams on the INEL. The only action that might be required in connection with the generalized flooding issue would be administrative action to allocate funds to provide partial support for the flooding study which was described in Section 3.1.4.1. (Whether or not such programmatic will be required or requested, however, has not been determined as of this writing.)

There are some site-specific data requirements for assessment of flooding potential due to local runoff. In order to identify these requirements the three flooding analysis steps identified in Section 3.2.2 have been broken down into specific tasks in the following section.

3.3.1 Task Descriptions for Localized Flooding Analysis

- (a) Assess basin hydrology. This task is to generate conceptual models of the drainage areas for each of the recommended IWPF/MLLW TF sites. This task would involve using existing information (e.g., from USGS 7-1/2 minute maps) to tentatively identify the following features of the respective drainage areas:
 - (1) Probable drainage area boundaries (i.e., ridgelines),
 - (2) Intermittent drainage streams and elevations along their reaches,
 - (3) Flow directions and interconnection points of streams identified in 3.3.1(a)(2),
 - (4) Ponding areas.
- (b) Identify deficiencies in topographic data. This task is to determine for which of the features identified in step 3.3.1(a) additional topographic data is required (i.e., smaller contour intervals) in order to be able to assemble an accurate lumped parameter type reservoir model. The following subtasks should be performed:
 - (1) Assess the adequacy of the definition of the following features which were tentatively defined in step 3.3.1(a):
 - i. Boundaries of drainage areas,
 - ii. Slopes of intermittent streams,
 - iii. Cross-sections of ponding areas, given the guidance from Ref. 2 cited in Section 3.1.4.2,
 - (2) Mark specific regions on the drainage area maps where additional topographic information should be obtained. Consistent with the assumptions, (see Section 1.3.4) where existing US Geologic Survey 7-1/2 minute maps provide sufficient topographic detail for the localized flooding analyses, they will be used in lieu of additional topographic maps.

- (c) Obtain required additional topographic data. This task is to obtain the required contour data in the locations identified in step 3.3.1(b)(2). It requires completion of the following subtasks:
- (1) Select a method for obtaining the required topographic data (e.g., Global Position System, direct survey, or digitization of data from orthographic flyover photographs),
 - (2) Obtain the required data,
 - (3) Document and archive the data, as appropriate (e.g., flyover data is typically archived in the ERIS ARCINFO computer database).
- (d) Perform frequency analysis of precipitation data. This task is to quantify the precipitation rate over the drainage areas identified in step 3.3.1(a). It involves the following subtasks:
- (1) Obtain available historical data for precipitation on and around the INEL,
 - (2) Select a suitable statistical method, and perform the required statistical analyses of the data to define the 100-year and 500-year storms for the area and quantify the precipitation rates on the drainages for the recommended sites for the IWPF/MLLW TF,
- (e) Determine the 100-year and 500-year flooding elevations. This task is to quantitatively evaluate the flooding potentials at the recommended sites for the IWPF/MLLW TF. The following subtasks will be performed:
- (1) Assemble input decks for computer analysis^a of the 100-year and 500-year events using the information obtained in steps 3.3.1(a) through 3.3.1(d). Also, determine a reasonable, conservative snow depth to assume to ensure conservatism in the flooding analyses,
 - (2) Perform computer analyses of 100-year and 500-year storm runoff for all recommended sites for the IWPF/MLLW TF,
 - (3) Document the results in an informal report, describing runoff rates, water depths in ponding areas, and locations of streams and ponds on the recommended sites.

^a Ref. 2 recommends HEC-1 or TR-20. Because of historical experience of EG&G personnel using HEC-1, it would probably be selected to perform the required analyses.

3.4 References for Section 3

1. D. J. Kufen, J. F. Zukauskas, M. J. Ancho, L. W. Ball, Preliminary Siting/Service and Support Criteria for the Proposed Idaho Waste Processing Facility at the Idaho National Engineering Laboratory, EGG-WMO-10303, June 1992.
2. Flood Insurance Study Guidelines and Specifications for Study Contractors, Federal Emergency Management Agency, Federal Insurance Administration, FEMA 37, March 1991.
3. Daniel H. Hoggan, Computer-Assisted Floodplain Hydrology and Hydraulics, McGraw-Hill, New York, NY, 1989.

4. ACTION PLAN FOR THE ARCHEOLOGICAL SURVEY AND CONSULTATIVE REPORT FOR THE SITING OF THE MLLWTF AND IWPF

4.1 Purpose

The purpose of the Archeological Survey and Consultative Report is to comply with several Federal laws and requirements for directing and restricting land altering activities in areas of prehistoric or historic significance. The Federal laws are:

- The Antiquities Act of 1906 (P.L. 59-209)
- The Historic Sites Act of 1935 (P.L. 74-292)
- The National Historic Preservation Act of 1966 (NHPA) (P.L. 89-665)
- The National Environmental Policy Act of 1969 (NEPA) (P.L. 90-190)
- The Archeological and Historic Preservation Act of 1974 (P.L. 93-291)
- The Archeological Resources Protection Act of 1979 (ARPA) (P.L. 96-95)

NHPA and ARPA require the protection of cultural resources during all preproject activities. The cultural resources must also be given proper consideration in the preparation of environmental assessments (EA) and environmental impact statements (EIS), as required by NEPA. However, federal agency obligations under NHPA are independent from NEPA and must be met during all land management activities even if an EA or EIS is not required. In situations where both NEPA and NHPA are applicable, cultural resource assessments are to be prepared and integrated into the EA or the EIS along with the other environmental impact analyses.

Additional requirements that are to be considered concern areas of Native American significance, as specified in the American Indian Religious Freedom Act (AIRFA) and the Native American Graves Protection and Repatriation Act (NAGPRA). If, during any phase of archeological field work or INEL construction activities, human burials are encountered, all work must stop and the Idaho State Historic Preservation Office (SHPO) must be consulted immediately for advice. If the burial is suspected of being prehistoric or historic Native American origin, the Shoshone-Bannock Tribe will be contacted in regard to the subsequent treatment of the human remains and any associated artifacts. The county sheriff and coroner with jurisdiction will also be contacted with regard to any human remains.

4.2 Project Description

The survey and report for this project will review candidate locations on the Idaho National Engineering Laboratory (INEL). These locations are candidate sites for the Mixed and Low-Level

Waste Treatment Facility (MLLWTF) and the Idaho Waste Processing Facility (IWPF) on the INEL. The results will be included as part of the site characterization for the IWPF and MLLWTF project. However, this archeological survey and report will be applicable to the construction of any facility on these locations.

The boundaries of the candidate locations will be marked by the IWPF and MLLWTF Project Managers and Project Engineers. The Center for Environmental Monitoring and Assessment (CEMA) will measure and record the location of these boundary markers using their Global Positioning System (GPS).

The archeological field survey, the consultative report, and the report to the SHPO, will be completed by the INEL Cultural Resources Management (CRM) Unit prior to the initiation of any ground-disturbing activity in any of the candidate locations. The field survey to be conducted is an intensive visual surface survey. Schedule and cost estimates do not include any subsurface investigation or excavation, which may be necessary at a later date as mitigation of the unavoidable adverse impacts of construction.

Neither the CRM office nor the Department of Energy - Idaho Field Office (DOE-ID) can grant the archeological "clearance" necessary to allow the project to proceed. The approval of the survey adequacy, reports, recommendations, and mitigation plans is made by the SHPO in consultation with other groups such as tribal governments and the national Advisory Council on Historic Preservation (ACHP).

Even after the advance field survey, possible test excavations, and careful compliance with NHPA and NEPA, it is possible to discover previously undetected cultural resources during the construction phase. Therefore, all archeological "clearance" recommendations from initial field surveys carry with them the stipulation that work must be halted and the staff of the INEL CRM Unit contacted if an unexpected find occurs. The CRM staff will be prepared to respond to the treatment of unexpected archeological or paleontological finds encountered during project activities.

4.3 Survey Methods

Prior to the ground survey, a literature search of relevant reports and documents will be conducted at the INEL CRM archives, and a request made to the SHPO for a check of State archives for any previously registered sites. This information will be used to generate expectations regarding the distribution, density, and nature of cultural resources in the candidate plots and will also prevent duplication of survey efforts in the event that previous projects have been completed in any of the construction areas.

The systematic ground survey will be conducted by a field crew of three archeologists walking parallel transects 15m to 20m apart within the defined areas. It is estimated that the field crew will survey 40-50 acres per day. Sites will be recorded by :

- completing a planimetric map at each resource location, noting the site dimensions, artifact and feature distributions, and other features of the natural and/or built environment.

- completing Intermountain Antiquities Computer System (IMACS) forms for each resource, describing artifact materials, features, vegetation, aspect, soils, and other natural features.
- entering the sites by sequential numbering on a USGS 7.5 minute map (due to lack of topographic detail in these areas, sites may be located on aerial photographs instead).

4.4 Survey Schedule

The field survey will be conducted only during periods of no snowcover. Present plans are that a representative 40 acre plot in each of the candidate locations will be field surveyed in November, 1992, weather permitting. The remainder of each candidate location will be surveyed in Spring, 1993, after loss of snowcover. Spring field work is tentatively planned to start March 22, 1993, and will be completed in about 6 weeks.

4.5 Site Registration and Artifact Preparation

All cultural resources will be registered through the state historic archival system by submittal of IMACS forms and maps, photographs, and notes. The SHPO requires that all cultural resource site registrations be done in IMACS format. Several state and federal agencies, universities, and private individuals in the region of Idaho, Nevada, Wyoming, and Utah subscribe to the IMACS.

Artifacts collected during the survey will also be submitted for permanent curation according to SHPO recommendations and will be prepared according to the specific guidelines of the Southeastern Idaho Regional Archeological Center (SIRAC) at the Idaho Museum of Natural History.

4.6 Consultative Report

A detailed report will be prepared, including the following:

- Introduction
- General Overview of the Archeological History of the INEL and vicinity, and the Candidate Locations
- Results
 - Description of the Study Areas
 - Detailed Description of Survey methods
 - Evaluation of Results
 - Recommendations
- References

- Appendices
 - Cultural Resources Location Maps
 - IMACS Forms

Information about the exact location of cultural resources on public land is protected by both NHPA and ARPA, and released by federal agencies and their cultural resources repositories on a "need to know" basis. At the INEL, it is considered "Official Use Only" information. The intent is to ensure protection of sites from theft, vandalism, or destruction, not to prohibit legitimate scientific or humanistic study.

To meet these criteria of confidentiality, the policy of the INEL CRM office and the DOE-ID is to limit the circulation of detailed maps and site location information. This information (maps, documents, and site registration forms) is kept in locked files in the CRM office. It is provided to program and project managers who need it for planning purposes, as separate appendices marked "Official Use Only". Copies of these appendices are maintained at the INEL CRM office and are also sent to the SHPO and the SIRAC. The cultural resources location information will be carefully screened and removed from reports that are placed in public reading rooms as part of the NEPA review process.

4.7 Report Schedule

Within two weeks of the completion of fieldwork, a preliminary letter report describing the methods and results of the survey, and providing recommendations for protection of significant finds, will be sent to the SHPO for review and concurrence (as specified by Sec. 106 of NHPA). At that time, contact will also be established with the SIRAC to determine the necessary actions to curate any material collected during the project. The final, referable Consultative Report, expanding on the summary provided in the initial preliminary letter report, will be completed by June 4, 1993. At that time, the Consultative Report will be sent for INEL security/patent review so that it can be sent to all interested parties and can be placed in public reading rooms.

4.8 Mitigation

If any properties that are potentially eligible to the National Register of Historic Places are identified within the bounds of the project area, DOE-ID is required to determine if the project will have any effect on the properties, and is required to provide the ACHP with an opportunity to comment on the project. DOE-ID is also directed by NHPA to make a good faith effort to preserve and protect any such properties.

The assessment of the effects of the project is conducted in consultation with the SHPO and any other parties or agencies that have made their interests known (Native Americans, local governments, general public). For INEL projects this should always include the Shoshone-Bannock Indian Tribes and possibly one or more of the local historical or archeological societies.

Any disagreements between DOE and the SHPO during this process of consultation are directed to the ACHP for mediation. Three determinations are possible:

- No effect (NE): the undertaking will not affect significant resources in any way.
- No adverse effect (NAE): the undertaking will affect one or more resources, but the effect(s) will not be detrimental.
- Adverse effect (AE): the undertaking will result in unavoidable damage to one or more properties.

NE findings are usually reserved for instances when project areas are found to be devoid of cultural resources materials after appropriate field surveys; when project activities will be limited to zones of previous ground disturbance; or when impacts are avoided by modification to the project scope and/or design. When an NE determination is supported, DOE-ID must provide documentation of this to the SHPO and other interested parties, who have 15 days to review the finding. If the SHPO concurs with the finding, along with any measures developed to ensure that no impacts will occur, DOE-ID has completed its responsibilities and the project can proceed. If the SHPO objects to the NE finding, it is assumed an effect will occur and additional consultation will be necessary.

If a project will have an effect, the determination must be made whether the effect is adverse or not. NAE determination is most often the case when the project is limited to rehabilitation of buildings in conformance with the Secretary of the U.S. Department of the Interior's standards for such work; when the project is limited to the transfer, lease, or sale of a property and the exchange contains appropriate preservation plans; or when the cultural resources are of value only for their potential contribution to archeological, historic, or architectural research and can be substantially preserved through the conduct of appropriate field research, data recovery, and analyses.

When an NAE finding is supported, DOE must obtain concurrence from the SHPO and notify the ACHP by submitting appropriate summary documentation for a 30 day review.

Although requirements for appropriate documentation will differ with each specific NAE finding, the following must always be included:

- A description of the project, including photographs, maps, and drawings as necessary
- A description of historic properties that may be affected by the project
- A description of the efforts used to identify historic properties
- A statement of how and why the criteria of adverse effect were found inapplicable
- The written concurrence of the SHPO with the NAE determination
- The views of other interested parties (i.e., local governments, Indian tribes, Federal agencies, public), as well as a description of the means employed to solicit those views.

When the documents are cleared for outside review, they are transmitted to all consulting parties for a 30 day review period. If all consulting parties concur with the NAE determination after

their review, DOE has completed its responsibilities and the project can proceed as long as any commitments made in the NAE summary documentation are honored.

If differences arise between DOE and the consulting parties at this time, they must be resolved through negotiation and may be directed to the ACHP for mediation. Until a resolution is reached, the effect of the project will be considered "adverse".

If it is determined that cultural resources may be adversely impacted, the DOE is legally obligated to consult with the SHPO, the ACHP, and others to mitigate the adverse effects. Whenever possible, adverse effects will be avoided by changes in project scope and/or design, or through means such as stabilization, burial, relocation, and rehabilitation. When adverse effects are unavoidable, DOE will initiate measures to reduce or compensate for the damage that will occur. This mitigation is planned and implemented in consultation with the SHPO and the ACHP, and any other interested parties.

5. ACTION PLAN FOR THE ECOLOGICAL SURVEY AND CONSULTATIVE REPORT FOR THE SITING OF THE MLLWTF AND IWPF

5.1 Purpose

The purpose of the Ecological Survey and Consultative Report is to comply with several Federal laws and Executive Orders to identify and evaluate any potential environmental impacts as a result of the project. The Federal laws and Executive Orders applicable to this project are:

- The National Environmental Policy Act of 1969 (NEPA) (P.L. 90-190)
- The Endangered Species Act of 1973
- Wetlands (Executive Order 11990)

Additional Federal laws which have been considered, but do not apply to this project are:

- Wild and Scenic Rivers Act
- Fish and Wildlife Coordination Act
- Coastal Zone Management Act
- Wilderness Protection Act of 1964

5.2 Project Description

The ecological survey for this project will evaluate candidate locations on the Idaho National Engineering Laboratory (INEL). These locations are candidate sites for the Mixed and Low-Level Waste Treatment Facility (MLLWTF) and the Idaho Waste Processing Facility (IWPF). The results will be a part of the site characterization for the IWPF and MLLWTF project. However, the results will be applicable to the construction of any facility on these locations.

The boundaries of the candidate locations have been marked by the IWPF and MLLWTF Project Managers and Project Engineers. The Center for Environmental Monitoring and Assessment (CEMA) will measure and record the location of these boundary markers using their Global Positioning System (GPS).

The ecological field survey and the consultative report will be done by the Department of Energy - Idaho Field Office (DOE-ID) Radiological and Environmental Sciences Laboratory (RESL) and CEMA.

5.3 Survey Methods

A field survey of each of the locations will be conducted by a field crew of representatives from RESL, CEMA, and the IWPf and MLLWTF projects. The crew will observe and make field notes on:

- the dominant and subdominant vegetation species present
- other vegetation species present, especially species of concern
- animal species present, either observed or indicated (by tracks, nests, burrows, dens, droppings, etc.)
- presence of any critical habitat for rare or endangered species

5.4 Survey Schedule

The field surveys will be conducted during the first three weeks of November, 1992.

5.5 Consultative Report

A detailed report will be prepared, including the following:

- Introduction
- General Overview of the Ecology of the INEL and vicinity, and the Candidate Locations
- Results
 - Description of the Study Areas
 - Soils
 - Vegetation
 - Fauna
 - Detailed Description of Survey methods
 - Evaluation of Results
 - Relationship of the Candidate Locations to Important Species
 - Relationship of the Candidate Locations to Important Habitats
 - Relationship of the Candidate Locations to other Ecological Study Areas
 - Recommendations
- References
- Appendices

This report will include review of the field findings, as well as a review by RESL of the candidate locations with respect to other ecological impacts. Examples of these impacts would be if the candidate location was in an area where ongoing breeding bird surveys have been conducted for several years, or in an area where long-term vegetation transects exist.

In addition, CEMA will review their vegetation maps and wetlands maps to further analyze the impacts, if any, on sensitive vegetation types and/or wetlands. Graphical output of the portions of these maps as defined by the Global Positioning System (GPS) measurements will be included in the Consultative Report as the vegetation and wetlands maps of the candidate locations.

6. ACTION PLAN FOR AIR POLLUTION ISSUES

6.1 Purpose

The purpose of this action plan is to obtain information that could impact site selection for the IWPF/MLLW TF on the basis of the ability to demonstrate compliance with regulatory requirements relating to air emissions from the facility. The regulatory requirements which drive the gathering of site-specific data are discussed in the following subsections.

6.1.1 Federal NESHAPs Program

Radionuclides. The National Emission Standards for Hazardous Air Pollutants (NESHAPs) Program is currently administered by the federal government in the state of Idaho. This program requires written approval from the EPA Administrator prior to construction or modification of a stationary air pollutant source which will emit airborne radionuclides (except in certain exceptional cases)^a. It also requires that the permitted facility comply with the following emission standard^b:

"Emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr."

Compliance with this standard must be demonstrated by calculating the effective dose equivalent (EDE) to the public of air emissions of radionuclide contaminants using the CAP-88 or AIRDOS-PC computer programs, or a model that has previously been approved by EPA. The source term to be used in these calculations is obtained per instructions in 40 CFR 61. Alternatively, actual measurements of radionuclide concentrations at critical receptor locations may be used in place of computer model calculations to determine effective dose equivalent to the public^c.

Toxic Air Pollutants. Under the Clean Air Act Amendments of 1990, the NESHAPs provisions (Section 112 of the Clean Air Act) were extensively revised, and now incorporate an elaborate program to regulate emissions of 189 toxic air pollutants through technology-based standards and, if necessary, additional risk-based standards. The technology-based standards

"shall require the maximum degree of reduction of hazardous air pollutants...that the Administrator, taking into consideration the cost of achieving such emission reduction, and any nonair quality health and environmental impacts and energy requirements, determines is achievable for new or existing sources in the category or subcategory..."^d

^a 40 CFR 61.05(a)

^b 40 CFR 61.92

^c 40 CFR 61.93

^d Clean Air Act §112(d)(2)

The above provision makes no reference to achievement of an ambient standard, but rather imposes technology-based source control requirements, *independent of site-specific conditions at the source*. Therefore, while the above requirement will impact facility design, it should not directly affect site selection. Consequently, no site characterization efforts aimed specifically at compliance with toxic air pollutant provisions of the Clean Air Act are recommended *at this time*.

Nonetheless, as suggested above, the 1990 Amendments include "Residual Risk Provisions" which provide Congress the opportunity to impose additional standards in the future, if it is determined that significant public health risks remain, even after the application of the best or maximum achievable source control technology. This language indicates the possibility of ambient concentration standards for certain toxic substances. Imposition of such standards would again make site-specific conditions (meteorology, geography, topography, etc.) relevant to determinations of compliance. However, no determinations of "residual risk" are mandated by EPA until November of 1996; consequently the above recommendation in regard to characterization activities is deemed appropriate, until such time as the regulatory requirement is changed.

6.1.2 DOE Environmental Monitoring Program

Chapter IV of DOE order 5400.1 (General Environmental Protection Program) mandates a program of monitoring at DOE facilities (that are not specifically exempted). This monitoring program involves measurements of the following types:

- (a) Direct measurement of effluents from DOE operations,
- (b) Environmental surveillance measurements to monitor the effects, if any, of DOE activities on onsite and offsite environmental and natural resources.

The monitoring requirement described under 6.1.2(a) above is directed at demonstration of facility compliance with regulatory limitations on emissions and require no site-specific data. Therefore, this requirement is not discussed further here. However, the surveillance monitoring requirement described under 6.1.2(b) has, as one of its objectives, the establishment of baselines of environmental quality, prior to construction and operation of a new facility in order to be able to assess the potential environmental impacts of the facility. In connection with air pollution-related issues the following specific measurements are required:

- Representative meteorological data to characterize atmospheric transport and dispersion conditions in the vicinity of the DOE facility for assessments of the impacts of airborne releases (routine and non-routine) on public health and safety^a,
- Ambient air quality monitoring to establish background and peak concentration levels of pertinent chemical species at areas where public health and other concerns should be considered, and to evaluate the effects of emissions on ambient contaminant levels.^b

^a DOE 5400.1, Chapter IV, Section 6.

^b DOE 5400.1, Chapter IV, Section 8.b

6.1.3 State of Idaho Permit to Construct Application

Idaho law states that no owner or operator may commence construction or modification of any stationary source, major facility, or major modification without first obtaining a permit to construct (PTC) from the Idaho State Department of Health and Welfare (except for certain specific classes of facilities)^a. For new *major* stationary sources or *major* modifications (see discussion of *major* in Section 6.1.4) in an attainment area (the INEL is currently classified as a Class II attainment area) the application for a PTC must include the following:

- An analysis of the existing ambient air quality in the area that the new facility or modification would affect for each air contaminant that the facility would emit in significant amounts, or that would result in a significant net emissions increase^b.
- An analysis of the effect on air quality by the new facility or modification, including meteorological and topographical data necessary to estimate such effects^c.
- Continuous air monitoring data, gathered over the year preceding the submittal of the application, for any air contaminant which has an ambient air quality standard. The state can approve a shorter time period for monitoring if it determines that such a period is adequate^d. Also, no analysis is needed if the projected increases in ambient concentrations or existing ambient concentrations in the affected area of the facility do not exceed published *de minimis* amounts^e. The operation of monitoring stations shall meet the requirements of 40 CFR 58 Appendix B, or such other requirements as the State may approve^f.
- Such air quality monitoring data that the state determines is necessary to assess facility effects on ambient air quality for any air contaminant which does not have an ambient air quality standard^g.
- Monitoring of visibility in any Class I area that the new facility would affect (as

^a IDAPA 16.01.01012,02

^b IDAPA 16.01.01012,04.a.iii.(g)

^c IDAPA 16.01.01012,04.a.iii.(b)

^d IDAPA 16.01.01012,04.a.iii.(i)

^e IDAPA 16.01.01012,04.a.iii.(h)

^f IDAPA 16.01.01012,04.a.iii.(l)

^g IDAPA 16.01.01012,04.a.iii.(j)

requested by the state)^a.

It should be noted that determinations of significance and impacts to air quality must consider both the proposed project, and all other INEL projects within the previous ten years whose emissions have not been accounted for in the issuance of a PSD permit. That is, the collective emissions of *all* new sources on the INEL (including the one under consideration) since the last PSD permit was issued are to be used in such determinations. The actual quantities of emissions and concentration impacts considered to be significant are prescribed by Idaho law on a pollutant-specific basis^b.

6.1.4 State of Idaho PSD Review

For new facilities or modifications to existing facilities in an attainment area (such as the INEL) Idaho law requires that an emissions review be conducted. This review is to demonstrate that the facility change will not cause the ambient concentration of any criteria pollutant to increase more than the allowable amount of increase (or "increment") for the area^c. Allowable increments for the criteria pollutants are listed in the Idaho Code^d. The emissions review (called a Prevention of Significant Deterioration [PSD] review) is mandatory for any *major* modification to a *major* facility with potential emissions of 250 tons per year or more of any contaminant. Since the INEL is considered a single source for air permitting purposes, and emissions of some air pollutants already exceed 250 tons per year, a PSD review is required for any major modification (or addition). A modification is considered major if a *significant* net emission increase would occur for any air contaminant, where significance is determined as described above (see final paragraph in Section 6.1.3)^e.

The PSD review must incorporate additional analyses and demonstrations to establish that the allowable emission increases from the new facility will not result in a violation of any ambient air quality standard or a degradation of the air quality beyond what is allowed by the PSD increment for the area^f. An allowable PSD increment for a given contaminant is defined once a *major source baseline date* is established. After this date, construction of any major new stationary source, or any major modification of a stationary source, will consume a portion of the increment for the pollutant under consideration. In addition to the major source baseline date, the *minor source baseline date* is the date after which emissions from all new or modified sources consume increment, and is the earliest date after a prescribed *trigger date* on which a complete application for a major source or major modification is submitted to the IAQB¹.

^a IDAPA 16.01.01012,04.a.iii.(k)

^b IDAPA 16.01.01003,86 and IDAPA 16.01.01003,87

^c IDAPA 16.01.01012,07.a

^d IDAPA 16.01.01101,05.

^e IDAPA 16.01.01012,07.d

^f IDAPA 16.01.01012,07.a.ii

6.1.5 New Source Performance Standards (NSPSs)

For certain categories of new facilities, 40 CFR 60 and Idaho Air Quality Bureau (IAQB) regulations are applicable. These regulations specify emission restrictions, equipment design requirements, and/or operational parameters. However, at the present time, it is not anticipated that the subject waste handling facilities will fall into any of the regulated categories. NSPS standards are therefore assumed nonapplicable.

6.2 Required Site-Specific Data

Projected impacts of the new facilities on the effective dose equivalent discussed in Section 6.1.1 will be assessed using computer models for atmospheric dispersion to calculate radionuclide concentrations at specific receptor locations chosen to conservatively represent an individual residing near the INEL who is maximally exposed on an annual basis. From the calculated concentrations of specific radionuclides the EDE will be estimated.

A similar approach will be used to project impacts of the new facilities on ambient air quality discussed in Section 6.1.3. In the case of federal NESHAPs, and state PTC and PSD requirements the evaluation of facility performance will depend on two types of site-specific measurements: (a) meteorological measurements which are necessary to model transport and dispersion of emitted contaminants, and (b) ambient contaminant concentrations prior to construction (and operation) of the new facilities which are necessary to determine the EDE due to all sources (including the new facilities) for NESHAPs, and to determine whether national air quality standards or allowable increments will be violated. The specific measurements that will be required are discussed below. A possible third type of measurement that could be required per Section 6.1.3 is (c) visibility at the Craters of the Moon Wilderness Area.

6.2.1 Meteorological Data

The following data is generally required for contaminant fate and transport calculations:

- Windspeed,
- Wind direction,
- Temperature,
- Precipitation,
- Vertical temperature gradient,
- Vertical mixing height.

Depending on the contaminant of concern, the required analyses discussed in Section 6.1 will require different time averages of the above meteorological data (e.g., 8-hr, 24-hr, quarterly, annual). In addition, some calculations will require joint frequency distributions of some of the measurements (most notably, windspeed and direction). Because of the variability of weather conditions on the INEL the data must be representative of at least a year.

Raw data is available for wind speed, wind direction, temperature, and precipitation at several locations on and around the INEL. Only recently, however, has instrumentation been installed to

measure upper air parameters such as vertical temperature gradient and mixing height. (A radar profiler was installed during the fall of 1992 which is capable of these types of measurements.) In addition, none of the above meteorological data have been obtained at the specific locations of the candidate sites for the IWPF/MLLW TF. National Oceanic and Atmospheric Administration (NOAA) personnel have indicated^a that the upper air measurements from the single radar profiler near the NPR site are adequate for characterization of the entire INEL. In regard to site specific measurements of the other parameters listed above, the following is recommended:

- (a) For Site #1 (see map in Section 1.3.3 for locations of Sites #1, #3, and #5) at the southern end of the INEL near the Radioactive Waste Management Complex the data from the existing meteorological station at the RWMC is sufficient.
- (b) For Site #3 located roughly midway between Test Area North (TAN) and the Idaho Chemical Processing Plant (ICPP) existing data from meteorological stations around the site could be used to estimate site specific parameters. However, owing to the location of Site #3 near the confluence of northeasterly air flows from TAN and northwesterly airflows from the Howe area, the representativeness of data from surrounding stations may be questioned. For this reason additional measurements on the site may be needed.
- (c) Site #5, located at the northern end of the INEL near the intersection of State Highways 22 and 28, also lies near the confluence of two airsheds on the INEL. In addition, the topographic characteristics of the site differ significantly from that of the meteorological stations near the site to the northwest, northeast, and south. For these reasons site specific measurements at Site #5 may be necessary.

Notwithstanding the above recommendations, required site-specific data should be discussed with DEQ prior to obtaining any measurements beyond those currently available from NOAA.

6.2.2 Existing Air Quality Data

The Department of Energy Radiological and Environmental Sciences Laboratory (DOE-RESL) has measured specific airborne radionuclide concentrations on the INEL for several years. In addition, it has monitored concentrations for three of the criteria pollutants identified in the Clean Air Act, namely, SO₂, NO_x, and Total Suspended Particulates (TSP)^b.

Because of the location where radionuclide concentrations are measured on the INEL these measurements are considered by RESL to be conservative estimates for maximal offsite concentrations for the purposes of calculating public EDEs. RESL's measurements of NO_x at two locations on the INEL are also considered to be representative of the ambient air quality since ambient NO_x standards are generally based on mean annual concentrations. In the case of SO₂ and TSP where ambient

^a Conversation with Gene E. Start, Jerrold F. Sagendorf, and C. Ray Dixon of the National Oceanic & Atmospheric Administration Air Resources Lab Field Research Division in Idaho Falls on 2/23/93.

^b Phone conversation with E. W. Chew of DOE-RESL on January 6, 1993.

standards are based on both short term (24-hr) and long term averages (annual)^a the spatial representativeness of the RESL measurements for the entire INEL may be questionable. In addition, any other contaminants besides the three monitored routinely by RESL that will be emitted in significant quantities may require ambient air quality monitoring as prescribed by the DEQ in order to provide the required information for a PTC.

The following considerations are prerequisites to any ambient air quality monitoring that may be required. First, a conceptual design for the IWPF/MLLW TF must be available to specify all air contaminants that may be emitted in significant quantities. Second, a determination must be made of the site-specific location where ambient air quality monitoring is to be done. State regulations specify that ambient air is "that portion of the atmosphere, external to buildings, to which the general public has access"^b. Therefore, a determination is needed for the location where the maximal impact on ambient air quality will be felt by the public for each of the three candidate sites for the IWPF/MLLW TF.

6.2.3 Existing Visibility at Craters of the Moon Wilderness Area

To date, all analyses of visibility degradation at the Craters of the Moon Wilderness Area (the nearest Class I area to the INEL) due to INEL facilities have shown that there is no significant impact. On this basis it is expected that the current facilities will yield the same result. The visibility impact is typically assessed by performing a screening analysis using EPA's VISCREEN model. Since the only required inputs for this model are²:

- Distance between the facility and the wilderness area,
- Location of the wilderness area within the United States,
- Particulate emission rate from the facility,
- NOx emission rate,
- SO2 emission rate

it is presumed that no further site-specific data will be required for site evaluations and comparisons on the basis of visibility impairment at the Craters of the Moon Wilderness Area.

6.3 Action Plan

The action plan outlined below provides a two-tiered approach to addressing the impact of air pollution concerns on site selection for the IWPF/MLLW TF. The first tier, consisting only of task 6.3.1(a), is a relatively inexpensive screening of the sites on the basis of atmospheric dispersion modeling performed using existing meteorological data from network of monitoring stations currently in place and operated by the National Oceanic and Atmospheric Administration on and near the INEL. There are two objectives of this first tier of the plan: (a) to provide an objective estimate of the average annual air pollutant concentration at offsite receptor locations that would result from a

^a See, for example, IDAPA 16.01.01003,87.a, IDAPA 16.01.01003,87.b, and IDAPA 16.01.01003,87.c.

^b IDAPA 16.01.01003,10

prescribed pollutant release rate at the locations of the candidate sites, (b) determine whether the uncertainty in the predicted annual pollutant concentration due to uncertainties in site-specific meteorological parameters is sufficiently great to warrant the cost of setting up additional meteorological monitoring stations at Sites #3 and #5 (see Section 6.2.1).

The estimates of annual offsite pollutant concentrations resulting from the first tier of the plan could provide a basis for comparing sites from the standpoint of the air pollution issue, depending on the result of the uncertainty analysis. The second tier of the plan, consisting of tasks 6.3.1(b) through 6.3.1(i), involves the state-imposed air quality monitoring and modeling requirements for permitting, together with any meteorological monitoring that may be deemed necessary on the basis of the first tier uncertainty analysis.

It should be noted that the results of the first tier (plus any additional meteorological monitoring) could provide a basis for site comparisons and a tentative site selection. If such a selection were done prior to the second tier of characterization activities, and no significant problems surfaced during the latter characterization, then plan costs would be substantially reduced (i.e., second tier characterization activities would then be performed only for the chosen site). In the event that second tier characterization indicated problem with the selected site, and an alternative site had to be chosen, then second tier characterization activities would have to be repeated for this site. In this case, there would be no cost saving. In addition, there would be a schedule penalty due to the time required for the characterization activities to be completed for the second site. Thus, the decision whether or not to perform second tier characterization efforts for a single, or for multiple sites, is a decision that project management will have to make.

6.3.1 Task Descriptions

- (a) Model offsite pollutant concentrations using existing data. This task is to provide a preliminary, quantitative estimate of the relative "goodness" of the candidate sites from the standpoint of expected offsite pollutant concentrations, and to identify whether additional meteorological data should be obtained in order to reduce uncertainties in this estimate. The objective of this task is to provide objective input to the site characterization and selection processes, and *not* to satisfy specific requirements for air permitting. Modeling for air permitting is addressed under task 6.3.1(i).

Accomplishment of task 6.3.1(a) requires completing the following subtasks:

- (1) Using the MESODIF atmospheric dispersion model created by NOAA and data from existing meteorological stations, calculate and map isopleths of air pollutant concentrations that would result by placing a source of fixed strength at each of the candidate sites for the IWP/MLLW TF. These calculations should include sensitivity studies corresponding to reasonable estimates for the uncertainties in the meteorological parameters at Sites #3 and #5.
- (2) On the basis of the size of the offsite concentration uncertainties calculated in task 6.3.1(a)(1) determine whether additional site-specific meteorological measurements are warranted at Sites #3 and #5.

- (b) Install new meteorological monitoring stations. This task assumes that the outcome of task

- 6.3.1(a)(2) is to require additional meteorological data at Sites #3 and #5. The task will involve procurement of monitoring instruments, and installation and testing of the equipment at the sites.
- (c) Perform required meteorological monitoring. This task involves operation and maintenance of all meteorological monitoring stations and collection and archival of data therefrom for the required period of time.
 - (d) Determine pollutants of regulatory concern. This task is to determine what contaminants are likely to be emitted in significant quantities from the new facility. This information is needed to prescribe what background monitoring is necessary to determine whether the facility will cause a violation of the ambient air quality standards or PSD increments. The following subtasks must be accomplished:
 - (1) Obtain the latest available description of processes to be employed in the IWPF/MLLW TF including conservative upper bound estimates of their respective throughputs.
 - (2) Obtain from the literature, vendors, and/or engineering analysis the emission rates and specific airborne contaminants from each of the processes identified in 6.3.1(d)(1). [For example, species which are likely to be emitted from any incineration process include CO, NO_x, SO₂, HCl, HF, hydrocarbons, toxic metals such as As, Cd, Cr, Pb, and Hg, and incompletely destroyed toxic components of the waste inputs such as polychlorinated biphenyls (PCBs), halogenated hydrocarbons, etc.]
 - (3) Generate a list of pollutants that are expected to be emitted in significant quantities (as defined by the State of Idaho).
 - (e) Determine monitoring locations. This task is to determine where the contaminants identified in 6.3.1(d) must be monitored in order to establish the required baselines of ambient air quality. It requires the performance of the following subtasks:
 - (1) Calculate concentration increases for various potential air pollutants at INEL site boundaries and along the public highways which traverse the INEL. Use an appropriate model for atmospheric dispersion with available meteorological data from NOAA.
 - (2) Analyze computed results and document recommendations for locations of ambient air quality monitors.
 - (f) Obtain state approval for monitoring plan. This task involves interfacing with the Idaho Air Quality Bureau (IAQB) through the Department of Energy Environmental Site Wide Support Division to obtain state of Idaho review and concurrence with the monitoring plan that is devised per the above. It requires documenting expected emissions from the new facilities, calculating the impacts of these emissions on ambient air quality, choosing monitoring locations in a formal monitoring plan, providing state officials with the monitoring plan, responding to any requests for additional information, and incorporating in the plan any comments, recommendations, or additional requirements that the state officials may request.

- (g) Install new air quality monitoring stations. This task involves the following subtasks:
- (1) Identify the required equipment for monitoring and telemetry, according to the expected conditions on the site.
 - (2) Procure the required equipment.
 - (3) Install and test all new equipment.
- (h) Perform required monitoring. This task involves operation and maintenance of all air quality monitoring stations and collection and archival of data therefrom for the required period of time.
- (i) Calculate EDEs and air quality impacts. This task is to outline a modeling approach and perform calculations to estimate EDEs for NESHAPs, and to determine for any required PSD review the ambient air quality impacts that would result from operation of the IWPF/MLLW TF. Its accomplishment requires completing the following subtasks:
- (1) Perform calculations using CAP-88 and/or AIRDOS computer codes to determine EDEs for the candidate sites required to demonstrate NESHAPs compliance.
 - (2) Calculate air quality impacts of pollutants emitted in significant quantities [as determined in task 6.3.1(d)(3)] using approved EPA models, background air quality data from monitoring activities, assumed upper bounds on emission rates, and meteorological data from existing and new monitoring stations.
- These calculations will determine whether either the National Ambient Air Quality Standards (NAAQS) or the applicable Prevention of Significant Deterioration (PSD) increments in air quality are exceeded. In addition, for all contaminants on the list generated in task 6.3.1(d)(3) that are also on the Idaho Air Toxics list, the calculations will show whether the expected ambient concentrations resulting from operation of the IWPF/MLLW TF are all below regulatory concern.
- (3) Document all modeling calculations and results.

6.4 References for Section 6

1. Air Permitting Handbook, prepared for the U.S. Department of Energy Idaho National Engineering Laboratory by MK Environmental Services Group, DOE/ID-10324, February 1991.
2. Workbook for Estimating Visibility Impairment, prepared for the U.S. Environmental Protection Agency, EPA 450/4-80-031, November 1980.

7. ACTION PLAN FOR CONTAMINANT MIGRATION ISSUES

7.1 Purpose

The purpose of this action plan is to obtain information that could impact site selection for the IWPFF/MLLW TF on the basis of contaminant migration characteristics of the sites being considered. It is reasonable to assume that the IWPFF/MLLW TF will incorporate limited storage facilities for untreated wastes, as well as facilities and processes for repackaging, unpackaging, sorting, and segregation of specific waste types. In addition to these preprocessing facilities there will be actual waste treatment processes. All the above will involve finite, but small, operational releases of contaminants and risks of larger releases due to possible accidents and/or natural disasters.

It is likely in today's regulatory environment that engineered systems to contain such releases will be mandatory parts of the design of the IWPFF/MLLW TF (e.g. HEPA filtration systems for operational releases, floodwater runoff/runoff containment systems for flooding, etc.). However, the contamination of the environment that might result if such systems proved inadequate, is a possibility that should be addressed. In such a situation, the extent and seriousness of the effects of any environmental contamination would depend on the natural barriers to contaminant migration that are present at the location of the facility. Therefore, site-specific characterization of these natural barriers may constitute a basis on which to select from among the sites recommended for the IWPFF/MLLW TF.

In the following sections the regulatory drivers and DOE orders that are relevant to contaminant migration are summarized.

7.1.1 DOE Order 5400.5

Section I.3 of the order indicates that the current DOE standard for maximum allowable exposure of members of the public to radiation from all sources due to normal operations of DOE facilities is 100 mrem/yr effective dose equivalent.

7.1.2 DOE Order 6430.1A

Section 0200-99.0.5 of the order requires that site studies be performed to determine hydrogeological characteristics that could influence the design or operation of the facility. These studies should include the potential transport of radioactive and chemical contaminants in groundwater.

7.1.3 NRC Guidance for Low-Level Waste Disposal Sites

The U.S. Nuclear Regulatory Commission (NRC) has provided guidance for characterization of low-level waste disposal sites with respect to potential interactions between deposited wastes and groundwater, and with respect to migration of contaminants from locations where wastes are handled to human exposure pathways. While the IWPFF/MLLW TF is currently envisioned as a waste treatment/storage facility (not a waste disposal facility), and is not subject to regulation by the NRC, the NRC guidance, summarized in Ref. 1, provides an authoritative list of site-specific parameters

that can influence contaminant migration patterns and rates. This list is given in Section 7.2 and can be compared with the list of site-specific measurements and modeling calculations that are recommended in Section 7.3.

7.2 Background

DOE Order 6430.1A mandates the performance of site studies to determine the potential for migration of radioactive and chemical contaminants in surface water and in groundwater. However, the order does not indicate the type or the required extent of such studies. Presumably the desired outputs are quantitative estimates of contaminant concentrations in surface water and groundwater, together with their respective flow rates. This information can then be used to calculate the maximum possible exposure of the public to ionization radiation in order to assess compliance with DOE Order 5400.1. To this end, Ref. 1 provides a description of a number of specific subsurface parameters considered relevant to analysis of the groundwater pathway. The parameters listed in Appendix A of Ref. 1 used to model groundwater flow in the unsaturated zone include:

- moisture potential
- moisture content
- hydraulic conductivity
- porosity (total and effective)
- geometry of the subsurface region of interest
- boundary conditions.

The parameters listed in the appendix which are required for modeling groundwater flow in the saturated zone include:

- hydraulic head
- hydraulic conductivity
- porosity (total and effective)
- specific storage
- geometry
- boundary conditions.

Finally, Appendix A of Ref. 1 lists a number of geochemical and hydrochemical parameters which also must be measured in order to estimate contaminant transport rates in conjunction with the hydrogeologic modeling mentioned above. These parameters include:

- soil water quality
- ion-exchange capacity
- organic content
- Eh-pH
- distribution coefficients
- temperature
- radiometric dating
- isotope content
- soil mineralogy

- mineral solubility
- hydrodynamic dispersion coefficients.

In discussions with members of the Earth, Environmental & Life Sciences Group at EG&G Idaho, Inc.^{a,b} it was agreed that measurements of the parameters listed above would provide a fairly complete basis for analysis of subsurface contaminant migration. However, reflecting on the purposes of the current characterization efforts, it was concluded by the author that exhaustive characterization of each of the candidate sites to provide all the above parameters is beyond the scope of the current effort (see Section 1.3.2). Therefore, in recommending the characterization activities below, the objective has been to focus on measurements which, together with reasonable assumptions and simplified models, can provide an indication of the rates of contaminant migration at the recommended sites, but which would not comprise a complete set of inputs to a fully deterministic model such as is implied in the NRC guidance. In particular, because of the high costs involved in subsurface drilling and probable cost constraints of the program, an attempt has been made to provide confidence in the conclusions derived from the measured data, without obtaining large statistical samples of each of the measured parameters.

To identify measurable site-specific parameters that can be used to assess contaminant migration potential we note that the threat to public health from contaminant migration is generally dependent on the following:

- time of arrival of a contaminant at the water table,
- rate of migration of the contaminant into the water after its initial arrival, and
- amount of the contaminant that ultimately will reach the water, undegraded.

In the simplest case one can imagine, involving steady inflow of water at the surface, one-dimensional non-dispersive flow, and a homogeneous porous medium from the surface to the water table, then the above data could be supplied as follows:

- time = DR / I
- rate = cI / R
- amount = $A - B$

where I is the infiltration rate, R is the contaminant retardation factor, D is the distance to the aquifer, A is the total amount of contaminant initial released, B is the amount of contaminant retained by the subsurface medium through adsorption and/or chemisorption, and c is a constant which accounts for the concentration of the contaminant in the infiltrating moisture. This model is grossly oversimplified but it indicates the types of parameters that should be measured in order to characterize subsurface contaminant migration at the candidate sites. The parameters listed in Section 7.3 are those which can be used to estimate I , R , D , and B , either directly or indirectly with the aid of modeling.

^a Conversation on 2/9/93 with Swen O. Magnuson of the Subsurface & Environmental Modeling unit of EG&G Idaho, Inc.

^b Conversation on 2/12/93 with Greg T. Norrell of the Applied Geosciences unit of EG&G Idaho, Inc.

7.3 Required Site-Specific Data

The following sections describe the parameters recommended for measurement (or estimation) at each of the candidate sites for the IWPF/MLLW TF. These parameters can be used to obtain, by modeling, objective estimates for the contaminant migration data described at the end of Section 7.2. Some of the parameters can also be used directly in comparing the candidate sites from the standpoint of minimization of contamination to the aquifer.

7.3.1 Unsaturated Zone Hydrogeologic Parameters

In order to model transient movement of moisture through the unsaturated zone during surface flooding and simulate contaminant migration to the aquifer the values of fundamental unsaturated porous medium properties must be obtained. A minimum list of such properties would include the following measurements in the sediment layers below the candidate sites:

- Soil matric potentials (characteristic curves)
- Vertical moisture content profiles
- Hydraulic conductivities
- Effective porosities.

7.3.2 Fracture Characteristics in Basalt

The measurements described in Section 7.3.1 are appropriate to model unsaturated flow through the sediments. Because the subsurface is composed of both sediment and basalt layers, there is a need for data that can be used to characterize unsaturated flow through the basalt. As indicated in Ref. 2, at low moisture contents, water flows through the fine pore structure of basalt in much the same manner as it does through sediments. Laboratory measurements have been performed to generate characteristic curves of matric potential for basaltic matrix material³. However, at higher moisture contents approaching saturation conditions water begins to flow preferentially into basalt fractures, and the hydraulic conductivity increases many orders of magnitude. Measurements of travel times of water through the unsaturated zone with flooding conditions at the surface suggest that the saturated hydraulic conductivity of fractured basalt is much higher than that of the sedimentary interbeds at the INEL⁴.

