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Site Evaluation Report for Candidate Basalt Quarry Sites

Environmental Excellence
HANFORD

Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management

Bechtel Hanford, Inc.
Richland, Washington

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EXECUTIVE SUMMARY

In response to the environmental remediation challenges at Hanford, parts of the *Hanford Waste Management Plan*[1] and a companion document, the *Hanford Waste Management Technology Plan*[2], call for the development, evaluation, and demonstration of barriers for use in waste disposal activities at the Hanford Site. The latter document provides additional details for the scope and direction of barrier technology development activities to facilitate selection of an appropriate barrier design for use in remediation and waste disposal activities at Hanford.

A Barrier Development Team was organized in 1985 at Hanford to address technical concerns and to develop and design long-term isolation surface barriers that can be placed over waste sites at Hanford and other arid sites. The result of nearly nine years of field studies and laboratory investigations has led to a nationally peer-reviewed design for the Hanford Isolation Surface Barrier (HISB). The HISB design consists of a number of discrete layers of naturally occurring materials that function together to protect the underlying waste form from infiltrating water, wind erosion, animal intrusion, plant intrusion, and other phenomena. Similarly, several graded barrier concepts are under consideration at Hanford that would provide a lower degree of protection than the HISB for less demanding scenarios. The graded barriers will use fewer and/or less substantial layers of materials than the HISB; however, definitive graded barrier designs are not available at this time.

One of the primary layers within the HISB consists of 1.5 m (4.9 ft) of basalt riprap. Lesser quantities of riprap may be included in other barrier designs in the graded barrier concept. There are many hundreds of acres on the Hanford Site that are potential candidates for surface barriers including numerous tank farms that contain high-level mixed wastes, contaminated disposal trenches, and burial grounds. Because of the numerous potential applications for implementing the HISB and other surface barriers, it is necessary to secure a basalt quarry site to provide the required volume of riprap and other basalt materials required for surface barrier construction. The purpose of this Site Evaluation Report (SER) is to identify candidate basalt quarry sites to supply this riprap, evaluate these sites against engineering criteria, and to provide information and recommendations to aid with final site selection.

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[1] *Hanford Waste Management Plan*, DOE/RL-87-13, United States Department of Energy Richland Operations Office, Richland, Washington.

[2] *Hanford Waste Management Technology Plan*, DOE/RL-87-14, United States Department of Energy Richland Operations Office, Richland, Washington.

Ten locations on or near the Hanford Site have been identified as suitable candidate quarry sites, and for completeness, represent the broad range of possibilities for development. This SER evaluates the ten sites based on a number of qualifying criteria (Hanford Site proximity, basalt availability, suitability of basalt, and threatened and endangered species impacts) and engineering criteria (haul distance, safety, expansion potential, and land reclamation). After evaluation of each site against the engineering criteria, using existing and available information, a ranking is established that identifies a preferred order of site selection. However, before the sites were evaluated against the engineering criteria, they first had to meet the conditions established for all the qualifying criteria.

Other important factors in determining the eligibility of a site for quarry development are the cultural, archaeologic, and historic resources. However, only about half of the area for each Hanford Site candidate quarry (and none of the privately operated off-site sources) have been surveyed for these resources. Because the cultural resources database is incomplete, it cannot be used as a qualifying criterion at this time. However, the ten candidate quarries represent sites with a broad range of possibilities for development, and some of these sites include areas that are known to be sensitive from a cultural resource perspective. Direction must be received from DOE-RL if a candidate site should be excluded from further consideration for quarry development; if so, the next highest ranking site would be considered for development. Surveys for cultural resources must be completed on the selected site (or sites), and all outstanding issues must be settled before quarry development activities commence.

Basalt volumes were calculated using the conservative assumption that only the HISB would be used on site. Presently, this is the only surface barrier being considered at Hanford that has a definitive design from which material volumes can be calculated. Also, the HISB represents an upper bound for material volumes that may be required for surface barriers. Basalt volumes for potential HISB applications were calculated assuming large contiguous barriers would be constructed over tank farms and surrounding burial grounds in 200 East and 200 West and a single barrier over the Environmental Restoration Disposal Facility (ERDF). These assumptions establish an upper bound volume of nearly 15 million m^3 (20 million yd^3) of loose riprap required for surface barrier construction. The actual volume of basalt required will likely be less than this quantity, but it cannot be determined until a waste disposal and surface barrier implementation strategy is developed for the Hanford Site.

Of the engineering criteria applied during the evaluation of the candidate sites, haul distance has the single most significant impact. Although the Safety criterion and the Haul Distance criterion are weighted equally important to the rating process, safety tends to be more of a constant because quarry operations do not differ greatly from site to site. Haul distance, on the other hand, is highly variable because it is a function of the quarry location and therefore has the greatest impact on total score. Because of the potentially large volume of riprap that may be required over several decades, haul costs could be enormous. For example, because of the relatively long haul distance to the 200 Area plateau, the costs for hauling 15 million m^3 (20 million yd^3) of loose riprap from the Horn Rapids candidate quarry using conventional highway licensed trucks approach an estimated $200 million. Similarly, the transportation costs for privately operated off-site commercial sources could exceed $500 million, also because of the long haul distance to the 200 Area plateau. Additionally, the infrastructure may not be in place and will have to be constructed (or at least upgraded) to support transporting the riprap from the quarry to the barrier construction site. Haul costs (especially from off-site sources) may be reduced if existing and old railroad grades are used. Once it is known which sites are acceptable for quarry development and which waste sites will require given volumes of riprap, a detailed transportation and infrastructure study should be conducted to determine the costs and benefits of specific modes of haulage (e.g., truck, rail, conveyor) and transportation route alternatives.

Strictly from an engineering perspective, the highest ranking site is the group of basalt outcrops identified immediately west of Gable Butte proper. The haul distance factored heavily in the ranking of this site as the first choice. These outcrops provide the shortest haul distance (and lowest transportation cost) to the 200 Areas, where most surface barriers are expected to be constructed. The remainder of the highest ranking candidate quarry sites are along the basalt outcrops stretching from Gable Mountain to the Vernita Quarry.

Initial cultural resource data from surveys conducted on Hanford property indicate that the most favorable sites for quarry development from an engineering perspective are the least favorable for development from a cultural resource perspective. The elevated features of these outcrops that make them desirable for quarry development are much the same features that are desirable to the Native Americans for cultural and religious practices. Consequently, a greater number of cultural sites and isolates per unit area are found along these outcrops. Conversely, the lowest ranking sites for quarry development from an engineering perspective are the most desirable of the alternatives for quarry development from a cultural resource perspective. The low ranking candidate quarry sites on Hanford property are near-surface basalt sources and/or do not have a commanding view of the surrounding terrain that was typically attractive for Native American cultural and religious practices. Therefore, fewer cultural sites and isolates per unit area are found at these candidate quarry sites. However, these sites will accrue the greatest transportation costs of the all the sites within Hanford boundaries.

This Site Evaluation Report provides information important to the decision making process for siting a basalt materials quarry to support surface barrier construction. A number of candidate sites are presented in this report that cover a wide range of possibilities for development. After receiving direction from DOE-RL on acceptable sites for quarry development, the regulatory and permit preparation, settlement of outstanding issues, operations and infrastructure planning, production planning, and development of the basalt resources can begin.