Given the above information, one characteristic that could be useful for estimating the peak possible migration velocity of water through basalt under near-saturation conditions is the number of fractures per unit volume and the distribution of fracture sizes. Fully-saturated flow through fractures can be modeled assuming channel flow with friction factors. The values used for these factors will depend on the fracture sizes. The total flow rate through the basalt layer will then depend on the size distribution and the density of fractures within the basalt matrix. Therefore, the following measurements are meaningful for near-saturation flows of water in basalts:

- Fracture density (number of fractures/unit volume of basalt)
- Fracture size distribution.

7.3.3 Infiltration Rate

The rate at which water percolates through the soil from precipitation at the surface may be used as a measure of the unretarded migration rate of contaminants downward. Alternatively, it may be used as a boundary condition for unsaturated flow models to simulate contaminant transport with retardation effects accounted for. In either context the infiltration rate is a meaningful measurement for quantifying the rate of contaminant migration to the aquifer. Because of the extreme changes in the hydraulic properties of both sedimentary material and fractured basalt as moisture content varies, infiltration rates should be measured under natural conditions (relatively low moisture content), and under flooded conditions at the soil surface (near-saturated moisture content). Both conditions need to be taken into account in considering contaminant migration potential at the candidate sites for the IWP/MLLW TF.

7.3.4 Subsurface Geometry

As indicated above, the first geometric parameter of interest in contaminant migration calculations is the total distance that contaminants must travel to reach the saturated zone. In addition to the total distance, the types of material which water and contaminants must pass through enroute to the aquifer influences the migration rate. As documented elsewhere⁵ the geologic structure of the Eastern Snake River Plain, on which the INEL is situated, involves a series of basalt layers separated in some cases with sedimentary interbeds. The hydrogeologic characteristics of the resulting geomorphic structure thus depend on the corresponding characteristics of the individual stratigraphic layers, and on the total thicknesses of the two types of layers (i.e., basalt and sediments).

In particular, since the sediments generally have lower hydraulic conductivities (at high moisture content; see Ref. 2) than the basalts, the total thickness of all the sediment layers between the surface and the groundwater provides an indication of the rate at which contaminants would be expected to migrate under worst-case conditions with flooding at the surface. In addition, higher sediment thickness may also indicate (depending on the adsorbing potential of the sediments) a higher retention of the contaminants in the soil, and thus a greater "filtering" of the contaminant from the infiltrating water, under either high or low moisture conditions. Thus the following two site-specific parameters are needed to characterize subsurface contaminant migration:

- Depth to the aquifer
- Total sediment thickness from the surface to the aquifer.

7.3.5 Subsurface Stratigraphy

In addition to the total thickness of sediment layers, the distribution of thicknesses of the basalt and sediment layers might influence the downward migration of contaminants. For example, it has been suggested^a, that the resistance of a basalt layer to saturated flow probably depends in a non-linear fashion on the thickness of the layer, due to the fact that a thicker basalt layer is more likely to contain unfractured or slightly-fractured regions than a thinner basalt layer. Thus, the number, thicknesses, and arrangement of basalt and sediment layers within the subsurface region would be

^a Conversation on 2/16/93 with Carrol F. Knutson of the Geology & Seismology unit of EG&G Idaho, Inc.

useful in evaluating the capacity for contaminant migration at the candidate sites. These measurement could be done most cost effectively with geophysical methods, such as seismic refraction.

7.3.6 Retentive Capacity of Soils

As previously discussed, another significant parameter in determination of contaminant migration potential at the candidate sites for the IWPF/MLLW TF is the retardation coefficient. This coefficient depends on the contaminant under consideration, the medium through which migration will occur, and the chemical characteristics of the water in which the contaminant is moving.

The Earth, Environmental & Life Sciences Group at EG&G Idaho, Inc. is preparing to perform a broad program of integrated tests to quantify migration of radioactive and hazardous constituents at the INEL. This program will involve a large-scale pumping test of the Snake River Plain Aquifer north of the RWMC, designed to quantify aquifer characteristics on a regional scale which should be more representative of the entire INEL than data obtained to date from smaller scale tests. This test will probably be performed during the summer of Fiscal 1994^a. In addition, the program will include a field scale evaluation of infiltration rates, and a series of tracer tests, using very short-lived, surrogate radioisotopes, to obtain in situ measurements of retardation factors. The field scale work will be complemented with laboratory studies to establish the relationship between retardation factors for the surrogates used in the tracer tests and those of the actual contaminants of interest. The laboratory studies will provide both rate data and equilibrium partitioning coefficients for contaminants so that the data from the field tests (where non-equilibrium conditions probably prevail due to the high infiltration rate) can be credibly extrapolated to natural conditions (where equilibrium is likely).

Much of the data from the program described above will be useful for the current site characterization effort for the IWPF/MLLW TF. The infiltration measurements may be directly applicable to candidate sites near the Radioactive Waste Management Complex (RWMC), and may provide useful information on how water moves downward through the basalts in the vadose zone under saturated or near-saturated conditions. The contaminant retardation data will also be applicable. However, in order to apply this information on a site-specific basis, it will be necessary to obtain additional data from each of the candidate sites. Specifically, it will be necessary to obtain core samples of sediments from these sites and measure retardation coefficients in the laboratory. The field measurements from the tracer studies described above can then be utilized to extrapolate the laboratory data to natural conditions. These extrapolated data can be used in comparing expected contaminant rates at the candidate sites.

Alternatively, if the lab tests do not show a significant variation of retention capacity of the soils between the candidate sites, then the retardation factor may be ruled out as a factor in final site selection.

^a Based on phone conversation on 5/4/93 with Swen O. Magnuson of the Subsurface & Environmental Modeling unit (B670) of EG&G Idaho, Inc.

7.4 Action Plan

In light of the discussion above, an action plan is outlined below which describes the site characterization activities and data that are required.

7.4.1 Task Descriptions

- (a) Obtain data from lithologic and geophysical logs of INEL wells. This task is to obtain the logs of all wells on the INEL and assemble a data base from which a contour map of the INEL can be constructed showing the aggregate thickness of all the sedimentary interbed materials between the surface and the water table. In addition, the information from the well logs will be reviewed to determine whether it is sufficient to supply the information described in task 7.4.1(b)(3) below. This will require a judgement about the representativeness of the data in wells which are near the sites of interest but not actually at these sites. It will also require interpreting data obtained from each well to determine whether credible estimates can be made for the subsurface parameters of interest.
- (b) Drill boreholes on sites where needed. Task 7.4.1(a) will result in the identification of the candidate sites where boreholes should be drilled because there is insufficient data available from existing holes. Task 7.4.1(b) will involve the following subtasks:
 - (1) Drill a single borehole on each site where existing data is judged to be insufficient. Case the holes using PVC pipe.
 - (2) Log cores from boreholes, recording all subsurface strata encountered, their thicknesses, and depth to the water table.
 - (3) Perform ex situ laboratory experiments to measure soil matric potential characteristic curves for each sediment layer encountered during drilling. Also measure soil moisture content, hydraulic conductivity, and effective porosity. Document results in an informal report.
- (c) Perform geophysical measurements. Because of the high cost of drilling boreholes on the INEL it has been suggested^a that geophysical measurements, rather than additional boreholes, be used, where feasible, to verify the thicknesses of surficial sediment layers. Seismic refraction will be used for this purpose. The task will involve the following subtasks:
 - (1) Set up grid for seismic refraction surveys 1/2 km x 1/2 km, centered on areas of principal interest at each site, and obtain data.
 - (2) Interpret data from above measurements and document in letter reports.

^a Conversations on 2/16/93 and 2/17/93 with Carrol F. Knutson and Glen S. Carpenter, respectively, of the Geology & Seismology unit of EG&G Idaho, Inc.

- (d) Measure infiltration rates. A parameter of primary interest in characterization of contaminant migration is the rate of moisture infiltration into the unsaturated zone. Recently the U.S. Geological Survey completed a series of determinations of infiltration to the unsaturated zone near the RWMC based on measurements of the location in the soil column of radioactive fallout (^{36}Cl and tritium) from atmospheric weapons tests in the early sixties⁶.

The measurements documented in Ref. 6 show the location of the "bomb pulse" (i.e., the peak concentrations of ^{36}Cl and tritium) to be between one and two meters below the surface. Since this is presumably below the root zones of most of the plant species on the INEL the measured infiltration rates should be fairly representative of the rate at which water moves down through the unsaturated zone to the water table. The task at hand will be to replicate these measurements at each of the candidate sites for the IWPF/MLLW TF, and will involve the following subtasks:

- (1) Collect and preserve soil column samples at each candidate site.
- (2) Prepare targets needed for analysis of the $^{36}\text{Cl}/^{35}\text{Cl}$ ratio in the soil samples.
- (3) Perform laboratory analyses to determine $^{36}\text{Cl}/^{35}\text{Cl}$ ratios, total chlorine, tritium, and total moisture concentrations in the soil samples.
- (4) Interpret laboratory measurements and document results in a letter report.

- (e) Perform infiltration rate tests under near-saturated conditions. The infiltration rate that will be determined under task 7.4.1(d) will reflect natural conditions which, for the desert environment of the INEL, involve relatively low moisture contents in the soil and unsaturated flow throughout the soil column, including the surface. The current task will be to measure infiltration rate at the wet end of the saturation spectrum. This task involves building a pond (3-4 meters on a side) at each candidate site, and then flooding the pond for a period of one month.

During the time that water is maintained in the pond moisture movement in the soil column will be monitored using both soil moisture measurements and a non-radioactive tracer. Because of the flooded condition in the pond, the soil near the wetting front will be near saturation. The measurements from this test will provide in situ measurements to aid in calibration of contaminant migration models which are based on the ex situ measurements discussed above, and will provide a direct measure of the peak possible rate at which contaminants might be expected to migrate downward following large liquid spills or under surface flooding conditions (as might occur at an evaporation pond which becomes contaminated with a hazardous substance).

This task will involve the following subtasks:

- (1) At each candidate site berm a pond roughly 3-4 meters on each side, and flood with water. Cover the ponds to minimize evaporation and maintain the flooded condition in the pond (by trucking water to the site) for one month. Inject a non-radioactive tracer (bromide) in each pond.

- (2) Hand auger holes near the ponds and install instrumentation to measure soil moisture profiles and to collect soil samples to determine tracer concentrations.
 - (3) Perform laboratory analyses of soil samples to determine tracer concentrations.
 - (4) Interpret the data to determine the site-specific infiltration rates. Model the movement of water down the soil column using an unsaturated zone flow model with the hydrologic parameters obtained from task 7.4.1(b)(3). Compare model predictions of soil moisture profiles and infiltration rates with measurements and correct the ex situ values of the hydrogeologic properties as appropriate. Document results in an informal report.
- (f) Measure retardation coefficients for selected contaminants. As previously noted, the characterization effort for the IWPF/MLLW TF sites can benefit from the integrated testing program currently planned by the Earth, Environmental & Life Sciences Group at EG&G Idaho, Inc. (See Section 7.3.6.) This program will produce laboratory testing procedures and hardware to determine ex situ measurements of distribution and rate coefficients for adsorptive and/or chemisorptive processes in the soil. These parameters can be used directly as inputs in contaminant migration models.

The current task involves collecting sediment samples from the boreholes generated under task 7.4.1(b)(1), performing the same laboratory soil column tests described in Section 7.3.6 on these samples, and interpreting the data to provide the required distribution coefficients and rate constants. The following subtasks are involved:

- (1) Obtain sediment samples from boreholes. This task will complement task 7.4.1(b)(2). Separate samples from those used to obtain unsaturated zone hydrogeologic parameters will be secured from the cores obtained during drilling. These samples will be prepared for and used in the laboratory soil column experiments to characterize contaminant retardation.
 - (2) Perform laboratory soil column experiments to obtain distribution and rate coefficient data for adsorption/chemisorption. (These experiments can be "piggy-backed" onto those that will be done under the integrated program described in Section 7.3.6.)
 - (3) Interpret laboratory data to generate distribution coefficients and rate constants, and document results in an informal report.
- (g) Model contaminant migration using site-specific data. The final task is to generate estimates for the contaminant migration parameters described previously. This task will require incorporation of the data generated by tasks 7.4.1(a) through 7.4.1(f) into one-dimensional hydrogeologic transport models for each of the candidate sites. This incorporation is assumed to include any necessary modifications to existing computer models to accommodate saturated flow through fractures in basalt.

The calculation of such flows will incorporate a mass conservation equation together with the measured fracture size distribution and number density in the INEL basalts (as described in

Section 4.2.2.3 of Ref. 7). In addition, it will incorporate a momentum equation so that transient scenarios (e.g., pulses of surface infiltration) can be analyzed.

Once the computer code has been suitably modified, a set of input parameters for the code will be generated from the data collected in the foregoing tasks, and the code will be run for one or more contaminant release scenarios to estimate:

- time of arrival of contaminants at the aquifer,
- rate at which contaminants enter the aquifer,
- total amount of contaminants reaching the aquifer

The results of the modeling will be documented in an informal report.

7.5 References for Section 7

1. Site Characterization Handbook for Low-Level Radioactive Waste Disposal Facilities, prepared for the U.S. Department of Energy Office of Environmental Restoration and Waste Management, DOE/LLW-67T, January 1992.
2. R. J. Bargelt, et al., Summary of RWMC Investigations Report, EGG-WM-9708, January, 1992.
3. C. W. Bishop, Fluid flow and Transport Properties of Vesicular Basalt, Quarterly Report, Department of Hydrology and Water Resources, 1989, University of Arizona, Tucson, Arizona.
4. J. T. Barraclough, et al., Hydrology of the National Reactor Testing Station, Idaho, U.S. Geological Survey Water Resources Division, TID 4500, 1966.
5. W. F. Downs, K. S. Moor, B. F. Russell, INEL Environmental Characterization Report, Vols. 1-3, EGG-NPR-6688, January, 1985.
6. L. DeWayne Cecil, John R. Pittman, Water Infiltration Rates in the Unsaturated Zone at the Idaho National Engineering Laboratory Estimated from Chlorine-36 and Tritium Profiles, and Neutron Logging, Proceedings of the 7th International Symposium on Water-Rock Interaction, Park City, Utah, July 13-18, 1993.
7. S. O. Magnuson, et al., Radioactive Waste Management Complex Low-Level Waste Radiological Performance Assessment, EGG-WM-8773, January, 1993.

8. ACTION PLAN FOR THE CONSIDERATION OF BURIED UTILITIES FOR THE SITING OF THE MLLWTF AND IWPF

8.1 Purpose

The purpose of the study of any buried pipe utilities in the areas involved in this project is to comply with DOE Order 6430.1A, General Design Criteria, Section 0285-2.2.5. This section, *Sites Traversed by Utilities*, requires that sites traversed by buried pipe utilities not be used for TSD facilities unless the relocation of the utilities is economically feasible.

8.2 Project Description

The survey and report for this project will review candidate locations on the Idaho National Engineering Laboratory (INEL). These locations are candidate sites for the Mixed and Low-Level Waste Treatment Facility (MLLWTF) and the Idaho Waste Processing Facility (IWPF) on the INEL. The results will be included as part of the site characterization for the IWPF and MLLWTF project. However, this survey and report will be applicable to the construction of any facility on these locations.

The boundaries of the candidate locations will be marked by the IWPF and MLLWTF Project Managers and Project Engineers. The Center for Environmental Monitoring and Assessment (CEMA) will measure and record the location of these boundary markers using their Global Positioning System (GPS).

The survey and report will be done by CEMA.

8.3 Survey Methods

A survey of each of the locations will be conducted by CEMA. CEMA will contact the Planning and Inspection Unit in the Facility Engineering Group, and the Telecommunications Systems Unit in the Information Systems Group, to obtain their description of any buried utilities in the candidate locations.

8.4 Survey Schedule

The survey will be conducted in November, 1992.

8.5 Survey Report

A brief report will be prepared to indicate if any buried pipe utilities will be encountered in the candidate locations.

9. ACTION PLAN FOR THE SOIL SURVEY AND CONSULTATIVE REPORT FOR THE SITING OF THE MLLWTF AND IWPF

9.1 Purpose

The purpose of the study of the soil cover of the areas involved in this project is to comply with DOE Order 6430.1A, General Design Criteria, Section 0285-2.2.6. This section, *Characteristics and Availability of Soil Cover*, requires that the characteristics and availability of on-site soil cover shall be considered with respect to site operation and performance requirements, including vehicle maneuverability, as part of the site selection criteria for TSD solid waste systems.

Soil surveying is an effective approach to classifying soils, wetlands, critical habitats, and agricultural potential. For wetlands, the soil survey is a reliable way to classify wetlands because vegetation does not have to be present in order to identify the hydric soil. This is particularly useful at the Idaho National Engineering Laboratory (INEL), which has been in drought conditions for six years and many of the plants that normally would occupy "wet" areas are not present. Soil surveying is also necessary for identifying site suitability for construction, and suitability for operation of treatment and disposal facilities.

9.2 Project Description

The soil survey and report for this project will characterize the soils at candidate locations on the INEL, which are candidate locations for the Mixed and Low-Level Waste Treatment Facility (MLLWTF) and the Idaho Waste Processing Facility (IWPF). The results will be included as part of the site characterization for the IWPF and MLLWTF project. However, this soil survey and report will be applicable to the construction of any facility on these locations.

The field work and consultative report will be done by EG&G Idaho, Inc. Center for Environmental Monitoring and Assessment (CEMA), and Applied Geosciences. Laboratory analyses will be performed by a subcontractor.

The following will be completed for each of the candidate locations:

- 1) A soil map will be developed, showing the distribution of soil types and the relationship of soils to geologic features, groundwater, vegetation, and site physiography. Interpretations will be provided for each soil type, addressing site suitability, potential for contaminant migration, and erosive and hydrologic properties
- 2) Laboratory analyses will be done, which will greatly enhance soil interpretations, and provide quantitative information for determining site suitability

9.2.1 Soil Mapping

Soil mapping will include identification and complete descriptions of the soil types. For each soil type, the following will be described by soil layer (horizon): field estimated texture; soil structure; field pH; depth to bedrock; color; consistence; abundance of roots, pores, clay films, and lime; and special features, such as whether the soil is subject to severe cracking, has hydrophobic properties, ash layer(s), salt, or is alkaline.

Surface properties will also be described as part of the soil mapping effort, including general topography, vegetative cover, habitat type, and drainage class. Mapping unit interpretations will address contaminant transport and soil erodibility in the context of microclimatic factors and topographic influences.

Field observations for soil mapping will take into account soil features that determine the suitability of the site for the proposed facilities, such as shrink-swell potential, frost heaving, depth to bedrock, and field-estimated texture.

9.2.2 Laboratory Analyses

Soil and site suitability determinations are greatly enhanced by laboratory measurements. Risk and performance assessment models require several soil parameters for calculations. Attachment 1 is a table from a U. S. Environmental Protection Agency (EPA) Groundwater Issue paper that shows required soil input parameters for 10 vadose zone models.

Once the site is selected, soil samples will be collected for alpha and gamma spectral analyses to establish baseline levels for radionuclides. These values are needed for the determination of radiological impact from the future facility. The portion of the sample collected that has not been used for analysis will be archived for future reference and analyses, and for potential use in establishing *de minimus* values.

9.3 Survey Methods

A field survey will be conducted to develop soil maps of the candidate locations. Each of the sites will be traversed, and auger holes will be made to expose subsurface soils and identify the soil types and distributions.

Based on the assumption that the area of a candidate location will be 200 acres, 50 auger holes will be bored at the candidate location. Fifty is felt to be a reasonable number to assure confidence in the soil survey results. Additional auger holes would increase the certainty of the results, but would also increase the cost of the soil survey.

Soils at each of the sites will be described in detail, and interpretations will be made regarding their suitability for construction, landfill, and other activities. Soil and vegetation associations will be identified; special features will be described, such as relict wetness, shrink-swell properties, frost heaves, erodibility, or other potential limiting factors.

Sample collection procedures will be determined and outlined in the sampling and analysis plan. Some samples will be composited, while others will be collected as undisturbed clods. Specific methods will also be outlined for *in situ* measurements, such as hydraulic conductivity. Partitioning coefficients for radionuclides will likely be performed by a subcontractor who has the expertise and facilities to run such tests.

9.4 Survey Schedule

The field survey and sample collection should be initiated in the Spring, and would be completed by late Fall, depending on the scope of the approved project. The field survey would take about three to four months to complete, which would include all the documentation from the activity, and could begin as soon as the ground thaws. Sample collection, laboratory analyses and an interpretive report would take about six months to complete.

9.5 Consultative Report

A report will be provided for the approved activities, and will include complete descriptions of the activities, interpretations of the findings, and conclusions and recommendations.

Table 9.5.1 is a complete list of the proposed laboratory analyses for each of the candidate locations, together with a ranking from most to least important (1-10) for facility siting and facility operation.

Assumptions used in the ranking process for "Rank for Siting" were:

- 1) All contaminants will be contained and within buildings
- 2) Discharges or disposal of contaminants outside buildings will not occur
- 3) Soil properties of most importance are those related to construction activities

Assumptions used in the ranking process for "Rank for Operations" were:

- 1) Construction is complete
- 2) Soil properties of most importance are those related to soil interactions with contaminants

Table 9.5.1. Laboratory analyses for soil surveys at candidate locations.

Soil Property	Justification for Measurement	Rank for Siting	Rank for Operations
Compaction	Behavior of soil under construction, suitability for roads	1	9
Shrink-swell potential	Suitability for construction, stability, roads	2	10
Texture	Effects contaminant transport, retention, water holding capacity, porosity	3	6
Bulk density	Influences water migration, road building, engineering, modeling	4	7
Hydraulic conductivity	Hydrology, contaminant transport, modeling	5	1
Moisture release curves	Risk assessment modeling	6	3
Porosity	Modeling	7	8
Cation exchange capacity	Determines soil's ability to sorb cations	8	4
Soil organic content	Modeling, contaminant retention	9	5
Partitioning coefficients (radionuclides, PCBs, select organics)	Critical for contaminant transport and performance assessment modeling	10	2

ATTACHMENT 1

Table 3. Soil Characteristics Required for Vadose Zone Models

Properties and Parameters	MODEL NAME (Reference(s))									
	HELP (A.S.)	SEZON (C.D.)	CREAM (E.F.)	PREM (B.J.U.)	VADOPT (N.L.)	MINTEC (I.)	POWER (T.)	RTZ (L.)	VP (M.)	CHEMPLO (N.)
Soil Bulk Density	●	●	●	●	●	●	●	●	●	●
Soil pH	○	●	●	○	○	●	●	○	○	○
Soil Texture	●	●	●	●	●	●	●	●	●	●
Depth to Ground Water	●	●	●	●	●	●	●	●	●	●
Horizons (Soil Layering)	●	●	●	●	●	●	●	●	●	●
Saturated Hydraulic Conductivity	●	●	●	●	●	●	●	●	●	●
Water Retention	●	●	●	●	●	●	○	○	○	●
Air Permeability	○	●	○	●	●	○	○	●	●	○
Climate (Precipitation)	●	●	●	●	●	○	●	●	●	●
Soil Porosity	●	●	●	●	●	●	●	●	●	●
Soil Organic Content	○	●	●	●	●	●	●	●	●	●
Cation Exchange Capacity (CEC)	○	●	○	○	○	●	○	○	○	○
Degradation Parameters	●	●	●	●	●	○	○	●	●	●
Soil Grain Size Distribution	○	●	●	●	●	○	○	○	○	○
Soil Redox Potential	○	●	●	○	○	●	○	○	○	●
Soil/Water Partition Coefficients	○	●	●	●	●	●	●	●	●	●
Soil Oxygen Content	○	●	○	○	○	●	○	○	○	○
Soil Temperature	●	●	●	●	●	●	●	●	●	●
Soil Mineralogy	○	●	○	○	○	●	○	○	○	○
Unsaturated Hydraulic Conductivity	●	●	●	●	●	●	○	○	○	●
Saturated Soil Moisture Content	●	●	●	●	●	●	●	●	●	●
Microorganism Population	○	●	○	○	○	○	○	○	○	○
Soil Respiration	○	●	○	○	○	○	○	○	○	○
Evaporation	●	●	●	●	●	○	○	●	●	●
Air/Water Contaminant Densities	●	●	●	●	●	○	●	●	●	●
Air/Water Contaminant Viscosities	●	●	●	●	●	○	●	●	●	●

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● Required
○ Not Required
● Used Indirectly*

* Used in the estimation of other required characteristics or in the interpretation of the models, but not directly entered as input to models.

Appendix D

Geoscience and Ground Motion Investigations Important for Siting of the Idaho Waste Processing Facility at the Idaho National Engineering Laboratory

**GEOSCIENCE AND GROUND MOTION INVESTIGATIONS
IMPORTANT FOR SITING OF THE
IDAHO WASTE PROCESSING FACILITY
AT THE IDAHO NATIONAL ENGINEERING LABORATORY**

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EXECUTIVE SUMMARY

Uncertainties in the locations of the southern terminations of major basin and range faults and uncertainties in the recurrence and magnitude of the ESRP random earthquake have the greatest effect on varying estimated ground motions at potential IWPF sites (Table 1). The choice of attenuation relationships (empirical vs band limited white noise/random vibration theory) for estimating ground motion also has significant effects, and uncertainties in the site specific subsurface stratigraphy at each site cause additional variation in estimated ground motions. Uncertainties in volcanic rift zone boundaries, because of their long seismic recurrence intervals, have little effect on ground motions. Even with the present uncertainties in ground motion estimation parameters, the estimated ground motions at the IWPF sites are not greatly different from each other. This suggests that earthquake ground motion variation is not a discriminating factor for selection of the final IWPF site.

Analysis of existing seismic reflection profiles supports termination of the Lost River fault about 5 km southeast of the town of Arco and the Lemhi fault about 1 km south of Howe Point (Figure 1). Terminations of the faults at these locations are supported by detailed mapping of fault structure and geometry. Discovery and documentation of a new fissure and a monocline during detailed geologic mapping of the INEL in 1991 help to define volcanic rift zones. Uncertainties in the age of the fissure and monocline contribute to uncertainties in the seismic recurrence intervals of volcanic rift zones. The occurrence of a northwest-trending linear aeromagnetic anomaly in the central part of INEL lends support for the occurrence of the postulated Howe-East Butte volcanic rift zone.

SENSITIVITY ANALYSIS OF GROUND MOTIONS TO UNCERTAINTIES IN SOURCE AND SITE PARAMETERS

As described and summarized in the draft report "Site-Specific Probabilistic Seismic Hazard Analyses for the Idaho National Engineering Laboratory", a probabilistic evaluation of ground motions was performed for seven facility sites at the INEL by Woodward Clyde Federal Services (WCFS, 1993). For this evaluation, WCFS was requested to assess the sensitivity of ground motions to uncertainties in several source and site parameters at three proposed IWPF sites (Figure 1). These parameters include uncertainties in: 1) the southern termination and rupture length (hence maximum magnitude) of the Lemhi, Lost River, and Beaverhead faults; 2) the recurrence of the Eastern Snake River Plain (ESRP) random earthquake; 3) the spatial extent of ESRP volcanic rift zones; and 4) attenuation relationships. The hazard curves for the parameter uncertainties (Figures 2 through 7) are compared to the total mean hazard curve incorporating the uncertainties in these parameters (Figure 8). The hazard curves shown in Figures 2 through 8 are developed for sites 1, 3, and 5 as shown in Figure 1, and are not to be used for design purposes.

Lemhi Fault

As described in the report "Earthquake Ground Motion Evaluations for the Proposed New Production Reactor at the Idaho National Engineering Laboratory, Volume 1: Deterministic Evaluation" (WCC, 1992), there are two possible scenarios for the southern termination of rupture on the southern Lemhi fault. The most likely scenario or base case is that rupture terminates at the end of the range-front coincident with a WSW-ENE-trending cross fault A

(Figure 1). A second scenario is that rupture could extend to the vicinity of an inferred graben about 1 to 1.3 km south of Howe Point (triangle in Figure 1). The increase in potential rupture length between the two cases is small and thus the best estimate maximum magnitude ($M_{\max}$) for the southern Lemhi fault is moment magnitude (M_w) 7. For either case, the effect of the southern termination of the Lemhi fault causes small changes in ground motions only at site 3 (Figure 2; Table 2).

Lost River Fault

Three possible rupture scenarios were considered for the southern Lost River fault to assess the effects of uncertainties in its southern termination and $M_{\max}$. The base case consists of the same southern termination used in WCC(1992) and WCFS (1993); the Lost River fault terminates at the town of Arco (Figure 1). As was previously done, the best estimate $M_{\max}$ is M_w 7. Considering the absence of late-Quaternary scarps on the adjacent Pass Creek segment, it is possible that the Arco segment ruptures as a single segment. Given its relatively short length, about 24 km, this would result in a $M_{\max}$ of M_w 6.75 or less. Thus in a second scenario, the southern termination remained the same as the base case but $M_{\max}$ is M_w 6.75. In the third case, possible rupture was extended out into the ESRP by about 11 km coincident with the seismic line ARCO-A4 (Figure 1). Because of the significant increase in potential rupture length, the $M_{\max}$ assigned to this scenario was M_w 7.

As expected, the uncertainty in the rupture termination of Lost River fault and $M_{\max}$ results in changes in ground motions at site 1 which lies closest to the fault (Figure 3). The effect on site 1 at an annual exceedance probability of 2×10^{-4} is about 10% increase in peak horizontal acceleration with respect to the base case (Table 2). For sites 3 and 5, which are more distant from the fault, the effect is negligible (Figure 3).

Beaverhead Fault

Two possible scenarios were considered for rupture of the southern Beaverhead fault. Case 1 terminates rupture at the end of the range front and case 2 extends the fault about 8 km onto the ESRP (Figure 1). The value for $M_{\max}$ is M_w 7 for both scenarios. At an annual exceedance probability of 2×10^{-4} , the position of the southern termination of the Beaverhead fault is not a significant contributor to hazard except at site 5. In relative terms, the difference between the two cases is significant but only at high peak acceleration values (Figure 4).

ESRP Random Earthquake

The ESRP areal source ($M_{\max}$ 5.5) can be a significant contributor to seismic hazard at the INEL particularly for sites more distant from the Basin and Range faults (WCFS, 1993). Unfortunately, the recurrence of earthquakes in the ESRP is poorly defined given the sparse historical record. To test the sensitivity of the seismic hazard at all three areas, the b-value (a factor describing earthquake recurrence) was varied from a low of 0.5 (corresponding to more large magnitude earthquakes) to a high of 1.3 (corresponding to more small magnitude earthquakes). The base case value is 0.85, derived from the ESRP seismicity catalog (WCC, 1992). These values incorporate the range of b-values observed on a worldwide basis. Greater weight, however, should be placed on higher b-values due to

the volcanic nature of the ESRP. As expected, the uncertainty in recurrence of the ESRP areal source causes large variation in ground motions at all three sites (Figure 5). The impact is greatest at site 1, slightly less so at site 3, and least at site 5 (Table 3).

Volcanic Rift Zones

Because of the relatively long recurrence intervals assigned to the volcanic rift zones and the $M_{\max}$ of $M_w 5 \pm 0.5$, their contribution to the mean hazard at all three sites is very small (Figure 6). The analysis assesses the worst case in which the site lies within a VRZ. The boundary of Arco VRZ, having the most frequent return period of INEL VRZ's, was expanded to include site 1 (Figure 1). In the probabilistic analysis, areal zones are treated by considering them as a set of closely-spaced discrete faults. For the revised Arco rift zone, one fault subparallel to the present set of faults was added. The hazard curves shown in Figure 6 indicate that the present and extended Arco volcanic rift zone boundaries have no significant effect on peak accelerations higher than 3×10^{-6} exceedance probabilities. Given the longer recurrence intervals for the Howe-East Butte and Lava Ridge-Hells Half Acre VRZ's, there would be no significant effects on ground motions at sites 3 and 5.

Site-Specific Attenuation

One of the most significant factors on ground motions at the INEL is the volcanic stratigraphy of the ESRP (WCC, 1992; WCFS, 1993). In the recent probabilistic seismic hazard analysis of the INEL (WCFS, 1993), the attenuation of ground motions were modeled using both empirical relationships and BLWN/RVT ground motion model. The BLWN/RVT model incorporates the site geology beneath each facility. Shown on Figure 7 are the effects of using either the empirical or BLWN/RVT model. Since no drill hole information exists beneath the IWPF sites, site-specific geologic profiles from analogous INEL facility areas were used. For site 1, the site-specific geologic profile developed for RWMC was used, for site 3, NRF, and for site 5, ICPP. The ICPP profile was used for site 5 because of the thick sequence of gravel near the surface at both sites.

At site 1, the BLWN/RVT model yields higher ground motions than the empirical approach for the same annual frequency of exceedance (Figure 7; Table 4). For sites 3 and 5, the opposite is true for all exceedance probabilities. The difference between the two attenuation relationships could be significant at site 5 because of the assumption that ICPP stratigraphy is appropriate for site 5.

Seismic Hazard Contributors

The total hazard curves incorporating the uncertainties discussed above are shown in Figure 8 for the 15th, 50th, mean, and 85th percentile for each site. Table 1 lists the peak ground acceleration (PGA) for the 3 hazard exceedance probabilities. Results in Figures 2-8 and Tables 2-4 were used to assess the dominant contributors to the seismic hazards at IWPF sites 1, 3, and 5. The dominant contributors to the seismic hazards at site 1 are the Lost River fault and the ESRP areal sources. These contributors result from the proximity of site 1 to the southern termination of the Lost River fault and the large uncertainty in earthquake recurrence for a randomly located $M_{\max} 5.5$ earthquake within the ESRP. For site 3 the Lemhi fault contributes most to the seismic hazard because of its proximity to the southern termination of the fault. At site 5 both the Lemhi and Beaverhead contribute most

to the seismic hazard. This results from the low return periods of earthquakes on the Beaverhead fault (Lemhi having more frequent return periods by comparison), and its estimated extension of 8 km onto the ESRP which results in a closer distance to site 5. At all three sites the choice of attenuation relationships contributes significantly to the seismic hazard. In using the BLWN/RVT model, the uncertainties in site-specific subsurface stratigraphy can greatly affect ground motions at each site.

Conclusions: The conclusions of the ground motion sensitivity analysis are listed by source and site parameters:

1. Lemhi fault - The variation in the location of the southern termination of the Lemhi fault causes small changes in ground motions only at site 3.
2. Lost River fault - Extending the fault 5 km onto the ESRP (as indicated by reflection seismic profiles) results in 10% higher ground motions from the base case at site 1. There are very small changes in ground motion at sites 3 and 5.
3. Beaverhead fault - Extending the fault 8 km onto the ESRP results in 10% increase in ground motions from the base case at site 5. There are very small changes in ground motions at sites 1 and 3.
4. ESRP Random Earthquake - Uncertainty in the recurrence of ESRP seismicity (b-values) causes large variation in ground motions at all three sites. Since sites 3 and 5 are closer to major basin and range faults (Lemhi and Beaverhead) than site 1, ground motions from the ESRP random earthquake could contribute more to the hazard at site 1.
5. Volcanic Rift Zones - Based on present assumptions of low recurrence intervals in VRZ's ($<10^5$), there is a very small contribution to the seismic hazard at all three sites, even if the site is located within a VRZ.
6. Attenuation Relationships - The BLWN/RVT model with present knowledge of subsurface stratigraphy produces larger ground motions than empirical relationships at site 1. At sites 3 and 5 empirical relationships result in higher ground motions at all probabilities.
7. Results of the sensitivity analyses were used to assess the dominant seismic hazard contributors for each site and are shown in Table 1.

Recommendations:

These ground motion results (Tables 1-4; Figures 2 through 8) are meant for relative site selection and should not be used for design purposes. Site specific geotechnical investigations should be performed at the selected site to provide a basis for determination of design ground motions.

**INTERPRETATIONS OF REFLECTION SEISMIC LINES AT THE
SOUTH ENDS OF THE LOST RIVER AND LEMHI RANGES.**

Background

Since 1981 a number of seismic reflection surveys have been conducted near the southern ends of the Lemhi and Lost River faults. For the New Production Reactors (NPR) program, several commercially available lines were selected and reprocessed because of their locations near the southern ends of the Lost River and Lemhi faults. Other lines were collected in 1984 by Sierra Geophysical and in 1991 by EG&G Geosciences, also under the NPR program. The purpose of collecting the additional seismic data was to determine if the Lost River and Lemhi faults extend onto the ESRP. The locations of the seismic reflection lines are shown in Figure 1.

Data Acquisition and Processing

All seismic reflection data were collected using standard petroleum industry practices. The commercial lines (HOWE-81-3, HOWE-82-2, ARCO-81-1, and ARCO81-2) located within the Basin and Range valleys were collected with a 48-channel recording system with stations spaced 33.5 m (110 ft) and source spacing 67 m (220 ft) which resulted in 12-fold data. The energy source was a vibroseis. The remaining nine lines are located on the ESRP and were collected using a 24-channel recording system using 16.8 m (55 ft) station spacing and 33.5 m (110 ft) between source locations resulting in 6-fold data. The energy source for these lines was an accelerated weight drop system using multiple impacts.

The seismic reflection data were reduced using refracted arrivals to resolve near surface velocity conditions and static corrections. The general sequence of processing included standard industry practices: 1) two passes of surface consistent static correction; 2) two passes of velocity analysis; 3) one pass of common depth point consistent static correction; 4) final stack; and 5) filter.

Interpretation of Seismic Reflection Profiles

Howe Segment of the Lemhi Fault

Six seismic reflection lines are located in the area of the Howe segment of the Lemhi fault (Figure 1). The two commercial lines cross the surface expression of the Howe segment; one is oriented north-south and the other northeast-southwest. The remaining four lines are located on the ESRP southeast of the surface trace of the Howe segment. They are oriented approximately in a northeast-southwest direction perpendicular to the projected fault trace. These lines are also positioned to cross the steepest portion of a regional gravity anomaly which may indicate extension of the Lemhi fault onto the ESRP.

Line HOWE-82-2, in Figure 9, shows a series of generally flat lying reflectors on the southwest end that dip down into a large depression that has been filled with a thick wedge of flat lying sediments. The northeast end of this line shows two normal faults that can be correlated with the Howe segment. Line HOWE-81-3, shown in Figure 10, obliquely crosses the large depression seen in HOWE-82-2. Both of these lines suggest that the basin has been subsiding and tilting toward the northeast as indicated by flat lying reflectors which pinch out to the southwest. At the northern end of the seismic profile, the HOWE-81-3 line also exhibits displacements along a normal fault that can be correlated to the Howe segment.

Lines HOWE-H1, HOWE-H2, HOWE-H3, and HOWE-S4 are shown in Figure 11. Line HOWE-H1 extends east-west across the southernmost topographic expression of the Howe segment and shows offset associated with two normal faults. Lines HOWE-H2 and HOWE-H3 show generally flat lying reflectors. Although the reflectors are not continuous across the section, there is no clear indication of faulting. The minimum offset confidently interpreted from all the seismic lines is approximately 30 m (100 ft). Line HOWE-S4 extends northwest-southeast across line HOWE-H3 and shows no fault offset.

Conclusions: The positions of the faults and their displacements for each seismic line are shown in Figure 1. The interpretation showing no offset in lines HOWE-H2 and HOWE-H3 suggests that the Howe segment terminates within 1 km from the southern end of the Lemhi range at Howe Point (Figure 1). A line drawn on the map in Figure 1 through the locations of the hinge points (beginning of tilted reflectors) seen in lines HOWE-81-3 and HOWE-82-2 projects to the southeast in such a manner that lines HOWE-H2 and HOWE-H3 should be within the tilted basin if the fault extended significantly onto the ESRP. Since no indication of rotation or tilting of layers is observed in the two lines (Figure 10), the interpretation that the fault does not extend that far onto the Plain is strengthened.

Arco Segment - Lost River Fault

Seven lines were located in the area of the Arco segment of the Lost River fault. Two commercial lines extend in an east-west direction across or near the surface expression of the fault. The remaining five lines are located on the ESRP south of the surface expression of the Arco segment (Figure 1). These lines cross surface expressions of small-offset normal faults interpreted by Smith and others (1989) to result from basalt dike injection within the Arco volcanic rift zone. The purpose of these lines was to determine if significant offset is evident at depth to infer a volcanic or tectonic origin of the small-offset normal faults.

Lines ARCO 81-1 and 81-2 both show generally flat lying reflectors dipping slightly to the east to the Arco segment (Figures 12 and 13, respectively). At the eastern ends of both lines, flat lying reflectors are offset by normal faults associated with the Arco segment. Line ARCO-A1, just south of the surface expression of the Arco segment, shows few reflections that can be confidently traced across the section (Figure 14). In the eastern half of the line, ARCO-A2, a normal fault with approximately 85 m of offset is interpreted. Although line ARCO-S1 changes direction from east-west to north-south, it also indicates the presence of a normal fault with similar displacement (Figure 14).

Line ARCO-A3 shows a series of generally flat lying reflectors on the eastern end of the line and a possible normal-faulting offset on the western end which has a minimum detectable displacement of about 30 m (Figure 14). The sense of offset of this possible fault is down to the northeast, opposite to that of the Arco segment. Since the normal fault in line ARCO-A3 has the opposite sense of movement, it is interpreted to be associated with small offsets along normal faults produced by dike-injection in the Arco volcanic rift zone. Line ARCO-A4 shows a series of generally flat lying discontinuous reflectors. No significant offset is observed in the section (Figure 14).

Conclusions: Figure 1 shows a map of the locations of the normal faults. Lines ARCO-81-1 and ARCO-81-2 show displacements along normal faults that are associated with the Arco fault. The lines located on the ESRP suggest the Arco fault may extend as far south as lines ARCO-A2 and ARCO-S2, but not as far southeast as line ARCO-A3. We interpret the fault termination to be located about 5 km southeast of the intersection of highways in the town of Arco. The possible small down-to-the-northeast offset interpreted for the western part of line ARCO-A3 could result from normal fault movement associated with basalt dike injection in the Arco volcanic rift zone.

SYNTHESIS OF NPR GEOSCIENCE RESULTS FOR APPLICATION TO IDAHO WASTE PROCESSING FACILITY SITING

Several geoscience results from the New Production Reactor geology, seismology, and geophysics (GSG) program contain information pertinent to siting of the Idaho Waste Processing Facility. The most important of these are the volcanic zone geologic mapping project, the structural mapping at the south ends of the Lemhi and Lost River faults, and the recompilation of the INEL aeromagnetic survey. The results of these studies, discussed and analyzed in the following sections, have been evaluated for their potential impacts on the screening and selection of potential IWPF sites. Figure 1 shows the favored IWPF sites along with pertinent geologic and geophysical data resulting from the NPR GSG investigations.

1. Volcanic zones geologic mapping project.

The Volcanic Zones Geologic Mapping report (Golder Associates, Inc., 1992) consists of 40 geologic maps of 7.5 minute quadrangles covering the INEL and surrounding areas and a short descriptive text. The maps place all volcanic vents and ground deformation features of the volcanic rift zones in proper geometric context. The ground deformation features are fissures, faults, and monoclines. They occur within and help define the Arco, Lava Ridge-Hells Half Acre, and the hypothesized Howe-East Butte volcanic rift zones. The most important of these ground deformation features are shown in Figure 1. Almost all of the features were known before the mapping was done, but their displacements and lengths are carefully documented in the report. In addition, one new ground deformation feature (the Kath fissure) was discovered and one poorly investigated feature (the LaPoint Monocline) was fully documented and measured. Since these features are located in the central part of INEL, they have potential implications for ground motions at IWPF site 3.

The Kath Fissure

This fissure, so-named because it was discovered and mapped in 1991 by Golder Associates, Inc. geologist Randall Kath, is located about 4 km northwest of Naval Reactors Facility (Figure 1). It is composed of a main fissure that trends N47W for a distance of 137 m and two smaller, more poorly exposed en echelon fissures trending N64W from its northwestern end. The main fissure has a maximum horizontal separation (opening) of 1.1 m.

The NRF fissure (which was known before the NPR mapping project) and the Kath fissure are the only recognized ground deformation features within the hypothesized Howe-East Butte volcanic rift zone (H-EB VRZ). The possibility of a VRZ extending from Howe to East Butte was first entertained by Kuntz (1978) and shown in figures but not discussed in a recent publication about ESRP volcanic rift zone features (Kuntz and others, 1992). The

speculation was based on the presence of four volcanic vents (Horseshoe Butte, AEC Butte, State Butte, and an unnamed butte) in the western part of INEL. Until 1991, the existence of the NRF fissure within the area of the four buttes was the only ground deformation feature that could be attributed to the H-EB VRZ. The discovery in 1991 of the Kath fissure doubled the number of ground deformation features attributable to the hypothesized VRZ.

The ages of the four vents which originally lead to the speculation of a VRZ in the area have been determined or estimated (AEC Butte - ~630,000 years; Horseshoe Butte - >400,000 years; State Butte - ~580,000 years; unnamed butte - probably older than 730,000 years) (Kuntz and others, 1990). The ages of the fissures are not as well established. They must be younger than the lava flow in which they occur; it has been dated at ~520,000 years. They are overlain by and have not disturbed Holocene and possibly late Pleistocene alluvial sediments of the Big Lost River, therefore they must be older than about 10,000 years.

The range in uncertainty in the age of the fissures (10,000 to 520,000 years) is very large (over half million years) and very significant for estimation of recurrence intervals of volcanism (and fissuring) in the VRZ and for evaluating the seismic capability of the VRZ. The proximity of site 3 to the postulated VRZ make it particularly important to assign a recurrence interval with high confidence.

The LaPoint Monocline

The LaPoint monocline (so-called because it was first recognized as a possible fault by LaPoint, 1977) occurs in the Lava Ridge-Hells Half Acre volcanic rift zone (LR-HHA VRZ) (Figure 1). The monocline is 1.4 km long and trends N50°-65°W. The maximum measured vertical displacement is 14m down to the southwest (Golder Associates, 1992). Since analysis of seismic lines south of the Lemhi range (see the previous section of this report) show that the Lemhi fault displacements die out just south of the end of the range, the displacement on the LaPoint monocline is interpreted to result from dike injection processes in the LR-HHA VRZ, as described in Smith and others (1989).

The significance of this structure to the IWPF facility site screening process is that it helps define the closest approach of the LR-HHA VRZ to site 3 and site 5 and uncertainties in its age affect the ground motion levels to be expected at the central sites. As with the Kath and NRF fissures, it seems most reasonable that the age of the monocline is not significantly younger than the lava flows that it deforms. This is because the lava flows were fed by vents along dikes that caused the deformation. If this interpretation is correct, the age of the LaPoint monocline, about 200,000 to 400,000 years, yields a low recurrence interval for volcanism and seismicity in the rift zone. If the interpretation is wrong, and the age of the monocline is much younger, say late Pleistocene or Holocene, then the recurrence interval would be much greater.

Conclusions

- a. The discovery of a previously unknown fissure and the detailed investigation of a poorly studied monocline have helped to define the boundaries of postulated volcanic rift zones in the central part of INEL.

- b. Uncertainties in the ages of the fissure and the monocline contribute to uncertainties in probabilistic ground motion levels at IWPF sites 3 and 5.

Recommendations

In order to reduce the uncertainty in the ages of the Kath and NRF fissures, a field and laboratory effort should be made to further constrain their ages. The effort would include thermoluminescence or radiocarbon dating of the oldest sediments found in the fissures (excavation and/or hand augering would probably be necessary to locate the oldest sediments) and in-situ cosmogenic radionuclides to date rock surfaces produced by the fissuring process. Similar studies would be appropriate for the LaPoint monocline. In addition, there are places along the monocline where significant thicknesses of sediments have accumulated against the uplifted side. An exploratory trench or excavation into these sediments could reveal opportunities for radiocarbon or thermoluminescence dating of buried sediment horizons that could constrain the minimum age of the structure.