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ACRONYMS AND ABBREVIATIONS

ALE	Arid Land Ecology Reserve
ARAR	Applicable or relevant and appropriate requirement
BDT	Barrier Development Team
BHI	Bechtel Hanford Incorporated
BWIP	Basalt Waste Isolation Project
CRS	Cultural Resource Survey
D&D	Decontamination and Decommissioning
DOE-RL	U.S. Department of Energy Richland Operations Office
ERDF	Environmental Restoration Disposal Facility
HCRL	Hanford Cultural Resources Laboratory
HISB	Hanford Isolation Surface Barrier
ICF KH	ICF Kaiser Hanford Company
kg	kilogram
km	kilometer
lb	pound
m^3	cubic meter
mi	mile
NEPA	*National Environmental Policy Act*
PNL	Pacific Northwest Laboratory
RCRA	*Resource Conservation and Recovery Act of 1976*
SER	Site Evaluation Report
SHPO	State Historic Preservation Officer
SR	State Route
T&E	Threatened and Endangered
t	metric ton
ton	short ton
TRU	transuranic
TWRS	Tank Waste Remediation System
USGS	United States Geological Survey
WHC	Westinghouse Hanford Company
yd^3	cubic yard

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

A basalt quarry is required to supply sufficient quantities of riprap material to support construction of protective surface barriers at the U.S. Department of Energy (DOE) Hanford Site in Richland, Washington. Chapters in this Site Evaluation Report (SER) include information on protective surface barriers at Hanford, estimated volumes of riprap required for those barriers, site selection criteria, and site evaluations. Appendices are included that provide details on the candidate quarry site ecological surveys, cultural resource surveys, and quarry reclamation.

DOE-RL Order 4320.2C stipulates that siting of Hanford facilities must meet program requirements while considering economic, engineering, and site planning factors. Specifically, the scope of this order includes the "removal of soil or gravel for transport to other locations." The purpose of this SER is to identify candidate basalt quarry sites, evaluate these sites against engineering criteria, and to provide information and recommendations to aid with final site selection. Because locating a sufficient quantity of basalt at a suitable site is paramount to this SER, this study focuses on the location of potential basalt sources on or near the Hanford Site and does not investigate detailed costs associated with transportation route and haulage mode alternatives, which will be completed at a later date after the final site or sites are selected. In addition to newly selected basalt resource sites, those previously investigated by Myers (1985) will be included in the evaluation, to provide completeness and continuity for ranking and scoring the broad range of possibilities for quarry sites.

In order to construct a matrix to determine the relative acceptability of each site, candidate quarry sites will be evaluated against a set of engineering criteria that are deemed most significant to the quarry site selection process. The sites will be ranked in order of acceptability, with the first site as the preferred candidate.

Because it is desirable to minimize the impact to natural resources as much as possible for a project of this magnitude, ecological surveys were completed at the area of impact for all on-site candidate quarries to identify threatened and endangered (T&E) species. The ecological surveys also document all other plant and wildlife species observed in order to better understand the overall impact to all natural resources present at the candidate quarry sites. Although cultural resource surveys have been conducted on 50 percent of each Hanford Site candidate quarry, it is not economically feasible to perform a complete survey on every candidate quarry at this time. Best judgement by qualified survey personnel using currently available cultural resource information, coupled with new pedestrian surveys at sites lacking information, were used to assess the cultural, archaeologic, and historic sensitivity of these sites. This consideration is important because future cultural resource surveys and/or T&E species surveys can affect siting decisions. If the preferred site is not approved for quarry development, the next site on the list will become the preferred site for development upon direction from the U.S. Department of Energy Richland Operations Office (DOE-RL). Off-site quarries will be surveyed for cultural resources at a later time if it appears these sites will be used as a source for riprap.

1.2 BACKGROUND

More than 40 years of plutonium production at the DOE Hanford Site near Richland, Washington has resulted in contamination of many building components and parcels of land. Additionally, millions of liters of high-level radioactive and mixed process wastes are stored in 177 underground storage tanks - 149 of which are of single-shell construction (DOE-RL, 1991; Stahl and Coles, 1992). Of these, 66 tanks are suspected or known to have leaked radioactive liquid waste into the ground. More than 50 percent of the nation's defense production-related wastes are found at Hanford (DOE-RL, 1991), including radioactive and mixed process wastes, solvents, heavy metals, and acids. Before 1970, contaminated solid wastes, plutonium, and hazardous chemicals were buried in trenches. After 1970, most plutonium-contaminated wastes were placed in partially lined vaults or surface trenches designed for easy retrieval.

Many contaminated facilities at Hanford are slated for decontamination and decommissioning (D&D) during the next several decades. Considerable quantities of material resulting from D&D work can be expected, and much of it will require a permanent and stable disposal solution. Solid, radioactive, hazardous, and/or mixed waste forms will need to be disposed of during the remediation of contaminated sites. Some of these waste forms may be sent to facilities to be sorted, stabilized, and packaged for disposal in an isolated environment protected by surface barriers. In some cases, it may be found that wastes should be left in place because the risk to the safety and health of workers is greater if the wastes are removed or excavated. In other cases, less dangerous waste forms may require some form of short-term stabilization, yet are not economically feasible to retrieve and place elsewhere. In all these scenarios, the waste form can be isolated by engineering and constructing surface barriers over the waste site. A surface barrier will isolate these wastes from environmental variables such as rain, wind, erosion, vegetation intrusion, animal intrusion, and inadvertent human intrusion.

1.3 PROTECTIVE SURFACE BARRIERS AND COVERS

Whether the solution calls for wastes to remain in situ or disposed of in an engineered facility, protective surface barriers are being considered for construction over contaminated sites to isolate the wastes from external environmental variables. The design of the protective surface barriers can include a variety of protective functions based upon specific waste site requirements. For example, protective surface barriers can be designed to isolate wastes from deeply infiltrating precipitation (from rain or snow) by storing and/or recycling water back to the atmosphere. By incorporating a layer consisting of several meters of riprap, wastes can be isolated from animal intrusion, plant root intrusion, and inadvertent human intrusion. Other useful functions can be designed into a protective surface barrier system that will isolate the waste from undesirable forces, such as wind erosion, water erosion, and subsidence, which can be expected to occur over an extended period of time. Besides minimizing deep infiltration of precipitation as described previously, protective surface barrier systems can also perform one or more of the following (Daniel and Koerner, 1992):

- Raise ground surfaces in low-lying areas
- Reduce precipitation runoff
- Promote controlled runoff of precipitation remaining on the surface
- Control gas release from the waste form.

Use of natural soil and rock materials in the design of protective surface barriers can enhance their long-term integrity and minimize maintenance requirements. Many synthetic materials are available that, when properly installed, provide excellent short-term impediments to moisture migration. However, long-term performance characteristics of synthetic materials are unknown, so the materials cannot be relied upon to perform as desired in a protective surface barrier designed to last a millennium or more.

2.0 BARRIERS AT HANFORD

2.1 BARRIER BACKGROUND

Since the end of the Cold War, the perceived threat from former Warsaw Pact countries has been greatly reduced, resulting in a planned dismantling of many facilities used to produce materials for nuclear weapons and an end to plutonium production. The DOE has changed the focus of its mission at Hanford from plutonium production to mitigating environmental remediation issues resulting from more than 40 years of defense production. This tremendous task will tackle environmental remediation projects at a scale never before undertaken anywhere in the world. Technologies and practices must be developed to help engineers and scientists with the remediation challenges at Hanford.