2. Structural mapping of the southern parts of the Lemhi and Lost River faults.

Several different approaches were taken in the NPR GSG investigations to develop information that constrains the positions of the southern ends of the Lemhi and Lost River faults. The approaches included seismic reflection surveys, mapping of structure and geometry of the southern segments of the faults, recompilation of ESRP and INEL aeromagnetic surveys, augmentation of ESRP gravity surveys, trenching investigations of the faults, and geologic mapping of the volcanic rift zones. Of these, the seismic reflection surveys (discussed previously), and structural mapping of the faults (discussed here) provided the most important constraints.

Lemhi Fault

For the Lemhi fault, structural mapping (Bruhn and others, 1992) provided substantial evidence that the Howe segment does not extend beyond the southern tip of the Lemhi range. That evidence includes:

- a. A series of cross faults (Figure 1) splay to the east from the southern part of the segment in a pattern that is characteristic of splays developed at fault terminations mapped in numerous other areas.
- b. An east trending gravity anomaly in the area just south of Howe Point suggests that a small graben (downfaulted block) exists beneath the sediments in the footwall of the fault. Such graben have been observed at the terminations of other faults.
- c. Late Quaternary scarp offsets measured in alluvial fan deposits along the range front diminish to near zero at the south end of the range, suggesting that fault displacement dies out there.
- d. A major change in the morphology of the range front occurs 2 km north of the southern tip of the range. South of that point, the Quaternary fault scarp is buried by loess deposits, the elevation of the range decreases, the relief of the range is diminished, alluvial fans are preserved high on the footwall block, and footwall rocks are mostly

covered by unconsolidated sediments. All of these morphologic changes are consistent with rapid decrease in earthquake activity of the fault near the southern tip of the range.

All of these observations suggest that the Howe segment of the Lemhi fault terminates near the southern end of the range. This interpretation is consistent with interpretations of reflection seismic lines (discussed previously) which show that displacements in stratigraphy cannot be interpreted to extend more than 2 km south of the range tip at Howe Point.

Lost River Fault

The structural mapping of the Lost River fault is not yet completed to the level of that for the Lemhi fault. Bruhn and others (1992) report that the late Quaternary scarp offsets measured in alluvial fan deposits along the range front do not diminish towards the south end of the range as they do at the south end of the Lemhi range. Instead they increase from the north end of the Arco segment and level off near the south end of the range, suggesting that late Quaternary offset continues some distance out onto the ESRP. This is consistent with the evidence from the reflection seismic lines (discussed previously) that displacements of stratigraphy extend out onto the ESRP about 5 km from the highway intersection in the town of Arco.

Conclusions

Thorough mapping of the structure and geometry of the southern part of the Lemhi fault and limited mapping of the southern part of the Lost River fault provides evidence for the locations of the southern terminations of these faults. The locations of the fault terminations determined from the fault mapping are consistent with the locations indicated by analysis of seismic reflection lines near the southern ends of the faults.

Recommendations

Additional structural investigations are underway for the southern Lost River fault and results will be available in early summer, 1994. It is not anticipated that the results will require significant changes in the present interpretations, but site selection activities should incorporate results of the on-going study.

For the NPR GSG investigation, work was planned for the Beaverhead fault, but was not done because of termination of the program. Since the fault has an effect on the ground motion at IWPF site 5 (see section on Ground Motion Sensitivity), an investigation of this fault should be done as part of a site-specific geotechnical study should site 5 be selected for construction. Suggested investigations are:

1. Run a series of reflection seismic lines out on the ESRP along the fault's extension (Figure 1).
2. Careful mapping of Quaternary deposits along the range front south of Blue Dome to establish whether or not the fault has had Quaternary displacements.

3. Recompilation of the INEL aeromagnetic survey.

The aeromagnetic data for the ESRP, including an existing survey specific to the INEL area, were reevaluated for the NPR project. One of the most prominent features in the magnetic data at the INEL is a linear magnetic high, as delineated by the 400 and 500 gamma contour lines, that is parallel to the hypothesized H-EB VRZ (Figure 1). This magnetic anomaly

is likely to be associated with a subsurface linear structure which has no surface expression. The width of this linear anomaly suggests that the top of the structure is between 0-5 kilometers but the depth to the bottom of the structure is undeterminable.

This anomaly is similar in amplitude, length, and width to other linear magnetic anomalies in the ESRP. Some of these anomalies are associated with recognized geologic structures. For instance, a northwest-trending anomaly occurs along the Great Rift where subsurface dike swarms are known to exist. However, other volcanic rift zones where subsurface dike swarms are known to exist (for example, the Lava Ridge-Hells Half Acre VRZ) are not associated with aeromagnetic anomalies. These conflicting relationships make it difficult to interpret anomalies, such as the one parallel to the H-EB VRZ, which have no recognizable geologic structures on the surface.

Despite the difficulties of interpretation, the presence of the strong linear anomaly alongside the hypothesized H-EB VRZ lends additional credence to the existence of the VRZ and suggests the presence of an unseen geologic structure in the subsurface. Such a structure could be a dike swarm associated with an inactive, buried VRZ or it could be some structure unrelated to dike swarms. Since there is no gravity anomaly (Bankey and others, 1985) associated with the aeromagnetic anomaly, the causative structure can have no significant mass concentration or deficit. The apparent offset of the magnetic anomaly to the northeast of the proposed H-EB VRZ is difficult to explain based on the existing magnetic and gravity data.

Conclusions

- a. A linear aeromagnetic anomaly beside the postulated H-EB VRZ furnishes additional support for the existence of the VRZ.
- b. The anomaly could be caused by buried dike swarm related to an inactive VRZ.
- c. Because of conflicting relationships of other aeromagnetic anomalies on the ESRP to recognized geologic structures, it is not possible to interpret the cause of the linear anomaly near the H-EB VRZ with any certainty.

Recommendations

If IWPF site 3 is chosen for development the site-specific geotechnical investigation should include activities aimed at resolving the cause of the aeromagnetic anomaly. Such studies should include:

- a. A deep drill hole (~5000 ft) designed to provide drill core for detailed geologic characterization and borehole geophysical logs for measurement of rock properties. Such a hole would be required anyway for determination of subsurface stratigraphy and shear wave velocity measurements in order to model ground motions at the site.
- b. Numeric modelling of the aeromagnetic anomaly to better constrain the interpretation possibilities. Numeric modelling would help constrain the possible geologic interpretations by eliminating structures that do not produce anomalies that are similar to those seen in the aeromagnetic data. Modelling would also help determine if the location of the magnetic anomaly to the northeast of the proposed boundaries of the Howe-East

Butte Rift Volcanic Zone is permissible for a dike swarm located beneath the rift zone. Modelling would also permit investigators to explore different geologic scenarios and their resulting magnetic signatures.

- c. A detailed time-domain electromagnetic (TDEM) survey. TDEM surveys map changes in the conductivity structure of the subsurface. In areas of dike swarms into layered structures the electromagnetic signature of dikes is often easily distinguishable. TDEM equipment that is available at present allows investigators to collect large quantities of high quality data quickly. Data from a TDEM survey contains horizontal and vertical conductivity information so that depth determination is possible along with areal anomaly mapping. This data can then be used in conjunction with the existing geologic, seismic, gravity and magnetic data to further constrain possible sources of the aeromagnetic anomaly.

CONCLUSIONS AND SITING RECOMMENDATIONS

The estimated ground motions at each IWPF site are not greatly different from each other. This suggests that, given the present level of knowledge of each site, earthquake ground motion may not be a discriminating factor in site selection for the IWPF. However, once a site is selected, prescriptive geotechnical engineering and seismic investigations must be done to develop site-specific design and construction parameters (DOE Order 5480.28, Natural Phenomena Hazards Mitigation for DOE Facilities). These investigations range from detailed foundation engineering explorations to regional geoscience studies. The existing information, especially the regional information developed under the NPR program, will be of great value in performing these investigations.

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**TABLE 1 - ESTIMATED GROUND MOTIONS^a FOR IWPf SITES,
AND MAJOR CONTRIBUTOR TO HAZARD**

	PC 1 2 x 10 ⁻³				PC 2 & 3 1 x 10 ⁻³				PC 4 2 x 10 ⁻⁴			
	15th	50th	85th	mean	15th	50th	85th	mean	15th	50th	85th	mean
1 RWMC Area	nd	0.061	0.085	0.069	0.069	0.089	0.131	0.096	0.14	0.19	0.26	0.21
3 Cent. INEL	nd	nd	0.076	0.057	0.051	0.072	0.10	0.084	0.11	0.14	0.21	0.17
5 N of TAN	nd	0.066	0.10	0.080	0.074	0.093	0.15	0.11	0.15	0.18	0.30	0.23
Dominant contributors to the hazard at Site 1 are the Lost River Fault, ESRP random earthquake, and choice of attenuation relationships												
Dominant contributors to the hazard at Site 3 are the Lemhi Fault and choice of attenuation relationships												
Dominant contributors to the hazard at Site 5 are the Lemhi and Beaverhead Faults and choice of attenuation relationships												

a - Estimated mean peak accelerations equivalent to largest horizontal accelerations at bed-rock surface for the 15th, 50th, and 85th percentiles and mean hazard. The values are based on the range of uncertainties in source and site parameters from the sensitivity analyses (see Figure 8). They are not to be used for design.

b - Performance Category and hazard exceedance probability as defined by DOE Order 5480.28.

nd - Values cannot be measured from hazard curves (Figures 2 through 5). Values are less than 0.05g.

TABLE 2 - RESULTS OF SENSITIVITY ANALYSES - FAULT TERMINATIONS
SENSITIVITY OF GROUND MOTIONS^a AT IWPF SITE 1 TO UNCERTAINTY
IN THE LOCATION OF THE SOUTHERN TERMINATION OF THE LOST RIVER FAULT

Performance Category ^b	Exceedence Probability ^b	Mean Hazard ^c	1 Base Case	2 24 km	3 29 km	4 35 km
1	2×10^{-3}	0.069	nd	nd	nd	nd
2	1×10^{-3}	0.096	nd	0.05	0.04 ^d	0.04 ^d
3	1×10^{-3}	0.096	nd	0.05	0.04 ^d	0.04 ^d
4	2×10^{-4}	0.21	0.099	0.108	0.109	0.109

1. Base Case with $M_w=7$ and southern termination of 24km-long Arco segment of the fault at town of Arco (WCC, 1992).

2. Case with $M_w=6.75$ and southern termination of 24km-long Arco segment of the fault at town of Arco.

3. Preferred case with $M_w=7$ and southern termination of 29km-long Arco segment of the fault 5 km southeast of town of Arco.

4. Conservative case with $M_w=7$ and southern termination of 35km-long Arco segment of the fault 11km southeast of town of Arco.

SENSITIVITY OF GROUND MOTIONS^a AT IWPF SITE 3 TO UNCERTAINTY
IN THE LOCATION OF THE SOUTHERN TERMINATION OF THE LEMHI FAULT

Performance Category ^b	Exceedence Probability ^b	Mean Hazard ^c	1 Base Case	2 Preferred Case
1	2×10^{-3}	0.057	nd	nd
2	1×10^{-3}	0.084	nd	nd
3	1×10^{-3}	0.084	nd	nd
4	2×10^{-4}	0.17	0.11	0.12

1. Base Case with $M_w=7$ and southern termination of Howe segment of the fault at the INEL boundary.

2. Preferred case with $M_w=7$ and southern termination of Howe segment of the fault 1km south of Howe Point.

TABLE 2 (CONTINUED)

**SENSITIVITY OF GROUND MOTIONS^a AT IWP SITE 5 TO UNCERTAINTY
IN THE LOCATION OF THE SOUTHERN TERMINATION OF THE BEAVERHEAD FAULT**

Performance Category ^b	Exceedence Probability ^b	Mean Hazard ^c	1* Base Case	2* Extended Fault
1	2×10^{-3}	0.080	nd	nd
2	1×10^{-3}	0.11	nd	nd
3	1×10^{-3}	0.11	nd	nd
4	2×10^{-4}	0.23	0.077	0.096

1. Base Case with $M_w=7$ and southern termination of the Beaverhead fault at the southern end of the Beaverhead range.

2. Extended case with $M_w=7$ and southern termination of the Beaverhead fault 3km south of the southern end of the Beaverhead range.

* - Both cases are extremely conservative because there is no evidence for Quaternary displacements on the Beaverhead fault south of the town of Blue Dome.

a - Estimated mean peak accelerations equivalent to largest horizontal accelerations at bedrock surface. Not to be used for design.

b - Performance Category and seismic hazard exceedence probability as defined in DOE Order 5480.28.

c - Mean hazard values from Figure 8.

d - Estimated by extrapolation of hazard curves (Figures 2 through 4).

nd - Values cannot be measured from hazard curves (Figures 2 through 4). Values are less than 0.05g.

**TABLE 3. RESULTS OF SENSITIVITY ANALYSES - B-VALUE
SENSITIVITY OF GROUND MOTIONS^a AT IWPf SITE 1
TO DIFFERENCES IN B-VALUE ASSUMED FOR ESRP**

Performance Category ^b	Exceedence Probability ^b	Mean Hazard ^c	Case 1 (Low)	Case 2 (High)	Case 3 (Base)
1	2×10^{-3}	0.069	nd	nd	nd
2	1×10^{-3}	0.096	0.069	nd	nd
3	1×10^{-3}	0.096	0.069	nd	nd
4	2×10^{-4}	0.21	0.21	nd	0.10

**SENSITIVITY OF GROUND MOTIONS^a AT IWPf SITE 3
TO DIFFERENCES IN B-VALUE ASSUMED FOR ESRP**

Performance Category ^b	Exceedence Probability ^b	Mean Hazard ^c	Case 1 (Low)	Case 2 (High)	Case 3 (Base)
1	2×10^{-3}	0.057	nd	nd	nd
2	1×10^{-3}	0.084	nd	nd	nd
3	1×10^{-3}	0.084	nd	nd	nd
4	2×10^{-4}	0.17	0.104	nd	0.051

**SENSITIVITY OF GROUND MOTIONS^a AT IWPf SITE 5
TO DIFFERENCES IN B-VALUE ASSUMED FOR ESRP**

Performance Category ^b	Exceedence Probability ^b	Mean Hazard ^c	Case 1 (Low)	Case 2 (High)	Case 3 (Base)
1	2×10^{-3}	0.080	nd	nd	nd
2	1×10^{-3}	0.11	nd	nd	nd
3	1×10^{-3}	0.11	nd	nd	nd
4	2×10^{-4}	0.23	0.078	nd	nd

- Case 1 - Low B-value of 0.5 indicating more large magnitude earthquakes.
- Case 2 - High B-value of 1.3 indicating more small magnitude earthquakes.
- Case 3 - Base case where B-value is 0.85 derived from ESRP seismicity catalog.

a - Estimated mean peak accelerations equivalent to largest horizontal accelerations at bed-rock surface. Not to be used for design.

b - Performance Category and seismic hazard exceedence probability as defined in DOE Order 5480.28.

c - Mean hazard values from Figure 8.

nd - Values cannot be measured from hazard curves (Figure 5). Values are less than 0.05g.

TABLE 4 - RESULTS OF SENSITIVITY ANALYSES - ATTENUATION MODEL
SENSITIVITY OF GROUND MOTIONS^a AT IWP SITE 1
TO CHOICE OF ATTENUATION MODEL

Performance Category ^b	Exceedence Probability ^b	Mean Hazard ^c	BLWN/RVT	Empirical
1	2×10^{-3}	0.069	0.070	0.064
2	1×10^{-3}	0.096	0.099	0.09
3	1×10^{-3}	0.096	0.099	0.09
4	2×10^{-4}	0.21	0.22	0.17

SENSITIVITY OF GROUND MOTIONS^a AT IWP SITE 3
TO CHOICE OF ATTENUATION MODEL

Performance Category ^b	Exceedence Probability ^b	Mean Hazard ^c	BLWN/RVT	Empirical
1	2×10^{-3}	0.057	nd	0.082
2	1×10^{-3}	0.084	0.071	0.11
3	1×10^{-3}	0.084	0.071	0.11
4	2×10^{-4}	0.17	0.14	0.22

SENSITIVITY OF GROUND MOTIONS^a AT IWP SITE 5
TO CHOICE OF ATTENUATION MODEL

Performance Category ^b	Exceedence Probability ^b	Mean Hazard ^c	BLWN/RVT	Empirical
1	2×10^{-3}	0.080	0.056	0.10
2	1×10^{-3}	0.11	0.084	0.15
3	1×10^{-3}	0.11	0.084	0.15
4	2×10^{-4}	0.23	0.17	0.29

a - Estimated mean peak accelerations equivalent to largest horizontal accelerations at bedrock surface. Not to be used for design. See Figure 7.

b - Performance Category and seismic hazard exceedence probability as defined in DOE Order 5480.28.

c - Mean hazard values from Figure 8.

nd - Values cannot be measured from hazard curves in Figure 7. Values less than 0.05g.

Figure 1. Map showing locations of IWPf sites and Geologic features.

Figure 2. Seismic hazard exceedence curves at IWP sites 1, 3, and 5 for variations in extension of the southern termination of the Lemhi fault. Lemhi fault base case includes both edge and extended case weighted at 0.7 and 0.3, respectively. Edge case is termination of fault at end of surface exposure and extended case is termination of fault 1 km south of Howe Point (Figure 1).

Figure 3. Seismic hazard exceedence curves at IWPf sites 1, 3, and 5 for variations in extension of the southern termination of the Lost River fault. See Table 2 for explanation of base case, $M_{\max} 6.75$ at 24km length, and extended case at 35km length.

Figure 4. Seismic hazard exceedence curves at IWP sites 1, 3, and 5 for variations in extension of the southern termination of the Beaverhead fault. Beaverhead is termination at southern tip of Beaverhead Range and extended case is termination 8km into the ESRP (Figure 1).

Figure 5. Seismic hazard exceedance curves at IWPF sites 1, 3, and 5 for variations in b-values or earthquake recurrence on the ESRP. See text for description of curves.

Figure 6. Seismic hazard exceedence curves at IWPF sites 1, 3, and 5 for variations in boundaries of the Arco volcanic rift zone. Arco rift case represents best estimate of boundaries and extended case expands the VRZ to include Area 1.

Figure 7. Seismic hazard exceedence curves at IWP sites 1, 3, and 5 for variations in attenuation relationships (Empirical and Band Limited White Noise/Random Vibration Theory).

Figure 8. Seismic hazard exceedence curves at IWPF sites 1, 3, and 5 for the 15, 50, 85th percentiles and mean hazard incorporating the uncertainties from the sensitivity analyses.

HOWE 82-2

Figure 9. Schematic cross-section showing the structural interpretation of seismic reflection profile.

HOWE 81-3

Figure 10. Schematic cross-section showing the structural interpretation of seismic reflection profile.

Figure 11. Schematic cross-sections showing the structural interpretation of seismic reflection profiles.

ARCO 81-1

Figure 12. Schematic cross-section showing the structural interpretation of seismic reflection profile.

ARCO 81-2

Figure 13. Schematic cross-section showing the structural interpretation of seismic reflection profile.

ARCO A1

ARCO A2

ARCO S2

ARCO A3

ARCO A4

LEGEND

REFLECTORS

INFERRED REFLECTORS

FAULT

INFERRED FAULT

Figure 14. Schematic cross-sections showing the structural interpretation of seismic reflection profiles.

Appendix E

**Flooding Potential at Candidate Sites
for
New Waste Handling Facilities
at the
Idaho National Engineering Laboratory**

**Flooding Potential at Candidate Sites
for
New Waste Handling Facilities
at the
Idaho National Engineering Laboratory**

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SUMMARY

Regulatory considerations and Department of Energy orders discourage or prohibit locating new waste treatment or disposal facilities in areas which are subject to flooding. Therefore, flooding potential is a major consideration in evaluating candidate sites for new waste handling facilities at the Idaho National Engineering Laboratory. In light of this consideration, flooding assessments were performed for the sites currently under consideration for these facilities. The objective in performing these assessments was to determine (if possible) the extent and severity of inundation of the candidate sites during a postulated 100-year flooding event, using an approach which is consistent with the guidelines established by the Federal Emergency Management Agency (FEMA), and using conservative assumptions (where defensible data are not available) to ensure that flooding assessments portrayed worst case scenarios. This conservative bias was introduced in an attempt to allay public concerns about flooding at waste handling facilities, and to augment the defensibility of the site that is finally chosen, in the event of later litigation.

The above objective was formally achieved for three of six candidate sites (sites 1, 3, and 9) under consideration. At these sites, the U.S. Army Corps of Engineers' HEC-1 and HEC-2 computer models were used to calculate credible estimates of stream discharges and ponding elevations for a postulated 100-year flooding event. For the three remaining sites considered (sites 5, 14, and 18), time, funding, and model constraints precluded obtaining comparable results, though conservative estimates were obtained for potential flood discharges on or near the sites.

The HEC modeling results indicated that sites 1, 3, and 9 contain areas which would be inundated to a depth exceeding 1.0 ft during the postulated event. Approximately 36 ac (27%) of site 3 would be inundated by the 100-year event. Moreover, the ponding areas are distributed fairly uniformly throughout the site. This fact tends to discourage the idea of refining the site 3's nominal boundaries to exclude the areas prone to flooding. About 7.2 ac (12%) of site 9 would be flooded from ephemeral streams during the 100-year event, but there are no significant ponding areas on the site. Site 1 contains both ponding areas and ephemeral streams, which would result in inundation of approximately 52 ac (27%) of the site. (The 500-year inundation areas on sites 1, 3, and 9 differ only slightly from the 100-year values.)

Though HEC modeling of Sites 14 and 18 was not performed, order of magnitude estimates of potential discharges from the local watershed suggest these sites are susceptible to major flooding during both 100-year and 500-year events. Surficial and geologic evidences indicate that site 5 is immune from natural flooding. However, the man-made Birch Creek Return Channel, which carries wintertime discharge from the Birch Creek Hydroelectric facility at Reno Ranch back toward the INEL, has been constructed within the past ten years. Because this channel passes within a point roughly half a mile and directly upgradient from site 5, consideration was given to the possibility that drainage flows entering the channel during the 100-year event would impact site 5 under some circumstances. HEC-1 was used to estimate upper bounds on these flows. However, because of the one-dimensional limitation of the models used in the study, the likely degree of flooding at site 5 from these flows was not reliably quantified.

Potential flooding problems at sites 9 and 1 could be adequately addressed by redefining the site boundaries to exclude flooded areas, without rendering the sites unusable. For this reason, sites 1

and 9 are judged to be superior to site 3 on the basis of flooding potential. The assessments of 14 and 18, though not as rigorous as for sites 1, 3, and 9, are sufficiently compelling to exclude these sites from further consideration for the subject facilities, unless further work is done to provide defensible bases for relaxation of conservatisms used in the assessments. Potential for flooding at site 5 requires further study before it can be ranked relative to sites 1, 3, and 9.

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ACRONYMS AND ABBREVIATIONS

ac	acres
ac-ft	acre-feet
BC	Birch Creek
BCRC	Birch Creek Return Channel
BCV	Birch Creek Valley
BLR	Big Lost River
CFA	Central Facilities Area
cfs	cubic feet per second
D&M	Dames & Moore
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIA	Federal Insurance Administration
ft	feet
FY	fiscal year
HEC	Hydraulic Engineering Center (United States Army Corps of Engineers)
INEL	Idaho National Engineering Laboratory
IWPF	Idaho Waste Processing Facility
mi	miles
min	minutes
MLLWDF	Mixed and Low-Level Waste Disposal Facility
NOAA	U.S. National Oceanic and Atmospheric Administration
RWMC	Radioactive Waste Management Complex
SCS	U.S. Soil Conservation Service
TRU	transuranic
TSD	treatment, storage, and disposal
USGS	United States Geological Survey
WIPP	Waste Isolation Pilot Plant
2-D	two-dimensional

Flooding Potential at Candidate Sites for New Waste Handling Facilities at the Idaho National Engineering Laboratory

1. INTRODUCTION

The Idaho Waste Processing Facility (IWPF) and the Mixed and Low-Level Waste Disposal Facility (MLLWDF) are new waste treatment, storage, and disposal (TSD) facilities that are currently in the planning stages at the Idaho National Engineering Laboratory (INEL). The treatment facility is being designed to handle stored transuranic (TRU) and alpha low-level wastes at the Radioactive Waste Management Complex (RWMC). The disposal facility will receive all treated wastes from this facility except for TRU wastes, which will be placed at the Waste Isolation Pilot Plant (WIPP) in New Mexico. In addition, the INEL disposal facility will receive treated low-level mixed wastes from other INEL operations.

An important step in the development of these facilities is site selection. A prior report¹ describes the preliminary siting study that was completed during fiscal year 1992. That study culminated in the recommendation of three candidate sites for the new TSD facilities (referred to as sites 1, 3, and 5). One of the criteria used in screening possible sites was site flooding potential based on existing information at the time. The purpose of the present work was to provide more information on flooding potential at the three recommended sites. In addition, flooding potential was assessed at three additional sites (referred to as sites 9, 14, and 18. Site 9 was so designated because eight sites were initially considered in the preliminary screening process. Sites 14 and 18 derived their designations from their proximity to monitoring wells assigned these numbers.) The locations of all six sites are shown in Figure 1-1.

The following sections describe the specific objectives of the work and provide an overview of the flooding analyses.

1.1 Objectives

1.1.1 100-year Flooding Elevation

U.S. Environmental Protection Agency (EPA) regulations [see 40 CFR 270.14(b)(11)(iii)] require that an owner or operator of a TSD facility provide information on whether the facility is located in a 100-year floodplain. The regulation further states that the determination of the boundaries of the floodplain should be done using either Flood Insurance Program maps [produced by the Federal Emergency Management Agency (FEMA) of the Federal Insurance Administration (FIA)], or, where FEMA maps are not available for a proposed facility location, "equivalent mapping techniques to determine whether the facility is within the 100-year floodplain, and if so located, what the 100-year flood elevation would be."

Figure 1-1. Six Candidate Sites for the Idaho Waste Processing Facility

As discussed in Reference 1, a further requirement for a treatment facility which handles polychlorinated bi-phenyls (PCBs) is that it be located "above the 100-year flooding elevation." The meaning that was attached to this phrase by the site selection committees was that the facility be located above "the lowland and relatively flat areas on the INEL subject to a one percent or greater chance of flooding in any given year."

These regulatory considerations suggest two flooding issues that should be addressed in the selection of a site for the facilities discussed above. The first issue is whether or not the site is in a floodplain. The second issue is whether the site is above the 100-year flooding elevation. According to FEMA officials^a the term "floodplain" implies an area adjacent to an established waterway (e.g., a river, the ocean, etc.) that is subject to inundation due to floodwaters from the waterway. However, as discussed in Reference 1, a "100-year flooding elevation" may be defined for a site, irrespective of the site's proximity to an established waterway. The meaning that was attached to this phrase by the site selection committees¹ was "lowland and relatively flat areas on the INEL subject to a one percent or greater chance of flooding in any given year."

Ultimately, both issues must be addressed in the selection of a site for the facilities. A study by the Environmental Monitoring Unit of EG&G Idaho is currently underway to outline the boundaries of the 100-year floodplain along the three established streams on the INEL [the Big Lost River (BLR), the Little Lost River, and Birch Creek (BC)]. While some reference is made in this document to generalized flooding, a formal delineation of the boundaries of the 100-year floodplains of these streams will await the outcome of the above-mentioned study. However, in the absence of the completed study, a diversion system has been built and extensively tested on the Big Lost River. This diversion is capable of carrying about 9,300 cfs of overflow from two 6-ft diameter gated culverts on the river channel.² The culverts allow for passage of up to 900 cfs through the diversion dam into the main channel of the river.³ The river channel itself is gravel filled and has a bankful capacity of 3,000 cfs.^b Flooding along the Big Lost River due to catastrophic events (e.g., failure of the Mackay Dam, located on the Big Lost River upstream of the INEL) has been addressed by previous studies.^{4,5}

The major objective of the work described in this document was to define the 100-year flooding elevation due to localized runoff. More specifically, the focus was to determine whether any portion of the sites would be inundated during flooding events with return periods of 100 years. Since all locations receive precipitation and experience runoff to some degree, further definition of the term "flooding" was required. FEMA⁶ has defined a zoning scheme for designating different levels of flooding hazard (with correspondingly different flood insurance rates) within a specified region. According to this scheme, areas within the regions with the lowest flooding hazard are termed Zone X areas. Such areas are "... areas of 100-year flooding where average depths are less than 1 foot . . ." (Appendix 2 of Reference 6). Thus, for purposes of accomplishing the stated objective, inundated areas were defined, consistent with the FEMA guideline, as areas on which floodwaters flow or accumulate to a depth of 1 ft or more. The 100-year flooding elevation was correspondingly defined as the area bounded by floodwaters from a 100-year event having a depth of at least 1 ft.

a. Phone conversation of October 13, 1993, with Mr. John Liou (FEMA Denver office).

b. Private communication between R.G. Jensen, U.S. Geological Survey, INEL Office, and K.N. Koslow (now K.N. Keck), EG&G Idaho, Geology & Seismology Unit, on January 25, 1990.

1.1.2 500-year Flooding Elevation

DOE Order 4320.1B requires creation of a Site Development Plan, pursuant to requirements of 10 CFR 1022, Compliance with Floodplain/Wetlands Environmental Review Requirements. The latter document requires a floodplain assessment as part of any action involving acquisition, management, and disposition of Federal lands and facilities [see 10 CFR 1022.4(a)(1)]. This assessment should include a determination of whether the action is located in the base or critical action floodplain, as appropriate [see 10 CFR 1022.11(b)]. The base floodplain is defined as the 100-year floodplain, and the critical action floodplain is defined as the 500-year floodplain.

Pursuant to the above requirement, a second objective of this study was to estimate the maximum inundation area associated with a 500-year flooding event. Consistent with the ideas expressed in Section 1.1.1, only flooding due to localized runoff was formally considered.

1.1.3 Comparison of Sites

The final objective of the study was to compare (if possible) the candidate sites on the basis of any flooding they might experience. The reason for making this comparison is that, while regulatory requirements only dictate that the site selected be above the 100-year flooding elevation, most sites will have to incorporate drainage systems to control storm runoff and snow melt, regardless of their vulnerability to 100-year events. Since costs associated with these systems will generally correspond with the amounts and intensities of precipitation runoff, the flooding analysis results provided a basis for comparison of the candidate sites.

1.2 Flooding Analysis Overview

The desired outcome of the siting process is to identify a site where potential flooding problems are minimal. The approach used to obtain this outcome was to base calculations on defensible flooding parameters. Defensibility was assumed to derive from one of two bases: (a) accurate data gathered over a sufficiently long timespan, and over a sufficiently representative area to typify the site under consideration, and (b) assumptions which can be shown be conservatively bounding. In defining the parameters for the flooding analyses described herein, accurate data were used where they were available. Where such data were unavailable, conservative assumptions were used. By systematically applying this methodology, the result is that some areas may appear to be floodprone, which, in fact, are not. However, those areas which are concluded to be *nonfloodprone* under this approach, are highly likely to be immune from inundation for the recurrence intervals considered. Thus, the above desired outcome was achieved.

1.2.1 Sites 1, 3, 5, and 9

The approach used in assessing flooding potential at sites 1, 3, 5, and 9 was based on the guidance provided by the Federal Insurance Administration in Reference 6. Consistent with this

guidance, the HEC-1 computer code was selected as a tool for performing flood inundation studies.^c The analytical methods in HEC-1 are discussed at some length in Reference 7, and are described briefly in Section 1.3.1. Application of the HEC methodology required the completion of a number of steps. These steps are described below. The results from completing the steps are given in Sections 3, 4, 5, and 2 for sites 1, 3, 5, and 9, respectively.

1.2.1.1 Identify Watershed. The first step was to identify the boundaries of the watershed adjacent to each site that could provide runoff onto the site during a 100-year flooding event. This was done on the basis of contour information on United States Geological Survey (USGS) 7-1/2 minute topographic maps, together with work in the field to investigate critical land features where additional detail was needed to resolve the direction of runoff from certain areas.

1.2.1.2 Route Runoff/Generate Conceptual Flooding Model. The second step was to identify ephemeral streams that runoff would generate enroute to the site, as well as any potential ponding areas where runoff could accumulate due to depression storage (natural reservoirs) and flow restrictions (e.g., culverts). The boundaries of the drainage areas (subbasins) supplying each of the streams had to be identified as part of this task. This was done, again, using the USGS maps and field observations. After the streams and subbasins were identified, a conceptual model for routing all runoff from the watershed was generated as the basis for computer simulation using HEC-1.

1.2.1.3 Define Flooding Events. The third step was to define the hydrological events to use in the computer model. The desired output from this task was a description of the most severe events (in terms of flooding impact to the site in question) that are plausible and that have specified return periods. The manner in which these events were determined is discussed in Section 1.3.3.

1.2.1.4 Generate Required Topographic Information. In order to perform flood routing of runoff from the watershed, detailed topographic information was needed. This step therefore involved aerial surveys and compilation of 2-ft and 4-ft contour maps for the watersheds identified in Section 1.2.1.1.^d These data were organized in the form of hard-copy topographic maps and digital elevation models. The former were used to guide the construction of the conceptual hydrologic models, and the latter were used to generate the model parameters described in Section 1.2.1.5. (The mylar topographic maps are available for review in the IWPF project files).

1.2.1.5 Define Inputs/Run HEC-1 Flood Hydrograph Models. This step required the determination of watershed parameters and other site-specific hydraulic parameters (see Section 1.3.2), which are required inputs for HEC-1. This data (generated from the topographic data

c. HEC-1 is the Flood Hydrograph Package, Computer Program 723-X6-L2010, written and maintained by the Hydrologic Engineering Center, United States Army Corps of Engineers, 609 Second Street, Davis, California. The version which was used is 4.0.3E, June 9, 1992.

d. Aerial photography, photogrammetric compilation of topographic maps, and generation of digital elevation models used in the study were provided by Aerographics, Inc., 2930 South West Temple, Salt Lake City, UT 84115-3599. Quality assurance procedures on the topographic data were performed by Butler Engineering and Land Surveying, 130 East Maple, Shelley, ID 83274, and are documented in Attachment A.

described in Section 1.2.1.4), together with the event description (Section 1.2.1.3), were used to generate HEC-1 input files. The computer models were then run to calculate flood flows in ephemeral streams and water levels in ponding areas at the candidate sites.

1.2.1.6 Estimate Flooding Impacts. The final step in the analysis was to convert the HEC-1 computed results into inundation areas on topographic maps of the respective sites. As discussed in Section 1.3.1, this step involved determining water surface elevations from normal depth and HEC-2 water surface profile calculations. Once this was done, the results were used to map the inundated areas.

1.2.2 Sites 14 and 18

Sites 14 and 18 are characteristically different from the other sites. They were chosen primarily as candidate locations for a mixed waste disposal facility. A major reason for selecting them is that they are located on deep, fine-grained sediments that may retard downward migration of contaminants toward the Snake River Plain Aquifer. The sites are situated in a relatively low-lying, triangular-shaped area bounded on the west by Lincoln Boulevard, and elsewhere by the 4,800 ft contour of elevation. Figure 6-1 shows this area (referred to as basin 14-18), the locations of the sites within it, and the large potential drainage area that was identified on the basis of USGS topographic maps.

Because of the location of these sites on the relatively flat, low terrain of basin 14-18, the worst-case flooding scenario for these areas is similar to that identified for site 3; i.e., the severity of flooding at these sites is dictated primarily by the total volume of runoff into the low areas around the sites, while the flooding at sites 1, 5, and 9 depends primarily on the peak discharge during the flooding event.

The scope of the current effort prohibited detailed modeling of the tributary watershed for basin 14-18 using the same analytical approach as was used for sites 1, 3, 5, and 9. However, in order to provide insight into the potential for flooding from local runoff at sites 14 and 18, the alternative approach described below was used. The results from using this approach are given in Section 6.

1.2.2.1 Identify Watershed. The first step was similar to Section 1.2.1.1. However, after the watershed for the sites was identified, it was divided into "direct" watershed and "indirect" watershed. The direct watershed is the part of the drainage area that empties directly into basin 14-18 without first flowing into any existing channel of the BLR. The indirect watershed is the part that empties first into the BLR and then, potentially, into basin 14-18 (as suggested in Section 1.2.2).

1.2.2.2 Assess Flooding Potential from Direct Watershed. A crude assessment of the "localized" flooding potential from the direct watershed was done by completing the following steps.

1.2.2.2.1 Estimate Depression Storage—The first step after defining the watershed was to estimate the total depression storage volume within the watershed from USGS topographic maps. No formal routing was analyzed to determine which depressions filled first, second, etc. Instead, it was assumed that runoff from the direct watershed would first fill all the available depression storage and then drain into basin 14-18. The reasoning behind this nonconservative assumption was as follows. If it were found that the sites are likely to be flooded under this assumption, then it is likely that the sites are indeed floodprone and should not be further considered.

On the other hand, if it were found that the sites are not flooded under this assumption, then it is still possible that there is flooding potential since not all depression storage may actually be used. In this case, further study would be needed to make a definitive statement regarding flooding potential at sites 14 and 18.

1.2.2.2.2 Define Flooding Event for Basin—The next step was analogous to Section 1.2.1.3 for sites 1, 3, 5, and 9, taking into account the special considerations mentioned in Section 1.2.2.

1.2.2.2.3 Estimate Runoff—On the basis of the assumption in Section 1.2.2.2.1, the total runoff volume into basin 14-18 was calculated using the total depression storage and the total excess precipitation from the assumed 100-year event.

1.2.2.2.4 Obtain 1-ft Topographic Contours—Contour information was needed in order to determine where runoff would accumulate in basin 14-18. Because of the fact that the basin contains relatively little topographic relief, 1-ft contours were needed to route the runoff through the basin. (Mylar topographic maps that were generated are available for review in the IWPf project files).

1.2.2.2.5 Estimate Storage Volumes for Ponding Areas—Using the 1-ft contours generated in Section 1.2.2.2.4, specific areas within basin 14-18 where runoff would accumulate were identified, and the storage volumes of these areas were calculated according to the procedure described in Section 1.3.2.2.6. In addition, for each ponding area (or reservoir), the water surface elevation was determined at which water would begin to spill over into the next reservoir downstream.

The extent of the flooded areas in basin 14-18 was then determined by distributing the total runoff calculated in Section 1.2.2.2.3 into each of the successive reservoirs until the entire runoff volume was accounted for. The final water surface elevations in all the reservoirs were then determined, and a map of the inundated areas for the 100-year event was produced from the contour maps. The impacts of the 100- and 500-year flooding events were then assessed from the proximities of sites 14 and 18 to the flooded areas.

1.2.2.3 Discuss Flooding Potential from Indirect Watershed. A very crude assessment of possible impact of runoff from the indirect watershed was generated by scaling the total runoff computed in Section 1.2.2.2.3 with the total watershed area on the INEL (direct plus indirect watersheds). Implicit in this assessment are the same assumptions used in the direct watershed assessment. In addition, there is an assumption that the runoff from the indirect watershed does not cross Lincoln Boulevard to the west for some reason (e.g., an ice jam at the culvert where the BLR crosses the road), and that the water flows northeastward along the road, eventually entering basin 14-18. The implications of the calculations, as well as their possible limitations, are also discussed.

1.3 Generic Modeling Details

Many of the modeling assumptions and inputs were identical or similar between the candidate sites analyzed. The analytical details that were common to one or more of the sites are described below.

1.3.1 HEC-1/HEC-2 Model Description

The HEC-1 modeling approach is described in detail in Reference 8. It is based on a lumped parameter representation of subcatchments within the watershed that could provide runoff to the area where flooding is a concern. This representation treats the watershed as a collection of homogeneous subbasins, each draining to an outlet location near the low point of the basin. The program provides a number of options for calculating a discharge hydrograph for each subbasin outlet and for simulating the effect of routing the subbasin discharges through the streams that they feed. The attenuation and lagging effects of storage areas (i.e., reservoirs) on the streamflows are also incorporated. The lumped parameter mathematical representation provides a flood hydrograph for each subbasin and stream junction that describes the volume flow rate of water as a function of time at the physical location corresponding to the basin outlet or junction point. In addition, reservoir water volumes and water surface elevations are provided as functions of time for all storage areas represented in the model.

In this study, inundation areas were determined from HEC-1 outputs in one of two ways. For areas adjacent to reservoirs, inundation boundaries associated with the peak water surface elevations were plotted on topographic maps using elevation contours in conjunction with the calculated water surface elevations. For areas adjacent to ephemeral streams, the water surface profiles along the streams were determined. This was accomplished with a one-dimensional, normal flow depth calculation^e in conjunction with backwater calculations^f using HEC-2.^g

e. A normal depth calculation is a solution of Manning's equation:

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

where V is the flow velocity (in ft/sec), n is an empirical friction factor, R is the hydraulic radius (in ft), and S is the slope (in ft/ft) of the energy grade line (which was assumed to be the same as the downstream channel slope). For a given discharge, Q, the above equation is solved for depth, d, by substituting $Q=VA$, together with expressions for the flow cross section, A, and R in terms of d, appropriate for the assumed channel cross section.

f. As described in Reference 8, a backwater calculation is a determination of the water surface profile along a watercourse during steady or slowly-varying flow conditions. This determination is generally done by solving the one-dimensional energy equation in step-wise fashion from a point of known depth (e.g., a reservoir or a location where a normal depth calculation may be performed). In locations where the flow is complex, additional conservation equations may be required to determine changes in water surface elevation.

g. HEC-2 is the Water Surface Profiles Computer Program, written and maintained by the Hydrologic Engineering Center, United States Army Corps of Engineers, 609 Second Street, Davis,

1.3.2 HEC Modeling Assumptions

A HEC-1 multiple subbasin model was developed for each candidate site analyzed. As previously stated, the philosophy applied in defining model inputs was to use measurements where they were available. In situations where measurements were either incomplete or unavailable, conservative assumptions were made, based on whatever data was available. For example, some of the sites analyzed are near the Union Pacific Railroad grade. Because the grade is relatively flat, any overtopping flow across the tracks will be essentially weir-type flow and will be spread over a wide section of track. Where such a track section spans a site boundary, only a fraction of the overtopping flow will run onto the site. Since this fraction was not quantifiable with the one-dimensional HEC-1 model, a conservative assumption was made that the effective width of the weir flow was limited to the track length that actually bordered the site, thus forcing the entire overtopping flow onto the site in question.

Runoff from subbasin areas in the HEC-1 model was calculated using the U.S. Soil Conservation Service (SCS) dimensionless unit hydrograph method with a T_c calculated according to the Kirpich method (see Section 1.3.2.1.1), which is frequently used for ungaged watersheds. The calculated runoff was then routed using the Muskingum-Cunge method (see Section 1.3.2.1.2). The analyses performed using these methods are hereafter referred to as baseline analyses. As a check on the accuracy of the baseline methods, a separate analysis was performed using the kinematic wave mathematical model to calculate and route runoff. This method relies to a greater extent on modeling from first principles than the unit hydrograph method, which uses empirically measured parameters. The modeling assumptions used in both analyses are described below.

1.3.2.1 Baseline Analyses. The assumptions and parameters used for the baseline analyses of the candidate sites are discussed in the following sections. When assumptions were made that differ materially from those described below, such assumptions are noted in the chapters devoted to those sites.

1.3.2.1.1 Time of Concentration—Only one parameter, L (the lag time), is required for the SCS unit hydrograph method. This parameter is the time from the center of rainfall excess to the peak of the runoff hydrograph. The parameter is estimated from the time of concentration (T_c) for the watershed ($L = 0.6 T_c$) and can be determined by several different methods, each of which gives slightly different results. The Kirpich T_c method⁹ was chosen for this study based on results published earlier for a similar flooding study¹⁰ performed by Dames & Moore (D&M) for the RWMC at the INEL. In their study, D&M considered five different methods for calculating T_c [Upland, Curve Number (both of which are SCS methods), Kirpich, U.S. Bureau of Reclamation (1987) method, and the Idaho State Highway Nomograph method]. For their study, the Kirpich method gave the lowest (or very nearly the lowest) times of concentration. Since lower times of concentrations generally mean higher peaks in runoff hydrographs, the Kirpich method was chosen for the baseline flooding analyses in this study, in keeping with the conservative approach discussed above.

California. The version that was used is 4.6.0, February 1991.

The time of concentration reflects the time lag between the onset of excess precipitation and the peak in the hydrograph at the outflow of a subbasin. It was estimated using the Kirpich equation as follows:

$$T_c = \frac{0.0078L^{0.77}}{S^{0.385}} \quad (1-1)$$

where:

- T_c = time of concentration for the subbasin (min)
- L = length of longest watercourse in the subbasin (ft)
- S = slope between maximum and minimum elevation (ft/ft)

The length and slope parameters for each subbasin were determined from 2-ft or 4-ft contour maps, depending on the degree of vertical relief.

1.3.2.1.2 Flow Routing—Runoff was assumed to collect in streams in which routing from subbasin outlet to subbasin outlet was performed by the Muskingum-Cunge method. This method is a nonlinear coefficient method that accounts for hydrograph attenuation based on physical channel properties and the inflow hydrograph. An eight-point typical channel cross section, an average channel slope, and Manning's roughness coefficients are used to define the channel conditions. A Manning's roughness of 0.05 was selected to represent sage brush with wild grass and weed undergrowth that prevails in the ephemeral channels of the watershed. This roughness value lies in the middle of the range of values recommended for flood plains with scattered brush and heavy weeds described in tables in Reference 11.

1.3.2.1.3 Precipitation, Snowmelt Losses, and Base Flow—Since ripe snow and frozen ground conditions were assumed in all flooding models at elevations where runoff was generated, snowmelt and rainfall losses and loss rates were set equal to zero. Although very small losses due to interception, sublimation, and evaporation may occur, their effect was considered negligible in the short time interval during which runoff would be generated. In addition, no ponding or water retention of any kind was assumed, except in reservoirs of sufficient size to be modeled explicitly. Base flow was considered negligible under conditions of frozen ground and the short time frame for generating runoff.

The HEC-1 output indicated that a significant amount of snowmelt loss was occurring in the computations, apparently due to interpolation and rounding error as the degree-day snowmelt rate (0.08 in/degree day) was applied with a small computational time interval (NMIN = 15 min). There was approximately a 10% loss in volume noted in the output. Adjustment of the snowmelt rate upward by 10% (i.e., to 0.088) corrected this problem.

1.3.2.1.4 Sensitivity of Computational Time Step—The selection of the HEC-1 computational time interval, which is also the duration of the unit hydrograph, should not be greater than 0.29 times the Lag L in the SCS unit hydrograph method.¹² Strict application of this limitation to some small subbasins used in this study would require very small computational time intervals, in some cases less than 5 min. To determine whether this restriction would be necessary, an analysis was performed to assess the sensitivity of computed peak Q and total volume of runoff to variations in the time step variable NMIN. Several HEC-1 calculations were done for subbasin 1 at site 9 using different values of NMIN covering a range of values from 3 to 60 min. Based on the subbasin area

of 0.17 mi², the lag time L is 0.19 hour, so the above timestep limitation suggests an NMIN not exceeding 3.3 min.

The results of the sensitivity study indicated that for NMIN between 3 and 30 min, the peak discharge remained constant at 21 cfs, while the volume varied from 2.218 to 2.210 in (less than 0.4% difference). With NMIN = 60 min, the peak discharge dropped to 20 cfs and the volume to 2.202 in. These variations were deemed insignificant in comparison to other uncertainties; thus, it was concluded that the model was insensitive to time steps of 30 min or shorter and that an NMIN of 15 min would provide suitable accuracy for the subbasins in this study.

1.3.2.2 Kinematic Wave Analysis.

1.3.2.2.1 Concept—The parameters of the kinematic wave model are developed from physical characteristics of the watershed, and equations of motion are used to simulate the movement of water through the system. Parameters such as catchment length and area, surface roughness, slope, and channel geometry are used to define the flow conceptually over basin surfaces into collector channels and through main channel networks. Like the unit hydrograph model, the components of a kinematic wave watershed model are subbasins. Each subbasin consists of one or two overland flow planes, one or two collector channels, and a main channel that may be linked to other subbasins in a network.

1.3.2.2.2 Overland Flow Plane—The kinematic wave method has been used primarily in urban drainage applications in which one overland flow plane represents impervious areas, such as roofs and driveways, and the other represents lawns and other pervious areas. The key to using this method in an open range setting typical of the sites in this study, is to define the overland flow component consistent with the conditions that exist. The U.S. Soil Conservation Service¹³ and others have found that Manning's kinematic wave solution should not be used for sheet flow longer than 300 ft. Thus, in this study, one overland flow plane of 300 ft length was used to represent flow into the collector channel system. The slope of the overland plane was taken as the area average slope of the subbasin. Roughness coefficients for sheet flow on overland flow planes are, in general, difficult to predict. For the rangeland conditions typical of the sites analyzed in this study, a roughness coefficient of 0.3 was selected. This value was based on an interpolation of tabulated values¹³ of 0.13 and 0.40 for "range (natural)" and "woods, light underbrush," respectively.

1.3.2.2.3 Subcollector Channel—The subcollector channel models the flow from the uppermost point of channel flow through the collector system to the main channel. Inflow from overland flow planes is distributed along the entire length of this channel. Model inputs for this component include: (1) longest flow path from the upstream end of the subcollector channel to its outlet at the main channel, (2) channel slope, (3) channel roughness coefficient, (4) channel cross section, and (5) surface area drained by a single representative subcollector channel. In this study, (1) was determined by dividing the average width of the subbasin by two, assuming that the main channel generally followed the longitudinal center of the area. The slope (2) for subcollector channels was assumed to be the same as the basin area-averaged slope. Manning's "n" for the channel, item (3), was assumed to be 0.05 as discussed above in Section 1.3.2.1.2. The channel cross section (4) was assumed to be triangular with a side slope of 2%, based on analysis of several surveyed cross sections. Item (5) was determined by multiplying the subcollector channel length by 600 ft, assuming that two 300-ft-wide overland flow planes drained into the channel on both sides.

1.3.2.2.4 Main Channel—A main channel carries flow from upstream subbasins as well as from the collector channels within the subbasin where the channel is located. For this reason, there are generally no separate routing reaches in a kinematic wave model. Inflow from the collector channels is assumed to be uniformly distributed along the length of the main channel. The model input for this channel is similar to that required for the subcollector channel. The length of the main channel in this study was taken as the length of the ephemeral channel shown on the quad maps. The slope was estimated from this length and the elevation differences indicated by the contours crossed. The channel cross section and Manning's "n" were assumed to be the same as for the subcollector. The area associated with the main channel was considered to be the total area of the subbasin.

1.3.2.2.5 Timestep for Model Computations—The accuracy of a finite difference solution to the kinematic wave equations depends on the difference increments Δx and Δt used for each overland flow or channel element. In HEC-1, these difference increments are automatically selected by the program on the basis of the depth of flow in the catchment. A variable time step is used to preserve computational accuracy. The hydrograph computed with the variable time step is interpolated to the computational time interval NMIN specified by the user in model input, and the amount of interpolation error is indicated in output. If the interpolation error is too great, the user can reduce NMIN specified in input. However, this was not necessary for the calculations in this study.

1.3.2.2.6 Reservoir Volume vs. Water Surface Elevation—The relation between these two characteristics was represented as a separate table for each reservoir. Table values were computed from the digital elevation models that were supplied by the photogrammetry contractor who generated the topographic maps (see Section 1.2.1.4). The reservoir volume at each water surface elevation was computed using the TerraModel personal computer software package.^h

1.3.3 Flooding Events

To define the flooding events to be analyzed, published meteorological data for the 40-year period from 1950 to 1990 were used.¹⁴ According to these data, storms with the highest intensity occur in connection with summer thundershower activity. However, such storms present little flooding potential because "the dry ground in the summer is able to absorb the moisture and also because thunderstorms tend to be very localized in size" (Reference 14).

The more likely flooding scenario is a period of sub-freezing temperatures and precipitation in the late fall or early spring, followed by above-freezing temperatures accompanied by additional precipitation in the form of rain or snow. Similar sequences to this have occurred at least three times during the 40-years of record. The first such sequence occurred in February 1962 when 1.94 in. of precipitation fell over a 7-day period at the Central Facilities Area (CFA) on top of 8 in. of snow. Approximately 1.5 in. of moisture (rain and snow) fell over 3 of the 7 days (0.58, 0.58, and 0.54 in. on February 9, 10, and 11). The air temperatures during this 3-day period were a few degrees above freezing, and diurnal variations in temperature were slight.

h. TERRAMODEL, version 8.21, developed and marketed by PlusIII Software, Inc., One Dunwoody Park, Atlanta, GA 30338.

The second instance of this above flooding sequence was in January, 1969. Just prior to this event, 11 in. of snow were reduced to 3 in. From January 19 to 21, approximately 1.69 in. of moisture fell (daily accumulations of 0.79, 0.31, and 0.59 in.). After initial freezing temperatures in the morning of January 19, temperatures remained above freezing both day and night, and the precipitation was generally continuous.

The third sequence occurred in February, 1982. A winter thaw reduced a 9-in. snow cover to 5 in. during late January. From February 14 to 19, warm air advection, combined with approximately 0.27 in. of rain (as recorded at CFA), reduced the snow cover to zero.

In addition to the above periods, Reference 14 describes other wintertime meteorological events deemed relevant to defining the 100-year baseline event. On December 22, 1964, the largest measured 24-hour accumulation of winter precipitation occurred. The amount measured was 1.07 in. in the form of light rain for most of the day. One of the largest 24-hour precipitation events of record occurred in the late spring on April 20, 1981, when 1.51 in. fell. Finally, the warmest average daily wintertime temperatures occurred on December 23, 1955, February 5, 1963, March 31, 1966, and January 16, 1974. The average temperatures on these days were 43.8, 42.8, 53.4, and 42.2, respectively.

The above information supports the choice of the "winter rain on snow with frozen ground" scenario as the most severe (but credible) flooding event for the INEL sites under consideration. The assumption of frozen ground presumes zero infiltration of the surface everywhere. In light of the fact that the sediment layer on top of the basalt flows is thin or nonexistent in many areas of the INEL, zero infiltration appears overly conservative. However, in the absence of representative measurements of infiltration losses over the candidate site locations (under the postulated frozen soil condition), the assumption of zero infiltration was used in order to obtain demonstrably conservative results.

The specific events chosen for determining the 100-year flooding elevation were the same as those used in a prior RWMC study¹⁰ where the details of the statistical foundation and rationale for parameter selection are presented.

1.3.3.1 100-year Flooding Event. The 100-year event consists of a 2-year, 24-hour winter rain storm (contributing 0.50 in. of precipitation at CFA) together with 50-year, 24-hour snowmelt (contributing 1.71 in. of precipitation at CFA) on frozen ground (zero infiltration loss) yielding 2.21 in. total runoff. The 50-year, 24-hour snowmelt was computed from the recorded hourly temperature variation on March 31, 1966. Data for this date was assumed to represent 50-year, 24-hour maximum daily average temperature for the INEL (see Reference 10) and is shown in Figure 2-3. It was shown in Reference 10 that the 50-year, 24-hour scenario produces significantly higher runoff than alternative 100-year events that were considered (e.g., 2-year, 24-hour snowmelt with 50-year, 24-hour winter rain).

In modeling the event, the rainfall was distributed temporally according to the SCS Type II synthetic rainfall distribution that is applicable to this region.¹⁵ In addition, the hourly temperatures on March 31, 1961, were lagged 4 hours so that the maximum hourly snowmelt coincided with the maximum hourly precipitation.

An assessment of the credibility of this event is provided in Section 1.3.3.3, below.

1.3.3.2 500-year Flooding Event. The 500-year event consists of a 10-year, 24-hour winter rain storm (contributing 0.75 in. of precipitation at CFA) together with 50-year, 24-hour snowmelt (contributing 1.71 in. of precipitation at CFA) on frozen ground (zero infiltration loss) yielding 2.46 in. total runoff. As with the 100-year event, this scenario produces the highest total runoff of the 500-year events considered and was thus assumed the most severe flooding event with a 500-year recurrence interval.

For each of the candidate sites, 100-year and 500-year flooding events were defined. For some sites, whose location was near the CFA area, these events were assumed to be identical to those described above. Some sites, however, required adjustments to the above events to account for meteorological differences between the sites and CFA and differences in the type of event chosen to be the most severe. For example, a site through which floodwaters flow but do not accumulate would be most vulnerable to flooding during events yielding the highest peak discharge, while an area in a closed basin where floodwaters accumulate would be most vulnerable to events yielding the highest total volume of runoff. Necessary adjustments to the baseline 100-year and 500-year flooding events for each of the candidate sites are described in the chapters discussing the site-specific results of the analyses.

1.3.3.3 Assessment of the Postulated 100-year Event. Reference 6 provides the following guidance in validating rainfall-runoff modeling: "Computed peak discharges from the hydrologic model should be comparable with the discharges from published USGS [United States Geological Survey] regression equations." In order to make the suggested comparison, a copy of Reference 16 was obtained on the recommendation of Dr. L. C. Kjelstrom of the USGS (Boise, Idaho office). However, the regression equations in the report are not considered applicable to the terrain of interest on and around the INEL (Reference 16 states, "The regression equations would not apply to streams that are ephemeral, that are subject to intensive thunderstorms, or that drain areas significantly affected by man's activities. Streams that drain unforested basins or that flow through alluvial valleys may also be poorly defined."). From this it was concluded that suitable regression equations for the INEL have not been developed by the USGSⁱ.

In the absence of regression equations for flooding discharges, the accuracy of the postulated 100-year flooding event may be assessed by comparison of computed specific discharges with indirect field measurements¹⁷ of specific discharge, obtained in seven small drainage basins near Argonne-West during the February, 1962 flooding event described in Section 1.3.3. These basins range in area from approximately 3.5 to 20 mi². The discharges reported in Reference 17 range from 10 to 76 cfs/mi², all of which were measured on February 11, 1962. By comparison, the steady state specific discharge corresponding to the assumed runoff excess of 2.21 inches in 24 hours, with zero infiltration (i.e., the assumed 100-year event), is about 59 cfs/mi². This value falls within the range of the indirect measurements.

The steady state specific discharge would actually be measured if the rainfall and snowmelt occurred at a constant rate over a time period sufficient to fill up all depression and interception

i. The validity of this conclusion was confirmed in a phone call to Dr. Kjelstrom on 25 July 1994.

storage. From the description of conditions during the 3-day period from February 9-11, 1962, it may be inferred that the measured discharges resulted from a combined rainfall and snowmelt rate which was fairly constant (e.g., Reference 14 states, "The temperatures over the three days were generally just a few degrees above freezing, with not much difference between daytime and nighttime values." See also, Table 3 from the reference for a semi-quantitative description of hourly precipitation). Thus, it is appropriate to compare the steady state specific discharge, for the hypothetical postulated 100-year event, with the measured range of discharges. As noted above, the comparison shows reasonable consistency between the two.

This suggests that the total *amount* of runoff for the postulated 100-year event is reasonable. However, it can also be noted (using the computed discharge hydrographs provided in the chapters which follow) that the peak *intensity* of computed specific discharge is substantially in excess of the steady state value of 59 cfs/mi². This excess reflects the assumption (noted above) of a non-uniform temporal distribution of rainfall and snowmelt, and a resulting concentration of both in a three hour period around noon. This assumption was made to maintain the conservatism discussed in Section 1.2.

1.3.4 Outline of this Report

The remaining sections of this report provide site-specific details of the application of the above methodologies to the six candidate sites. Separate sections (Sections 2 through 5) are dedicated to each of sites 1, 3, 5, and 9. Flooding analyses for both sites 14 and 18 are described in a single section (Section 6). The information in each section is organized into the following subsections:

- **Site Description**

This section contains a general description of each site, including its location and a brief overview of the site topography.

- **Potential Watershed**

This section describes the potential drainage that could provide runoff to the site and the rationale used to define this area.

- **Conceptual Model**

This section describes the major features of the model used to determine flooding potential on the site. For those sites where HEC-1 was used, a schematic diagram of the conceptual model is provided.

- **Flooding Events**

This section describes the site-specific hydrological events used to drive the flooding model. It includes any required changes to the baseline 100-year and 500-year events described in Section 1.3.3.

- **Modeling Assumptions**

This section discusses any required changes made to the baseline assumptions and parameters described in Section 1.3.2.

- **Flooding Analysis Results**

The major results from the flooding analyses for the site are presented.

- **Site Flooding Potential**

A summary assessment of site's flooding potential is given.

Overall conclusions from the study are summarized in Section 7.

2. FLOODING POTENTIAL AT SITE 9

2.1 Site Description

Site 9 is located near the southern boundary of the INEL within Sections 17 and 20 of township T2N, range R29E (see Figure 1-1). The site covers approximately 62 ac and is situated about 1 mi east of the RWMC, just north of the Union Pacific Railroad. The elevation of the site is between 5,026 and 5,072 ft above mean sea level (1927 North American datum), or roughly 20-65 ft above the elevation of the east end of the RWMC. The site slopes gently to the north, and USGS maps indicate the presence of at least two ephemeral streams passing through the site.

2.2 Potential Watershed

Figure 2-1 shows the area included within site 9, the potential watershed for the site, and the ephemeral streams and reservoirs. The boundaries of the drainage subbasins into which the watershed was divided are also shown. The potential watershed was defined from 20-ft contour maps, site inspection, and using drainage information that was previously obtained¹⁸ to support flooding analyses at the RWMC. It includes all area that is higher in elevation than the site and that drains either directly or indirectly to the site through ephemeral streams identified on USGS topographic maps or through low-lying areas that could become streams on the basis of their topography.

The watershed incorporates an area of roughly 82 ac south of the railroad and extends about 0.4 mi in this direction. This southern portion of the watershed (subbasin 1) drains to a ponding area adjacent to the railroad, as indicated in the figure. This ponding area can store approximately 23 ac-ft before water begins to spill over the railroad grade. The area is drained by a culvert 24 in. wide by 24 in. high that runs northward under the railroad and empties into one of the previously mentioned ephemeral streams which pass through the site.

The watershed also includes an area of roughly 142 ac north of the railroad. This area includes the 62-ac site plus 80 ac adjoining the site and was subdivided into subbasins 4 and 5. The entire watershed for site 9 comprises an area of only about 223 ac. All other surrounding terrain can be shown to drain away from the site, either northward toward Adams Boulevard or eastward toward site 1 and away from site 9.

Floodwaters that are collected by the two ephemeral streams passing through the site will flow in a north-northwesterly direction toward another ponding area on the south side of Adams Boulevard. The water then crosses the road (through culverts or overtopping, depending on the magnitude of the flooding event) and then flows in a northeasterly direction toward the main channel of the BLR. Once floodwaters reach the ponding area along Adams Boulevard, it is assumed they are no longer a threat to the site. This assumption is based on the difference in elevation between this location and the lowest point on the site (roughly 20 ft); the actual volume of runoff required to raise the water surface at the Adams Boulevard ponding area by this amount was not determined, but it was assumed to be in excess of what the 100-year or 500-year events could supply.

Figure 2-1. Site 9, its Potential Watershed, and Inundation Area for 100-year Event

2.3 Conceptual Model

2.3.1 Major Model Features

The major features of the conceptual model are the three drainage subbasins indicated in Figure 2-1, the ponding area (reservoir 1) next to the railroad, the culvert that drains this ponding area, and the two ephemeral streams that flow through the site and eventually into the ponding area south of Adams Boulevard. Because of the large change in elevation between this ponding area and the boundary of site 9, it was assumed that the depths of the flows in the streams on and near the site boundary are not influenced by the ponding area at Adams Boulevard. Therefore, the conceptual model did not include this area, but it extended north only to an arbitrary point in the ephemeral streams, just downgradient from the site boundary.

A schematic of the conceptual HEC-1 model is given in Figure 2-2. The input decks for the baseline HEC-1 calculations are reproduced in Attachment C.

```
SB1
V
RES1
V
1T04      SB4
.
CP1.....
SB5
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Figure 2-2. Schematic of HEC-1 Model for Site 9 ("V"=Routing, "-->"=Diversion, "."=Connector)

2.3.2 Effects of Ephemeral Streams on the Site

Except for water impounded behind the railroad and unable to flow through the culvert, all the drainage from the watershed passes through the ephemeral streams on the site. To characterize the potential flooding problem on the site, it was therefore necessary to determine flow depths and inundation boundaries for these streams. This was done by performing backwater calculations with HEC-2 once the stream hydrographs were calculated with the HEC-1 model. The water depth at the starting point for the HEC-2 calculation (i.e., the downstream extremity of the HEC-1 model) was calculated using normal depth calculations.

2.4 Flooding Events

The 100-year and 500-year events used in the flooding analysis for this site were unchanged from the baseline events described in Section 1.3.3.

2.5 Modeling Assumptions

In addition to the assumptions discussed in Section 1.3.2, two different assumptions were made regarding the culvert that drains subbasin 1; that is, that the culvert was either completely plugged or

completely free-flowing during the entire flooding event. These two extreme cases were assumed to bracket all possible conditions at the culvert.

For the case of a free-flowing culvert, the flow was assumed to be governed by the following orifice equation:

$$Q = 0.6A(2gh)^{0.5} \quad (2-1)$$

where:

Q = volume flow rate through culvert

A = flow cross section

g = acceleration of gravity

h = elevation difference between upstream water surface and centerline of the culvert

2.6 Flooding Analysis Results

2.6.1 100-year Event

2.6.1.1 Flood Hydrographs and Volumes. The excess precipitation (runoff) for the 24-hour, 100-year event (consisting of rain plus melting snow) is shown in Figure 2-3, together with the corresponding assumed temperatures for the period. The flood hydrograph at the outflow to subbasin 1 is shown in Figure 2-4. Comparison of the precipitation curve and the flood hydrograph indicates very little lag time between the midpoint of the precipitation excess curve and the peak in the flood hydrograph. This result is consistent with the comparatively small area of the watershed and the short routing distance for runoff.

The area under the hydrograph indicates a runoff volume of 15 ac-ft, which is less than the capacity (23 ac-ft) of the ponding area (reservoir 1) next to the railroad. Thus, for the assumption of a plugged culvert, the entire drainage from subbasin 1 is contained and does not flow onto the site. Since this means that subbasin 1 would have zero flooding impact on the site, this case was not considered further. Rather, the conservative assumption was made that the culvert is free-flowing for the entire event.

Flood hydrographs at the outlets to subbasins 4 and 5 are shown in Figure 2-5 and Figure 2-6. Subbasin 5 incorporates only a small fraction of site 9, and most of the runoff drains away from the site. The peak combined runoff flow from site 9 is 43 cfs and includes runoff from subbasins 1 and 4 but excludes the small amount from subbasin 5 that originates on the site. The corresponding total runoff volume is 32 ac-ft. If the boundaries of the site were expanded to include all the area of subbasin 5, the total combined runoff would be 56 cfs, with a corresponding runoff volume of 42 ac-ft.

Figure 2-3. Total Excess Precipitation (Rain & Snowmelt) and Temperatures During 100-year Event (Site 9)

Figure 2-4. Outlet Hydrograph for Subbasin 1, 100-Year Event (Site 9)

Figure 2-5: Outlet Hydrograph for Subbasin 4, 100-Year Event (Site 9)

Figure 2-6. Outlet Hydrograph for Subbasin 5, 100-Year Event (Site 9)

2.6.1.2 Inundation Area for 100-year Event. A HEC-2 backwater calculation was performed for the stream comprises the outflows from subbasins 1 and 4. The calculation assumed a stream depth of 0.4 ft at the outlet of subbasin 4, based on a normal depth calculation. The HEC-2 results are summarized in Figure 2-2, which shows the boundary of the inundated area. This boundary was defined from stream widths implied by the HEC-2 water surface profile together with the nine prismatic cross-sections used to represent the floodway. The total inundation area shown is approximately 7.2 ac or roughly 12% of the total site area. The stream depth and width were 0.5 ft and 116 ft, respectively, at the north boundary of the site, and 0.78 ft and 38 ft at the middle of the site. As indicated in the figure, the inundation area is confined to the area along the main ephemeral stream through the site.

2.6.2 500-year Event

2.6.2.1 Flood Hydrographs and Volumes. Excess precipitation (runoff) and temperatures for the 24-hour, 500-year event are shown in Figure 2-7. The hydrograph at the outflow to subbasin 1 is shown in Figure 2-8. Since the only difference between the 100-year and the 500-year events is an approximately 10% higher rainfall for the latter, there are only slight differences between the respective hydrographs. As in the case of the 100-year storm, the ponding area south of the railroad has sufficient storage volume to accommodate all the runoff (17 ac-ft) from subbasin 5, so the culvert across the railroad was assumed to be free-flowing for the entire event.

Flood hydrographs for the 500-year events at the outlets to subbasins 4 and 5 are shown in Figure 2-9 and Figure 2-10. The peak combined runoff flow to site 9 due to runoff from subbasins 1 and 4 is 52 cfs, with a corresponding total runoff volume of 35 ac-ft. Inclusion of the small amount of runoff in subbasin 5 that originates on site 9 will produce a total combined runoff of 69 cfs, with a corresponding total runoff volume of 46 ac-ft.

2.6.2.2 Inundation Area for 500-year Event. The HEC-2 backwater calculation for the 500-year event, based on a stream depth of 0.4 ft at the outlet of subbasin 4 (again, from a normal depth calculation), predicts an inundation area of approximately 7.4 ac, again roughly 12% of the total site area. The stream depth and width were 0.53 ft and 120 ft, respectively, at the north boundary of the site, and 0.86 ft and 41 ft at the middle of the site. As for the 100-year event, the inundation area is confined to the area along the main ephemeral stream. (The 500-year inundation area is very nearly identical to the 100-year and is therefore not shown graphically.)

2.6.3 Assessment of Model Fidelity

As discussed in Section 1.3.2, the fidelity of the baseline (unit hydrograph) model was assessed by comparing the results with those obtained using the kinematic wave model for generating hydrographs and routing steam flows. The results of the comparison are indicated in Figure 2-11, where the outlet hydrographs for subbasin 1, generated by the two methods, are plotted together. The maximum difference in the peak discharge was for subbasin 1 during the 500-year event, where the difference amounts to about 3%. This comparison suggests that the fidelity of the baseline results is acceptable.

Figure 2-7. Total Excess Precipitation (Rain & Snowmelt) and Temperatures During 500-year Event (Site 9)

Figure 2-8. Outlet Hydrograph for Subbasin 1, 500-Year Event (Site 9)

Figure 2-9. Outlet Hydrograph for Subbasin 4, 500-Year Event (Site 9)

Figure 2-10. Outlet Hydrograph for Subbasin 5, 500-Year Event (Site 9)

Figure 2-11. Subbasin 1 Outlet Hydrographs for 500-Year Event From Kinematic Wave and Unit Hydrograph Runoff Models (Site 9)

2.6.4 Generalized Flooding from Big Lost River

The potential for site 9 being threatened by generalized flooding along the BLR was not directly addressed in this study. The 100-year floodplain for the BLR will be defined as part of the study by the Environmental Monitoring Unit described in Section 1.1.1. However, the results of an earlier study⁵ indicated that the RWMC would not be inundated by a catastrophic failure of the Mackay dam during the probable maximum flood. Since site 9 is at least 30 ft higher than the RWMC in elevation, and since the probable maximum flood, coupled with failure of Mackay dam, is the most severe hydrological event that is credible, it is inconceivable that generalized flooding due to the BLR would threaten the site.

2.7 Site Flooding Potential

The foregoing flooding analysis results for site 9 are summarized as follows:

- The site lies wholly above the 100-year flooding elevation, as defined in Section 1.1.1.
- Approximately 7.2 ac of the 62-ac site are inundated during the 100-year event to a depth of less than 1 ft by the flood flow in one ephemeral stream passing through the site. The corresponding inundation area during the 500-year event is 7.4 ac.
- Maximum water depths, discharges, and total volume of runoff on the site for the 100- and 500-year events, plus the above inundation areas, are summarized in the following table:

	<u>100-year event</u>	<u>500-year event</u>
Maximum depth, d (ft):	1.02	1.07
Inundation area, d < 1 ft (ac):	7.15	7.08
% of site flooded, d < 1 ft:	12.0	12.0
Inundation area, d ≥ 1 ft (ac):	0.05	0.20
% of site flooded, d ≥ 1 ft:	0.08	0.32
Total inundation area (ac):	7.2	7.4
Total % of site flooded:	12.0	12.0
Maximum discharge to site (cfs):	43.0	52.0
Total runoff to site (ac-ft):	42.0	46.0

The fact that there are no significant ponding areas on the site, together with the comparatively small watershed providing runoff, both indicate that site 9 has low flooding potential. While the total potential runoff volumes for the 100-year and 500-year events would present a problem if accumulated in one place, the natural grade on the site, together with its elevation above the natural ponding area at Adams Boulevard, suggest that it could easily be graded and drained in such a way as to facilitate the passage of floodwaters through or around the site to preclude any potential accumulation of water. The calculated discharges from the current study could be used to size the required flood drainage system.

3. FLOODING POTENTIAL AT SITE 1

3.1 Site Description

Site 1 is located near the southern boundary of the INEL within Sections 15, 21, and 22 of township T2N, range R29E (see Figure 1-1). It covers approximately 193 ac and is situated roughly 2 mi east of the RWMC. The site lies entirely within the area bounded on the south by the Union Pacific Railroad, on the east by the INEL railroad spur (which goes north to TAN), and on the west by Farragut Boulevard (the north boundary degenerates to a single point where Farragut Boulevard and the rail spur intersect). It incorporates roughly 70 ft of vertical relief, varying in elevation between 5,006 ft above mean sea level (1927 North American datum) at the extreme northeast boundary and 5,076 ft at the extreme southwest boundary. Site 1 slopes generally to the northeast, and USGS maps indicate the presence of at least one ephemeral stream passing through the site.

3.2 Potential Watershed

Figure 3-1 shows the area included within site 1, the potential watershed for the site, the boundaries of the drainage subbasins into which the watershed was divided, and the streams formed from the runoff. The potential watershed was defined from 2-ft and 4-ft contour maps of the areas shown, site inspection, and with drainage information previously obtained¹⁸ to support flooding analyses at the RWMC. It incorporates all area that is higher in elevation than the site and that drains to the site through ephemeral streams or low-lying areas that could become streams on the basis of their topography.

The bulk of the watershed comprises an area of about 954 ac south of the Union Pacific Railroad, extending about 2 mi in this direction. There are two ponding areas (reservoirs 4 and 6) adjacent to the railroad in subbasins 7 and 10 with storage capacities of 21 and 62 ac-ft, respectively, when filled to the elevation of the railroad track. The majority of the watershed south of the railroad is situated in subbasins 7, 8, and 9. Runoff from the latter two subbasins converges into a single ephemeral stream through subbasin 7, which feeds a ponding area (reservoir 6) adjacent to the INEL railroad spur. This ponding area drains under the railroad grade through a single concrete culvert, with an elliptical cross-section 3 ft by 3.5 ft.

The remaining part of the watershed north of the Union Pacific Railroad constitutes a total area of 461 ac, a small portion of which lies east of the INEL rail spur. On the basis of the 2-ft contour maps that were used, this eastern portion (subbasins 11 and 12) drains westward to the railroad grade and thence under the grade through two culverts. One of these is a concrete pipe with a round, 18-in cross section. The other culvert was not measured, as it was assumed sufficiently large to carry all runoff reaching it (a conservative assumption, since the flow would be onto the site).

Figure 3-1. Site 1, its Potential Watershed, and Inundation Area for 100-year Events

3.3 Conceptual Model

3.3.1 Major Model Features

The major features of the conceptual model are the 10 drainage subbasins indicated in Figure 3-1; the ponding areas (reservoirs 4, 5, 6) next to the railroad in subbasins 7, 10, and 16; various culverts that permit runoff from the areas south and east to enter the site, and the ephemeral streams that flow through subbasins 7, 8, 9, 13, 14, and 16. The ephemeral streams in subbasins 13 and 14 provide the conduits through which the drainages south and east of site 1 pass enroute to the large ponding area (reservoir 5) in subbasin 16 adjacent to the INEL rail spur near the extreme northern boundary of the site. Most of the watershed drainage that reaches site 1 (with the exception of runoff from subbasins 12, 13, and 16) enters one of these ephemeral streams. They converge at combining point 3, at which point the runoff from subbasins 12, 13, and 16 also join, with all flows eventually emptying into the ponding area reservoir 5.

A schematic of the conceptual HEC-1 model is given in Figure 3-2. The input decks for the baseline HEC-1 calculations are reproduced in Attachment C.

3.3.2 Effects of Ephemeral Streams on the Site

While no ponding areas were modeled inside subbasins 13 or 14, the gradients of the ephemeral streams that pass through them are small. Thus, the possibility of flooding along the streams due to elevated stream water surfaces was recognized, and HEC-2 backwater calculations to evaluate this possibility were performed to determine flow depths and inundation boundaries for these streams. As with site 9, HEC-2 calculations were done using the stream hydrographs calculated with HEC-1.

3.4 Flooding Events

The 100-year and 500-year events used in the flooding analysis for this site were unchanged from the baseline events described in Section 1.3.3.

3.5 Modeling Assumptions

Modeling assumptions for site 1 included those discussed in Section 1.3.2 plus the following. First, all culverts were assumed to be free-flowing (unplugged) and were modeled as orifices using Equation 2-1.

Second, for HEC-2 backwater calculations on ephemeral streams in subbasins 13 and 14, the downstream boundary condition was obtained in the following way. The downstream boundary condition for the stream in subbasin 14 was a specified water surface elevation where the stream empties into the ponding area of subbasin 16 (the computed value from the HEC-1 calculation was used). For the stream in subbasin 13, the downstream boundary condition was the water surface elevation computed by HEC-2 for the first stream at the point where the two streams converge.

Figure 3-2. Schematic of HEC-1 Model for Site 1 ("V"=Routing, "-->"=Diversion, "."=Connector)

3.6 Flooding Analysis Results

3.6.1 100-year Event

3.6.1.1 Flood Hydrographs and Volumes. The excess precipitation (runoff) and temperatures for the 24-hour, 100-year event are shown in Figure 3-3. The flood hydrograph at the inflow to the ponding area in subbasin 7 is shown in Figure 3-4. This ponding area fills and flows over the railroad grade with a peak overtopping flow of 150 cfs. This flow combines with runoff from subbasin 14 as it traverses the subbasin. These two flows combine with runoff from subbasins 11, 12, 13, 15, and 16 prior to entering reservoir 5 in subbasin 16 next to the railroad spur. The inflow hydrograph for this reservoir is shown in Figure 3-5. The two distinct peaks reflect the fact that water from the lower subbasins reaches the reservoir prior to that from the higher subbasins.

Runoff from subbasin 10 enters reservoir 6 on the south side of the Union Pacific Railroad at the location where the INEL spur originates. No other subbasin contributes drainage to this reservoir, and the analysis indicated that the depression storage at this location (62 ac-ft) is sufficient to contain the entire runoff volume of 26 ac-ft. Thus, for the 100-year event, subbasin 10 does not impact site 1.

Peak flows in the two major streams on the site (flowing through subbasins 13 and 14) were calculated to be 26 and 167 cfs, respectively. The peak total discharge of these two streams (taken to be the total discharge onto the site) was 180 cfs. The total runoff volume flowing onto the site was 232 ac-ft, which included the overflow from reservoir 4 in subbasin 7 plus the runoff from subbasins 11 through 16. The peak water storage in reservoir 5 was 17 ac-ft.

3.6.1.2 Inundation Area for 100-year Event. HEC-2 backwater calculations were performed for the streams through subbasins 14 and 13. The results of these calculations are illustrated in Figure 3-1, which shows the boundary of the inundated area (see Section 2.6.1.2 for a description of how this boundary was defined). This area was calculated by HEC-2 to be 37.72 ac for both streams combined, which is roughly 20% of the total site area (193 ac). The depth of the stream in subbasin 14 varies from 0.8 ft to 2.3 ft. The corresponding range for the stream in subbasin 13 is 0.4 to 0.9 ft.

All runoff passing through the site eventually reaches reservoir 5 in subbasin 16. This reservoir reaches a maximum depth of 3.15 ft and covers 14.55 ac when this depth is reached. The total area of site 1, which is inundated by the 100-year event (streams plus reservoir 5), is 52.27 ac or about 27% of the total site area.

3.6.2 500-year Event

3.6.2.1 Flood Hydrographs and Volumes. Excess precipitation and temperatures for the 24-hour, 500-year event are shown in Figure 3-6. The flood hydrograph at the inflow to the ponding area in subbasin 7 is shown in Figure 3-7. This ponding area fills and flows over the railroad grade with a peak overtopping flow of 224 cfs. The total inflow hydrograph for the ponding area in subbasin 16 for the 500-year event is shown in Figure 3-8.

Figure 3-3. Total Excess Precipitation (Rain & Snowmelt) and Temperatures During 100-year Event (Site 1)

Figure 3-4. Inlet Hydrograph for Ponding Area in Subbasin 7, 100-Year Event (Site 1)

Figure 3-5. Inflow Hydrograph for Ponding Area in Subbasin 16, 100-Year Event (Site 1)

Figure 3-6. Total Excess Precipitation (Rain & Snowmelt) and Temperatures During 500-year Event (Site 1)

Figure 3-7. Inlet Hydrograph for Ponding Area in Subbasin 7, 500-Year Event (Site 1)

Figure 3-8. Inflow Hydrograph for Ponding Area in Subbasin 16, 500-Year Event (Site 1)

The total runoff from subbasin 10 entering reservoir 6 on the south side of the Union Pacific Railroad was 29 ac-ft, again well below the depression storage capacity of 62 ac-ft at this location. Thus, as for the 100-year event, subbasin 10 does not impact site 1.

Peak flows in the two major streams on the site in subbasins 13 and 14 were calculated to be 33 and 252 cfs, respectively. The peak total discharge of these two streams was 277 cfs. The total runoff volume flowing onto the site was 260 ac-ft, which included the overflow from reservoir 4 plus the runoff from subbasins 11 through 16.

3.6.2.2 Inundation Area for 500-year Event. HEC-2 backwater calculations were performed for the 500-year event as for the 100-year event. The total inundation area calculated by HEC-2 for the streams in subbasins 13 and 14 is 41.84 ac, which is about 22% of the total site area (193 ac). The depth of the stream in subbasin 14 varies from 1.0 ft to 2.7 ft. The corresponding range for the stream in subbasin 13 is 0.5 to 1.0 ft.

Reservoir 5 in subbasin 16 reaches a maximum depth of 3.22 ft and covers approximately 15.00 ac when this depth is reached. The total area of site 1, which is inundated by the 500-year event (streams plus reservoir 5), is 56.84 ac or 29% of the total site area. (The inundation area for the 500-year event is nearly identical with that for the 100-year event and is therefore not shown graphically.)

3.6.3 Assessment of Model Fidelity

The comparison of baseline results with those obtained using the kinematic wave model for generating hydrographs and routing stream flows is shown in Figure 3-9, where the outlet hydrographs for the two methods are plotted together at the point just below the confluence of runoff from subbasins 7 and 11 through 15. The difference in the peak discharge calculated by the two methods is about 1%. This small difference, together with the similarity of the two curves, suggests that the fidelity of the baseline analysis is acceptable.

3.6.4 Generalized Flooding from Big Lost River

The potential for site 1 being threatened by generalized flooding along the BLR was not directly addressed in this study. The 100-year floodplain for the BLR will be defined as part of the study by the Environmental Monitoring Unit described in Section 1.1.1.

3.7 Site Flooding Potential

The foregoing flooding analysis results for site 1 are summarized as follows:

- The site is subject to flooding from ponding and from ephemeral stream flows during the 100-year event. The average depth of water in reservoir 5 is 1.17 ft. In addition, the water depth in the ephemeral streams in subbasins 13 and 14 exceeds 1 ft over much of their combined length. Therefore, from the definition of the 100-year flooding elevation in Section 1.1.1, a portion of site 1 lies below the 100-year flooding elevation.

Figure 3-9. Hydrographs at Combining Point for Runoff from Subbasins 7, 11-15 for 500-Year Event From Kinematic Wave and Unit Hydrograph Models (Site 1)

- Approximately 38 ac of the site are inundated during the 100-year event to a depth of more than 1 ft in the channels of ephemeral streams, and 14 ac are covered by reservoir 5.
- Maximum water depths, discharges, and total volume of runoff on the site for the 100- and 500-year events, plus the inundation areas, are summarized in the following table:

	<u>100-year event</u>	<u>500-year event</u>
Maximum depth, d (ft):	3.15	3.22
Inundation area, d < 1 ft (ac):	12.4	7.9
% of site flooded, d < 1 ft:	6.4	4.1
Inundation area, d ≥ 1 ft (ac):	39.9	48.9
% of site flooded, d ≥ 1 ft:	20.7	25.3
Total inundation area (ac):	52.3	56.8
Total % of site flooded:	27.1	29.4
Maximum discharge to site (cfs):	180.0	277.0
Total runoff to site (ac-ft):	232.0	260.0

Though the site, as currently defined, includes areas that would be flooded during major hydrological events, most of the area would not be impacted. Refinement of the site boundaries to include only nonflooded areas could easily be done so that floodwaters from the events considered herein would not reach facilities on the site. Alternatively, flood control systems could be installed to control floodwaters throughout the site as now constituted. This alternative, however, may not be cost effective, given the rocky terrain and the expense of digging drainage channels.

4. FLOODING POTENTIAL AT SITE 3

4.1 Site Description

Site 3 is located near the center of INEL within Sections 7 and 8 of township T4N, range R31E (see Figure 1-1). The site covers 133 ac and is situated on a lava flow approximately 2 mi east of Lincoln Boulevard between two ridges. The site elevation varies between 4,843 and 4,864 ft above mean sea level (1927 North American datum), which places it at least 40 ft above the low-lying basin lying off the lava field and about 2 mi north of the site (i.e., basin 14-18; see Section 1.2.2). The majority of the site is fairly flat, lying between 4,842 and 4,850 ft elevation, with several slight depressions that constitute natural ponding areas. The site is currently accessible via INEL trail T-20, which traverses the site from west to east.

4.2 Potential Watershed

Figure 4-1 is an expanded view of site 3 showing the site boundaries relative to trails T-17 and T-20, which lie east of Lincoln Boulevard near the center of the INEL. The figure also shows the boundaries of the watershed that drains directly to the site (as determined from 2-ft contour maps), the boundaries of the drainage subbasins (into which the watershed was divided for modeling), the drainage paths (ephemeral streams) for runoff, and the locations of ponding areas (reservoirs). The watershed includes all area that is higher in elevation and that drains either directly or indirectly to the site. There are currently no man-made flood control structures of any kind on the site or on any of the watershed. The subbasin boundaries and drainage paths were identified using contour maps and field measurements.

The total area encompassed by the watershed shown in the figure is 1,215 ac. The site is situated in the extreme northwest corner of the watershed, which extends roughly 1.5 mi to the south and 1.0 mi to the east of the site boundaries. The entire watershed is on the lava flow mentioned above and the topographic features are typical of lava flows on the INEL (lava ridges and gently undulating terrain). Most of the lava surfaces are covered with some sediments and vegetation typical of the area (e.g., sagebrush, rabbitbrush, broom snakeweed, Great Basin wild rye, and grasses). The lava has experienced relatively little water erosion, and there are many natural depressions in the surface that can provide storage for surface runoff. Once these depressions fill, they become a part of the water course for overland flow to lower elevations. In particular, as noted above, several of these depressions appear on site 3 and become ponding areas during the hydrological events discussed below. Once the water surface reaches a certain elevation, however, it begins to flow toward the north boundary of the site and thence down the lava ridge into the basin area described in Section 4.1.

4.3 Conceptual Model

The major features of the conceptual flooding model for site 3 are the thirty drainage subbasins indicated in Figure 4-1, the ephemeral runoff streams, topographic depressions (reservoirs) scattered throughout the watershed, topographic "saddles" around the rims of the depressions that constitute the reservoir outlets, and a number of combining points where streams converge. Attention is focused on

the storage depressions on the site, as it is primarily these areas that are subject to inundation. Water accumulates in these depressions until the water surface elevation in reservoir 19 (located in subbasin 15) reaches the minimum elevation of the outflow saddle (4,749.2 ft). After this occurs, water begins flowing northward off the site, into basin 14-18, and out of the model for site 3.

A schematic of the conceptual HEC-1 model comprising the above features is given in Figure 4-2. The input decks for the baseline HEC-1 calculations are reproduced in Attachment C.


```

SB1
V
RES1
V
1T02
.
.      SB2
.
CP1.....
V
RES2
V
2T03
.
.      SB3
.      .
.      .      SB4
.      .
CP2.....
V
3T07
.
.      SB7
.      .
.      .      SB5
.      .      V
.      .      RES3
.      .      V
.      .      3T06
.      .      .
.      .      .      SB6
.      .      .
CP3.....
V
6T08
.
.      SB8
.      .
.      .      SB9
.      .      V
.      .      9T010A
.      .      .
.      .      .      SB10A
.      .      .
.      .      CP4.....
.      .      V
.      .      RES4A
.      .      V

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Figure 4-2. Schematic of HEC-1 Model for Site 3 ("V"=Routing, "-->"=Diversion, "."=Connector).

.	.	4AT04		
.	.	.	SB10	
.	.	.		
.	.	CP5.....		
.	.	V		
.	.	RES4		
.	.	V		
.	.	4T011		
.	.	.	SB11	
.	.	.	.	SB12
.	.	.	.	V
.	.	.	.	RES5
.	.	.	.	V
.	.	.	.	12T013
.	.	.	.	.
.	.	.	.	SB13
.	.	.	.	.
CP6.....				
V				
RES6				
V				
6T014				
.	SB14			
.	.	SB17		
.	.	V		
.	.	RES7		
.	.	.	SB16	
.	.	.	.	
.	.	CP7.....		
.	.	V		
.	.	RES8		
.	.	V		
.	.	8T018		
.	.	.	SB18	
.	.	.	.	
.	.	CP8.....		
.	.	V		
.	.	RES9		
.	.	V		
.	.	9T019		
.	.	.	SB19	
.	.	.	.	
.	.	CP9.....		
.	.	V		
.	.	RES10		
.	.	.	SB20	
.	.	.	.	
.	.	CP10.....		
.	.	V		

Figure 4-2. Continued

4.4 Flooding Events

Because site 3 contains major ponding areas, it was assumed that the most severe flooding would result from complete filling of these areas. Thus, the hydrological events used to assess flooding potential at site 3 were events with the highest total runoff volume. This is in contrast to sites 9, 1, and 5 where the most severe flooding events are those with the highest intensity of runoff. Therefore, in place of the 24-hour baseline events described in Section 1, the 100- and 500-year storms used to evaluate flooding potential at site 3 were 72-hour events yielding higher total runoff (but lower intensities) than the baseline events.

4.4.1 100-year Flooding Event

The 100-year event for site 3 consists of a 2-year, 72-hour winter rain storm (contributing 0.62 in. of precipitation at CFA) together with a 50-year, 72-hour snowmelt (contributing 3.93 in. of runoff at CFA) on frozen ground (zero infiltration loss) yielding 4.55 in. total runoff. The 2-year, 72-hour rainfall was obtained from statistical analysis of National Oceanic and Atmospheric Administration (NOAA) data of record for the period November 15 through March 15 for the years 1950 to 1993 (see Attachment B). A 50-year, 72-hour maximum average wintertime temperature of 48.42°F was obtained from the same database and was used to calculate the equivalent precipitation for a 50-year, 72-hour snowmelt. As in the case of the 24-hour event (see Section 1.3.3.1), 50-year snowmelt was combined with 2-year rainfall to produce the 100-year event, rather than 2-year snowmelt with 50-year rainfall.

In modeling the event, identical rainfall and temperature distributions were assumed for three consecutive 24-hour periods. The same distribution functions were used for rainfall and temperature as were used for the baseline event described in Section 1.3.3.1 (the distributions were normalized to achieve the above total rainfall and 72-hour average temperature). Hourly temperatures were lagged as in the case of the baseline event so that the maximum hourly snowmelt coincided with the maximum hourly precipitation.

4.4.2 500-year Flooding Event

The 500-year event for site 3 consists of a 10-year, 72-hour winter rain storm (contributing 1.26 in. of precipitation at CFA) together with 50-year, 72-hour snowmelt (contributing 3.93 in. of precipitation at CFA) on frozen ground (zero infiltration loss) yielding 5.19 in. total runoff. Thus, the 10-year, 72-hour rainfall is more than double the 2-year, 72-hour rainfall (both were obtained from the same NOAA database; see Attachment B). This is in contrast to the situation for the 24-hour baseline storm (see Section 1.3.3.1) where the 500-year storm produced only 50% more runoff than the 100-year event.

Snowmelt for the 500-year event was identical to that for the 100-year event. In addition, the normalized rainfall and temperature distributions assumed for the 500-year event were identical to those for the 100-year event, described above.

4.5 Modeling Assumptions

No changes were made to the modeling assumptions discussed in Section 1.3.2. In addition to these assumptions, the three ponding areas in subbasins 24, 25, and 26 were treated (in the baseline unit hydrograph method) as a single reservoir. This was done because it was found that for both the 100-year and the 500-year events these three ponding areas received sufficient inflow to eventually coalesce into one pond. For the kinematic wave model, however, these areas were modeled as three distinct reservoirs with interflow between them once the water surface reached a sufficiently high level.

Runoff from subbasins 16, 17, and 18 flows northward toward reservoir 9 in subbasin 18. The 2-ft contour map of this area indicated two possible saddle outflows—one to the north (and away from site 3) and one to the west (toward the site). In keeping with the conservative approach used in the modeling, it was assumed that the overflow from the reservoir would be to the west, directing the runoff from subbasins 16, 17, and 18 toward the site. It was felt that a detailed field survey could later be performed to determine whether or not this assumption might be relaxed if analysis showed these subbasins to be major contributors to flooding on the site.