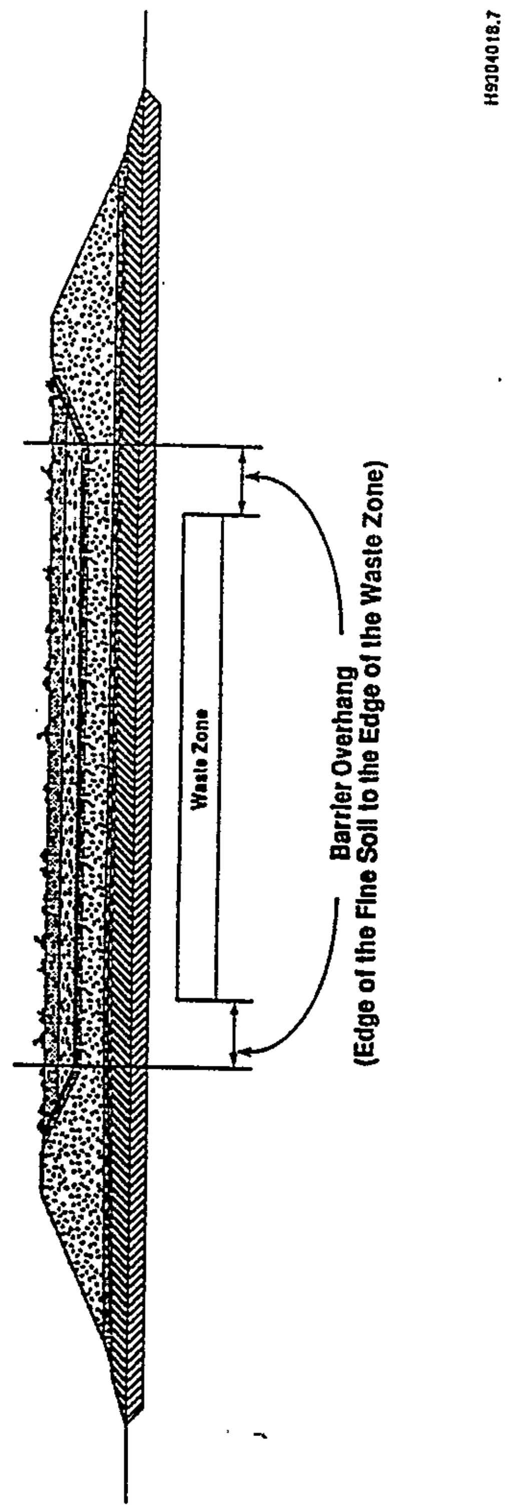
In response to some of the environmental remediation challenges, the *Hanford Waste Management Plan* (DOE-RL, 1987a) calls for development, evaluation, and demonstration of barriers for use in waste disposal activities at the DOE Hanford Site in Richland, Washington. A companion document, the *Hanford Waste Management Technology Plan* (DOE-RL, 1987b), provides additional detail for the scope and direction of barrier technology development activities to facilitate selection of an appropriate barrier design for use in remediation and waste disposal activities at Hanford.

To meet this challenge at Hanford, a Barrier Development Team (BDT) was organized to develop technologies required to provide a long-term surface barrier. The BDT comprised engineers and scientists from Westinghouse Hanford Company (WHC), Pacific Northwest Laboratory (PNL), ICF Kaiser Hanford (ICF KH), and Bechtel Hanford Incorporated (BHI)[(1)]. Fifteen task groups were identified to investigate areas important to protective surface barrier performance, such as biointrusion control, water infiltration control, and erosion control (Wing, 1993). Technology development and research activities by the BDT at Hanford have led to a nationally peer-reviewed design for a protective surface barrier system for long-term protection and isolation of buried waste forms.

The Hanford Isolation Surface Barrier (HISB) (Figure 2-1) has been developed to provide extended protection and isolation to buried radioactive, hazardous, or mixed waste forms from the long-term effects of infiltrating precipitation; erosion; and animal, human, or vegetation intrusion. In turn, the HISB provides protection to plant life, animal life, and

[(1)] Bechtel Hanford Incorporated now administers the Environmental Restoration funding for the Barrier Development Program; formerly administered by Westinghouse Hanford Company prior to July 1994.

Figure 2-1. Hanford Isolation Surface Barrier.



water resources by acting as an impediment to natural forces that could transport unprotected waste across the surrounding landscape or into the groundwater.

A graded barrier concept is also under consideration for use at Hanford. The graded barrier concept is based on designing barriers with features varying from the HISB to meet the cover and closure requirements of a particular waste site. The HISB provides the greatest degree of isolation and protection for the waste form in the graded barrier concept. Further details on the HISB can be found in Wing (1993) and Wing (1994). Under the graded barrier concept, the HISB will be applied to high-risk and high-danger sites, such as those containing transuranic (TRU) waste and to sites requiring protection over many hundreds or thousands of years. In concept, the remaining graded barriers would be applied to sites with less demanding waste protection requirements.

The graded barrier approach is in the conceptual stage, and definitive designs have not been approved as of this writing. A cost/benefit analysis should be conducted of the surface barrier definitive design alternatives to choose the most appropriate barrier for a given application. This analysis must consider the impacts of short-term and long-term barrier performance, and the level of protection or isolation required at the surface of a given waste site to achieve the desired end result set forth by applicable or relevant and appropriate requirements (ARAR). Because the purpose of this SER is to secure a sufficient quantity of riprap to support surface barrier construction, and because the HISB requires the greatest quantity of material, the conservative assumption is made that only the HISB will be used to cover waste sites. This will establish an upper bound of material required.

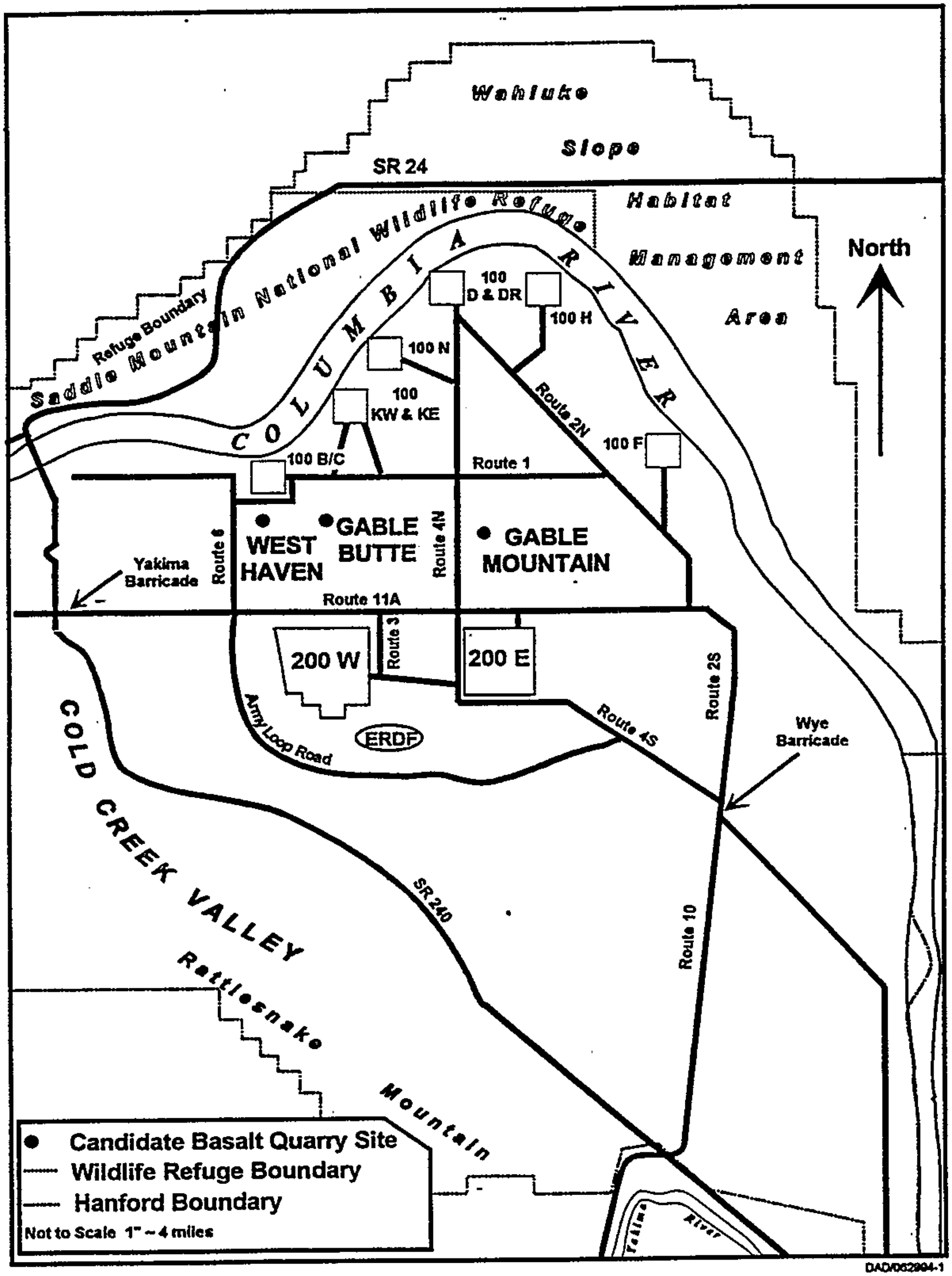
2.2 PREVIOUS SITING STUDIES FOR BARRIER MATERIALS