4.6 Flooding Analysis Results

4.6.1 100-year Event

4.6.1.1 Flood Hydrographs and Volumes. The runoff for the 72-hour, 100-year event (consisting of rain plus melting snow) and the corresponding temperatures are shown in Figure 4-3. The flooding flows onto site 3 consist of runoff from subbasins 15, 23, 24, 25, 26, and 27; overflows from reservoirs 15 and 16; and the total discharge from subbasin 29 (combining point 12). The hydrographs for these flows are shown in Figure 4-4 through Figure 4-12. The peak combined discharge onto the site from all these flows is approximately 69 cfs. The total volume of floodwaters from these sources flowing onto the site is 160 ac-ft. [Of this total, approximately 47 ac-ft were from subbasins 16-18. Since the calculated volume of flow off the site was 47 ac-ft (see below), relaxing the conservative assumption in Section 4.5 would not significantly alter the ponding levels predicted by the analysis.] These flows fill ponding areas represented by reservoirs 13, 14, 17, 18, and 19, which lie partly or entirely within the site boundaries. After filling these reservoirs, the overflow runs northward from reservoir 19, off the site, and down the lava ridge to the basin to the north. The total volume of floodwater that was calculated to flow off the site and into this basin was 47 ac-ft.

The hydrograph for combining point 12 is illustrative of the hydrology of the watershed for site 3. The three distinct peaks in this hydrograph (as well as others) reflect the nature of the design storm, with three consecutive days of precipitation, and identical temporal distributions of rainfall and snowmelt for all three days. The large peak on the third day reflects the fact that runoff from some parts of the watershed does not affect site 3 until all the depression storage in its path is filled.

Note that of the 20 reservoirs represented in the watershed model, 18 filled while two did not. At zero outflow in each reservoir, the total reservoir storage capacity is 458 ac-ft. Of this storage capacity, 406 ac-ft (88.6%) was filled by runoff from the event.

Figure 4-3. Total Excess Precipitation (Rain & Snowmelt) and Temperatures During 100-year Event (Site 3)

Figure 4-4. Outlet Hydrograph for Subbasin 15, 100-Year Event (Site 3)

Figure 4-5. Outlet Hydrograph for Subbasin 23, 100-Year Event (Site 3)

Figure 4-6. Outlet Hydrograph for Subbasin 24, 100-Year Event (Site 3)

Figure 4-7. Outlet Hydrograph for Subbasin 25, 100-Year Event (Site 3)

Figure 4-8. Outlet Hydrograph for Subbasin 26, 100-Year Event (Site 3)

Figure 4-9. Outlet Hydrograph for Subbasin 27, 100-Year Event (Site 3)

Figure 4-10. Outlet Hydrograph for Reservoir 15, 100-Year Event (Site 3)

Figure 4-11. Outlet Hydrograph for Reservoir 16, 100-Year Event (Site 3)

Figure 4-12. Hydrograph for Combining Point 12, 100-Year Event (Site 3)

4.6.1.2 Inundation Area for 100-year Event. Because the flooding on site 3 is primarily due to ponding, backwater calculations were not deemed necessary to determine the inundation areas. Instead, the peak water storage in all reservoirs on the site was used to determine the inundated areas from topographic maps. The reservoirs that are wholly or partly on site 3 are reservoirs 13, 14, 17, 18, and 19. In addition, reservoirs 6 and 16 constitute large impoundments of water near the site boundary. The peak water storages computed for these reservoirs during the 100-year event were 3, 12, 26, 37, 47, 190, and 11 ac-ft, respectively. The water surface areas corresponding to these water volumes were 3.1, 4.5, 11.6, 18.8, 14.4, 30.6, and 6.0 ac, respectively, and are shown in Figure 4-1. The average depths in the above reservoirs were 1.0, 2.6, 2.2, 2.0, 3.2, 6.2, and 1.8 ft. The total inundated area of the site was approximately 36.2 ac or 27.2% of the total site area of 133 ac.

4.6.2 500-year Event

4.6.2.1 Flood Hydrographs and Volumes. Runoff and temperatures for the 500-year event are shown in Figure 4-13. The flooding flows onto site 3 are those described in Section 4.6.1.1. The corresponding hydrographs for the 500-year event are shown in Figure 4-14 through Figure 4-22. The peak combined discharge onto the site from all these flows is approximately 107 cfs. The total volume of floodwaters from these sources is 196 ac-ft. As in the case of the 100-year event, these flows fill reservoirs 13, 14, 17, 18, and 19. The overflow from these reservoirs runs northward and down the lava ridge to basin 14-18 to the north. The total volume of floodwater calculated to flow off the site and into this basin was 78 ac-ft.

For the 500-year event, 18 of the 19 reservoirs in the watershed model filled while one did not. Out of the total reservoir storage capacity of 458 ac-ft, 440 ac-ft (96.1%) was filled by runoff from the event.

[NOTE: The model for the 500-year event contained 19 reservoirs, whereas that for the 100-year event contained 20. The two differ because the 500-year event provided sufficient runoff for two of the reservoirs in the 100-year model to fill to the point of merging. These two reservoirs were, therefore, lumped into a single reservoir in modeling the 500-year event.]

4.6.2.2 Inundation Area for 500-year Event. The peak water storage in all reservoirs on the site was used to determine the inundated areas in the same manner as for the 100-year event. The peak water storages computed for reservoirs 13, 14, 17, 18, 19, 6, and 16 during the 500-year event were 3, 12, 31, 38, 49, 219, and 11 ac-ft, respectively. The total water surface areas corresponding to these volumes were 3.3, 4.6, 14.9, 19.1, 14.7, 30.6, and 6.1 ac, and corresponding average depths were 0.9, 2.6, 2.1, 2.0, 3.3, 7.2, and 1.8 ft. The total inundated area of the site was very nearly the same as for the 100-year storm (36.2 ac or 27.2% of the total site area). This result is not surprising since the water surface elevation changes little once the reservoirs fill and begin to overtop. (For this reason, a separate inundation map for the 500-year storm is not shown.)

Figure 4-13. Total Excess Precipitation (Rain & Snowmelt) and Temperatures During 500-year Event (Site 3)

Figure 4-14. Outlet Hydrograph for Subbasin 15, 500-Year Event (Site 3)

Figure 4-15. Outlet Hydrograph for Subbasin 23, 500-Year Event (Site 3)

Figure 4-16. Outlet Hydrograph for Subbasin 24, 500-Year Event (Site 3)

Figure 4-17. Outlet Hydrograph for Subbasin 25, 500-Year Event (Site 3)

Figure 4-18. Outlet Hydrograph for Subbasin 26, 500-Year Event (Site 3)

Figure 4-19. Outlet Hydrograph for Subbasin 27, 500-Year Event (Site 3)

Figure 4-20. Outlet Hydrograph for Reservoir 15, 500-Year Event (Site 3)

Figure 4-21. Outlet Hydrograph for Reservoir 16, 500-Year Event (Site 3)

Figure 4-22. Hydrograph for Combining Point 12, 500-Year Event (Site 3)

4.6.3 Assessment of Model Fidelity

The fidelity of the baseline (unit hydrograph) model was assessed, as for previous analyses, by comparing the results with those obtained using the kinematic wave model. The results of the comparison are indicated in Figure 4-23 where the inlet hydrographs for reservoir 6, generated by the two methods for the 500-year event, are plotted together. The maximum difference in the calculated peak discharge amounts to about 4%. This comparison suggests that the fidelity of the baseline results is acceptable.

Figure 4-23. Inlet Hydrographs to Reservoir 6 for 500-Year Event From Kinematic Wave and Unit Hydrograph Runoff Models (Site 3)

Note, however, that for the 100- and 500-year events on site 3, accurate calculation of the peak discharges is not as important as for other sites. This is because the flooding potential at site 3 is primarily driven by the total volume of runoff that eventually accumulates on the site; i.e., the total inundation area is not as strongly influenced by the peak height of the discharge hydrograph as by the total area under the curve.

4.6.4 Generalized Flooding from Big Lost River

The BLR channel lies approximately 3.5 mi west of site 3 at an elevation of about 4,825 ft. From that location, the channel runs northward and splits into multiple channels, from which it eventually infiltrates completely through the lava into the Snake River Plain Aquifer. The terminus of the river is at an elevation below 4,795 ft. The terrain through which the river channels flow enroute to this elevation is relatively flat, sloping downward to the north. Lincoln Boulevard provides a hydraulic barrier to flooding flow from the river toward site 3. In addition, the minimum elevation

on site 3 (~4,840 ft) is at least 15 ft above the nearest point of the BLR channel (~4,825 ft). Therefore, it is extremely unlikely that generalized flooding along the river could impact the site. (Formal demonstration of this fact, however, is part of the study by the Environmental Monitoring Unit described in Section 1.1.1.)

4.7 Site Flooding Potential

The foregoing flooding analysis results for site 3 are summarized as follows:

- The site is subject to flooding from ponding during the 100-year event. The average depths of water in the seven reservoirs located on or near the site all exceed 1 ft. Therefore, from the definition of the 100-year flooding elevation in Section 1.1.1, a portion of site 3 lies below the 100-year flooding elevation.
- Approximately 32 ac of the 133-ac site are inundated during both the 100- and 500-year events to a depth of more than 1 ft in reservoirs 13, 14, 17, 18, 19, and 16.
- Maximum water depths, discharges, and total volume of runoff on the site for the 100- and 500-year events, plus the inundation areas, are summarized in the following table:

	<u>100-year event</u>	<u>500-year event</u>
Maximum depth, d (ft):	6.2	6.2
Inundation area, d < 1 ft (ac):	0.0	0.0
% of site flooded, d < 1 ft:	0.0	0.0
Inundation area, d ≥ 1 ft (ac):	36.2	36.2
% of site flooded, d ≥ 1 ft:	27.2	27.2
Total inundation area (ac):	36.2	36.2
Total % of site flooded:	27.2	27.2
Maximum discharge to site (cfs):	69.0	107.0
Total runoff to site (ac-ft):	160.0	196.0

Ponding areas on site 3 are subject to flooding during the 100-year and 500-year events to depths exceeding 1 ft. The presence of these ponding areas indicates that the site, as presently defined, is not acceptable from a regulatory standpoint. The fact that only 27% of the site lies in the ponding areas suggests the possibility of redefining the boundaries of the site to include only those areas that are not flooded. However, this alternative is probably not feasible since the ponding areas are fairly evenly distributed geographically across the site. Thus, it may be impossible to delineate a single contiguous block of land with sufficient area for the facility without a portion of it lying in a flooding area. (This, however, would depend on the actually area requirement for the facility.)

5. FLOODING POTENTIAL AT SITE 5

5.1 Site Description

Site 5 is located near the northern boundary of the INEL within Sections 1 and 2 of township T7N, range R31E (see Figure 1-1). It covers approximately 202 ac and is situated approximately 1 mi south of the intersection of state highways 22 and 28 on a large alluvial deposit near the southern end of the Birch Creek Valley (BCV) between the Lemhi and Beaverhead mountain ranges. A hydrological description of BCV is given in Reference 19.

The geology of BCV influences the distribution of precipitation runoff from the mountains during most of the year when the ground surface is not frozen. In areas underlain by impermeable materials, runoff leaves as surface water. In areas underlain by limestone, excess runoff leaves as ground water through joints and fissures and later emerges as springs from alluvial deposits. These springs constitute the major portion of the perennial flows in BC.^j Surface flows into BC constitute a relatively small portion of the total stream discharge due to the high infiltration rates into the alluvial sediments along the valley floor. Infiltration is apparently a strong attenuating factor in flood flows. This is reflected by relatively flat flood-frequency curves for various gaging stations along BC [e.g., Eight Mile Canyon road near Reno station has peak discharges of 86, 104, and 116 cfs for recurrence intervals of 5, 25, and 100 years,¹⁹ respectively].

The alluvium on which site 5 is located spreads out across the mouth of BCV onto the north end of the INEL in a characteristic fan shape. The fan slopes nearly due southeast at the site with a 1.3% grade. Sediments in the area have been derived from the adjoining mountain ranges, which consist of Paleozoic limestones, dolomite, siltstone, and tertiary rhyolites. Alluvial fan deposits in BCV contain boulders, gravel, sand, and silt. The lake deposits near the southern terminus of BCV in the immediate vicinity of the site are better sorted, finer grained, and more stratified than the alluvial and fluvial sediments.¹⁹

At the southern end of BCV where BC enters the INEL, the main channel of the stream runs down the west side of the valley approximately 3 mi west-southwest of site 5. There has been little or no flow in this channel in nearly a decade since the primary flow in BC was diverted to a hydroelectric generating station at Reno Ranch. Approximately 70 cfs is diverted from the main stream on a year-round basis, and only stream flows in excess of this amount bypass the diversion and continue down the old stream channel.

After passing through the generating turbine at Reno Ranch, the diverted portion of BC flows into the Birch Creek Return Channel (BCRC). During the summer growing season, this water is routed into irrigation canals for agricultural use on and around the Reno Ranch. During the balance of the year, the BCRC carries the water southward from Reno Ranch, under state highways 22 and 28, onto the INEL, and finally in a southeasterly direction back to the old BC channel roughly 1 mi south of Richard Butte and about 1,000 ft east of state highway 22. The return channel was formed by excavating a channel approximately 3-4 ft in depth and mounding the excavated material in a berm on the downslope side of the channel. The berm rises about 7 ft above the natural ground surface.

j. Phone conversation with J. T. Barraclough, July 21, 1993.

The resulting channel cross section (excluding the berm) is approximately trapezoidal with a mean width of 33 ft. The bottom slope in the section of channel nearest site 5 was determined from topographic maps to be about 0.004 ft/ft (0.4%). Using these channel characteristics, the flow-carrying capacity of the BCRC was estimated from normal depth calculations to be approximately 823 cfs when filled to the natural surface elevation with no water against the berm and 12,253 cfs when filled to the top of the berm.

During the years before the generating station was built, BC was diverted during the summer months into the Reno Ditch from about 1-1/4 mi below the current diversion. The water flowed in a southeasterly direction across the alluvium, around Reno Point, and finally to the Reno Ranch. The ditch is no longer used, but it still constitutes a hydraulic channel that routes a portion of the runoff from the southern end of the Beaverhead mountains to the north and east away from BC toward Reno Point and site 5. Its width varies from 7 to 14 ft and its depth varies along its length from about 1.5 ft to over 10 ft. There are indications at a number of locations where flows have left the ditch channel. One such location is roughly 0.5 mi southeast from where the ditch crosses state highway 28. At this location, visual inspection and aerial photos suggest that runoff flows from the north have entered Reno Ditch and spilled over the banks and continued toward the southeast, roughly parallel to highway 28.

5.2 Potential Watershed

The potential watershed for site 5, together with the drainage subbasins into which it was divided for modeling, are shown in Figure 5-1. The watershed comprises all the surrounding area that is higher in elevation than the site and that drains either directly to the site or indirectly through ephemeral streams and/or low-lying areas that could become streams on the basis of their topography. Each of the subbasins is a drainage area for an ephemeral stream indicated on USGS topographic maps.

The watershed includes the areas bounded by state highways 22 and 28 on the south and specific mountain ridge lines to the north. These ridge lines were identified by tracing the path of runoff from the higher elevations. All the region north of the ridge lines drains either directly to BC on the west, or to areas east of Reno Ranch.

In addition to the area defined above, it is likely that a portion of the area on the southwestern side of highway 28 drains toward the southeast, approximately parallel to the road. Since these flows would eventually empty into the BCRC, they are considered to be a potential flooding threat to the site (see Section 5.3.4).

Note that the drainage area for localized flooding of site 5 excludes most of the BC watershed upstream of the ridges noted above. Floodwaters from this watershed were considered in the context of generalized flooding along BC (see Section 5.6.5). The only way BC influences localized flooding is through the manmade diversion to the hydroelectric station mentioned above. The effect of the diversion is to provide a near-constant flow rate (assumed to be 70 cfs) at the entrance to the BCRC.

Figure 5-1. Site 5 and its Potential Watershed

5.3 Conceptual Model

5.3.1 Major Model Features

The features shown in Figure 5-1 that were incorporated in the conceptual flooding model include the 14 drainage subbasins, ephemeral runoff streams, junction points for streams and subbasin outlet flows, the BCRC, and the BCRC culverts at highways 22 and 28. These culverts are identified hereafter as culverts 1 and 2, respectively. They are significant components of the model because they limit the downstream discharge in the BCRC and redirect portions of the flow to other locations.

Some subbasin boundaries were chosen to encompass multiple streams. This was done whenever all streams within a subbasin appeared to be of roughly the same length and reached a common collector channel (notably, the one along highway 28) at approximately the same location. In most cases, routing reaches were identified where ephemeral streams are shown on USGS topographic maps. In some instances, however, the maps did not indicate streams where they were thought likely to form during flooding events on the basis of the topography shown on the maps or on the basis of field observations and topographic measurements.

5.3.2 Subbasin Definitions and Stream Routing

In the following subsections, descriptions and rationales are given for the manner in which the subbasin boundaries indicated in Figure 5-1 were selected.

5.3.2.1 West Side of Beaverhead Mountains. This part of the watershed was represented as subbasins 21-30 in Figure 5-1. Flows from this area were assumed to collect in a broad, shallow collector channel that flows roughly parallel to state highway 28 along its northeast side as indicated. Eventually, this channel crosses highway 22 and enters the BCRC between culverts 1 and 2.

5.3.2.2 East Side of Beaverhead Mountains. All runoff from the east side of the mountains apparently collects in the Reno Gulch. Therefore, this region was treated as a single subbasin (subbasin 1). The outflow from this subbasin was routed to the generating station, upstream of culvert 1. Though it is likely that a portion of this flow is intercepted by the Reno Ditch and routed toward the Reno Ranch while the remainder overflows the ditch and flows directly toward to the BCRC, the entire flow was assumed to enter the return channel at a single location. This assumption was justified on the basis that the only effect of a division of the flow is to delay a portion of the flood hydrograph at the confluence of the Reno Gulch outflow with the BCRC. Because of the relatively small travel time of water around the Reno Ranch and back to the confluence, the effect was neglected.

5.3.2.3 Southern Tip of Beaverhead Mountains. Runoff from the portion of the watershed at the southwest tip of the mountains (subbasin 4A) was assumed to flow behind the small butte immediately west of Reno Point and thence to Reno Point where it enters the Reno Ditch. The ditch at this location is about 10 ft deep and was judged capable of carrying the entire flow around the point and then northeast to the Reno Ranch. It was assumed to enter the BCRC at the location shown in Figure 5-1.

5.3.2.4 Flat Area North of Highway Intersection. The area between state highways 22 and 28 and immediately north of their intersection (subbasin 4B) has little vertical relief in comparison to the mountain slope areas described above. Study of the elevation contours in this area together with field observations, suggested that the drainage is generally to the east and ultimately into the BCRC above culvert 1 as shown by the stream routing in Figure 5-1.

5.3.2.5 Area Between Highway 28 and Birch Creek. As previously stated, a portion of the BCV floor on the southwest side of state highway 28 was assumed to contribute runoff that flows southeast, away from the BC main channel and toward site 5. Because of the absence of any clearly marked channels in this area, it is reasonable to assume sheet flow. For this reason, the boundary of the subbasin representing the area was estimated to lie midway between BC and the highway as shown in Figure 5-1. The collective runoff from this area was routed normal to the contours and conservatively assumed to enter the BCRC at a single point immediately downstream of culvert 2.

5.3.3 Birch Creek Return Channel

The BCRC crosses under both state highways 22 and 28 as shown in Figure 5-1. At the locations of these crossings, the berm previously described (see Section 5.1) is discontinuous; i.e., the berm drops down to the level of the undisturbed surface. Thus, at both highway crossings, any flow from upstream in the BCRC in excess of the carrying capacity of the culverts under the road will flow out the return channel, through the opening in the berm, and thence eastward or southward.

On the basis of topography, all overflow at the first culvert (under highway 22) was assumed to flow eastward toward Montevieu and away from site 5. Overflow at the second culvert (under highway 28), however, would likely split and flow partly down the borrow pits on either side of the highway to the southeast and partly out onto the alluvium toward the site as indicated in Figure 5-1.

5.3.4 Overview of Model

Most of the runoff from the local watershed reaches site 5 through culvert 2, where it may overflow the BCRC due to the flow restriction as described above. The remainder of the runoff that could impact the site is from the part of the watershed between highway 28 and the BC main channel. This runoff enters the BCRC below culvert 2 and could impact the site either by causing the BCRC berm to fail or by raising the water surface at the culvert until water begins to flow through the low spot in the berm near the highway.

A schematic diagram of the HEC-1 conceptual model used to generate the flood hydrographs at and below culvert 2 is shown in Figure 5-2. The input decks for the baseline HEC-1 calculations are reproduced in Attachment C.

Figure 5-2. Schematic of HEC-1 Model for Site 5 ("V"=Routing, "-->"=Diversion, "."=Connector)

5.4 Flooding Events

5.4.1 100-year Flooding Event

According to historical accounts, past flooding in the general proximity of site 5 has resulted from rain-on-snow events that produced runoff from areas of the BC watershed below 5,500 ft elevation.²⁰ Although mountains within the watershed reach 10,000 ft elevation, colder temperatures and lower snow densities (unripened snow conditions) at the higher elevations generally prevent runoff from these higher regions during such flooding events. Thus, a 100-year rain-on-snow event was applied to the contributing part of the BC watershed below 6,000 ft to produce a 100-year flood discharge at site 5. (The 6,000 ft elevation was chosen as a cutoff to allow some conservatism for the 5,500 ft elevation mentioned above since the 5,500 ft elevation appears from the historical account to have been estimated rather than actually measured.) The baseline 100-year event described in Section 1.3.3.1 was altered by adjusting the rainfall intensity upward by 10 % (to 0.55 in) to account for additional precipitation at the site 5 watershed. The 10-percent adjustment was based on the difference in isopleth lines at the two locations for 2-year, 24-hour rainfall in Reference 21. The total precipitation for the 100-year event at site 5 was thus 2.26 in (1.71 in snowmelt plus 0.55 in rainfall).

5.4.2 500-year Flooding Event

The baseline 500-year event described in Section 1.3.3.2 was altered in the same manner as the baseline 100-year event described above by adjusting the rainfall intensity upward by 10 percent (to 0.83 in). The total precipitation for the 500-year event at site 5 was thus 2.54 in (1.71 in snowmelt plus 0.83 in rainfall).

5.5 Modeling Assumptions

The major modeling assumptions discussed in Section 1.3.2 were applied without change to the HEC-1 analysis of site 5. Additional assumptions regarding routing of runoff flows have already been discussed above. Other assumptions were made in the HEC-1 model as follows:

- Runoff from both subbasins 5 and 30 crosses highway 22. A portion of this runoff was assumed to be channeled down the borrow pits on both sides of state highway 22. The magnitude of this flow was estimated with a normal depth calculation using a channel slope of 0.005 ft/ft (determined from topographic maps) and a trapezoidal cross section 3 ft in height and 12 ft in bottom width with a side slope of 0.25 ft/ft. The combined flow-carrying capacity of the two borrow pits was calculated to be 792 cfs. In the HEC-1 model, all flow in the borrow pits was assumed to be from subbasin 30, i.e., the borrow pits were assumed to be flowing full at the point where subbasin 5 runoff reaches the highway. Thus, none of the discharge from subbasin 5 was diverted in crossing the highway, and the runoff was routed to the BCRC (CP6 in Figure 5-1).
- All overflow at culvert 1 was assumed to travel away from site 5 and was not modeled beyond the point of discharge from the BCRC.

- The limiting flow rate through culvert 2 was calculated using a HEC-2 backwater analysis. The starting water surface elevation downstream of the culvert in the HEC-2 model was based on a normal depth calculation. The analysis indicated a peak flow rate of 1,060 cfs through the culvert with no weir flow over the top of the road. This flow was verified with hand calculations using highway design methods.^k Weir flow over the road was not included in the calculation because it was conservatively assumed that all the overflow would be directed away from the BCRC, i.e., the entire overflow was assumed to be potential flooding flow toward site 5.
- A portion of the overflow from culvert 2 was assumed to be channeled down the borrow pits on both sides of state highway 28. The magnitude of this flow was estimated in the same manner as was done for the flows down the borrow pits of highway 22 (see above). For the normal depth calculation, a channel slope of 0.014 ft/ft was determined from topographic maps, and profiles of the borrow pits on both sides of the road were measured in the field. The borrow pits were approximated with triangular cross sections, and the combined flow-carrying capacity of both was estimated to be 148 cfs.

5.6 Flooding Analysis Results

5.6.1 100-year Event

5.6.1.1 Flood Hydrographs and Volumes. Excess precipitation for the 24-hour, 100-year event (consisting of rain plus melting snow) and the assumed temperatures for the period are shown in Figure 5-3. The flood hydrographs at the outflow to subbasins 30, 4A, 4B, 1, and 5 are shown in Figure 5-4 through Figure 5-8. The figures indicate the peak discharges and the time when each peak occurs relative to the start of the precipitation event. The flood hydrograph for the BCRC at the upstream entrance to culvert 2 is shown as a dotted line in Figure 5-9. Comparison of Figure 5-9 with Figure 5-3 indicates a lag time of about 30-60 min between the center of the precipitation excess curve and the time of peak overflow discharge at culvert 2.

The solid line in Figure 5-9 indicates the flow through the culvert. When the water surface in the BCRC upstream of the culvert reaches the top of the channel, the flow rate through the culvert becomes constant (1,060 cfs, see Section 5.5), independent of the flow rate in the BCRC. The difference between this flow rate and the hydrograph at the entrance to the culvert represents the overflow discharge out of the channel. The total volume of this overflow discharge was calculated to be 267 ac-ft. Of this amount, a maximum of about 68 ac-ft could flow down the borrow pits of the highway (see Section 5.5), leaving roughly 199 ac-ft of water spreading two-dimensionally downgradient from the culvert toward site 5.

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Figure 5-3. Total Excess Precipitation (Rain & Snowmelt) and Temperatures During 100-year Event (Site 5)

Figure 5-4. Outlet Hydrograph for Subbasin 30, 100-Year Event (Site 5)

Figure 5-5. Outlet Hydrograph for Subbasin 4A, 100-Year Event (Site 5)

Figure 5-6. Outlet Hydrograph for Subbasin 4B, 100-Year Event (Site 5)

Figure 5-7. Outlet Hydrograph for Subbasin 1, 100-Year Event (Site 5)

Figure 5-8. Outlet Hydrograph for Subbasin 5, 100-Year Event (Site 5)

scope and schedule for this project. Hence, an area of inundation on site 5 was not determined for the 100-year event.

5.6.2 500-year Event

5.6.2.1 Flood Hydrographs and Volumes. Excess precipitation and assumed temperatures for the 24-hour, 500-year event are shown in Figure 5-10. The flood hydrographs at the outflow to subbasins 30, 4A, 4B, 1, and 5 are shown in Figure 5-11 through Figure 5-15. Figure 5-16 is the 500-year analog to Figure 5-9, showing the flood hydrograph at the upstream entrance to culvert 2 (dotted) together with the actual flow through the culvert (solid). The same limiting flow of 1,060 cfs was used as for the 100-year event. The difference between this rate and the hydrograph at the entrance to the culvert represents the 500-year overflow discharge out of the channel. The total volume of this overflow discharge was calculated for the 500-year event to be 411 ac-ft. Of this amount, a maximum of 80 ac-ft could flow down the borrow pits of the highway (see Section 5.5), leaving roughly 331 ac-ft of water spreading two-dimensionally from the culvert toward site 5.

For the 500-year event, the HEC-1 analysis showed that runoff from subbasin 5 together with the discharge from culvert 2 results in a combined flow into the BCRC below the culvert that peaks at approximately 3,700 cfs. As for the 100-year event, this is significantly more than the 823 cfs capacity of the BCRC (see Section 5.1). Making the same assumption as for the 100-year case (i.e., that the berm fails) the total calculated discharge out of the BCRC, upgradient of site 5, would be 1,754 ac-ft.

5.6.2.2 Inundation Area for 500-year Event. An area of inundation on site 5 was not determined for the 500-year event (see Section 5.6.1.2).

5.6.3 Assessment of Model Fidelity

Figure 5-17 shows the hydrographs calculated by the baseline unit hydrograph method and by the kinematic wave model at the inlet to culvert 2 for the 500-year event at site 5. The maximum difference in the peak discharge at this location amounts to about 0.1%. Though the hydrograph generated by the kinematic wave model appears to show a 15-20 minute lag from that generated by the baseline method, both the peaks and the durations of the peaks are in good agreement. Since these parameters are the most important in assessing potential for flooding at the site, it was concluded that the baseline modeling results were sufficiently well-corroborated by the kinematic wave model.

Figure 5-10. Total Excess Precipitation (Rain & Snowmelt) and Temperatures During 500-year Event (Site 5)

Figure 5-11. Outlet Hydrograph for Subbasin 30, 500-Year Event (Site 5)

Figure 5-12. Outlet Hydrograph for Subbasin 4A, 500-Year Event (Site 5)

Figure 5-13. Outlet Hydrograph for Subbasin 4B, 500-Year Event (Site 5)

Figure 5-14. Outlet Hydrograph for Subbasin 1, 500-Year Event (Site 5)

Figure 5-15. Outlet Hydrograph for Subbasin 5, 500-Year Event (Site 5)

Figure 5-16. Hydrograph at Culvert 2, 500-Year Event (Site 5)

Figure 5-17. Subbasin 1 Outlet Hydrographs for 500-Year Event From Kinematic Wave and Unit Hydrograph Runoff Models (Site 5)

5.6.4 Other Flooding Events Considered for Site 5

In the course of determining the most extreme yet credible scenario for the 100-year flooding event, other possibilities were considered as described below.

5.6.4.1 100-year Rain on Frozen Ground. This scenario envisioned a 24-hr, 100-year rainfall on frozen ground with no snow cover occurring over the entire watershed for site 5 described in Section 5.2. The total precipitation from this event (based on Reference 21) was 3.0 in. This event gives a peak discharge in the BCRC at culvert 2 of 17,999 cfs and a total runoff volume of 8,752 ac-ft. Thus, this event is hydrologically more severe than the baseline 100-year event described in Section 5.4. However, the historical data does not indicate a precedent for this type of event. In addition, the argument exists that the occurrence of a 100-year storm is likely to be statistically independent of the occurrence of frozen ground. Thus, the simultaneous occurrence of both events is an event with a recurrence interval in excess of 100 years. Hence, no further analysis or discussion of this event is provided.

5.6.4.2 100-year Event with Snowmelt at all Elevations. This scenario was originally assumed as the baseline event until the historical information documented in Reference 19 was considered. That information indicated that when flooding near TAN occurred in 1969, it was due to an event similar to the assumed baseline event. However, in 1969, snowmelt only contributed to runoff at elevations below about 5,500 ft. This, together with the logical assumption that higher elevation snowpacks are not likely to "ripen" at the same time as those at lower elevations, led to the rejection of this scenario as a credible 100-year flooding event.

5.6.5 Generalized Flooding from Birch Creek

The potential for flooding at site 5 due to its proximity to BC and any associated floodplain was examined because it appeared likely that this will not be addressed as part of the study by the Environmental Monitoring Unit study described in Section 1.1.1.¹ Consideration of flooding from BC was motivated by the fact that site 5 lies on the large alluvial fan at the base of BCV, together with guidelines in Reference 6 which recommend assessment of flooding potential associated with such fans. These guidelines are based on the assumption that all locations on an alluvial fan at a fixed elevation (i.e., all points along a given elevation contour) have equal probability of flooding in any given year. Reference 6 indicates, however, that this assumption may be challenged on the basis of site-specific geomorphological data to the contrary. This approach was used in the case of site 5.

1. Floodwater flows from Birch Creek onto the INEL have occurred as recently as 1969 when spring snowmelt in conjunction with frozen ground resulted in approximately 3,500 ac-ft of runoff in the vicinity of TAN. However, on the basis of observations and stream measurements, this flooding was concluded to be the result of local basin snowmelt and not large stream flows from the upper reaches of the watershed. This conclusion was supported by historical stream gaging data that indicates fairly constant flows and comparatively small peaks (Reference 19). Therefore, a decision was made that little need exists for extensive study of the entire Birch Creek watershed, and the task of defining the associated floodplain was omitted from the forthcoming generalized flooding study.

On the advice of Dr. Peter Kneupfer,^m a geologist with expertise and field experience in assessment of geomorphological processes in areas surrounding the INEL, a two-day field inspection was made to assess future flood potential for site 5. The inspection assessed the history of past floods on the BC alluvial fan subsequent to its formation. In particular, this study was to address the question of whether the portion of the alluvial fan occupied by the site has been flooded within the last 15,000-30,000 years (i.e., post-Pinedale age). Dr. Kneupfer examined several types of geological data in order to form a conclusion. These data included the thickness of the loess cover (wind-blown silt and fine sand) on the ground, the presence (or absence) of smooth-surface morphology over the parts of the alluvial fan that are immediately up-gradient from the site, signs from aerial photos and surface features suggesting the origins of past flooding flows near the site, and thicknesses of carbonate rinds on rocks in the area. The conclusions drawn from these evidences are briefly summarized as follows:

- While there exist large areas of the BC alluvial fan marked by shallow fluvial channels, there are also numerous areas of the surface (including the proposed site) that show no evidence of flooding (other than sheet flows with depths on the order of centimeters) in the past 15,000 years.
- Floods from the current BC channel have not reached site 5 in the past, except in an area of the western site margin.
- Site 5 lacks evidence of recent fluvial deposits. This, together with a degraded carbonate horizon on the grassy surface, indicate that there have been no significant surface flows across the site during the past 10,000-12,000 years.
- The lack of evidence of flooding on site 5 in the past 15,000 years makes it extremely unlikely that the site will be flooded in the future.

The full text of Dr. Kneupfer's report on the above study, which provides the support for the above conclusions, is in Attachment D to this report.

The results of the geomorphological studies, together with the historical flooding data previously mentioned (see footnote, page 5-18), support the conclusion that site 5 is not subject to flooding due to floodwaters originating in the upper BC watershed. Moreover, even though this conclusion does not take into account the recent diversion of BC, it is still valid. The reason is that the flow into the diversion channel is controlled to a maximum of approximately 70 cfs. Flows in excess of this amount bypass the diversion and continue downstream in the natural BC channel. Thus, as long as the peak diversion flow is restricted at or below its design value, site 5 will be immune from flooding due to flows originating in the upper BC watershed.

m. Professor of geology at the State University of New York at Binghamton.

5.7 Site Flooding Potential

The foregoing flooding analysis results for site 5 are summarized as follows:

- Geomorphological investigation of the natural setting of the site suggests that it has not been subject to major flooding within the past 10,000 years.
- Overflows from the manmade BCRC during the 100-year and 500-year events may pose a flooding threat to the site. Whether or not inundation of the site actually would occur under the 100-year and 500-year events postulated, could not be determined from the present one-dimensional analysis. The following table provides upper bounds to the total runoff volume that could impact site 5 during the postulated events, if it is conservatively assumed that BCRC overflows would reach the site. The table also gives upper bounds on the peak discharges to the site that could result, with zero attenuation of the discharges between culvert 2 and CP7, and the site.

	<u>100-year event</u>	<u>500-year event</u>
Maximum depth, d (ft):	NC ⁿ	NC
Inundation area, d < 1 ft (ac):	NC	NC
% of site flooded, d < 1 ft:	NC	NC
Inundation area, d ≥ 1 ft (ac):	NC	NC
% of site flooded, d ≥ 1 ft:	NC	NC
Total inundation area (ac):	NC	NC
Total % of site flooded:	NC	NC
Maximum BCRC overflows (cfs):	3,379.0	4,470.0
Total runoff toward site (ac-ft):	1,716.0	2,085.0

To assess the impact of overflows from the BCRC, 2-D analyses of the overflow discharges from culvert 2 and CP7 could be performed. Such analyses may indicate that all or a significant fraction of the overflows drain innocuously away from site 5. Alternatively, such analyses could be used to help design a suitable drainage system to divert any floodwaters that would otherwise flow onto the site.

n. Not calculated.

6. FLOODING POTENTIAL AT SITES 14 AND 18

6.1 Site Description

Sites 14 and 18 are located near the middle of the INEL in township T5N, range R31E (see Figure 1-1). Site 14 lies in Section 27, and site 18 in Sections 9, 10, 15, and 16. Both are within a triangular-shaped region (referred to as basin 14-18) bounded on the west by Lincoln Boulevard and elsewhere by the 4,800 ft contour of elevation, and having a total area of approximately 10.7 mi.² The sites are situated north of a major basalt ridge in a low-lying basin on relatively deep, fine-grained sediment deposits. These sediments would retard the downward migration of potential soil contaminants toward the Snake River Plain Aquifer. It was primarily for this reason that sites 14 and 18 were selected as candidates for siting a new waste handling facility.

Basin 14-18 would be a closed basin except for a short stretch of Lincoln Boulevard that drops to approximately 4,782 ft elevation. However, 1-ft contour maps of the area indicate that this low point lies within a small, bowl-shaped area surrounded by a ridge whose minimum elevation is 4,789 ft. This potential outlet for basin 14-18 is within a closed basin and is relatively inaccessible as an escape route for floodwaters (see Section 6.6.1.2).

6.2 Potential Watershed

Figure 6-1 shows basin 14-18, sites 14 and 18 in relation to the entire INEL, and the potential watershed determined for basin 14-18. The watershed boundaries were determined by identifying the largest contiguous parcel of land on the INEL which is adjacent to basin 14-18 and higher in elevation. This watershed incorporates most of the area on the INEL south of basin 14-18 and west of the BLR. Much of the area of the watershed is indirect watershed (i.e., areas that could contribute runoff to the BLR and thus provide floodwaters to basin 14-18, as discussed in Section 1.2.2). The remaining portion of the watershed is the direct watershed for basin 14-18 (runoff would flow directly into the basin without flowing first into the BLR). Only this portion of the watershed for basin 14-18 was addressed in the current study. Flooding associated with the BLR will be addressed as part of the study by the Environmental Monitoring Unit study described in Section 1.1.1.

The direct watershed encompasses approximately 51,350 ac (80.2 mi²). This total is distributed geographically as follows:

- 6,870 ac in basin 14-18
- 42,240 ac in the lava flows south of basin 14-18
- 2,240 ac in the lava flows east of basin 14-18.

6.3 Conceptual Model

As discussed in Section 1.2.2, the approach used to assess flooding potential on sites 14 and 18 was different from that used for sites 1, 3, 5, and 9. This approach is less rigorous than the other approach and was used to provide a basis for deciding whether or not site 14 and 18 merit further

Figure 6-1. Sites 14 and 18, Basin 14-18, and the Potential Watershed

consideration. A complete HEC-1/HEC-2 analysis was not performed on these sites because the cost of obtaining 2-ft contour maps of the entire direct watershed was prohibitive, given the funding level for the project. In addition, these sites were considered prime candidates for the MLLWDF (disposal facility) but not for the IWPF (treatment facility). Since the majority of funding for the flooding assessment was provided by the IWPF, detailed analysis of flooding at sites 14 and 18 was given a lower priority.

Given the funding constraints, the scope of the flooding analysis for sites 14 and 18 was reduced to the following:

- Estimate the total volume of runoff from the direct watershed during the 100-year and 500-year events
- Estimate the volume of water that could flow into basin 14-18, assuming all the depression storage in the direct watershed is filled first
- Determine the final water surface elevation, and identify the area of inundation after all the floodwaters have been accumulated in the basin, using 1-ft elevation contours of basin 14-18.

An implicit assumption in the last step is that infiltration and evaporation losses are zero. This assumption was made because the flooding events that were analyzed assumed winter rain on frozen, snow-covered ground. For this type of event, the assumption is reasonable (albeit conservative).

6.4 Flooding Events

As previously discussed in Section 1.2.2, the worst case 100-year and 500-year events for sites 14 and 18 are driven by runoff volume rather than runoff intensity. In addition, the sites are in close geographical proximity to site 3. Therefore, the flooding events used in the analysis for these sites were identical to those for site 3. The 100-year event is described in Section 4.4.1, and the 500-year event is described in Section 4.4.2.

6.5 Modeling Assumptions

Most of the modeling assumptions used to determine the inundation area in basin 14-18 have been stated elsewhere. For completeness, the major assumptions are summarized as follows:

- Infiltration and evaporation losses were zero.
- Total depression storage was estimated from USGS topographic maps with 5- and 10-ft contour intervals. For each depression indicated on the maps, the volume was calculated as follows:

$$V = \frac{Ah}{3} \quad (6-1)$$

where:

- V = storage volume in depression
- A = area enclosed by highest contour defining the depression
- h = depth of depression

The above relation is exact for an inverted cone and was thus taken to be a reasonable approximation, given the lack of detailed information about the topology of the surface. The value "h" was defined to be:

$$h = (N - \frac{1}{2})(CI) \quad (6-2)$$

where:

N = number of contours used to represent the depression
CI = contour interval

The above formula for the depth reflects the fact the depth is only known to within a contour interval; thus, the most probable depth of depressions represented by a single contour line, for example, is half a contour interval.

- Usable depression storage in each subbasin was filled before runoff was allowed to flow to the next downstream subbasin. For each subbasin, the usable depression storage was estimated from the total depression storage by inspecting the locations of depressions relative to the highest point in the subbasin. In general, usable depression storage varied from 80-100% of total depression storage.

The total usable depression storage in the direct watershed for basin 14-18 is 4,045 ac-ft. This total is distributed geographically as follows:

- 3,357 ac-ft in the lava flows south of basin 14-18
- 545 ac-ft in the lava flows east of basin 14-18.
- The elevation at which overflow from a ponding area begins is determined by the elevation of the lowest saddle point reached by the water surface. The elevations of these saddle points are only resolvable to within one contour interval (1 ft). For the current analysis, each saddle point elevation was taken from the lower of the two bounding contours. Thus, the storage capacities of the ponding areas were slightly underestimated, making the inundation area calculation conservative.

6.6 Flooding Analysis Results

6.6.1 100-year Event

6.6.1.1 Runoff Volume. For the 72-hour, 100-year event assumed for sites 14 and 18, the total excess precipitation (runoff due to rainfall and snowmelt) is 4.55 in. Applying this precipitation to the direct watershed, and accounting for the usable depression storage, gives the following volumes of water flowing into basin 14-18:

- 2,600 ac-ft from basin 14-18
- 12,672 ac-ft from the lava flows south of basin 14-18
- 305 ac-ft from the lava flows east of basin 14-18.

Note that no depression storage has been deducted from the runoff due to basin 14-18 itself since the next step in the analysis routes the runoff from all three sources to accumulation points in the basin. The total runoff into basin 14-18 is thus 15,577 ac-ft.

6.6.1.2 Ponding Areas. The above runoff volumes enter basin 14-18 from different locations. The runoff from the basin itself is distributed over the entire area and follows the local surface gradient downhill to accumulation points. The runoff from the south and east enters the basin through ephemeral stream channels along its southern and eastern boundaries. In determining the inundation areas within the basin, an attempt was initially made to account for these facts (however, as shown below, the runoff from the lava flows to the south are more than sufficient to inundate both sites 14 and 18, reducing the significance of the latter point).

The largest volume of runoff comes from the watershed to the south. This volume was assumed to enter the lowest depression area in the southeast portion of the basin. This ponding area, up to the 4,791 ft contour, is shown as Pond Area 1 in Figure 6-2. Its storage capacity was calculated (per the procedure in Section 1.3.2.2.6) to be 4,160 ac-ft. The 1-ft contour maps indicate the overflow saddle point (saddle point 1 in the figure) is slightly higher than 4,791 ft. The water surface must reach this elevation before flowing into the next ponding area to the north.

The second ponding area, up to the 4,790 ft contour, is shown as Pond Area 2 in Figure 6-2. Its storage capacity was calculated to be 289 ac-ft, and it overflows at saddle point 2, which is between the 4,790 and 4,791 ft elevations.

The third ponding area (Pond Area 3, which consists of multiple distinct ponds) is shown up to the 4,788 ft contour. Its storage capacity is approximately 36 ac-ft. This ponding area has two saddle point outlets, shown in Figure 6-2 as saddle points 3a and 3b. If floodwaters were to overtop point 3a, they would flow down toward the low-lying basin next to Lincoln Boulevard (area labelled "(Basin 14-18 Outlet" in the figure). The highway elevation drops to about 4,782 ft in this basin, and flows reaching this area would cross the road and leave basin 14-18. However, according to the 1 ft contour maps used, saddle point 3b is below 4,789 ft. In addition, it is hydraulically closer to the advancing water line as the water surface increases above 4,787 ft. Therefore, the conclusion is that the floodwaters would overtop saddle point 3b first and all (or most) of the flow out of the third ponding area would be northward through saddle point 3b. That is, the overtopping flow would not leave basin 14-18 but would continue moving northward toward site 18.

The land surface slopes down from saddle point 3b into a large, relatively flat region labeled in the figure as Pond Area 4. This area, up to the 4,786 ft contour, includes the major portion of site 18. The storage capacity of this ponding area (up to the 4,786 ft contour) is 113 ac-ft. If the water surface were to reach this level, site 18 would be inundated.

Figure 6-2. Inundation Areas in Basin 14-18

6.6.1.3 Inundation Area for 100-year Event. The combined storage capacities of ponding areas 1 through 4 is approximately 4,600 ac-ft. Comparing this with the runoff volume from the southern part of the direct watershed (12,672 ac ft), all four areas are easily filled with the runoff from this portion of the watershed alone. Thus, for the assumptions of the analysis, the inundation region of basin 14-18 includes at least the shaded area shown in Figure 6-2, which shows that sites 14 and 18 are both inundated by the 100-year storm.

6.6.2 500-year Event

6.6.2.1 Runoff Volume. For the 72-hour, 500-year event the total excess precipitation is 5.13 in. Applying this precipitation to the direct watershed, and accounting for the usable depression storage, gives the following volumes of water flowing into basin 14-18:

- 2,928 ac-ft from basin 14-18
- 14,697 ac-ft from the lava flows south of basin 14-18
- 413 ac-ft from the lava flows east of basin 14-18.

As in the case of the 100-year event, no depression storage has been deducted from the runoff from basin 14-18 itself. The total runoff into basin 14-18 is thus 18,038 ac-ft.

6.6.2.2 Inundation Area for 500-year Event. Because sites 14 and 18 were shown to be inundated for the 100-year event, no additional analysis was done for the 500-year event. The contour maps strongly suggest that for both the 100-year and 500-year events, ponding areas 1 through 3 will fill to the elevations described in Section 6.6.1.2. Ponding area 4 will fill to a water surface elevation between 4,786 ft and 4,790 ft and then begin to overtop saddle point 3a, thus flooding the basin 14-18 outlet area. Floodwaters would then flow west over the highway, out of basin 14-18, and toward the terminus of the BLR.

6.6.3 Assessment of Model Fidelity

The analysis in Section 6.6.1 suggests that only 30% of the total runoff into basin 14-18 is required to flood both sites 14 and 18. The validity of this conclusion might be challenged on the basis of several major assumptions. The first of these is the assumption that the elevation of the saddle points is the lower of the two bounding contour elevations (see Section 6.5). To estimate the effect of this assumption on the conclusions above, the following exercise was done.

First, storage capacities were determined for four random areas in basin 14-18 at both the 4,791 and 4,792 ft elevations, and the ratios of the storage capacities at the two elevations were determined. The maximum of these computed ratios was 2.7 and the minimum was 1.2. It was then assumed that the aggregate storage capacity of all ponding areas would be increased by a factor of 2.7, if the water surface elevation were raised 1 ft (i.e., if the higher of the two bounding contours were used instead of the lower). The resultant total storage capacity of the four ponding areas would then be 12,420 ac-ft. In this case, the estimated runoff from the 100-year event is still 127% of the capacity of the ponding areas. Thus, both sites would still be flooded even if the conservative assumption regarding the elevations of the saddle points were changed.

The second assumption that water would flow through saddle point 3b in preference to 3a could only affect the conclusion regarding flooding at site 18. Based solely on the 1 ft contour maps, the conclusion is sound. However, the difference in elevations between the two saddle points is about 1 ft and may be within the error limits of the contour maps. A first field survey of the two points could establish which point is actually higher. Another alternative would be to artificially raise the elevation of saddle point 3b to force the overtopping flow through point 3a and away from the site. This alternative, however, may not be acceptable because the definition of the 100-year flooding elevation may not allow for man-made barriers.

A third assumption in the analysis that may be questioned is the accuracy of the estimate for usable depression storage on the direct watershed. The use of 5 ft and 10 ft contour maps to calculate the volumes of the depressions using the formula discussed in Section 6.5 is subject to considerable error. If the error in the estimate for usable storage were 100% (which is probably a reasonable upper bound) and the usable storage estimate were doubled, then the runoff to basin 14-18 would be reduced to 11,675 ac-ft. Since this still exceeds the storage volume in ponding areas 1-4, the above flooding conclusions would still be valid.

A last major assumption, which can reasonably be challenged, is the assumption of zero infiltration loss. The present analysis takes no account of the time required for the runoff to flow from the direct watershed to the ponding areas in basin 14-18. In routing the runoff flows from the part of the watershed directly south of basin 14-18, it was concluded that most of the water probably flows off the lava toward Lincoln Boulevard and then follows Lincoln Boulevard north until it reaches basin 14-18. From the entry point in the southwestern corner of the basin, runoff would flow downgradient to the east and finally into ponding area 1. During the time required to make this circuitous journey, it is likely that the warming effect of the runoff and the precipitation on the frozen ground would probably result in considerable thawing and, consequently, infiltration of water through the soil layer. However, though this seems plausible, a quantitative estimate of the extent to which infiltration would occur is impossible without historical data on the depths to which the ground has frozen in the past, empirical measurements of thawing rates, and in situ measurements of infiltration on "recently unfrozen" soils in basin 14-18. Collection of these types of data was beyond the scope of the current study. Therefore, the assumption of frozen ground for the full duration of the event had to be made.

In summary, subject to the accuracy of the topographic data used and the reasonableness of the postulated hydrologic events, the conclusion that sites 14 and 18 are both vulnerable to flooding during the 100-year and 500-year events is correct.

6.6.4 Generalized Flooding from Big Lost River

The role of the BLR in flooding of sites 14 and 18 was only assessed to the extent mentioned in Section 1.2.2.3. That is, the flooding discharge discussed above for the direct watershed was linearly scaled by the ratio of the total watershed area (direct plus indirect) to the area of the direct watershed, only. The ratio was estimated from USGS topographic maps to be roughly 1.6 ($129 \text{ mi}^2/80 \text{ mi}^2$). This crude calculation suggests that, under the possible scenario for the 100-year event described in Section 1.2.2, the total flooding discharge to basin 14-18 could be 1.6 times the 15,577 ac-ft

calculated above for the direct watershed alone. This figure underscores the concerns raised above regarding the vulnerability of sites 14 and 18 to flooding.^o

6.7 Site Flooding Potential

The results of the foregoing assessment of flooding potential for sites 14 and 18 are summarized as follows:

- Both sites would be inundated during the 100-year and 500-year hydrologic events. This flooding would be due to runoff from precipitation in the watershed for basin 14-18, which contains the sites. The total area contributing in this watershed is about 80 mi² (51,200 ac).
- The above results are based on a simple flooding model with no account taken of the timescales of the various contributing drainage basins. The only considerations in the analysis were the total runoff volume, the total usable depression storage in the watershed, the storage capacities of ponding areas near the sites, and the topographic features that would determine the routes the floodwaters would follow in filling the low-lying areas of basin 14-18.

Because of the nature of above flooding assessment, as well its conclusions, a summary table, similar to those that were provided for the other four sites, has not been generated for sites 14 and 18.

o. In his review of this report, Jack T. Barraclough, EG&G Idaho, Applied Geosciences Unit, indicated "The Big Lost River could flood site 14 (and has done so in the past). Any flood routing maps would show the depth of water to be 2 ft or less. Site 14 has other natural advantages and, with some suitable flood mitigation, could still be a viable site." (Handwritten review comments to the authors, January 24, 1994.)

7. CONCLUSIONS

The foregoing flooding analyses show that no one of the six candidate sites is wholly below the 100-year flooding elevation, as defined in Section 1.1.1. However, the degree of inundation of the sites varies considerably, and it is likely that judicious refinement of boundaries could alter the above conclusion for sites 9, 1, and possibly 3.

Geomorphological studies of site 5 strongly suggest that the site has not experienced major flooding from natural sources in the last 10,000 years. However, the flooding analysis indicates that the BCRC (manmade) could concentrate runoff from the local watershed and discharge it upgradient from the site. Whether the resulting flows would actually impact the site could not be determined without a 2-D free-surface flow analysis of the discharges from the BCRC. Thus, flooding potential at site 5 was considered indeterminate for purposes of site evaluation as of this writing.

Sites 14 and 18 are both in a low-lying, closed basin within a few miles of the terminus of the BLR. The potential watershed for this basin was estimated to be between 77 and 129 mi². Analysis of the runoff from this watershed under the conservative assumption of zero infiltration loss (see Section 1.3.3) indicates that sites 14 and 18 would both be inundated by the 100-year event considered in the study. Though the analysis of these sites was not as rigorous as for the others (for reasons described herein), reasonable allowance for uncertainties still leads to the above conclusion. While the flooding hazard to Site 18 might be mitigated with suitable diking, this alternative may not find favor with regulators. Therefore, sites 14 and 18 should be withdrawn from further consideration.

Site 3 contains a number of small, flat depressions that act as ponding areas for runoff. These areas grow and fill during both the 100-year and 500-year events analyzed. After the water surface elevation reaches a zenith level, the ponding areas cease to increase in area, and additional runoff flows easily off the site to the basin containing sites 14 and 18. The combined surface areas of all the ponds on site 3 is about 36 ac, or 27% of the 133-ac site (as now constituted) for both the 100-year and the 500-year flooding events. (The principal difference between the two events is the volume of water that runs through the site and then off of it.) This leaves about 97 ac of land that is not inundated, suggesting that the site boundaries might be redefined to exclude the ponding areas. However, because the ponding areas are evenly distributed (geographically) through the site, realigning the boundaries may result in a site that is so fragmented as to be unfeasible.

Flooding at site 9 is due to the presence of ephemeral streams that pass through the site. Filling of these streams results in inundation of about 7.2 ac (11.6%) of the 62-ac site during the 100-year event and about 7.4 ac (11.9%) during the 500-year event. Because the streams divide the site fairly evenly, realignment of the site boundaries to exclude flooded areas would result in a substantially smaller site unless additional land were carefully selected and added from outside the site boundary as now defined. Another alternative would be to provide storm drainage and design the facility to ensure that regulated wastes are not stored (or treated) in the area subject to inundation. Since this area is relatively small, accomplishing this objective should not be costly.

Flooding at site 1 is also due primarily to the presence of ephemeral streams running through the site. However, in addition to streams, site 1 also encompasses one major ponding area, resulting in a total inundation area (streams plus pond) of 52 ac (27%) of the 193-ac site during the 100-year

event and 57 ac (29%) during the 500-year event. Because site 1 is considerably larger than site 9, the most feasible alternative for dealing with the flooding issue would be to redefine the boundaries of the site. Doing so would leave a single, nonfragmented parcel of about 140 ac, which is demonstrably above the 100-year flooding elevation.

These conclusions are summarized in Table 7-1, below. The sites are listed in the order of preference on the basis of flooding potential, alone.

Table 7-1. Candidate Sites in Order of Preference on the Basis of Flooding Potential

Site	Rationale
1	<ul style="list-style-type: none"> • 140 ac of site not inundated • Site boundaries easily redefined to put site above 100-year flooding elevation
9	<ul style="list-style-type: none"> • 55 ac of site not inundated • Streams are only source of inundation • Flood control achievable for reasonable cost
3	<ul style="list-style-type: none"> • 97 ac of site not inundated • Nonflooded area not contiguous • Redefinition of boundaries would yield a fragmented site
?	<ul style="list-style-type: none"> • Site appears immune from natural flooding; however, BCRC (manmade) may be significant flood hazard • Additional studies could show BCRC not a significant flooding hazard
18	<ul style="list-style-type: none"> • Current (limited) study strongly suggests site is subject to significant flooding • Diking could eliminate flooding hazard • Potential problems with regulators
14	<ul style="list-style-type: none"> • Current (limited) study strongly suggests site is subject to significant flooding • Site should not be considered further

In considering the above ranking, other factors besides flooding will also influence the final choice of a site for the IWPF. If these other concerns become overriding, it may be possible to control flooding at most locations with minor earthworks, diking, or ditching.

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Attachment A

Quality Assurance Report on Topographic Data

Butler Engineering & Land Surveying

130 E. Maple • P.O. Box 473 • Shelley, Idaho 83274

(208) 357-3898 or (208) 357-3896 (Fax)

REPORT ON RESULTS OF TOPOGRAPHIC CHECK SURVEYS

A topographic check survey was conducted by Butler Engineering during December 1 through 13 to assess the accuracy of the topographic data provided by the aerial mapping contractor for the flooding potential study for the Idaho Waste Processing Facility at the INEL.

ACCURACY REQUIREMENTS

The accuracy requirements stated in the aerial mapping and surveying specifications which were used for the project required that 90% of all the contours shall have an accuracy with respect to true elevation of one-half the contour interval, or better. The remaining 10% of the contours were required to have an accuracy of within 1 contour interval. Ninety percent of all spot elevations were required to have an accuracy of $1/4$ of a contour interval and the remaining 10% were required to have an accuracy of within $1/2$ contour interval. The contour interval on the maps which were produced for this study was 2 feet. The required accuracy for the contours would then equal 1 ft. for 90% of the contours. The required accuracy for the spot elevations would be $1/2$ ft. for 90% of the elevations.

The map scale was 1 inch = 200 feet. Planimetric features were required to be plotted within .025 inches of their true position which equals within 5 feet on the ground.

ACCURACY CHECK SURVEY

A horizontal control traverse using U.S. Coast and Geodetic survey stations "Cobble" and "Ville" was run connecting to 6 of the monumented control points used in the field for control of the photogrammetric surveying. The horizontal control traverse established the positions were in good agreement with the coordinates given for the same positions. See Appendix 1 detailing the results of this survey.

Differential levels were run between U.S. Coast and Geodetic Survey bench marks and the control points checking the elevation of the established control points in good agreement with the data provided. Differential level loops were closed within the required accuracy of .05 feet times the square root of the number of miles in the level loop.

Traverses were run between the found control points along the terrain checking the position of several spot elevations and planimetric features with both horizontal and vertical control. The differences in elevation between the levels run by Butler

Engineering and the aerial mapping contractor were determined by plotting check profiles in a land modeling program in the computer. The base map was from data provided by EG&G.

A large number of points were compared to check the map accuracy. A small sampling of the data is presented on the tables in the following pages. An analysis of the all of the data run indicates that the aerial mapping company met or exceeded the specifications for map accuracy.

Robert B. Butler, P.E.

Attachment B

Letter report from NOAA on 72-hour meteorological data

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES

September 13, 1993

Mr. Dean Taylor
Engineering
EG&G Idaho, Inc.

SUBJECT: 50 YEAR 72 HOUR PRECIPITATION AND AVERAGE TEMPERATURE
EVENTS

Dear Mr. Taylor:

The maximum 3 day precipitation totals and average temperatures were determined for each year from 1950 through 1993 from the Central Facilities Area (CFA) at the INEL. (The 1993 data was for a partial year only, including data from January through July.) The precipitation totals and average temperatures for each year were assembled in two ways: first using data from the entire year and second using data only from the winter season. For the purposes of this work the winter season was defined as the period of November 15th through March 15th.

Table 1 contains the maximum 3 day precipitation data from each year using data from the entire year. The table is sorted from the year with the smallest maximum precipitation accumulation to the year with the highest maximum 3 day precipitation accumulation. The data is graphically presented in figure 1. Equation 1 relates 3 day precipitation to return years.

$$\text{Precip} = \log(\text{Return Years}) * 0.951 + 0.840 \quad (1)$$

Using the above equation the expected 50 year 3 day storm would yield 2.46 inches of precipitation.

Table 2 contains the same information as Table 1 except it was compiled using the winter season only. Figure 2 shows the plot of the data in table 2 and equation 2 gives us the relationship between winter time 3 day precipitation totals and return years.

$$\text{Precip} = \log(\text{Return Years}) * 0.958 + 0.361 \quad (2)$$

The expected 50 year 3 day storm in the winter time would yield 1.99 inches of precipitation.

Table 3 contains the maximum 3 day average temperatures for each year ordered from the lowest to the highest. the average temperatures were calculated by averaging the daily high and low

temperatures for each day in the 3 day period. Figure 3 is the graphical representation and equation 3 relates 3 day average temperature to return years.

$$\text{Temp} = \log(\text{Return Years}) * 6.045 + 72.400$$

The expected highest 3 day average temperature in a 50 year period would be 82.67 degrees Fahrenheit.

Table 4 and figure 4 contain the same temperature information as table 3 and figure 3 except they were compiled using only winter-time data. Equation 4 relates 3 day winter time average temperatures to return years.

$$\text{Temp} = \log(\text{Return Years}) * 7.592 + 35.518$$

The expected highest winter-time 3 day average temperature in a 50 year period would be 48.42 degrees Fahrenheit.

Sincerely,

Jerry Sagendorf
NOAA ARLFRD.

Table 1. Maximum 3 day CFA precipitaion table
based on annual data.

yymmdd	Precip in	rank	return years
520623	0.50	1	1.000
771121	0.70	2	1.023
740519	0.72	3	1.048
500811	0.72	4	1.073
580421	0.79	5	1.100
551222	0.81	6	1.128
510804	0.84	7	1.158
660509	0.84	8	1.189
780905	0.85	9	1.222
720607	0.85	10	1.257
800906	0.87	11	1.294
880420	0.92	12	1.333
750424	0.96	13	1.375
900113	0.98	14	1.419
560526	1.02	15	1.467
920614	1.03	16	1.517
890926	1.06	17	1.571
670612	1.07	18	1.630
821221	1.15	19	1.692
701129	1.15	20	1.760
850729	1.16	21	1.833
860216	1.18	22	1.913
730720	1.18	23	2.000
830930	1.20	24	2.095
530523	1.23	25	2.200
910508	1.23	26	2.316
760425	1.24	27	2.444
790722	1.30	28	2.588
710929	1.34	29	2.750
600608	1.36	30	2.933
590819	1.44	31	3.143
870516	1.45	32	3.385
630426	1.50	33	3.667
650624	1.53	34	4.000
840607	1.62	35	4.400
930605	1.68	36	4.889
690119	1.69	37	5.500
620209	1.70	38	6.286
810419	1.74	39	7.333
680607	1.76	40	8.800
570511	1.81	41	11.000
641221	1.81	42	14.667
540609	1.96	43	22.000
610916	2.04	44	44.000

Figure 1 Maximum 3 day precipitation totals using data from entire year.

Table 2. Maximum 3 day CFA precipitaion table
based on Nov 15th through Mar 15th data.

yymmdd	Precip in	rank	return years
560125	0.23	1	1.000
511201	0.33	2	1.023
530228	0.36	3	1.048
501206	0.39	4	1.073
790111	0.41	5	1.100
520216	0.44	6	1.128
891124	0.45	7	1.158
881115	0.45	8	1.189
610201	0.45	9	1.222
721203	0.48	10	1.257
580224	0.50	11	1.294
830312	0.51	12	1.333
921229	0.51	13	1.375
870126	0.52	14	1.419
841125	0.53	15	1.467
750108	0.54	16	1.517
741204	0.54	17	1.571
760228	0.56	18	1.630
730211	0.60	19	1.692
710217	0.61	20	1.760
811122	0.62	21	1.833
800112	0.62	22	1.913
780115	0.62	23	2.000
850120	0.66	24	2.095
570223	0.70	25	2.200
771121	0.70	26	2.316
661203	0.71	27	2.444
930218	0.75	28	2.588
670120	0.81	29	2.750
551222	0.81	30	2.933
600207	0.85	31	3.143
540212	0.85	32	3.385
681224	0.88	33	3.667
650106	0.93	34	4.000
591223	0.96	35	4.400
900113	0.98	36	4.889
910302	1.07	37	5.500
821221	1.15	38	6.286
701129	1.15	39	7.333
860216	1.18	40	8.800
630130	1.32	41	11.000
690119	1.69	42	14.667
620209	1.70	43	22.000
641221	1.81	44	44.000

CFA WINTER PRECIPITATION PROBABILITY
DATA PERIOD OF RECORD: 1950-1993

Figure 2 Maximum 3 day precipitation totals using data from November 15th through March 15th.

Table 3 Maximum 3 day CFA temperature table
based on annual data.

yymmdd	Temp deg F	rank	return years
930728	67.7	1	1.000
520724	70.8	2	1.023
840725	71.7	3	1.048
500629	71.7	4	1.073
730709	71.7	5	1.100
620721	71.8	6	1.128
570727	72.0	7	1.158
780725	73.2	8	1.189
860816	73.3	9	1.222
810704	73.5	10	1.257
800723	73.5	11	1.294
660719	73.5	12	1.333
650808	73.5	13	1.375
640711	73.5	14	1.419
790717	73.7	15	1.467
670712	73.7	16	1.517
630722	73.7	17	1.571
870726	73.8	18	1.630
760709	74.2	19	1.692
680726	74.2	20	1.760
700717	74.3	21	1.833
710806	74.7	22	1.913
910713	74.8	23	2.000
820721	75.0	24	2.095
690802	75.0	25	2.200
740615	75.2	26	2.316
590715	75.3	27	2.444
720810	75.7	28	2.588
560709	76.0	29	2.750
920812	76.2	30	2.933
770716	76.2	31	3.143
530713	76.2	32	3.385
750707	76.2	33	3.667
900807	76.5	34	4.000
540711	76.5	35	4.400
580815	77.5	36	4.889
890725	77.5	37	5.500
830806	77.5	38	6.286
610803	77.7	39	7.333
510717	78.0	40	8.800
550714	78.2	41	11.000
600726	78.2	42	14.667
850706	79.8	43	22.000
880623	80.8	44	44.000

Figure 3 Maximum 3 day average temperature using data from entire year.

Table 4 Maximum 3 day CFA temperature table
based on Nov 15th through Mar 15th data.

yymmdd	Temp deg F	rank	return years
850108	24.3	1	1.000
521218	32.0	2	1.023
560104	33.0	3	1.048
930315	33.7	4	1.073
780206	33.8	5	1.100
840314	34.3	6	1.128
690112	35.8	7	1.158
790212	35.8	8	1.189
710116	36.0	9	1.222
700122	36.7	10	1.257
621120	37.3	11	1.294
731116	37.5	12	1.333
880229	37.7	13	1.375
760226	37.7	14	1.419
751205	38.0	15	1.467
771213	38.2	16	1.517
511128	38.3	17	1.571
500303	38.5	18	1.630
580222	38.7	19	1.692
591123	38.7	20	1.760
660313	39.0	21	1.833
890310	39.2	22	1.913
601124	39.3	23	2.000
811116	39.5	24	2.095
740315	39.8	25	2.200
910302	39.8	26	2.316
800218	40.0	27	2.444
551221	40.0	28	2.588
680304	40.0	29	2.750
900108	40.0	30	2.933
670309	40.0	31	3.143
570307	40.7	32	3.385
651117	40.7	33	3.667
531115	40.8	34	4.000
641222	40.8	35	4.400
540307	41.2	36	4.889
820309	41.2	37	5.500
630205	41.5	38	6.286
870311	41.5	39	7.333
830309	42.3	40	8.800
860301	42.5	41	11.000
610314	42.7	42	14.667
720311	44.3	43	22.000
920302	45.8	44	44.000

CFA WINTER TEMPERATURE PROBABILITY
DATA PERIOD OF RECORD: 1950-1993

Attachment C
HEC-1 Input Decks

HEC-1 Input Decks

Site 1, 100-Year and 500-Year Events

Differences are marked as follows: 100-year data and 500-year data)

```

ID Site 1 Drainage Study, 100-Yr Flood
ID 2-yr rain on ripe snow pack; Max hourly temps of record (Mar 31, 1961)
ID Site 1 Drainage Study, 500-Yr Flood
ID 10-yr rain on ripe snow pack; Max hourly temps of record (Mar 31, 1961)}
ID SCS UH Method, Kirpich Tc
* Routing method changed from Muskingum-Cunge to Kinematic Wave (10-27-93)
* Routing method changed from Muskingum-Cunge to Kinematic Wave on 10/28/93.
IT 15 01MAR99 0000 192
IO
*DIAGRAM
KK SB8
KM RUNOFF FROM SUBBASIN 8
BA .51
PB .50
PB .75
IN 60
PC .013 .027 .036 .054 .065 .082 .096 .115 .141 .176
PC .245 .516 .774 .828 .862 .889 .910 .929 .946 .957
PC .967 .978 .990 1.000
LU
LM
MC 3.3 .088 32
IN 60
MT 44.1 40.9 40.0 45.4 50.3 55.0 58.2 61.9 63.7 66.0
MT 66.5 66.8 66.8 62.9 60.0 57.0 54.5 48.9 52.2 50.1
MT 44.0 40.1 43.1 43.9 32
MA .51 5
UD .41
KK SB9
KM RUNOFF FROM SUBBASIN 9
BA .36
LU
LM
UD .45
KK CP1
KM COMBINE TWO HYDROGRAPHS
HC 2
KK8&9T07
KM ROUTE FROM SB8-SB9 TO SB 7
RK 5567 .004 .05 TRAP .002
* RD
* RC .05 .05 .05 5567 .004
* RX 0 100 150 200 300 400 450 500
* RY 83.1 80.0 79.8 79.6 79.7 80.0 80.0 79.7
* RY 100.3 97.8 96.4 95.7 95.3 95.6 98.0 99.0
KK SB7
KM RUNOFF FROM SUBBASIN 7
BA .38
LU
LM
UD .50
KK CP2
KM COMBINE TWO HYDROGRAPHS
HC 2
ZW A=SITE1 C=FLOW F=100-YR(UH)
ZW A=SITE1 C=FLOW F=500-YR(UH)

```


KK RES4
 KM Route through reservoir behind culvert C4
 RS 1 FLOW 0
 SV 0 .020 .156 .463 1.350 6.071 18.258 34.449 66.984
 SE 71.33 72.33 73.33 74.33 75.33 76.33 77.33 78.33 79.33 62
 SS
 ST 77.5 3.1 1.5
 SW 0 165 328 492 540
 SE 77.5 77.6 77.7 77.8 77.9
 SL 72.07 8.25 0.6 0.5
 KK 4T014
 KM ROUTE FROM RES4 TO SB14
 * RD
 * RC .05 .05 .05 4753 .01
 * RX 0 50 100 150 200 250 300 350
 * RY 55.2 55.6 52.5 46.6 44.0 46.1 48.0 48.1
 RK 4753 .01 .05 TRAP .02
 KK SB14
 KM RUNOFF FROM SUBBASIN 14
 BA .24
 LU
 LM
 UD .31
 ZW A=SITE1 C=FLOW F=100-YR(UH)
 ZW A=SITE1 C=FLOW F=500-YR(UH)
 KK SB11
 KM RUNOFF FROM SUBBASIN 11
 BA .02
 LU
 LM
 UD .07
 * KK RES7
 * KM Route through reservoir behind culvert C5
 * RS 1 FLOW 0
 * SV 0 .003 .068 .327 1.640
 * SE 63.85 64.85 65.85 66.85 67.85
 * SS
 * ST 66.0 3.1 1.5
 * SW 0 335
 * SE 66.0 68.1
 * SL 63.9 1.8 0.6 0.5
 KK11T013
 KM ROUTE FROM RES11 TO SB13
 * RD
 * RC .05 .05 .05 3700 .01
 * RX 0 50 100 150 200 250 300 350
 * RY 59.4 57.2 55.1 52.3 50.0 51.8 53.7 54.5
 RK 3700 .01 .05 TRAP .02
 KK SB13
 KM RUNOFF FROM SUBBASIN 13
 BA .14
 LU
 LM
 UD .29
 KK SB12
 KM RUNOFF FROM SUBBASIN 12
 BA .07
 LU
 LM
 UD .20
 KK12T015
 KM ROUTE FROM SB12 TO SB15
 * RD
 * RC .05 .05 .05 675 .009
 * RX 0 50 100 150 200 250 300 350
 * RY 36.4 35.5 34.9 34.5 34.3 35.2 36.4 37.5

RK 675 .009 .05 TRAP .02
 KK SB15
 KM RUNOFF FROM SB15
 BA .01
 LU
 LM
 UD .07
 KK CP3
 KM COMBINE SIX HYDROGRAPHS
 HC 6
ZW A=SITE1 C=FLOW F=100-YR(UH)
ZW A=SITE1 C=FLOW F=500-YR(UH)
 KK 3T016
 KM ROUTE FROM CP3 TO SB16
 * RD
 * RC .05 .05 .05 2857 .004
 * RX 0 50 100 150 200 250 300 400
 * RY 32.5 31.4 30.1 27.8 25.1 28.6 29.7 33.2
 RK 2857 .004 .05 TRAP .02
 KK SB16
 KM RUNOFF FROM SB16
 BA .24
 LU
 LM
 UD .30
 KK CP4
 KM COMBINE TWO HYDROGRAPHS
 HC 2
ZW A=SITE1 C=FLOW F=100-YR(UH)
ZW A=SITE1 C=FLOW F=500-YR(UH)
 KK RES5
 KM Route through reservoir behind culverts at RR track
 RS 1 FLOW 0
 SV 0 .254 4.671 14.814 31.131
 SE 17 18 19 20 21
 SS
 ST 20 3.1 1.5
 SW 570 890 1180 1260
 SE 20 22 24 24.9
 SL 16.6 11 0.6 0.5
 KK SB10
 KM RUNOFF FROM SB10
 BA .24
 LU
 LM
 UD .34
 KK RES6
 KM Route through reservoir behind culverts at RR track
 RS 1 FLOW 0
 SV 0 .012 .069 .336 1.533 3.652 6.853 12.357 21.522 32.862
 SV46.423 62.624
 SE 65 66 67 68 69 70 71 72 73 74
 SE 75 76
 SS 74 400 3.1 1.5
 ST
 SW
 SE
 SL 67 .1 0.6 0.5
 ZZ

HEC-1 Input Decks

Site 3, 100-Year and 500-Year Events

Differences are marked as follows: 100-year data and 500-year data)

```

ID Site 3 Drainage Study 100-yr 72-hr Flood
ID 2-yr rain on ripe snow, max mean 72-hr temp. (hourly dist. of 3/31/66)
ID Site 3 Drainage Study 500-yr 72-hr Flood
ID 10-yr rain on ripe snow, max mean 72-hr temp. (hourly dist. of 3/31/66)
ID SCS unit hydrograph method, Kirpich Tc
IT 15 01MAR99 0000 384
IO 5
KK SB1
KM Runoff from subbasin 1
BA .237
PB .52
PB 1.26
IN 60
PI .010 .011 .011 .013 .015 .017 .018 .020 .026 .035
PI .069 .271 .258 .054 .034 .027 .021 .019 .017 .012
PI .011 .011 .010 .010 .010 .011 .011 .013 .015 .017
PI .018 .020 .026 .035 .069 .271 .258 .054 .034 .027
PI .021 .019 .017 .012 .011 .011 .010 .010 .010 .011
PI .011 .013 .015 .017 .018 .020 .026 .035 .069 .271
PI .258 .054 .034 .027 .021 .019 .017 .012 .011 .011
PI .010 .010
LU
LM
MC 3.3 .089 32
IN 60
MT 40.0 37.1 36.3 41.2 45.6 49.9 52.8 56.1 57.8 59.8
MT 60.3 60.6 60.6 57.0 54.4 51.7 49.4 44.3 47.3 45.4
MT 39.9 36.4 39.1 39.8 40.0 37.1 36.3 41.2 45.6 49.9
MT 52.8 56.1 57.8 59.8 60.3 60.6 60.6 57.0 54.4 51.7
MT 49.4 44.3 47.3 45.4 39.9 36.4 39.1 39.8 40.0 37.1
MT 36.3 41.2 45.6 49.9 52.8 56.1 57.8 59.8 60.3 60.6
MT 60.6 57.0 54.4 51.7 49.4 44.3 47.3 45.4 39.9 36.4
MT 39.1 39.8 32
MA 0.237 5
UD .27
KK RES1
KM Route through natural depression - RES1
RS 1 FLOW 0
SV 0 .002 .177 1.657 4.384 9.434 15.612
SE 92 93 94 95 96 97 98
SS
ST 96 3.1 1.5
SW 0 60.3 78.9
SE 96 97 98
SL 93 .01 0.6 0.5
KK 1T02
KM Route from RES1 through SB2
RD
RC .05 .05 .05 1172 .015
RX 0 100 150 200 250 300 350 400
RY 87.07 84.00 84.00 82.00 84.52 88.62 95.81 102.00
KK SB2
KM Runoff from SB2
BA 0.046
LU
LM
MA 0.046 5
UD .090
KK CP1
KM Combine two hydrographs
HC 2
KK RES2
    
```

KM Route through natural depression - RES2

RS	1	FLOW	0					
SV	0	.024	1.308	4.856	9.614			
SE	78	79	80	81	82			
SS								
ST	79.8		3.1	1.5				
SW	0	13.5	82.4	153.1				
SE	79.8	80	81	82				
SL	79	.01	0.6	0.5				
KK	2T03							

KM Route from RES2 through SB3

RD								
RC	.05	.05	.05	1755	.005			
RX	0	50	100	150	250	300	350	400
RY	86.33	87.68	81.30	76.31	76.12	78.87	78.65	77.60
KK	SB3							

KM Runoff from SB3

BA	0.031							
LU								
LM								
MA	.031	5						
UD	.189							
KK	SB4							

KM Runoff from SB4

BA	0.079							
LU								
LM								
MA	0.079	5						
UD	.184							
KK	CP2							

KM Combine three hydrographs

HC	3							
KK	3T07							

KM Route from SB3 through SB7

RD								
RC	.05	.05	.05	625	.010			
RX	0	25	50	100	150	200	250	300
RY	69.42	69.40	69.39	69.49	70.23	70.00	75.66	78.04
KK	SB7							

KM Runoff from SB7

BA	0.008							
LU								
LM								
MA	0.008	5						
UD	.065							
KK	SB5							

KM Runoff from SB5

BA	0.017							
LU								
LM								
MA	0.017	5						
UD	.126							
KK	RES3							

KM Route through natural depression - RES3

RS	1	FLOW	0					
SV	0	.152	1.139	3.356	6.212			
SE	78	79	80	81	82			
SS								
ST	80.4		3.1	1.5				
SW	0	98.5	273.1					
SE	80.4	81	82					
SL	78	.01	0.6	0.5				
KK	3T06							

KM Route from RES3 through SB6

RD								
RC	.05	.05	.05	1266	0.013			
RX	0	50	100	150	200	250	300	350
RY	77.76	78.12	77.64	76.91	76.11	78.53	80.38	80.57
KK	SB6							

KM Runoff from SB6

BA	.025							
LU								
LM								

MA 0.025 5
 UD .102
 KK CP3
 KM Combine four hydrographs
 HC 4
 KK 6T08
 KM Route from CP3 through SB8
 RD
 RC .05 .05 .05 1421 .010
 RX 0 50 100 150 200 250 300 350
 RY 67.65 66.46 66.05 64.78 64.00 64.92 67.10 65.52
 KK SB8
 KM Runoff from SB8
 BA 0.047
 LU
 LM
 MA 0.047 5
 UD .130
 KK SB9
 KM Runoff from SB9
 BA 0.087
 LU
 LM
 MA 0.087 5
 UD .140
 KK 9T010A
 KM Route from SB9 to SB10A
 RD
 RC .05 .05 .05 2000 .008
 RX 0 50 100 150 200 250 300 400
 RY 82.29 82.00 81.29 80.00 75.80 75.44 75.51 77.36
 KK SB10A
 KM Runoff from SB10A
 BA 0.101
 LU
 LM
 MA 0.101 5
 UD .177
 KK CP4
 KM Combine two hydrographs
 HC 2
 * There are two reservoirs in SB10 (RES4A and RES4). Half of the runoff from
 * SB10 is introduced at each reservoir.
 KK RES4A
 KM Route through natural depression
 RS 1 FLOW 0
 SV 0 .303 2.830 9.174 17.100
 SE 69 70 71 72 73
 SS
 ST 71.3 3.1 1.5
 SW 0 63.4 259.9
 SE 71.3 72 73
 SL 70 .01 0.6 0.5
 KK 4AT04
 KM Route from RES4A to RES4
 RD
 RC .05 .05 .05 2018 .008
 RX 0 50 100 150 200 250 300 400
 RY 71.78 73.46 70.14 72.00 70.00 70.05 71.14 73.94
 KK SB10
 KM Runoff from the lower half for SB10
 BA .100
 LU
 LM
 MA .100 5
 UD .177
 KK CP5
 KM Combine two hydrographs
 HC 2
 KK RES4
 KM Route through natural depression - RES4
 RS 1 FLOW 0
 SV 0 .087 .760 1.731 3.042 4.649 7.775

SE	58	59	60	61	62	63	64
SS							
ST	61.4		3.1	1.5			
SW	0	39.4	63	87.4			
SE	61.4	62	63	64			
SL	59	.01	.06	.05			
KK	4T011						
KM	Route from RES4 through SB11						
RK	1124	.008	.05		TRAP		.02
KK	SB11						
KM	Runoff from SB11						
BA	0.017						
LU							
LM							
MA	0.017	5					
UD	.112						
KK	SB12						
KM	Runoff from SB12						
BA	0.020						
LU							
LM							
MA	0.020	5					
UD	.107						
KK	RES5						
KM	Route through natural depression - RES5						
RS	1	FLOW	0				
SV	0	.251	1.919	4.619			
SE	69	70	71	72			
SS							
ST	71.4		3.1	1.5			
SW	0	361.0					
SE	71.4	72					
SL	69.5	.01	0.6	0.5			
KK	12T013						
KM	Route from SB12 through SB13						
RK	2136	.003	.05		TRAP		.002
KK	SB13						
KM	Runoff from SB13						
BA	0.05						
LU							
LM							
MA	0.05	5					
UD	.27						
KK	CP6						
KM	Combine 6 hydrographs						
HC	6						
ZW	A=SITES C=FLOW F=100-YR						
ZW	A=SITES C=FLOW F=500-YR(UH)						
KK	RES6						
KM	Route through natural depression - RES6						
RS	1	FLOW	0				
SV	0	.44	1.964	8.460	21.287	37.392	56.618
SV	0	.45	1.964	8.460	21.207	37.392	56.618
SV	160.60	193.294	228.809	266.701			
SE	51	52	53	54	55	56	57
SE	61	62	63	64			
SS							
ST	63.2		3.1	1.5			
SW	0	49.8	371.8				
SE	63.2	64	65				
SL	53	.01	0.6	0.5			
KK	6T014						
KM	Route from RES6 through SB14						
RD							
RC	.05	.05	.05	1407	.010		
RX	0	50	100	150	200	300	350
RY	64.32	69.02	67.21	59.52	56.73	60.16	59.98
KK	SB14						
KM	Runoff from SB14						
BA	.044						
LU							
LM							
MA	.044	5					

UD .122
 KK SB17
 KM Runoff from SB17
 BA 0.016
 LU
 LM
 MA 0.016 5
 UD .068
 KK RES7
 KM Route through natural depression - RES7
 RS 1 FLOW 0
 SV 0 .0593 .1980
 SE 94 95 96
 SS
 ST 95.8 3.1 1.5
 SW 0 100
 SE 95.8 96
 SL 95 .01 0.6 0.5
 * No routing between SB17 and SB16 (negligible distance)
 KK SB16
 KM Runoff from SB16
 BA 0.131
 LU
 LM
 MA 0.131 5
 UD .30
 KK CP7
 KM Combine two hydrographs
 HC 2
 KK RES8
 KM Route through natural depression - RES8
 RS 1 FLOW 0
 SV 0 .059 1.362 5.120
 SE 91 92 93 94
 SS
 ST 92.5 3.1 1.5
 SW 0 98.6 412.1
 SE 92.5 93 93.5
 SL 92 .01 0.6 0.5
 KK 8T018
 KM Route from RES8 through SB18
 RD
 RC .05 .05 .05 1075 .008
 RX 0 50 100 150 200 250 300 350
 RY 89.21 90.08 90.30 90.16 89.34 91.56 97.08 96.80
 KK SB18
 KM Runoff from SB18
 BA 0.049
 LU
 LM
 MA 0.049 5
 UD .101
 KK CP8
 KM Combine two hydrographs
 HC 2
 KK RES9
 KM Route through natural depression
 RS 1 FLOW 0
 SV 0 .007 .526 2.93
 SE 92 93 94 95
 SS
 ST 93 3.1 1.5
 * This is a fictitious outlet profile to conservatively direct flow
 * toward site.
 SW 0 195
 SE 93 94
 * SL 92 .1 0.6 0.5
 KK 9T019
 KM Route from RES9 through SB19
 RD
 RC .05 .05 .05 2159 .010
 RX 0 200 400 403 413 416 616 816
 RY 100 99 98 95 95 98 99 100

KK SB19
 KM Runoff from SB19
 BA 0.063
 LU
 LM
 MA 0.063 5
 UD .170
 KK CP9
 KM Combine two hydrographs
 HC 2
 KK RES10
 KM Route through natural depression - RES10
 RS 1 FLOW 0
 SV 0 .699 4.756 10.685 18.614 28.089
 SE 61 62 63 64 65 66
 SS
 ST 62.4 3.1 1.5
 SW 0 111.4 215.4 240.6 266.6 291.9
 SE 62.4 63 64 65 66 67
 SL 62 .01 0.6 0.5
 KK SB20
 KM Runoff from SB20
 BA 0.110
 LU
 LM
 MA 0.110 5
 UD .184
 KK CP10
 KM Combine two hydrographs
 HC 2
 KK RES11
 KM Route through natural depression - RES11
 RS 1 FLOW 0
 SV 0 .077 .648 2.006 4.186 6.963 10.736 15.625 22.148 30.107
 SV40.451 52.816 68.189
 SE 53 54 55 56 57 58 59 60 61 62
 SE 63 64 65
 SS
 ST 64.5 3.1 1.5
 SW 0 75.1
 SE 64.5 65
 SL 55 .01 0.6 0.5
 * Neglect channel routing between RES11 and SB23 because of short distance
 * Neglect channel routing because of short distance to reservoir
 * KK11T028
 * KM Route from RES11 through SB28
 * RD
 * RC .05 .05 .05 812 .002
 * RX 0 200 400 403 413 416 616 816
 * RY 100 99 98 95 95 98 99 100
 KK SB28
 KM Runoff from SB28
 BA .059
 LU
 LM
 MA .059 5
 UD .148
 KK CP11
 KM Combine two hydrographs
 HC 2
 KK RES12
 KM Route through natural depression - RES12
 KO 1
 RS 1 FLOW 0
 SV 0 .001 .237 .942 2.318 4.275 8.759 14.812 22.669
 SE 57 58 59 60 61 62 63 64 65
 SS
 ST 62.6 3.1 1.5
 SW 0 18 53.2 79.4 133.8 203.5 244.9
 SE 62.6 63 64 65 66 67 68
 SL 59 .01 0.6 0.5
 * Use kinematic wave routing since a routing xsection was not provided
 KK 28-29


```

KM Route from 28 through 29
KO 1
RK 1181 .012 .05 TRAP .02
KK SB29
KM Runoff from SB29
BA 0.020
LU
LM
MA 0.020 5
UD .100
KK CP12
KM Combine four hydrographs
KO 1
HC 4
ZW A=SITE3 C=FLOW F=100-YR(UH)
ZW A=SITE3 C=FLOW F=500-YR(UH)
KK RES13
KM Route through natural depression - RES13
KO 1
RS 1 FLOW 0
SV 0 .064 .969 4.010
SE 48 49 50 51
SS
ST 50.2 3.1 1.5
SW 0 244.1 898.8
SE 50.2 51 52
SL 49 .01 0.6 0.5
KK13T015
KM Route from RES13 through SB15 to next Res (abt half way)
KO 1
RD
RC .05 .05 .05 900 .0004
RX 0 50 100 150 200 250 300 350
RY 50.98 50.83 50.67 50.22 49.97 50.34 51.91 53.56
KK SB15
KM Runoff from SB15
KO 1
BA .065
LU
LM
MA .065 5
UD .122
ZW A=SITE3 C=FLOW F=100-YR(UH)
ZW A=SITE3 C=FLOW F=500-YR(UH)
*-----
KK SB21
KM Runoff from SB21
BA 0.128
LU
LM
MA 0.128 5
UD .267
KK RES15
KM Route through natural depression - RES15
KO 1
RS 1 FLOW 0
SV 0 2.290 5.078 8.500 12.858 18.021 24.660 32.720
SE 54 56 57 58 59 60 61 62
SS
ST 58 3.1 1.5
SW 0 151.1 231.7 323.0
SE 58 58.1 59 60
SL 56 .01 0.6 0.5
ZW A=SITE3 C=FLOW F=100-YR(UH)
ZW A=SITE3 C=FLOW F=500-YR(UH)
KK 15-24
KM Route from RES15 through SB24
KO 1
RD
RC .05 .05 1022 .012
RX 0 50 100 150 200 250 300 350
RY 51.58 54.00 52.00 52.00 50.84 51.47 54.20 51.34
KK SB24

```

KM Runoff from SB24
 KO 1
 BA 0.047
 LU
 LM
 MA 0.047 5
 UD .167
ZW A=SITE3 C=FLOW F=100-YR(UH)
ZW A=SITE3 C=FLOW F=500-YR(UH)
 KK SB22
 KM Runoff from SB22
 KO 1
 BA .072
 LU
 LM
 MA 0.072 5
 UD .126
 KK RES16
 KM Route through natural depression - RES16
 KO 1
 RS 1 FLOW 0
 SV 0 .007 1.083 3.510 8.391 14.839 24.872 37.537
 SE 45 46 47 48 49 50 51 52
 SS
 ST 49 3.1 1.5
 SW 0 75.9 208.7
 SE 49 50 51
 SL 47 .01 0.6 0.5
ZW A=SITE3 C=FLOW F=100-YR(UH)
ZW A=SITE3 C=FLOW F=500-YR(UH)
 * Neglect channel routing (RES17 is very close to RES19)
 KK SB23
 KM Runoff from SB23
 KO 1
 BA 0.078
 LU
 LM
 MA 0.078 5
 UD .297
ZW A=SITE3 C=FLOW F=100-YR(UH)
ZW A=SITE3 C=FLOW F=500-YR(UH)
 KK CP13
 KM Combine two hydrographs
 KO 1
 HC 2
 KK RES17
 KM Route through natural depression - RES17
 KO 1
 RS 1 FLOW 0
 SV 0 .014 .520 3.217 7.751 16.628 27.820 42.772
 SE 44 45 46 47 48 49 50 51
 SS
 ST 50.2 3.1 1.5
 SW 0 38.7 106.6 144.1 200.8
 SE 50.2 51 52 53 54
 SL 46 .01 0.6 0.5
 * No channel routing between RES17 and RES18 (too close together)
 KK SB26
 KM Runoff from SB26
 KO 1
 BA 0.046
 LU
 LM
 MA 0.046 5
 UD .262
ZW A=SITE3 C=FLOW F=100-YR(UH)
ZW A=SITE3 C=FLOW F=500-YR(UH)
 KK SB25
 KM Runoff from SB25
 KO 1
 BA 0.070
 LU
 LM

MA 0.070 5
 UD .167
 ZW A=SITE3 C=FLOW F=100-YR(UH)
 ZW A=SITE3 C=FLOW F=500-YR(UH)
 KK RES14
 KM Route through natural depression - RES14
 KO 1
 RS 1 FLOW 0
 SV 0 .296 1.543 3.253 5.471 8.237 12.276 18.762
 SE 45 46 47 48 49 50 51 52
 SS
 ST 50.8 3.1 1.5
 SW 0 125.2 344.3
 SE 50.8 51 52
 SL 46 .01 0.6 0.5
 * No channel routing between RES14 and RES18 (too close together)
 KK SB27
 KM Runoff from SB27
 KO 1
 BA 0.035
 LU
 LM
 MA 0.035 5
 UD .184
 ZW A=SITE3 C=FLOW F=100-YR(UH)
 ZW A=SITE3 C=FLOW F=500-YR(UH)
 KK CP14
 KM Combine six hydrographs
 KO 1
 HC 6
 KK RES18
 KM Route through natural depression - RES18
 KO 1
 RS 1 FLOW 0
 SV 0 .213 1.240 2.806 5.743 10.403 19.227 31.697 53.348
 SE 43 44 45 46 47 48 49 50 51
 SS
 ST 50 3.1 1.5
 SW 0 85.5 310.7
 SE 50 50.1 51
 SL 46 .01 0.6 0.5
 KK18to19
 KM Route from RES18 to RES19
 KO 1
 RK 1000 .002 .05 TRAP .02
 KK CP15
 KM Combine three hydrographs
 KO 1
 HC 3
 KK RES19
 KM Route through natural depression - RES19
 KO 1
 RS 1 FLOW 0
 SV 0 .296 1.899 4.316 7.841 12.248 18.645 26.985 38.091 51.731
 SE 41 42 43 44 45 46 47 48 49 50
 SS
 ST 49.2 3.1 1.5
 SW 0 184 375
 SE 49.2 49.9 50.2
 SL 42 .01 0.6 0.5
 ZZ

KM ROUTE FROM OUTLET OF 29 TO OUTLET OF 30
 RK 17000 .02 .05 TRAP .02
 KK SB25
 KM RUNOFF FROM SUBBASIN 25
 BA 1.65
 MA 1.65 5
 UD .20
 KK 25-30
 KM ROUTE FROM SUBBASIN 25 TO 30
 RK 18000 .02 .05 TRAP .02
 KK SB30
 KM RUNOFF FROM SUBBASIN 30
 BA 4.47
 MA 4.47 5
 UD .70
 ZW A=SITES C=FLOW F=100-YR(UH)
 ZW A=SITES C=FLOW F=500-YR(UH)
 KK CP3
 KM COMBINE THREE HYDROGRAPHS
 HC 3
 ZW A=SITES C=FLOW F=100-YR(UH)
 ZW A=SITES C=FLOW F=500-YR(UH)
 KK 30-X
 KM ROUTE FROM OUTLET OF SUBBASIN 30 TO INTERSECTION HWYS 22 AND 28
 RK 18000 .014 .05 TRAP 12 1
 KK DIV2
 KM DIVERT FLOW DOWN DRAINAGE DITCH TO SOUTHWEST ALONG HWY 22
 DT DIV2
 DI 792 1000 2000 3000 4000 5000
 DQ 792 792 792 792 792 792
 KK X-XA
 KM ROUTE FROM INTERSECTION HWYS 22 & 28 TO HYDRO CULVERT AT HWY 28
 RK 1200 .014 .05 TRAP 12 1
 KK SB1
 KM RUNOFF FROM SUBBASIN 1
 BA 5.22
 MA 5.22 5
 UD .56
 ZW A=SITES C=FLOW F=100-YR(UH)
 ZW A=SITES C=FLOW F=500-YR(UH)
 KK HYDRO
 KM DISCHARGE OF 70 CFS FROM HYDROPOWER FACILITY
 BA 0
 IN 360
 QI 70 70 70 70
 KK CP6
 KM COMBINE TWO HYDROGRAPHS
 HC 2
 KK 1-4B
 KM ROUTE FROM OUTLET OF SUBBASIN 1 TO OUTLET SUBBASIN 4B
 RK 6000 .0016 .03 TRAP 20 .3
 KK SB4A
 KM RUNOFF FROM SUBBASIN 4A
 BA 2.79
 MA 2.79 5
 UD .46
 ZW A=SITES C=FLOW F=100-YR(UH)
 ZW A=SITES C=FLOW F=500-YR(UH)
 KK 4A-4B
 KM ROUTE FROM 4A TO 4B
 RK 9000 .16 .05 TRAP .02
 KK SB4B
 KM RUNOFF FROM SUBBASIN 4B
 BA 3.07
 MA 3.07 5

UD .46
 ZW A=SITE5 C=FLOW F=100-YR(UH)
 ZW A=SITE5 C=FLOW F=500-YR(UH)
 KK CP4
 KM COMBINE THREE HYDROGRAPHS
 HC 3
 KK DIV1
 KM DIVERSION OF OVERFLOW FROM HYDRO DITCH AT HWY 22 CULVERT
 DT DIV1
 DI 900 1500 2000 2500
 DQ 0 600 1100 1600
 KK 4B-XA
 KM ROUTE HYDRO DITCH FLOW FROM 4B TO HWY 28 CULVERT
 RK 5500 .02 .03 TRAP 20 .3
 KK CP5
 KM COMBINE TWO HYDROGRAPHS AT INLET TO HWY CULVERT
 HC 2
 ZW A=SITE5 C=FLOW F=100-YR(UH)
 ZW A=SITE5 C=FLOW F=500-YR(UH)
 KK DIV3
 KM DIVERT OVERFLOW FROM HYDRO DITCH AT HWY 28 CULVERT
 DT DIV3
 DI 1060 2000 3000 4000 5000 6000 7000 8000
 DQ 0 940 1940 2940 3940 4940 5940 6940
 ZW A=SITE5 B=FLOW F=100-YR(UH)
 ZW A=SITE5 C=FLOW F=500-YR(UH)
 KK XA-5
 KM ROUTE FROM INTERSECTION OF HWY 28 TO SOUTHEAST CORNER OF SB 5
 RK 10500 .004 .03 TRAP 20 .3
 KK SB5
 KM RUNOFF FROM SUBBASIN 5
 BA 14.13
 MA 14.13 5
 UD 1.62
 ZW A=SITE5 C=FLOW F=100-YR(UH)
 ZW A=SITE5 C=FLOW F=500-YR(UH)
 KK CP7
 KM COMBINE TWO HYDROGRAPHS
 HC 2

HEC-1 Input Decks

Site 9, 100-Year and 500-Year Events

Differences are marked as follows: 100-year data and 500-year data)

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ID Site 9 Drainage Study - Revised 3-Subbasin Model
ID 2-yr rain on ripe snow pack; Max hourly temps of record (Mar 31, 1961)
ID Site 9 Drainage Study - Revised 3-Subbasin Model, 500-Yr Event
ID 10-yr rain on ripe snow pack; Max hourly temps of record (Mar 31, 1961)
ID SCS UH Method - Kirpich Tc
IT 15 01MAR99 0000 192
IO 5
KK SB1
KM RUNOFF FROM SUBBASIN 1
KO 1 2
BA .127
PB 50
PB .75
IN 60
PC .013 .027 .036 .054 .065 .082 .096 .115 .141 .176
PC .245 .516 .774 .828 .862 .889 .910 .929 .946 .957
PC .967 .978 .990 1.000
LU
LM
MC 3.3 .088 32
IN 60
MT 44.1 40.9 40.0 45.4 50.3 55.0 58.2 61.9 63.7 66.0
MT 66.5 66.8 66.8 62.9 60.0 57.0 54.5 48.9 52.2 50.1
MT 44.0 40.1 43.1 43.9 32
MA .127 5
UD .19
ZW A=SITE1A C=FLOW F=100-YR(UH)
ZW A=SITE1A C=FLOW F=500-YR(UH)
KK RES1
KM Route through reservoir behind culvert C1
RS 1 FLOW 0
SV 0 .004 .029 .162 .728 1.676 3.252 5.579 8.948 13.009
SV17.763 23.294 30.256
SE 53 54 55 56 57 58 59 60 61 62
SE 63 64 65
SS 64.7
ST 64.7 3.1 1.5
SW 400 550 600 700 800 900 1100 1250 1400 1500
SE 64.7 64.9 65.0 65.3 65.7 66.0 66.3 66.7 67.0 67.4
SW 1650
SE 67.7
SL 55 4 0.6 0.5
KK 1T04
KM ROUTE FROM RES1 TO SUBBASIN 4
RD
RC .05 .05 .05 3366 .00242
RX 0 19 58 85 99 150 153 200
RY 40.2 40.0 38.0 37.3 36.7 38.0 38.0 38.3
KK SB4
KM RUNOFF FROM SUBBASIN 4
BA .141
LU

```

LM
UD .40
MA .141 5
ZW A=SITE1A C=FLOW F=100-YR
ZW A=SITE1A C=FLOW F=500-YR(UH)
KK CP1
KM COMBINE TWO HYDROGRAPHS
HC 2
ZW A=SITE1A C=FLOW F=100-YR
ZW A=SITE1A C=FLOW F=500-YR(UH)
KK SB5
KM RUNOFF FROM SUBBASIN 5
BA .081
LU
LM
UD .17
ZW A=SITE1A C=FLOW F=100-YR
ZW A=SITE1A C=FLOW F=500-YR(UH)
ZZ

Attachment D

**Letter report from Peter Kneupfer on geomorphology of the
Birch Creek alluvium**

INTRODUCTION

1. Setting and Scope of Study

Birch Creek empties into the Eastern Snake River Plain (ESRP) in the northern portion of the INEL. Siting of structures on the alluvial fan that is formed by Birch Creek as it enters the Plain must consider the potential for flooding on the fan surfaces. The purpose of this informal report is to assess the history of past floods on the Birch Creek fan subsequent to its late Pleistocene formation as a guide for assessing future flood potential for the site just south of the Hwy. 22-Hwy. 28 junction. In particular, the report addresses whether this alluvial fan has been subject to post-Pinedale flooding, particularly in the area of the proposed low-level facility. In order to complete this assessment, I first summarize previous work on the extent and age of Pinedale deposition, then summarize field and aerial-photograph techniques that allow a preliminary assessment of post-glacial flood history.

The main channel of Birch Creek drains into the Birch Creek sinks, a characteristic it has in common with the Lost River and Little Lost River. In fact, at an elevation of less than 4780', this is the lowest of the northern Snake River Plain sinks. Most Birch Creek flows that reach the ESRP probably are restricted to its main channel and the sinks area. However, again in common with the other main drainages of the ESRP, Birch Creek carried much larger flows and sediment loads during the late Quaternary during the last glaciation, culminating around 12-15 thousand years (ka) ago. During that time, Birch Creek deposited a large, low-gradient alluvial fan into the northern ESRP. Pierce and Scott (1982) and Scott (1982) show that this fan and associated main-channel deposits begins as far upstream as Long Canyon about 4 miles south of Blue Dome, where it occupies the center of Birch Creek Valley. It is confined on both sides by alluvial fans of tributary streams such as Eightmile Canyon on the west and Long Canyon on the east. However, south of Reno Point and the south end of the Beaverhead Mountains, the fan widens considerably. It is confined on the west by alluvial fans from the south end of the Lemhi Range and older basalt of the Lava Ridge field (Kuntz et al., 1990), and it terminates at the south against an unnamed flow north of Circular Butte and in the lacustrine sediments of Pleistocene Lake Terretton (and the Birch Creek sinks). These relationships are evident on Scott's map, the relevant portions of which are reproduced as Figure 1.

The area studied in reconnaissance for this report includes most of this Birch Creek fan, to which Scott (1982) and Pierce and Scott (1982) have assigned a late Pinedale (30-15 ka) age based on correlations with other areas of the ESRP.

2. Previous Studies

Streams draining into the Eastern Snake River Plain have undergone alternating periods of deposition and relative stasis that correspond closely to glacial and interglacial cycles (Pierce and Scott, 1982; Funk, 1976). Funk showed that major depositional episodes of alluvial fans that drain eastward from the Lemhi Range into Birch Creek Valley were directly tied to glacial advances within the ranges. He and Pierce and Scott argue further that "the alluvial-fan systems are essentially inactive under the prevailing [present] climatic and hydrologic regimes; gravel deposition occurred under conditions of much greater sustained discharge and sediment yield than at present" (Pierce and Scott, 1982, p. 692). Furthermore, Pierce and Scott argue that Holocene (last 10-12 ka) deposition has been restricted in general to locations adjacent to main channels. Holocene deposition of lower Birch Creek is shown on Scott's 1982 map by the yellow **amf** coloring; clearly, he concludes that Holocene deposition is restricted to a narrow band along the channels of Birch Creek and has not extended out onto the Pinedale alluvial fan surface (his **amp** surface).

Another mode of deposition has been important in the ESRP during the late Quaternary. Extensive eolian (wind-blown) deposits mantle surfaces--whether of alluvial or volcanic origin--especially those older than about 12 ka. Pierce et al. (1982) described two episodes of late Quaternary loess (wind-blown silt and fine sand)--one older than about 130 ka and a younger event from 70 to 10 ka. Forman et al. (1993) recently have revised the chronology of the younger event. They recognized a depositional episode between 80 ka and 60 ka and a younger episode between 35 ka and 10 ka, based on thermoluminescence (TL) dating of loess, particularly deposits baked and buried by younger basalt flows in the ESRP. D. Rodbell (personal communication, October 1993) has indicated that the young event may itself have been composite, with a depositional episode centered around 30 ka and another 25 ka to 10 ka. Continued TL studies by Forman and his colleagues on the INEL and

surrounding areas will certainly further refine the loess chronology. However, for the purposes of this study the following salient features are important:

1. A major loess accumulation episode accompanied and closely followed the deposition of alluvial-fan gravels in the ESRP. Pinedale fan gravels of the ESRP and southern parts of the main valleys (i.e. Birch Creek, Lost River, Little Lost River) are invariably overlain by a few tens of centimeters of loess.
2. Holocene deposits generally are not overlain by loess; the only loess accumulations are extremely thin.

Studies with one of my students in the ESRP corroborates these observations. We have examined loess accumulations on basalt surfaces of a wide variety of ages near the INEL from Arco to Idaho Falls. Very young flow surfaces like Hells Half Acre are largely unburied; the only loess deposits are discontinuous, thin mantles (of course, there is a current dust flux in the ESRP, as anyone who has been out on a windy day can attest). Latest Pinedale surfaces, such as the North Robbers flow, are mantled by discontinuous loess, generally no more than a few cm to 10-20 cm thick. However, surfaces older than about 30 ka tend to be more widely loess-mantled.

A third important characteristic of late Quaternary gravels in the ESRP area is the characteristic of carbonate soil development. In semi-arid and arid areas like the ESRP, one of the most common characteristics of soil development is the formation of a horizon impregnated by calcium carbonate (e.g., Machette, 1985). Initial development of carbonate horizons generally involves precipitation of CaCO_3 at a depth of around 50 cm to 100 cm. Continued precipitation with time produces a thickening of the accumulation zone, including cementation of the horizon (into a petrocalcic horizon or calcrete). This process may take on the order of 100 ka or longer in environments like the ESRP. Much of the CaCO_3 in fact is added from eolian sources (e.g., McFadden et al., 1991). In gravelly deposits like those of the alluvial fans of the ESRP and surrounding areas, carbonate accumulations in soils are marked by the accretion of CaCO_3 rinds to (initially) the underside and (later) the top of clasts within the carbonate accumulation zone. Pierce (1985) has quantified the rate of rind growth in alluvial fan deposits in the Lost River Valley near Arco. He obtains a rind-growth rate of approximately 0.6 mm per 10 ka. This suggests that late Pinedale deposits should have rind thicknesses of 1-2 mm within the calcic horizon of the soil, whereas Holocene deposits should

have rind thicknesses of less than 1 mm. My experience, and that of my students, studying rind growth of the alluvial fans along the western margin of the Lemhi Range and on basalt flows in the ESRP indicate that Pierce's rind-growth curve is applicable throughout the INEL area. Thus, the general age of a geomorphic surface, or at least the deposits underlying that surface, can be estimated from the thickness of carbonate rinds developed on subsurface clasts.

These prior studies lead to the hypothesis that most alluvial fan depositional surfaces should be Pinedale in age or older, with Holocene deposition generally confined to the current trunk channels. Unlike most alluvial fans of the Great Basin, the fans of the ESRP region have been stable during the Holocene and have not, in general, received additional sediments (except locally). Late Pinedale surfaces generally are mantled by tens of centimeters of loess; the absence of a loess cover implies either a younger age or a stripping event (either by wind or surface water flow). This further implies that, in the absence of evidence for younger deposition and/or erosion, flood hazard must be considered to be minimal on Pinedale-aged alluvial fan surfaces, as these surfaces do not tend to be occupied during interglacial times when both sediment load and discharge are relatively minor.

3. Complicating Factors

The argument that the principal depositional episode of the lower Birch Creek fan in the ESRP is of Pinedale age is based on the general thickness of loess mantling the surface and the thickness of carbonate rinds on the clasts, plus experience that elsewhere in the ESRP, including the dated deposits in the Lost River Valley, similar fans are of late Pinedale age. This conclusion had already been drawn by Scott (1982) and was incorporated into the geologic maps of INEL by Kuntz et al. (most recently in 1990). As noted above, it is consistent with this experience to argue that, lacking any direct evidence to the contrary, it can be assumed that late Pinedale surfaces have not been occupied by younger flood or depositional events in the Holocene (last 10-12 ka). It also follows that flooding of such surfaces is extremely unlikely in the future, especially within the lifetime of any structure. However, some portions of alluvial fans, particularly low-gradient fans like that of Birch Creek, may well be occupied by floodwater at times. The key is to recognize the evidence for this by examining the complexities that may be present on a late Pinedale surface.

Morphologic evidence of post-Pinedale surface flooding includes continuous or discontinuous channels incised into the Pinedale surface. These should be recognizable on aerial photographs. They should also be recognizable because any post-Pinedale channel development would result in removal of the upper loess layer from the affected area, which at the least should bring the Pinedale carbonate horizon closer to the surface. Complications to recognizing channels can arise from partial or complete infilling of channels by younger deposits, including channel deposits themselves, eolian influx (although the rate of loess accumulation has been low in the last 10 ka, dust will tend to settle into hollows and low areas in the topography), or surface wash into the slightly lower channels. These kinds of complications can be recognized by surface reconnaissance in most cases. However, it is possible that channels produced by early Holocene floods and subsequently filled may not be morphologically distinct enough to be recognized. Nonetheless, I would expect that any late Holocene (last few ka) channelization on the surface of the Pinedale Birch Creek fan would be readily recognizable.

Stratigraphic evidence of post-Pinedale flood deposition includes partial burial of loess-mantled alluvial gravels by younger distal gravels of Birch Creek or its channels. My own experience in looking at distal surfaces of Big Lost River near the Big Lost River sinks, shown to me by the Golder Associates group that was mapping on the INEL a few years ago, is that young deposits are characterized by scattered to common surface gravel clasts that have no carbonate coatings on them. Thus a surface that has been covered by post-Pinedale flooding on the Birch Creek fan ought to have a thin, perhaps discontinuous layer of gravel clasts, and these should be obvious at the ground surface as a denser lag of scattered surface gravels lacking any carbonate coatings. There are at least two important complications to this assumption. First, removal of some or all of the top layer of loess from a Pinedale surface--by wind or surface wash--will expose Pinedale-aged clasts at the surface. However, these clasts would generally have thin carbonate rinds on them, and this should be an obvious difference from a depositional gravel. Second, desert pavements are at least weakly developed on some surfaces in the ESRP. McFadden et al. (1987) have shown that at least some desert pavements in the Mojave Desert form by uplift of clasts from the original depositional surface by accreted eolian deposition, so that the clasts remain at the surface even though significant eolian material has filtered past them into the subsurface. This kind of a

depositional process generally involves the development of continuous surface pavements, which are mostly absent in the Birch Creek fan area. Thus it is an unlikely, though possible, explanation for concentrations of surface pebbles. In any case, misinterpretation of the surficial stratigraphic record in this way would err on the conservative side: I would be implying that a surface had been recently flooded when in fact it has not.

A further complication in the interpretation of post-Pinedale flooding can arise due to surface stripping. Range fires on the ESRP can strip vegetation, often in a linear fashion, leaving bare soil much more easily removed by wind. Bare patches of loess overlying gravels on the ESRP are especially susceptible to wind stripping. Thus, large areas can be stripped of their loess cover, bringing the underlying gravels to the surface. Such stripping could, at least in theory, also be accomplished by overland surface runoff, although that process probably would be less efficient in remobilizing sediment. Regardless of the cause, a stripped surface is recognizable because the gravels that originally underlaid the loess (and their associated carbonate horizons) are found at or near the ground surface. The older the deposit, the more likely stripping is--thus, an early Pinedale (30 ka) surface is more likely to have been partly or completely stripped of its loess cap than a late Pinedale (15 ka) surface.

METHODOLOGY OF THIS STUDY

This evaluation of the past history of flooding for a site south of the Hwy. 22-Hwy. 28 junction involved two steps. Aerial photographs and a Landsat image were examined to identify the outlines of the lower Birch Creek fan and to identify any channels cut into the Pinedale fan surface. Although the fan was mapped by Scott (1982) and included in the INEL map of Kuntz et al. (1990), these maps were not designed to show details of the complexity of the fan surfaces, so portions of the fan that may have been occupied by rare post-Pinedale floods are not differentiated. Where channels or channelized zones were identified on aerial photographs, they were traced upstream to determine if the origin is from Birch Creek or from tributary drainages on the east side of Birch Creek Valley.

The second part of this study was a two-day field reconnaissance of the Birch Creek fan. The first part of the field study was to assess the nature of channels and channel-like features identified on aerial photographs. This involved examining surface morphology and

nature of ground cover (scattered gravels, loess, rind-covered gravels, etc.). Where possible, existing exposures were examined to identify thicknesses of carbonate rinds and overlying loess in order to gain experience about the changes that occur between parts of the fan that appear to be channelized and those that do not. The second part of the field study was a systematic examination of exposures along a flood-return channel that was excavated from the Reno Ranch area to near the Birch Creek sinks. This channel intersects nearly all of the Birch Creek fan, and it was examined in detail from its downstream end to the Hwy. 28 intersection. This examination included measurement of carbonate rinds from portions of the Birch Creek fan surface identified as different from aerial photograph analysis.

RESULTS AND INTERPRETATIONS

Large areas of the Birch Creek fan have evidence of post-glacial re-occupation by surface-flow events. However, it appears that large sections of the fan surface have not been affected by these flow events. This section of the report is divided into four sections. The first describes the active channels of Birch Creek. The second section summarizes evidence for post-Pinedale flooding on portions of the fan surface, principally by characterizing textures on aerial photographs and a Spot satellite image and by presenting the corresponding surface characteristics observed in the field. The third section discusses likely sources of these floods, including consideration of which areas of the Birch Creek fan have been affected by overflow floods from the channels of Birch Creek, which currently are found only on the west side of the fan (and west of the study site). The final section provides a contrast of the areas with apparent post-glacial flooding with areas showing evidence of no post-depositional flooding. This includes a summary of criteria from aerial photographs and field observations that lead to this interpretation.

1. Birch Creek Channels

The main channel of Birch Creek is incised about 3 m below the Pinedale fan surface at the old Reno Ditch. Farther downstream, where Birch Creek crosses Hwy. 22, the channel is incised about 2 m. At both sites, the channel cuts into older fan and channel deposits. At Reno Ditch, fan deposits with carbonate rinds 2-3 mm thick are overlain by about 0.5 m of silt with numerous gravel clasts. Many of these clasts have carbonate rinds, but the rinds are

found on random clast surfaces--some at the top, some at the base. This character is indicative of reworking of the surface layer of a Pinedale soil, with clasts with thin carbonate rinds redeposited in a silt matrix, perhaps in an overbank setting. The exposure in the Birch Creek channel at Hwy. 22 shows clasts with carbonate rinds less than 1 mm thick, suggesting a Holocene age for these channel deposits. Thus, deposits along the present channel of Birch Creek locally are Pinedale in age with reworking of surface deposits in the Holocene, whereas in other areas Holocene deposits are preserved along the channel margins. The extent of these Holocene deposits is outlined by Scott (1982).

2. Evidence of Past Flooding

Aerial photographs (and even satellite images) show a curious contrast in surface textures on much of the Birch Creek fan. Portions of the fan surface are characterized by a serpentine network of discontinuous channel-like forms clearly visible on aerial photographs. The zones of channel-like features are shown on the small-scale maps that accompany this report. One group of these features originates at the now-abandoned Reno Ditch; these channels or channel-like features appear to re-occupy a pre-existing channel-like network to the north. A second group of channel-like features extends southeastward from the base of the Long Canyon alluvial fan complex.

Field observations of the western group of features at the old Reno Ditch show that this group is composed of distinct, but discontinuous, channels up to 1 m below the interfluvies. Channel bottoms typically are silt-filled, probably either by surface wash or by late-stage flood flows. Farther south, in the area of the return channel at Hwy. 22, the channels in this zone are less distinct. Areas between individual channels are characterized at the surface by a higher concentration of pebbles than unchanneled parts of the Birch Creek fan. Exposures in the return ditch of the channel-like area west of the study site yield carbonate rinds 1-2 mm thick.

Although the eastern group of channel-like features is obvious on the aerial photographs, no individual channels are visible on the ground. Instead, this area is characterized by a greater amount of silt at the surface, suggesting that pre-existing discontinuous channels like those at the Reno Ditch have been infilled with silt.

The accumulations of wash-derived (?) silt in channels and channel-like features and the presence of relatively thin carbonate rinds on clasts beneath the silt all point to a post-

Pinedale origin for the "textured" topography of parts of the Birch Creek fan. However, the fact that the freshness of channel morphology and the thickness of carbonate rinds in the channelized parts of the fans differ from place to place suggests that not all of these channels or channel-like features are of the same age. It is not possible to systematically subdivide the channels and channel-like features into distinct age groups on either a relative or absolute basis from the reconnaissance analysis undertaken for this report. However, it is clear that the channel-like features on the west side of the proposed site, and between the site and the younger Birch Creek channel deposits, are at least early Holocene in age (given the 1-2 mm carbonate rind thicknesses).

3. Sources of Channels and Channel-like Features

Channels on the Pinedale fan of Birch Creek have three possible origins. First, channels may have originated from floods escaping from the main Birch Creek channel. Second, channels may have carried flow that originated from the alluvial fans on the east side of Birch Creek valley north of Reno Point. Finally, channels may have originated locally on the fan surface due to concentrations of overland flow.

Inspection of upstream origins of channelized areas indicate that the western group of channels have two origins. One is from the Reno Ditch. Apparently at some time during the operation of the old Reno Ditch, one or more flood events overflowed the ditch and debouched south onto the Birch Creek fan. Most of the channels occupied by this flood or series of floods appear very fresh on aerial photographs, but they are southward continuations of less obvious channels and channel-like features. Thus the Reno Ditch flood(s) apparently reactivated previously developed channels and channel-like features. Upstream of Reno Ditch, these older channels and channel-like features diverge from Birch Creek, indicating that they were formed by one or more floods from Birch Creek.

Channels and channel-like features on the east side of the Birch Creek valley originate from flow off the alluvial fans, such as the Long Canyon fan. Downstream of Reno Point, this set of channel-like features bifurcates into an east-trending group and a southeast-trending group. The latter group is confined to an area east of Hwy. 28.

All of the areas of channels and channel-like features identified in this study can be traced upstream to one of these two sources. The only possible exception is a group of channel-like features at the north end of the area shown on the 1:100,000-scale map. With

this exception, it appears that no channels originate internally on the Birch Creek fan due to convergent overland flow.

One final consideration is whether flows from Birch Creek have contributed to development of the eastern group of channels. Birch Creek is isolated from these eastern channels by the distal parts of the Long Canyon alluvial fan complex south of Blue Dome which forms a divide for flows in the eastern part of the valley. Thus it is extremely unlikely that Birch Creek has ever contributed naturally (i.e. prior to construction of the Reno Ditch) to the eastern group. Furthermore, the overflow channels along Reno Ditch appear to channel flow only to the western channel group.

4. Unflooded Portions of the Birch Creek Fan

Large areas of the Birch Creek fan do not have the channel or channel-like texture previously described. These portions of the fan appear to be smooth on aerial photographs. On the ground, these portions of the fan are less sage-covered than the channelized areas, and they typically have fewer clasts exposed at the surface. In a few locations, however, there are weak surface pavements developed. More commonly, exposures show carbonate rind thicknesses of at least 2-3 mm, with some rinds locally partly dissolved. The carbonate horizon is generally overlain by a 20-40 cm-thick silt (loess) zone. Exposures in the return ditch of the large grass-covered surface on which the site is located indicate rinds as thick as 4.5 mm, but more commonly rinds have been partly dissolved. This suggests that this part of the Birch Creek fan has a soil considerably older than adjacent, more channelized areas (a literal application of Pierce's rind-growth curve would suggest an age approaching 60 ka, which I find unlikely). It is likely, particularly given the partial dissolution (which can occur when rinds originally formed at greater depth are placed higher into the carbonate transport zone), that some of the loess cover has been stripped from this surface. The cause of this stripping is unclear, although given the lack of channel forms and the presence of 20-40 cm of loess, it must have occurred no more recently than late Pleistocene time.

Although the carbonate rinds obtained from the surface on which the site is located are the thickest of any of the exposure I examined, it is not possible within the present scope of work to subdivide the smooth, apparently unflooded portions of the Birch Creek fan into subgroups of similar age. What they appear to share, however, is a lack of flooding by channelized flows during post-Pinedale time.

CONCLUSIONS

Large areas of the late Pleistocene (15-30 thousand years old) Birch Creek fan have shallow channels. Some these have had flooding that has produced a young (late Holocene) surface age, as evidenced by gravel clasts at the surface or in the shallow (upper 20-40 cm) subsurface that have been reworked from older Pinedale-aged deposits (these are recognizable because the carbonate rinds on clasts are found at random orientations instead of on the underside of clasts as would be the case for the original deposit). Some of these Holocene surface deposits also are characterized by extremely thin ($\ll 1$ mm) carbonate coatings on clast undersides, even within 10 cm of the ground surface (due to the limited leaching depth of calcium carbonate during the Holocene), which suggests that they probably have not been occupied by depositional floods over longer periods (6-10 thousand years). However, it was not possible in the course of this brief study to differentiate early from late Holocene surfaces (except near the main Birch Creek channels). Numerous areas of the fan surface show no evidence of post-depositional flooding. This is manifested by loess cover and smooth surface morphology and includes most of the area of the proposed site. The lack of past flooding in the past 15,000 years makes it extremely unlikely that the areas will be flooded in the future. The unflooded areas could be subject to overland flow (i.e. thin--cm-scale--surface flooding) but not to larger channelized flows. That is, local storms may produce surface runoff, but not concentrated surface runoff.

The channels on the east side of the Birch Creek valley, along the bases of the alluvial fans, have not developed from flows of Birch Creek. Birch Creek cannot divert to these channels because of upstream blockage by late Pleistocene alluvial fans. Instead, the eastern channels receive flow only from the local fan surfaces.

Birch Creek channels downstream of Reno Ditch have not contributed flow onto most of the site, although they apparently have contributed flow to the western site margin. The channelized areas of the fan surface owe their origin to overflow floods from Birch Creek. Most of the flow event(s) preceded the development of Reno Ditch; they are natural flows. In fact, the overflow events from Reno Ditch probably did not contribute any significant flow to the channel-like area on the west side of the site, given the thickness of carbonate rinds indicating late Holocene stability of the channel-like area.

At the site itself, the grassy surface that is mapped as part of the non-channelized area of the Birch Creek fan has characteristics suggesting no significant surface flooding in the Holocene. No Holocene deposits are found at the surface. Furthermore, the carbonate horizon is the thickest of any observed on the Birch Creek fan, suggesting an early (30 ka or even older) Pinedale age. The carbonate horizon is degraded, at least locally: some clasts that had accumulated carbonate rinds at soil depths of 50 cm or greater are now found at shallower depths in the soil, where they are subject to dissolution (thus, some rinds are partly dissolved in the upper part of the present soil). This can happen only if part of the loess cover has been removed. The fact that the surface horizons of the soil are undisturbed by fluvial action (i.e. rinds are consistently on clast bottoms, even if they are partly dissolved) indicates that loess removal was not by water; instead, wind deflation is a more likely cause (perhaps following range fires, as seems common on the ESRP). Thus, except for possible shallow overland flow that produced neither significant erosion nor deposition, apparently no flooding has occurred at the site in the Holocene.

Finally, note that this analysis is of the unaltered condition of the site. The presence of the return-flow channel presents additional flooding potential that had not naturally developed across the site.

Scale 1:24,000
Brown: unchanneled areas
Black: channelized or channel-like areas

Not shown in detail

Not subdivided on this map

14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
CLARK CO
BUENA CO
JEFFERSON CO
R 3113
BIRCH CREEK
RICHARD BUTTE LAKE
Channel
Scale 1:24,000
Brown: unchanneled areas
Black: channelized or channel-like areas
Not shown in detail

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Appendix F

**Archeological Survey of Candidate Locations for Waste
Treatment, Storage, and Disposal Facilities on the Idaho
National Engineering Laboratory, Volume I, EGG-CS-10997**

**Archaeological Survey
of Candidate Locations for
Waste Treatment, Storage, and Disposal Facilities
on the
Idaho National Engineering Laboratory**

Volume I

Brenda L. Ringe

Published September 1993

Notice

The information contained herein regarding the location of cultural resources is exempt from the Freedom of Information Act under Section 9 of the Archaeological Resources Protection Act of 1979 (as amended) and under Section 304 of the National Historic Preservation Act of 1966 (as amended). Distribution of any locational information from this document must be approved in advance by contacting the INEL Cultural Resource Management Office, P.O. Box 1625-2091, Idaho Falls, ID 83415, telephone: (208)525-0063.

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**Prepared for the
U.S. Department of Energy
Office of Environment, Safety, and Health
Under DOE Idaho Field Office
Contract DE-AC07-76ID01570**

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Appendix G

Ecological Survey for the Siting of the Mixed and Low-Level Waste Treatment Facility and the Idaho Waste Processing Facility, EGG-CIET-11057

**Ecological Survey for the Siting of the
Mixed and Low-Level Waste Treatment Facility
and the Idaho Waste Processing Facility**

Reed L. Hoskinson

Published May 1994

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ABSTRACT

This report summarizes the results of field ecological surveys conducted by the Center for Integrated Environmental Technologies (CIET) on the Idaho National Engineering Laboratory (INEL) at four candidate locations for the siting of the Mixed and Low-Level Waste Treatment Facility (MLLWTF) and the Idaho Waste Processing Facility (IWPF). The purpose of these surveys was to comply with all Federal laws and Executive Orders to identify and evaluate any potential environmental impacts because of the project. The boundaries of the candidate locations were marked with blaze-orange lath survey marker stakes by the project management. Global Positioning System (GPS) measurements of the marker stakes were made, and input to the Arc/Info® geographic information system (GIS). Field surveys were conducted to assess any potential impact to any important species, important habitats, and to any environmental study areas. The GIS location data was overlaid onto the INEL vegetation map and an analysis of vegetation classes on the locations was done. Results of the field surveys indicate use of Candidate Location #1 by pygmy rabbits (*Sylvilagus idahoensis*) and expected use by them of Candidate Locations #3 and #9. Pygmy rabbits are categorized a C2 species by the U. S. Fish and Wildlife Service (USFWS). Two other C2 species, the ferruginous hawk (*Buteo regalis*) and the loggerhead shrike (*Lanius ludovicianus*) would also be expected to frequent the candidate locations. Candidate Location #5 at the north end of the INEL is in the winter range of a large number of pronghorn antelope (*Antilocapra americana*). None of the candidate locations are in other environmental study areas. Candidate Location #9 and Candidate Location #1, both at the southern end of the INEL, are recommended as the best sites to minimize any ecological impact. The coordinates defining the boundaries of the candidate locations are included as an appendix.

ACKNOWLEDGMENTS

G. L. Olson conducted the field soil surveys and wrote the description of the soils. N. L. Hampton collected the field GPS data and assisted in the data conversion to GIS. R. D. Lee converted the GPS data into GIS format and assisted in the GIS analysis of the data. Their assistance is appreciated.

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ACRONYMS

BLM	Bureau of Land Management
CIET	Center for Integrated Environmental Technologies
DOE-ID	Department of Energy - Idaho Field Office
E&ES	Environmental & Earth Sciences
EPA	Environmental Protection Agency
ESRP	Eastern Snake River Plain
GIS	geographic information system
GPS	global positioning system
IDFG	Idaho Department of Fish and Game
INEL	Idaho National Engineering Laboratory
IWPF	Idaho Waste Processing Facility
MLLWTF	Mixed and Low-Level Waste Treatment Facility
MU	Mapping Unit
NEPA	National Environmental Policy Act
NRF	Naval Reactors Facility
RESL	Radiological and Environmental Sciences Laboratory
RWMC	Radioactive Waste Management Complex
SCS	Soil Conservation Service
SOP	Standard Operating Procedures
TSD	treatment, storage, and disposal
USDA	U. S. Department of Agriculture
USFWS	U. S. Fish and Wildlife Service
USGS	U. S. Geological Survey

Ecological Survey for the Siting of the Mixed and Low-Level Waste Treatment Facility and the Idaho Waste Processing Facility

1. INTRODUCTION

This ecological survey is the result of a review of four locations on the Idaho National Engineering Laboratory (INEL). These locations are candidates for the siting of the Mixed and Low-Level Waste Treatment Facility (MLLWTF) and the Idaho Waste Processing Facility (IWPF).

The purpose of the ecological survey is to comply with all Federal laws and Executive Orders to identify and evaluate any potential environmental impacts because of the project. There are several Federal laws and Executive Orders concerned with the environment that are applicable to this project.

The National Environmental Policy Act (NEPA) of 1969 (P.L. 90-190, 42 U.S.C. 4321 *et seq.*) establishes national policies and goals for the protection of the environment. In particular, all Federal agencies are required to give appropriate consideration to the environmental effects of their proposed actions in their decision making. They are required to prepare detailed environmental statements on recommendations or reports on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment.

The Endangered Species Act of 1973 (16 U.S.C. 1531 *et seq.*) requires the regional administrator of the U.S. Environmental Protection Agency (EPA) to ensure that any act authorized by the EPA does not jeopardize the continued existence of any endangered or threatened species, or adversely affect its critical habitat.

Executive Order 11990, Protection of Wetlands, in furtherance of NEPA, orders that each agency shall take action to minimize the destruction, loss or degradation of wetlands wherever there is a practicable alternative.

There are other Federal laws that are concerned with environmental issues that have been reviewed for this project, but do not apply to this project.

The Wild and Scenic Rivers Act (16 U.S.C. 1273 *et seq.*) prohibits projects that would have a direct, adverse effect on wild and scenic rivers. The rivers located on the INEL are the Big Lost River, the Little Lost River, and Birch Creek. None of these rivers have been designated as wild and scenic.

The Fish and Wildlife Coordination Act (16 U.S.C. 661 *et seq.*) provides for protection of fish and wildlife resources in any project that impounds, controls, or modifies the waters of a stream or other body of water that is greater than or equal to 10 acres in surface area. This project will not affect any stream or other body of water.

The Coastal Zone Management Act (16 U.S.C. 1451 *et seq.*) requires protection for coastal areas, which does not apply to the INEL.

The Wilderness Protection Act of 1964 (16 U.S.C. 1131 *et seq.*) designates wilderness areas within public lands. These wilderness areas cannot be used for treatment, storage, and disposal (TSD) facilities without congressional approval. There are no designated wilderness areas on the INEL.

2. GENERAL OVERVIEW OF THE ECOLOGY OF THE INEL AND VICINITY

The INEL is a 2305 km² (890 mi²) area of the Eastern Snake River Plain (ESRP) in southeastern Idaho. The Snake River Plain is essentially flat, with an average elevation of the INEL at about 1500 m (4920 ft). The topography of the INEL is flat to gently rolling terrain with frequent lava outcrops, interrupted by East, Middle, and Big Southern buttes rising as high as 2300 m (7546 ft) at the southern end of the INEL.

The Big Lost River enters the INEL in the southwest corner of the INEL and naturally would flow north on the INEL to the Lost River Sinks near Howe, Idaho. However, during peak flows the river is diverted to spreading areas approximately 8 km (5 mi) east of where the river enters the INEL. The Little Lost River and Birch Creek naturally entered the INEL in the past along the west and north borders, but are now both diverted for agricultural irrigation before reaching the INEL. Birch Creek is now also diverted through a low-head hydroelectric plant. In the winter when Birch Creek is not used for irrigation, the outflow from the hydroelectric plant is diverted to a channel along the north end of the INEL and flows onto the INEL. This flow in the winter, and any Big Lost River flow that reaches the spreading areas, percolates into the Snake River Plain aquifer beneath the ESRP.

The soils on the INEL are derived from silicic volcanic and Paleozoic rocks from nearby mountains and buttes and are underlain by basalt (McBride *et al.*, 1978). Rock outcrops are common. Soils in the southern part of the INEL are relatively shallow and gravelly to rocky. The northern portion of the INEL is covered by lake and aeolian deposits, mostly of unconsolidated clay, silt, and sand (Atwood 1970).

The ESRP is in the sagebrush-grass vegetation zone, mostly covered by dense stands of sagebrush (*Artemisia* spp.), rabbitbrush (*Chrysothamnus* spp.), and bunchgrasses (Daubenmire 1952).

The INEL supports an abundant population of pronghorn antelope (*Antilocapra americana*), especially during winter, as well as limited numbers of elk (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*), and several species of small mammals, raptors, passerines, and game birds (Reynolds and Rose 1978, Reynolds, *et al.* 1986).

3. RESULTS

3.1 Field Survey Activities

In October, 1992, three candidate locations for the IWPF and MLLWTF were staked out with blaze-orange lath survey marker stakes. In April, 1993, a fourth candidate location was also staked out (Figure 3-1).

Candidate Location #5, at the north end of the INEL, was staked in October, 1992, in four corners approximating the square mile under consideration. In April, 1993, Candidate Location #5 was restaked to define the northern half as the area under consideration.

Field surveys of Candidate Locations #1 and #3 were conducted on November 18, 1992, by representatives of the project and the Center for Integrated Environmental Technologies (CIET) in the Environmental & Earth Sciences (E&ES) Group of EG&G, Idaho, Inc., and a representative from the Department of Energy - Idaho Field Office (DOE-ID) Radiological and Environmental Sciences Laboratory (RESL). A field survey of Candidate Location #9 was conducted with RESL on May 21, 1993. RESL survey reports were submitted to the DOE-ID NEPA Officer (Reynolds 1992, Reynolds 1993, Reynolds 1993a).

Additional field surveys have been conducted by CIET while marking the candidate locations, and while recording global positioning system (GPS) measurements of the boundaries. All field surveys of Candidate Locations #1, #3, and #5 were conducted in Fall, 1992. Field surveys of Candidate Location #9 were conducted in Spring, 1993. Observations were made of soils, vegetation types, animals, and animal signs such as tracks, droppings, dens, burrows, nests, and perches.

GPS locations of the boundary marker stakes for Candidate Locations #3 and #5 were collected in Fall, 1992. A detailed description of the methods used to collect the GPS field locations is in the E&ES Standard Operating Procedures (SOP), Global Positioning System (GPS) Field Operations. GPS locations for Candidate Locations #1, #5 (north half), and #9 were collected in Spring, 1993. The field GPS location data were later corrected against the surveyed community base station data (E&ES SOP, IRC GPS Community Base Station). The location data for all four candidate locations (Appendix A) were input to the Arc/Info® geographic information system (GIS), and overlaid onto the CIET vegetation map of the INEL. The results of these vegetation analyses are included as tables following the maps.

Additional background information has been supplied by RESL based on previous field observations and research by them, regarding other ecological concerns such as animal movement patterns, sensitive vegetation, and the relation of the candidate locations to past or ongoing ecological research study areas.

Figure 3-1. Candidate locations on the INEL

3.2 Description of the Study Areas

3.2.1 Soils

Field investigations were conducted to identify the specific soil series at each of the candidate locations. Information applicable to those soil series was then extracted from U. S. Department of Agriculture (USDA) Soil Conservation Service (SCS) surveys for Jefferson (SCS 1979) and Bonneville (SCS 1981) counties. While all three candidate locations are in Butte County, there is no detailed SCS survey for Butte County that could provide engineering and construction data and limitations by soil series. Relevant engineering and soil physical and chemical data from the Bonneville and Jefferson County soil surveys are summarized in tables by candidate location. Data provided in the tables apply to typical soils found at the candidate locations and do not necessarily apply to small areas of anomalous soils (inclusions).

The candidate locations at the south end of the INEL (Candidate Locations #1 and #9), are dominated by the Pancheri and Polatis soil series, which are moderately deep (20-40") to deep (>40") fine grained soils over lava. Relief is dominated by lava flows, and slopes range from 2 to 12 %. Shallow soils and rock outcrops are present on the pressure ridges. Deep soils are classified by the SCS as Pancheri silt loam, and shallower soils are Polatis silt loam. Typically, the surface layer is pale brown silt loam about 8" thick. The soil is calcareous throughout and has a layer of lime accumulation at a depth of 8 inches. Polatis series consist of moderately deep (20-40"), well-drained soils on basalt plains. They are similar to Pancheri soils, but shallower.

The candidate location in the lava flows in the central part of the INEL (Candidate Location #3) is dominated by Malm, Matheson, and Bondfarm soil series, which are sandy soils over lava. Sands originated from local (Big Lost River) and distant (Snake River) sources, and are still transient. (Wind erosion might be a factor requiring further attention at this site.) Relief of the site is dominated by lava flows, and slopes range from 2 to 12 %. Shallow soils are Bondfarm sandy loams, moderately deep (20-40") soils are Malm sandy loams, and deep (>40") soils are Matheson sandy loams.

The candidate location at the north end of the INEL (Candidate Location #5) is dominated by the Whiteknob soil series, in an alluvial deposit of Birch Creek, which originates between the Beaverhead Mountains to the north and the Lemhi Range to the west. The relief of the site is generally flat, with hummocky microtopography resulting from deposition of gravel bars, recent mammal activity, and possibly from frost heaves. The soils are classified by the SCS as Whiteknob gravelly loam, which are typically found in alluvium derived from mixed sources. Soils are frequently gravelly to the surface.

Based on the above general soil classification information, the following tables suggest characteristics for engineering planning. "The information is not site-specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works" (SCS 1981, p. 40). The information for Candidate Locations #1 and #9 is from the Jefferson County Mapping Unit (MU) 98 (SCS 1979) and Bonneville County MU 33 (SCS 1981). Candidate Location #3 information is from Jefferson County MU 67 (SCS 1979), and Candidate Location #5 information is from Jefferson County MU 122 (SCS 1979).

Table 3-1 summarizes the degree and kind of soil limitations for building site development. *Shallow excavations* are trenches or holes dug to a maximum depth of 5 or 6 feet, and include utility lines, open ditches, basements, and graves. Limitations are based largely on ease of excavation. *Dwellings and small commercial buildings* are structures built on shallow foundations on undisturbed soil. The load limit is the same as that for single-family dwellings no higher than three stories. *Local roads and streets* have an all-weather surface and carry automobile and light truck traffic all year.

Table 3-1. Limitations for building site development.

Candidate Location	Shallow Excavation	Dwelling without basement	Dwelling with basement	Small commercial buildings	Local roads and streets
#1 and #9	Moderate to severe: slope, depth to rock	Moderate: slope, low strength	Moderate: slope, low strength, depth to rock	Severe: slope	Moderate: slope, frost action, low strength
#3	Severe: depth to rock	Severe: depth to rock	Severe: depth to rock	Severe: depth to rock	Severe: depth to rock
#5	Severe: small stones	Slight	Slight	Slight	Moderate: frost action

Limitation categories are:

- Slight:** soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome;
- Moderate:** soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations;
- Severe:** soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.

Table 3-2 summarizes limitations for the construction and operation of sanitary facilities. *Septic tank absorption fields* are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 and 72 inches is evaluated. Groundwater can be polluted if highly permeable sand and gravel or fractured bedrock is less than 4 feet below the base of the absorption field, if slope is excessive, or if the water table is near the surface. *Sewage lagoons* are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. *Sanitary landfills* are areas in which solid waste is disposed. In trench landfills, waste is placed in a trench, spread, compacted, and covered daily with a thin layer of

Table 3-2. Limitations for the construction and operation of sanitary facilities.

Candidate Location	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
#1 and #9	Moderate: depth to rock, slope	Severe: slope, depth to rock	Moderate to severe: depth to rock	Moderate: slope	Fair to poor: thin layer
#3	Severe: large stones, depth to rock	Severe: depth to rock, seepage, slope	Severe: depth to rock, large stones, seepage	Severe: seepage	Poor: large stones
#5	Slight	Severe: seepage, small stones	Severe: seepage	Severe: seepage	Poor: small stones, thin layer

indigenous soil. In area landfills, the waste is placed in successive layers on the soil surface, spread, compacted and covered daily with a thin layer of soil from a source away from the site.

In summarizing the suitability of a site for providing *daily cover for landfills*, suitability categories are:

Good: soil properties and site features are favorable and good performance and low maintenance can be expected;

Fair: soil properties and site features are moderately favorable for the use and one or more soil properties or site features make the soil less desirable than soils rated good;

Poor: one or more soil properties or one or more site features are unfavorable for the use and overcoming the unfavorable properties requires special design, extra maintenance, or costly alteration.

Physical and chemical properties of the soils are summarized in Table 3-3, and are potentially useful for modeling contaminant transport, determining site stability, and identifying potential for corrosion.

Values are presented by depth, based on the depth of the major soil horizons. *Permeability* refers to the ability of a soil to transmit water or air, and are reported in inches/hour under saturated conditions. *Available water capacity* refers to the quantity of water that the soil is capable of storing for use by plants, and is reported in inches of water per inch of soil. The *pH* is a measure of acidity or alkalinity and is important in the determination of mobility of contaminants and availability of plant nutrients. *Shrink-swell potential* is the potential for volume change in a soil with a loss or gain in moisture. It is based on the change in length of an unconfined clod as moisture content is increased from air-dry to field

Table 3-3. Physical and chemical properties of the soils.

Candidate Location	Permeability (in/hr)	Available water capacity	pH	Shrink swell potential	Corrosion risk: Uncoated steel	Corrosion risk: Concrete
#1 and #9						
0-6" depth	0.6-2.0	0.19-0.21	7.9-9.0	low	high	low
6-31" depth	0.6-2.0	0.19-0.21	7.9-9.0	low	high	low
>31" depth	bedrock	bedrock	bedrock	bedrock	bedrock	bedrock
#3						
0-4" depth	2.0-6.0	0.13-0.15	7.4-9.0	low	high	low
4-24" depth	2.0-6.0	0.11-0.13	7.4-9.0	low	high	low
24" + depth	bedrock	bedrock	bedrock	bedrock	bedrock	bedrock
#5						
0-14" depth	0.6-2.0	0.09-0.11	7.4-9.0	low	moderate	low
14-20" depth	2.0-6.0	0.05-0.07	7.4-8.4	low	moderate	low
20-60" depth	>20	0.03-0.05	7.4-8.4	low	moderate	low

capacity. The classes are:

Low: a change of less than 3 percent
 Moderate: a change of 3 to 6 percent
 High: a change of more than 6 percent

Risk of corrosion pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to soil moisture, particle-size distribution, total acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate content, texture, and acidity of the soil.

3.2.2 Vegetation

Vegetation maps for areas including the four candidate locations were produced by overlaying the location data defining the boundaries of the candidate locations onto the CIET vegetation map of the INEL. The vegetation map has been developed by CIET from satellite imagery data.

Figure 3-2 is the vegetation map of the area around Candidate Location #1. Table 3-4 summarizes the vegetation classes within Candidate Location #1, by area and by percent of total area of Candidate Location #1. As indicated, over 95% of Candidate Location #1 is sagebrush-steppe. Figure 3-3 and Table 3-5 describe Candidate Location #3, which is over 97% sagebrush-steppe cover class. Candidate Location #5 (the north half of the original area staked in October, 1992) is described by Figure 3-4 and Table 3-6. As indicated, Candidate Location #5 is dominated by the sagebrush-steppe cover class (76%), but has more sagebrush/rabbitbrush (21%) than the other three candidate locations.

Figure 3-2. Vegetation map of candidate location #1.

0 3000 6000 9000 12000 15000

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ENVIRONMENTAL
TECHNOLOGIES

Vegetation Map

Vicinity of Candidate Location 1

	Salt Desert-Shrub		Juniper
	Sagebrush/Rabbitbrush		Great Basin Wildrye
	Sagebrush/Low Sagebrush/Rabbitbrush on Lava		Steppe (bunchgrass)
	Playa/Bare ground		Grassland
	Lava		Sagebrush-Steppe off Lava
	Old fields, Disturbed Areas, and Seedings		Sagebrush-Steppe on Lava
	Facilities		Sagebrush-Winterfat
	Unknown		

	U.S. Highways
	State Highways
	Paved Roads
	Unpaved Roads
	Trails
	Railroad Tracks
	River
	Candidate Location

Note:
An accuracy assessment
of this map has not
been conducted.

Table 3-4. Vegetation on Candidate Location #1.

Cover Class Description	Area (ha)	% Area	Comments (very general based on limited information)
Juniper Woodlands	0	0.00	Very unique habitat on INEL; important raptor and other bird nesting/perching habitat, provides cover for elk & deer
Great Basin Wildrye	0	0.00	Relatively unique habitat; associated with basins, playas, and deeper soils
Steppe (bunchgrass)	0	0.00	Common, but not abundant; provides forage
Grassland	1.35	1.73	Common, but not abundant; provides forage
Sagebrush-Steppe off lava	42.91	54.97	Very abundant community
Sagebrush-Steppe on lava	32.00	41.01	Most abundant community on INEL
Sagebrush-Winterfat	1.07	1.36	Common, not abundant; more in N. part of INEL. Winterfat is important forage.
Salt Desert Shrub	0	0.00	Common, not abundant; more in N. part of INEL
Sagebrush/Rabbitbrush	0.72	0.93	Common, not abundant; more in N. part of INEL
Sagebrush/Low Sagebrush/ Rabbitbrush on lava	0	0.00	Unique; associated with lava outcrops, may provide habitat for rodents, raptors, and rabbits. These areas may also have juniper trees associated with them. Greater potential for archeological finds.
Wetlands	0	0.00	Unique; Big Lost River, Birch Creek, the Sinks, spreading areas, and many playas are mapped by the USFWS as wetlands.
Playa/Bare ground	0	0.00	Unique; playas may be associated with temporary flooding and, therefore, ephemeral wetlands. Area surrounding playa may include good forage habitat.
Lava	0	0.00	Unique; lava outcrops provide good habitat for small and large mammals, raptors, and reptiles. Also, good potential for archaeological sites. These areas may also have juniper trees associated with them.
Old Fields, Disturbed Areas, and Seedings	0	0.00	Potential for establishment and spread of exotic plant species.
Shadow	0	0.00	N to NW facing areas with significant slope.
Unknown 1	0	0.00	Class seems to be associated with bare ground or disturbed areas.
TOTAL	78.05	100.00	(192.87 acres)

Figure 3-5 and Table 3-7 describe Candidate Location #9, which is also dominated by the sagebrush-steppe cover class.

Although each of the candidate locations has minor amounts of different plant cover classes, all are dominated by sagebrush and bunchgrasses. None of the plant cover classes occurring in any of the candidate locations is uncommon in the sagebrush-steppe ecosystem of the ESRP, and other similar undisturbed associations are common on the INEL.

Figure 3-3. Vegetation map of candidate location #3.

Vegetation Map

Vicinity of Candidate Location 3

Juniper	Salt Desert Shrub
Great Basin Wildrye	Sagebrush/Rabbitbrush
Steppe (bunchgrass)	Sagebrush/Low Sagebrush/Rabbitbrush on Lava
Grassland	Playa/Bare ground
Sagebrush-Steppe off Lava	Lava
Sagebrush-Steppe on Lava	Old fields, Disturbed Areas, and Seedings
Sagebrush-Winterfat	Facilities
Unknown	

U.S. Highways
State Highways
Paved Roads
Unpaved Roads
Trails
Railroad Tracks
River
Candidate Location

Note:
An accuracy assessment
of this map has not
been conducted.

15000 Feet

Table 3-5. Vegetation on Candidate Location #3.

Cover Class Description	Area (ha)	% Area	Comments (very general based on limited information)
Juniper Woodlands	0	0.00	Very unique habitat on INEL; important raptor and other bird nesting/perching habitat, provides cover for elk & deer
Great Basin Wildrye	0.36	0.67	Relatively unique habitat; associated with basins, playas, and deeper soils
Steppe (bunchgrass)	0	0.00	Common, but not abundant; provides forage
Grassland	0.58	1.08	Common, but not abundant; provides forage
Sagebrush-Steppe off lava	0.90	1.68	Very abundant community
Sagebrush-Steppe on lava	51.22	95.44	Most abundant community on INEL
Sagebrush-Winterfat	0	0.00	Common, not abundant; more in N. part of INEL. Winterfat is important forage.
Salt Desert Shrub	0	0.00	Common, not abundant; more in N. part of INEL
Sagebrush/Rabbitbrush	0	0.00	Common, not abundant; more in N. part of INEL
Sagebrush/Low Sagebrush/ Rabbitbrush on lava	0.39	0.73	Unique; associated with lava outcrops, may provide habitat for rodents, raptors, and rabbits. These areas may also have juniper trees associated with them. Greater potential for archeological finds.
Wetlands	0	0.00	Unique; Big Lost River, Birch Creek, the Sinks, spreading areas, and many playas are mapped by USFWS as wetlands.
Playa/Bare ground	0	0.00	Unique; playas may be associated with temporary flooding and, therefore, ephemeral wetlands. Area surrounding playa may include good forage habitat.
Lava	0.22	0.40	Unique; lava outcrops provide good habitat for small and large mammals, raptors, and reptiles. Also, good potential for archaeological sites. These areas may also have juniper trees associated with them.
Old Fields, Disturbed Areas, and Seedings	0	0.00	Potential for establishment and spread of exotic plant species.
Shadow	0	0.00	N to NW facing areas with significant slope.
Unknown 1	0	0.00	Class seems to be associated with bare ground or disturbed areas.
TOTAL	53.67	100.00	(132.61 acres)

3.2.3 Fauna

Tracks of pronghorn and coyotes (*Canis latrans*) were very common on Candidate Locations #1 and #9. Cottontail rabbits (*Sylvilagus nuttallii*) and black-tailed jackrabbits (*Lepus californicus*) were commonly observed. One white-tailed jackrabbit (*Lepus townsendii*) and two pygmy rabbits (*Sylvilagus idahoensis*) were observed at Candidate Location #1. Droppings indicated use of Candidate Locations #1 and #9 by sage grouse (*Centrocercus urophasianus*). Magpies (*Pica pica*) and crows (*Corvus brachyrhynchos*) were common, and rough-legged hawks (*Buteo lagopus*) were observed hunting overhead. Candidate Location #1 also has been used occasionally by pronghorn for fawning and neonatal cover (Reynolds 1992). Reynolds (pers. comm.) indicated that Candidate Location #1 has been used by

Figure 3-4. Vegetation map of candidate location #5.

Vegetation Map

Vicinity of Candidate Location 5

Juniper	Salt Desert Shrub
Great Basin Wildrye	Sagebrush/Rabbitbrush
Steppe (bunchgrass)	Sagebrush/Low Sagebrush/Rabbitbrush on Lava
Grassland	Playa/Bare ground
Sagebrush-Steppe off Lava	Lava
Sagebrush-Steppe on Lava	Old fields, Disturbed Areas, and Seedings
Sagebrush-Winterfat	Facilities
Unknown	
-
	U.S. Highways
	State Highways
	Paved Roads
	Unpaved Roads
	Trails
	Railroad Tracks
	River
	Candidate Location

Note:
An accuracy assessment
of this map has not
been conducted.

12000 15000 Feet

Table 3-6. Vegetation on Candidate Location #5.

Cover Class Description	Area (ha)	% Area	Comments (very general based on limited information)
Juniper Woodlands	0	0.00	Very unique habitat on INEL; important raptor and other bird nesting/perching habitat, provides cover for elk & deer
Great Basin Wildrye	0	0.00	Relatively unique habitat; associated with basins, playas, and deeper soils
Steppe (bunchgrass)	0	0.00	Common, but not abundant; provides forage
Grassland	2.26	2.76	Common, but not abundant; provides forage
Sagebrush-Steppe off lava	62.60	76.46	Very abundant community
Sagebrush-Steppe on lava	0	0.00	Most abundant community on INEL
Sagebrush-Winterfat	0.09	0.11	Common, not abundant; more in N. part of INEL. Winterfat is important forage.
Salt Desert Shrub	0	0.00	Common, not abundant; more in N. part of INEL
Sagebrush/Rabbitbrush	16.92	20.67	Common, not abundant; more in N. part of INEL
Sagebrush/Low Sagebrush/ Rabbitbrush on lava	0	0.00	Unique; associated with lava outcrops, may provide habitat for rodents, raptors, and rabbits. These areas may also have juniper trees associated with them. Greater potential for archeological finds.
Wetlands	0	0.00	Unique; Big Lost River, Birch Creek, the Sinks, spreading areas, and many playas are mapped by USFWS as wetlands.
Playa/Bare ground	0	0.00	Unique; playas may be associated with temporary flooding and, therefore, ephemeral wetlands. Area surrounding playa may include good forage habitat.
Lava	0	0.00	Unique; lava outcrops provide good habitat for small and large mammals, raptors, and reptiles. Also, good potential for archaeological sites. These areas may also have juniper trees associated with them.
Old Fields, Disturbed Areas, and Seedings	0	0.00	Potential for establishment and spread of exotic plant species.
Shadow	0	0.00	N to NW facing areas with significant slope.
Unknown 1	0	0.00	Class seems to be associated with bare ground or disturbed areas.
TOTAL	81.87	100.00	(202.31 acres)

elk, and that just to the south of this location is a large juniper tree that has been used as a nesting site and hunting perch by ferruginous hawks (*Buteo regalis*). A relatively small bushy-tailed woodrat (*Neotoma cinerea*) midden was found near the western edge of Candidate Location #9.

Tracks and droppings at Candidate Location #3 showed use by pronghorn, coyotes, and elk. A large bushy-tailed woodrat midden was found along the southern edge of Candidate Location #3. Sage grouse, black-tailed jackrabbits, and rough-legged hawks were also observed at the location.

Large wintering herds of pronghorns were observed at Candidate Location #5, as well as several sage grouse. Tracks and droppings showed past use by elk in winter, and tracks in the snow indicated

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TECHNOLOGIES

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Figure 3-5. Vegetation map of candidate location #9.

Vegetation Map

Vicinity of Candidate Location 9

Juniper	Salt Desert Shrub
Great Basin Wildrye	Sagebrush/Rabbitbrush
Steppe (bunchgrass)	Sagebrush/Low Sagebrush/Rabbitbrush on Lava
Grassland	Playa/Bare ground
Sagebrush-Steppe off Lava	Lava
Sagebrush-Steppe on Lava	Old fields, Disturbed Areas, and Seedings
Sagebrush-Winterfat	Facilities
Unknown	

	U.S. Highways
	State Highways
	Paved Roads
	Unpaved Roads
	Trails
	Railroad Tracks
	River
	Candidate Location

Note:
An accuracy assessment
of this map has not
been conducted.

Table 3-7. Vegetation on Candidate Location #9.

Cover Class Description	Area (ha)	% Area	Comments (very general based on limited information)
Juniper Woodlands	0	0.00	Very unique habitat on INEL; important raptor and other bird nesting/perching habitat, provides cover for elk & deer
Great Basin Wildrye	0	0.00	Relatively unique habitat; associated with basins, playas, and deeper soils
Steppe (bunchgrass)	0	0.00	Common, but not abundant; provides forage
Grassland	0	0.00	Common, but not abundant; provides forage
Sagebrush-Steppe off lava	13.66	54.70	Very abundant community
Sagebrush-Steppe on lava	7.72	30.93	Most abundant community on INEL
Sagebrush-Winterfat	3.01	12.04	Common, not abundant; more in N. part of INEL. Winterfat is important forage.
Salt Desert Shrub	0	0.00	Common, not abundant; more in N. part of INEL
Sagebrush/Rabbitbrush	0.27	1.08	Common, not abundant; more in N. part of INEL
Sagebrush/Low Sagebrush/ Rabbitbrush on lava	0	0.00	Unique; associated with lava outcrops, may provide habitat for rodents, raptors, and rabbits. These areas may also have juniper trees associated with them. Greater potential for archeological finds.
Wetlands	0	0.00	Unique; Big Lost River, Birch Creek, the Sinks, spreading areas, and many playas are mapped by USFWS as wetlands.
Playa/Bare ground	0.31	1.25	Unique; playas may be associated with temporary flooding and, therefore, ephemeral wetlands. Area surrounding playa may include good forage habitat.
Lava	0	0.00	Unique; lava outcrops provide good habitat for small and large mammals, raptors, and reptiles. Also, good potential for archaeological sites. These areas may also have juniper trees associated with them.
Old Fields, Disturbed Areas, and Seedings	0	0.00	Potential for establishment and spread of exotic plant species.
Shadow	0	0.00	N to NW facing areas with significant slope.
Unknown 1	0	0.00	Class seems to be associated with bare ground or disturbed areas.
TOTAL	24.97	100.00	(61.71 acres)

the presence of coyotes and jackrabbits. During one field survey, a flock of domestic sheep was grazing just south of Candidate Location #5.

3.3 Evaluation of Results

3.3.1 Relationship of the Candidate Locations to Important Species

The peregrine falcon (*Falco peregrinus*) and the bald eagle (*Haliaeetus leucocephalus*) are the only endangered species recorded on the INEL. Peregrine falcons are considered rare during all seasons, but the bald eagle is found in limited numbers in winter on the INEL. No peregrines or bald eagles were observed during the field surveys, but Reynolds (1992) reports that there is a bald eagle winter roost about four miles north of Candidate Location #5, and that wintering eagles have been observed hunting and flying over Candidate Location #5.

Pygmy rabbits were observed at Candidate Location #1 during field surveys, and could be expected to occur in the type of habitat and terrain at Candidate Locations #3 and #9. The pygmy rabbit is now categorized a C2 species by the U. S. Fish and Wildlife Service (USFWS) (Moseley and Groves 1992). A C2 species is a species for which information indicates proposing to list as endangered or threatened is possibly appropriate, but for which conclusive data are lacking to support a final decision. The National Heritage Programs and Conservation Data Centers ranks the pygmy rabbit within Idaho as "rare or uncommon but not imperiled" (Moseley and Groves 1992). Idaho presently has a hunting season for pygmy rabbits.

Reynolds (1992) also reported that two other C2 species, the ferruginous hawk and the loggerhead shrike (*Lanius ludovicianus*), would be expected to frequent the candidate locations. Neither of these species was observed at the candidate locations during field surveys.

Candidate Location #3 has the sandy soils in which *Oxytheca dendroidea* is known to occur (Cholewa and Henderson 1984). *Oxytheca dendroidea* is a small buckwheat-like annual, which is on the Idaho State Watch List, and has been recorded on the INEL in areas very near Candidate Location #3 (Cholewa and Henderson 1984). (The State Watch List is a list of taxa of plants that are rare and of special interest, but are not in jeopardy and may be common elsewhere.)

3.3.2 Relationship of the Candidate Locations to Important Habitats

As shown in the tables of vegetation classes, none of the candidate locations include areas categorized as wetlands or playa/bare ground.

Candidate Location #5 at the north end of the INEL is in the winter range used by a significant portion of the Idaho pronghorn population. This area is also an important wintering area for large numbers of sage grouse.

Candidate Location #3 is in the area used extensively by the elk population that became resident on the INEL in the last several years. During Winter, 1992-93, the Idaho Department of Fish and Game (IDFG) trapped and transplanted a significant portion (over 230) of this elk population off the INEL.

Candidate Location #5 is in the area where Mr. Paul Martin, DOE-ID/SMD, has preliminary plans to use water from the Birch Creek hydroelectric outflow canal for some wildlife habitat improvements (Reynolds 1992).

3.3.3 Relationship of the Candidate Locations to Environmental Study Areas

As reported by Reynolds (1992, 1993), RESL has no environmental monitoring or sampling stations or long-term research plots on or near any of the candidate locations.

Appendix A

Location Data for the Four Candidate Locations

Table A-1. GPS location data (UTM coordinates) for candidate location #1.

Easting	Northing
339343.46	4816988.19
338937.20	4816279.80
338463.18	4816506.13
338583.50	4816807.57
339172.97	4817472.39
339363.95	4817722.21
339888.41	4817710.16
339475.97	4817858.04
338871.16	4816443.41

Table A-2. GPS location data (UTM coordinates) for Candidate Location #3.

Easting	Northing
356344.38	4838652.32
356453.04	4838552.84
356346.38	4838307.45
356007.77	4838282.70
355895.15	4838853.33
355781.13	4838194.28
355262.24	4838262.60
355266.93	4838426.08
355398.56	4838553.10
355453.71	4838733.90

Table A-3. GPS location data (UTM coordinates) for Candidate Location #5.

Easting	Northing
361503.48	4869153.70
361697.26	4869105.21
361896.23	4869054.02
362106.05	4869001.17
361305.78	4869202.83
361398.98	4868377.21
362445.17	4868366.08
362356.93	4869953.49

Table A-4. GPS location data (UTM coordinates) for Candidate Location #9.

Easting	Northing
336238.21	4817137.99
336428.62	4817121.05
336601.92	4817103.86
336647.84	4817288.72
336659.14	4817507.35
336269.44	4817637.49
336061.94	4817357.93

Appendix H

Ecological Survey for the Siting of the Mixed and Low-Level Waste Disposal Facility, EGG-CIET-11058

Ecological Survey for the Siting of the Mixed and Low-Level Waste Disposal Facility

Reed L. Hoskinson

Published May 1994

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**Prepared for the
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Office of Environmental Restoration and Waste Management
Under DOE Idaho Field Office
Contract DE-AC07-76ID01570**

ABSTRACT

This report summarizes the results of field ecological surveys conducted by the Center for Integrated Environmental Technologies (CIET) on the Idaho National Engineering Laboratory (INEL) at two candidate locations for the siting of the Mixed and Low-Level Waste Disposal Facility (MLLWDF). The purpose of these surveys was to comply with all Federal laws and Executive Orders to identify and evaluate any potential environmental impacts because of the project. The boundaries of the candidate locations were marked with blaze-orange lath survey marker stakes by the project management. Global Positioning System (GPS) measurements of the marker stakes were made, and input to the Arc/Info® geographic information system (GIS). Field surveys were conducted to assess any potential impact to any important species, important habitats, and to any environmental study areas. The GIS location data was overlayed onto the INEL vegetation map and an analysis of vegetation classes on the locations was done. Two species of rare vascular plants have previously been reported to occur in the vicinity of the candidate locations. Two C2 species, the ferruginous hawk (*Buteo regalis*) and the loggerhead shrike (*Lanius ludovicianus*) would also be expected to frequent the candidate locations. Neither of the candidate locations is in other environmental study areas. One candidate location is about 500 m from the Cinder Butte hibernacula, which is a winter den in which about 750 snakes hibernate, of which nearly 500 are rattlesnakes. No significant ecological impact is anticipated if the MLLWDF were constructed on either candidate location. However, both candidate locations are in the central area of the INEL where there is minimal disturbance to the ecosystem by facilities or humans. It would be very desirable from an ecological point to limit the fragmentation of the INEL ecosystem by placing future facilities close to existing facilities, rather than placing them within vast undisturbed areas. Further field surveys and analyses should be done for the final selected location. Consideration of the potential interactions between workers and the snakes should also be made in the assessment of the candidate locations. The coordinates defining the boundaries of the candidate locations are included as an appendix.

ACKNOWLEDGMENTS

G. L. Olson conducted the field soil surveys and wrote the description of the soils. N. L. Hampton collected the field GPS data and assisted in the data conversion to GIS. R. D. Lee converted the GPS data into GIS format and assisted in the GIS analysis of the data. Their assistance is appreciated.

ACRONYMS

CIET	Center for Integrated Environmental Technologies
DOE-ID	Department of Energy - Idaho Field Office
E&ES	Environmental & Earth Sciences
EPA	Environmental Protection Agency
ESRP	Eastern Snake River Plain
GIS	geographic information system
GPS	global positioning system
INEL	Idaho National Engineering Laboratory
MLLWDF	Mixed and Low-Level Waste Disposal Facility
NEPA	National Environmental Policy Act
RESL	Radiological and Environmental Sciences Laboratory
SOP	Standard Operating Procedures
TSD	treatment, storage, and disposal
USFWS	U. S. Fish and Wildlife Service

Candidate Location #14 contains stratified deposits of silt loam and sandy loam (mostly silt loam). When examined during the field survey on July 2, 1993, the subsoil from about 5" to 5' was moist. At a depth of about 4', the soil gets heavier, grading from silt loam to a silty clay loam. Soil surfaces are cracked and have been smoothed and hardened by wind and water action (weathering). Underlying this hardened cap is a soil layer with vesicular structure, which presumably formed following repeated wetting and drying from rainfall events that forced the soil gas into large pores. Structure of the subsoil is not well developed. Color changes with depth are nearly imperceptible, and are usually around IOYR 4/2 on the Munsell Color Chart. In light of the depositional environment, it is likely that the dark color means that these soils are relatively high in sodium. Small oxidation mottles are present in fine root channels of the subsoil. Free carbonates are present in localized "splotches" in the subsoil, indicating local congregation of carbonates, but not *en masse* migration from overlying layers. There is no calcic horizon, or any other diagnostic horizon, indicating that the soil is undeveloped and relatively young.

Candidate Location #18 is similar to Candidate Location # 14, with surface cracks, vesicular structure in the shallow subsoil, stratified silt loam deposits (with a sandy layer around 4 to 4.5 feet), an undeveloped solum, and some sand deposits on the surface. The surface sands are less prominent on Candidate Location #18 than on Candidate Location #14, the mud cracks are more prominent, and the lime splotches appear as shallow as 7". The soil was drier than the soil from Candidate Location #14.

Regarding development of these candidate locations, the main concerns are that the soils may exhibit high shrink-swell potential, and both candidate locations may be vulnerable to flooding in the very long term (*i.e.*, 1000 years). Field investigation involved hand-augering to about 5', examining the micropedological features of the soils, and field-texturing the soil for clay content. It was evident that the soils were relatively young water-laid deposits, and that there is sufficient clay present to pose problems if the clay were of the expanding type (*e.g.*, montmorillonite). In one of the subsurface samples, a slickensides-type feature was observed. This feature, which appears as a smooth, shiny face on a soil clod, develops when soils expand wetted and rub against each other. This feature was quite discrete in the sample examined and merits further investigation. The shrink-swell potential of the soil should be carefully examined.

Regarding the flood potential of the site, the geological records (Bright and Davis 1982) suggest that ancestral Lake Terreton may have filled and supported aquatic life as recently as 700 years ago. Additionally, there was a small ice age about 200 years ago, resulting in increased water flows in mountain drainages. Nace *et al.* (1975) have assigned the Lake Terreton deposits to the Holocene, suggesting an age of less than 11,000 years, but in light of the minimal soil development, it is clear that the soils are younger than that. Dating techniques are available to help with this determination.

3.2.2 Vegetation.

Vegetation maps for areas including the two candidate locations were produced by overlaying the GPS location data defining the boundaries of the candidate locations onto the CIET vegetation map of the INEL. The vegetation map has been developed by CIET from satellite imagery data.

Figure 3-2 is the vegetation map of the area around Candidate Location #14. Table 3-1 summarizes the vegetation classes within Candidate Location #14, by area and by percent of total area of Candidate Location #14. As indicated, Candidate Location #14 is dominated by the sagebrush-steppe

Figure 3-2. Vegetation map of candidate location #14.

Vegetation Map

Vicinity of Candidate Location 14

Juniper	Salt Desert Shrub
Great Basin Wildrye	Sagebrush/Rabbitbrush
Steppe (bunchgrass)	Sagebrush/Low Sagebrush/
Rabbitbrush on Lava
Grassland	Playa/Bare ground
Sagebrush-Steppe
off Lava	Lava
Sagebrush-Steppe
on Lava	Old fields, Disturbed
Areas, and Seedings
Sagebrush-Winterfat	Facilities
Unknown	

U.S. Highways
State Highways
Paved Roads
Unpaved Roads
Trails
Railroad Tracks
River
Candidate Location

Note:
An accuracy assessment
of this map has not
been conducted.

000 Feet

Table 3-1. Vegetation on Candidate Location #14.

Cover Class Description	Area (ha)	% Area	Comments (very general based on limited information)
Juniper Woodlands	0	0.00	Very unique habitat on INEL; important raptor and other bird nesting/perching habitat, provides cover for elk & deer
Great Basin Wildrye	2.14	6.56	Relatively unique habitat; associated with basins, playas, and deeper soils
Steppe (bunchgrass)	0.63	1.93	Common, but not abundant; provides forage
Grassland	12.25	37.55	Common, but not abundant; provides forage
Sagebrush-Steppe off lava	15.77	48.34	Very abundant community
Sagebrush-Steppe on lava	0.29	0.89	Most abundant community on INEL
Sagebrush-Winterfat	0.09	0.28	Common, not abundant; more in N. part of INEL. Winterfat is important forage.
Salt Desert Shrub	0	0.00	Common, not abundant; more in N. part of INEL
Sagebrush/Rabbitbrush	1.17	3.59	Common, not abundant; more in N. part of INEL
Sagebrush/Low Sagebrush/ Rabbitbrush on lava	0	0.00	Unique; associated with lava outcrops, may provide habitat for rodents, raptors, and rabbits. These areas may also have juniper trees associated with them. Greater potential for archeological finds.
Wetlands	0	0.00	Unique; Big Lost River, Birch Creek, the Sinks, spreading areas, and many playas are mapped by the USFWS as wetlands.
Playa/Bare ground	0	0.00	Unique; playas may be associated with temporary flooding and, therefore, ephemeral wetlands. Area surrounding playa may include good forage habitat.
Lava	0	0.00	Unique; lava outcrops provide good habitat for small and large mammals, raptors, and reptiles. Also, good potential for archaeological sites. These areas may also have juniper trees associated with them.
Old Fields, Disturbed Areas, and Seedings	0.28	0.86	Potential for establishment and spread of exotic plant species.
Shadow	0	0.00	N to NW facing areas with significant slope.
Unknown 1	0	0.00	Class seems to be associated with bare ground or disturbed areas.
TOTAL	32.62	100.00	(80.62 acres)

and grassland plant communities. Figure 3-3 and Table 3-2 describe Candidate Location #18, which is predominantly salt desert shrub, sagebrush-steppe, and sagebrush/rabbitbrush communities.

Although each of the candidate locations has differing amounts of different plant cover classes, none of the plant cover classes occurring in either of the candidate locations is uncommon in the sagebrush-steppe ecosystem of the ESRP, and other similar undisturbed associations are not uncommon on the INEL.

Figure 3-3. Vegetation map of candidate location #18.

Vegetation Map

Vicinity of Candidate Location 18

Juniper	Salt Desert Shrub
Great Basin Wildrye	Sagebrush/Rabbitbrush
Steppe (bunchgrass)	Sagebrush/Low Sagebrush/Rabbitbrush on Lava
Grassland	Playa/Bare ground
Sagebrush-Steppe off Lava	Lava
Sagebrush-Steppe on Lava	Old fields, Disturbed Areas, and Seedings
Sagebrush-Winterfat	Facilities
Unknown	

	U.S. Highways
	State Highways
	Paved Roads
	Unpaved Roads
	Trails
	Railroad Tracks
	River
	Candidate Location

Note:
An accuracy assessment
of this map has not
been conducted.

000 Feet

Table 3-2. Vegetation on Candidate Location #18.

Cover Class Description	Area (ha)	% Area	Comments (very general based on limited information)
Juniper Woodlands	0	0.00	Very unique habitat on INEL; important raptor and other bird nesting/perching habitat, provides cover for elk & deer
Great Basin Wildrye	0	0.00	Relatively unique habitat; associated with basins, playas, and deeper soils
Steppe (bunchgrass)	0	0.00	Common, but not abundant; provides forage
Grassland	0.23	1.41	Common, but not abundant; provides forage
Sagebrush-Steppe off lava	4.36	26.81	Very abundant community
Sagebrush-Steppe on lava	0.21	1.30	Most abundant community on INEL
Sagebrush-Winterfat	0.09	0.55	Common, not abundant; more in N. part of INEL. Winterfat is important forage.
Salt Desert Shrub	5.22	32.09	Common, not abundant; more in N. part of INEL
Sagebrush/Rabbitbrush	3.95	24.28	Common, not abundant; more in N. part of INEL
Sagebrush/Low Sagebrush/ Rabbitbrush on lava	0	0.00	Unique; associated with lava outcrops, may provide habitat for rodents, raptors, and rabbits. These areas may also have juniper trees associated with them. Greater potential for archeological finds.
Wetlands	0	0.00	Unique; Big Lost River, Birch Creek, the Sinks, spreading areas, and many playas are mapped by USFWS as wetlands.
Playa/Bare ground	2.21	13.56	Unique; playas may be associated with temporary flooding and, therefore, ephemeral wetlands. Area surrounding playa may include good forage habitat.
Lava	0	0.00	Unique; lava outcrops provide good habitat for small and large mammals, raptors, and reptiles. Also; good potential for archaeological sites. These areas may also have juniper trees associated with them.
Old Fields, Disturbed Areas, and Seedings	0	0.00	Potential for establishment and spread of exotic plant species.
Shadow	0	0.00	N to NW facing areas with significant slope.
Unknown 1	0	0.00	Class seems to be associated with bare ground or disturbed areas.
TOTAL	16.27	100.00	(40.20 acres)

3.2.3 Fauna

A bachelor band of pronghorn antelope was observed on and near Candidate Location #14 during three different field surveys. Other pronghorns were observed nearby, especially during June and early July, while the U. S. Fish and Wildlife Service (USFWS) designated wetland just northeast of Candidate Location #14 had water in it. Pronghorn tracks were observed on Candidate Location #18. Tracks of coyotes (*Canis latrans*) were common on both candidate locations. A cottontail rabbit (*Sylvilagus nuttallii*) was observed along the southern edge of Candidate Location #18, at the edge of the basalt outcrops. An adult sage grouse (*Centrocercus urophasianus*) was observed at Candidate Location #14, and droppings indicated more use of both candidate locations.

As indicated by Reynolds (1993), Candidate Location #18 is about 500 m from the Cinder Butte hibernacula, which is a winter den in which about 750 snakes hibernate, of which nearly 500 are rattlesnakes.

3.3 Evaluation of Results

3.3.1 Relationship of the Candidate Locations to Important Species

The peregrine falcon (*Falco peregrinus*) and the bald eagle (*Haliaeetus leucocephalus*) are the only endangered species recorded on the INEL. Peregrine falcons are considered rare during all seasons, but the bald eagle is found in limited numbers in winter on the INEL. No peregrines or bald eagles were observed during the field surveys.

Two species of rare vascular plants have previously been reported to occur in the vicinity of the candidate locations (Cholewa and Henderson 1984). Painted milkvetch (*Astragalus ceramicus*) and oxytheca (*Oxytheca dendroidea*) might be expected on either of the candidate locations, although neither was observed. Painted milkvetch was observed on the elevated basalt ridges just east of Candidate Location #14. *Oxytheca dendroidea* has no Federal status, and *Astragalus ceramicus* has a Federal status of C3 (*i.e.*, a taxon that is more widespread or abundant than previously believed, or is not subject to identifiable threats) (Moseley and Groves 1992).

Reynolds (1993) has suggested that loggerhead shrikes (*Lanius ludovicianus*) may occur in or near both candidate locations. Loggerhead shrikes are classified as a C2 species by the USFWS (Moseley and Groves 1992). A C2 species is a species for which information indicates proposing to list as endangered or threatened is possibly appropriate, but for which conclusive data are lacking to support a final decision.

3.3.2 Relationship of the Candidate Locations to Important Habitats

Neither of the candidate locations is a unique habitat, and neither is in an area that has been officially designated as a wetland by the USFWS. Candidate Location #14 has no areas classified as wetland or playa/bare ground according to the INEL vegetation classifications, although a USFWS National Wetlands Inventory wetland is just northeast of the location. Candidate Location #18 does have over 13% of its area classified as playa/bare ground. Both candidate locations exhibit topographic, vegetative, and hydrologic features similar to other areas designated as wetlands.

The rattlesnake hibernacula near Candidate Location #18 is a unique resource on the INEL (Reynolds 1993).

Both candidate locations are in the central area of the INEL where there is minimal disturbance to the ecosystem by facilities or humans.

3.3.3 Relationship of the Candidate Locations to Environmental Study Areas

As reported by Reynolds (1993), RESL has no environmental monitoring or sampling stations or long-term research plots on or near either of the candidate locations.

The second of two significant research efforts sponsored by RESL at the rattlesnake hibernacula near Candidate Location #18 is currently in progress (Reynolds 1993).

4. RECOMMENDATIONS

No significant ecological impact is anticipated if the MLLWDF were constructed on either candidate location. However, both candidate locations are in the central area of the INEL where there is minimal disturbance to the ecosystem by facilities or humans. It would be very desirable from an ecological point to limit the fragmentation of the INEL ecosystem by placing future facilities close to existing facilities, rather than placing them within vast undisturbed areas.

Further field surveys and analyses should be done for the final selected location. These efforts should include surveys of the occurrence of rare vascular plants and loggerhead shrikes, and an assessment of the potential impact on the rattlesnake hibernacula if Candidate Location #18 is selected.

Consideration of the potential interactions between workers and the snakes should also be made in the assessment of Candidate Location #18.

It is recommended that detailed sampling and analyses of the soils at both candidate locations be conducted. In addition, more review of the long-term flooding history of the areas might be beneficial.

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Appendix A

Location Data for the Two Candidate Locations

Table A-1. GPS location data (UTM coordinates) for Candidate Location #14.

Easting	Northing
359282.79	4843673.93
358907.01	4844161.28
368462.97	4843804.95
358772.00	4843390.00

Table A-2. GPS location data (UTM coordinates) for Candidate Location #18.

Easting	Northing
358395.54	4847330.00
358807.90	4847534.19
358922.07	4847291.33
358597.17	4847078.72
358866.84	4847015.47

Appendix I

Relative Dispersion Calculations from Three Potential Sites for a Proposed Waste Management Facility

**RELATIVE DISPERSION
CALCULATIONS FROM THREE
POTENTIAL SITES FOR A PROPOSED
WASTE MANAGEMENT FACILITY**

TECHNICAL REPORT

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1. Background

A facility for the treatment of low level transuranic wastes has been proposed for the INEL. There have been three candidate sites identified for assessment of the relative merits of their locations. These sites will be called Site 1, Site 3, and Site 5. They are located in the southern, middle, and northern portions of the INEL, respectively. One criterion used in making the final site selection is the potential for public exposure to airborne pollutants released from the facility. To examine this potential, atmospheric transport and diffusion from the three sites was examined using the MESODIF computer model.

2. Method

MESODIF is a forward time-marching Gaussian plume model in which successive, small plume elements are advected using meteorological data. These data derive from a network of meteorological sensors mounted on over 2 dozen towers located throughout the Upper Snake River Plain. Plume elements are advected at each time step by a wind interpolated for the geographical location of the plume element from the surrounding meteorological stations. The rate of growth and diffusion of the plume elements varies with the atmospheric stability class, and is based on diffusion studies conducted at the INEL. Atmospheric stability class is determined by the angle of the sun and the wind speed. By using the regional time and space varying meteorological parameters the model avoids some conceptual biases of joint frequency models. Some of these obvious biases result from changes of stability class during travel to a receptor, flow stagnation, and flow-field reversals.

Meteorological information from 1983 was used for these calculations. The year 1983 was chosen because it was a year of very good data recovery and because it was a year of "typical diffusion." Each year since 1973 MESODIF has been used to model the annual impact from ICPP. Most years the maximally exposed location from the model is at Atomic City. In 1983 the calculated dispersion coefficient at Atomic City was near the mid point for all the years. It was also the same as the value produced using a 9-year data period.

Impact of a pollution source on any given receptor depends on the distance between the source and receptor, and their orientation with respect to the wind direction. For this effort 72 receptor locations were selected for each of the prospective sites. The first receptor was due North, and the remaining receptors were at increments of 5 degrees surrounding each site. Radial distances to the receptors were the distance to the nearest site boundary, or place of public access at the receptor's bearing from the site. Plume elements were simulated every 20 minutes from each site for a one year period using a release of one unit/hour. Units of

release could be curies or other mass related units of measure. Total integrated concentrations were summed for consecutive 1, 3, 6, 12, and 24 hour periods at each receptor. The concentration values exceeding 95% of all the cases were found for each receptor. These values, averaged over the summing period, were used to compare the relative potential impact to the public from the three sites in a "worst case" scenario. The 95% concentrations were used rather than the extreme largest value so that undue weight on an extremely rare event was not considered. There is no known regulatory requirement to utilize the extreme largest values. However, they are also listed to help the user recognize the modeled upper-limit values in relation to the 95% guideline concentrations. The highest 1, 3, 6, 12, and 24 hour concentrations are identified as the 100% values (all other calculated values are smaller).

3. Results

Tables 1 through 5 contain the 95% and 100% concentration averages at the most impacted receptor for each of the three sites for the 1, 3, 6, 12, and 24 hour periods respectively.

TABLE 1. One hour average concentrations.

Site	Bearing (degrees)	95% Concentration hr/m**3	Bearing (degrees)	100% Concentration hr/m**3
1	190	4.8E-09	170	6.7E-08
3	15	1.1E-09	5	3.9E-08
5	20	5.9E-09	30	3.1E-07

TABLE 2. Three hour average concentrations.

Site	Bearing (degrees)	95% Concentration hr/m**3	Bearing (degrees)	100% Concentration hr/m**3
1	185	4.9E-09	25	4.5E-08
3	15	1.2E-09	350	2.4E-08
5	15	9.3E-09	15	1.6E-07

TABLE 3. Six hour average concentrations.

Site	Bearing (degrees)	95% Concentration hr/m**3	Bearing (degrees)	100% Concentration hr/m**3
1	185	4.4E-09	30	2.7E-08
3	15	1.3E-09	350	2.2E-08
5	30	1.0E-08	25	1.1E-07

TABLE 4. Twelve hour average concentrations.

Site	Bearing (degrees)	95% Concentration hr/m**3	Bearing (degrees)	100% Concentration hr/m**3
1	185	3.7E-09	30	1.5E-08
3	15	1.3E-09	350	1.3E-08
5	20	9.4E-09	25	7.6E-08

TABLE 5. Twenty-four hour average concentrations.

Site	Bearing (degrees)	95% Concentration hr/m**3	Bearing (degrees)	100% Concentration hr/m**3
1	180	3.0E-09	170	9.0E-09
3	15	1.1E-09	350	6.8E-09
5	20	7.7E-09	25	3.9E-08

Site 3 is the most isolated of the three locations from areas of public access while Site 5 is the most exposed to the public. It is not surprising therefore, that the potential for public exposure due to airborne pollutants would be the least from emissions at Site 3 and the greatest from emissions at Site 5. The results are depicted graphically with the total integrated concentrations plotted versus bearing to the receptor points. Figures 1, 3, 5, 7, and 9 compare the 95% concentration averages for the three sites for the 1, 3, 6, 12, and 24 hour periods respectively. The same information for the 100% concentration averages is contained in figures 2, 4, 6, 8, and 10.

4. Sensitivities to Data Set Limits

MESODIF calculations were also made for Site 5 with the wind information from the TAN meteorological station omitted. TAN is

the closest wind station to the Site 5 area. These calculations were done to test of the sensitivity of the wind interpolation scheme in the area of Site 5. Results for the one and twenty-four hour concentration averages are graphically depicted in Figures 11 and 12 respectively. Numerical values at the receptors receiving the heaviest impact are contained in Table 6 for the one hour averages and Table 7 for the 24 hour averages.

TABLE 6. One hour average concentrations.

Wind Field	Bearing (degrees)	95% Concentration hr/m**3	Bearing (degrees)	100% Concentration hr/m**3
Tan on	15	5.9E-09	30	3.1E-08
Tan off	60	5.3E-09	300	3.0E-08

TABLE 7. Twenty-four hour average concentrations.

Wind Field	Bearing (degrees)	95% Concentration hr/m**3	Bearing (degrees)	100% Concentration hr/m**3
Tan on	15	7.7E-09	25	3.9E-08
Tan off	40	7.0E-09	300	3.7E-08

magnitudes of the total integrated concentrations for the 95% and 100% points are similar when the TAN winds are not used although the maximum impact comes at different receptors. The nearest public accesses to Site 5 are along State Highway 28 and 22. These highways are oriented to the Site 5 location so that the distance from Site 5 to a highway is similar for plumes traveling with bearings from Northwest through the Northeast directions. Since the magnitudes of the concentrations are not very different, it makes little difference for the site evaluation how the winds are interpolated at the Site 5 area. In case of an emergency however, the wind direction would be critical. For that event a meteorological tower should be installed at the Site 5 location if that site is selected.

5. Median Concentrations

It is also of interest to examine the 50% concentrations for the receptors surrounding the three sites. These are the concentrations that exceed 50% of all cases and may be thought of as an average concentration due to normal plant operations. Figure 13 graphically depicts the average concentrations and Table 8 summarizes the highest values.

TABLE 8. Average Daily Concentrations.

Site	Bearing (degrees)	50% Concentration hr/m**3
1	50	3.9E-10
3	15	2.0E-11
5	20	3.0E-10

The largest 50% receptor average concentration for each site is to the NNE of Sites 3 and 5 and to the NE of Site 1. This might be expected since southwest winds predominate at the INEL. One can see in table 8 that the highest impact to the public from normal site operations would be from Site 1 with the least impact from Site 3.

6. Summary

Figures 14, 15, and 16 contain wind roses from the RWMC, GRID III, and TAN wind stations, respectively. The RWMC station is near the Site 1 location, GRID III is close to Site 3, and TAN is near Site 5. These wind roses are based on the 1983 wind data set. The angle and length of the barbs describe the frequency of wind direction and speed classes for each of those locations. Note that wind direction is the direction from which the wind is blowing. The wind roses for RWMC and GRID III clearly show the dominance of the SW and NE wind directions in the Upper Snake River Plain. However, the TAN wind rose also shows a strong influence of winds from the NNW. This is due to winds coming out of the Birch Creek Canyon. Birch Creek winds may also be expected to have some influence in the Site 5 area.

The orientation of the prospective site locations with existing facilities can be compared with the predominant wind directions from the wind roses. In this way one may get an idea of the effect a plant built at the sites may have on existing facilities, or how existing facilities may affect the new plant.

From the standpoint of public exposure to airborne pollutants Site 3 would be the preferred location for the facility. This is primarily due to Site 3's distance from areas of public access.

7. Acknowledgements

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95% Concentrations

Figure 1 Hourly average total integrated concentrations exceeding 95% of the cases for one hour periods.

100% Concentrations

Figure 2 Maximum hourly average total integrated concentrations for one hour periods.

95% Concentrations

3 hour average

Figure 3 Hourly average total integrated concentrations exceeding 95% of the cases for three hour periods.

100% Concentrations

3 hour average

Figure 4 Maximum hourly averaged total integrated concentrations for three hour periods.

95% Concentrations

Figure 5 Hourly averaged total integrated concentrations exceeding 95% of the cases for six hour periods.

100% Concentrations

Figure 6 Maximum hourly averaged total integrated concentrations for six hour periods.

Figure 7 Hourly averaged total integrated concentrations exceeding 95% of the cases for twelve hour periods.

Figure 8 Maximum hourly averaged total integrated concentrations for twelve hour periods.

95% Concentrations

24 hour average

Figure 9 Hourly averaged total integrated concentrations exceeding 95% of the cases for twenty-four hour periods.

100% Concentrations

24 hour average

Figure 10 Maximum hourly averaged total integrated concentrations for twenty-four hour periods.

95% Concentrations

1 hour average

Figure 11 Comparison of the one hour 95% total integrated concentrations from Site 5 with and without the winds from the Tan wind station.

95% Concentrations

24 hour average

Figure 12 Comparison of the twenty-four hour 95% total integrated concentrations from Site 5 with and without the Tan winds.

Average Concentrations

Figure 13 Median hourly averaged total integrated concentrations for twenty-four hour periods.

RWMC 10 meter 1983

January 1

December 31

Midnight-11 PM

NOTE: Frequencies
indicate direction
from which the
wind is blowing.

CALM WINDS 0.78%

Figure 14 1983 wind rose from the ten meter RWMC meteorological tower.

GRID III 10 meter 1983

January 1

December 31

Midnight-11 PM

NOTE: Frequencies
indicate direction
from which the
wind is blowing.

CALM WINDS 2.18%

WIND SPEED (KNOTS)

1-3 4-6 7-10 11-16 17-21 +21

CALMS

Figure 15 1983 wind rose from the ten meter level of the GRID III meteorological tower.

TAN 10 meter 1983

January 1

December 31

Midnight-11 PM

NOTE: Frequencies
indicate direction
from which the
wind is blowing.

CALM WINDS 4.32%

Figure 16 1983 wind rose from the ten meter level of the TAN meteorological tower.