Several studies have been conducted to secure materials suitable for use in barrier construction (Myers, 1985; Skelly and Wing, 1992). These studies investigated the availability of a variety of materials, including basalt, fine soils (silt), sands, and gravels.

2.2.1 Basalt

Three basalt sources were identified as candidate quarry sites for barrier materials in Myers (1985) and include the outcrops at Gable Mountain, Gable Butte, and West Haven. These sites are located north of the 200 Areas plateau relatively close to the proposed ERDF and other potential sites for protective surface barriers in the 200 Areas. The locations of these sites are shown in Figure 2-2, and the land parcel coordinates are given in Table 2-1.

Figure 2-2. Candidate Basalt Sources from Previous Materials Study.



Minimizing distance would result in a considerable cost savings compared with a site farther removed from the 200 Areas plateau, which makes Gable Mountain, Gable Butte, and West Haven attractive for basalt quarry development. Each of these sites could supply all the basalt required for protective surface barriers at Hanford based on current estimates.

Myers (1985) cites Gable Butte as the preferred location for basalt quarry development and truck as the preferred mode of transferring the basalt to the barrier construction site. Reasons given for this choice included the following:

- Central location relative to potential protective surface barrier sites
- Location in relation to other site activities
- Specific location, which is near existing railroad and paved roads that could simplify transportation and distribution of the basalt riprap
- Essentially unlimited supply of basalt.

However, immediate plans to pursue quarry development at Gable Mountain, Gable Butte, and West Haven were suspended because of their cultural significance to the Native Americans. Information from tribal elders (Chatters, 1989) conveys the spiritual and mythical importance of basalt outcrops such as Gable Mountain and Gable Butte, including all outcrops of Gable Butte, to the Native American people. Chatters (1989) indicates that Gable Mountain and Gable Butte also were to be nominated as cultural districts.

Table 2-1. Land Tract Coordinates for Candidate Quarry Sites in Myers (1985).

Site Name	USGS Quadrangle (WA)	Land Parcel Location
Gable Mountain	Gable Butte	• E1/2, SW1/4, Section 15, T13N, R26E • W1/2, SE1/4, Section 15, T13N, R26E
Gable Butte	Gable Butte	• W1/2, NW1/4, Section 19, T13N, R26E • W2/3, S2/3, Section 18, T13N, R26E • NE1/2, Section 24, T13N, R25E • NE1/4, Section 24, T13N, R25E
West Haven	Riverland	• S1/2, N1/2, Section 14, T13N, R25E

2.2.2 Fine-Textured Soils and Coarse Soil Materials

Materials other than basalt already have been identified on Hanford property for use in constructing protective surface barriers. Skelly and Wing (1992) identified McGee Ranch as the only site with large volumes of suitable textural properties - a critical protective surface barrier component. The extensive reserves of fine-textured soils quantified at the McGee Ranch site (Lindberg, 1994; Last et al., 1987) include volumes of more than 31 million m^3 (40 million yd^3).

Sand and gravel reserves have been identified at Pit 30 in the 200 Areas corridor (between the 200 East and 200 West Areas). Approximately 129 ha (320 acres) of land have been identified for expanding the current gravel pit to the north and west to accommodate the long-term needs of protective surface barrier construction. Also, this proposed expansion has been incorporated into the master planning process for the TWRS Complex to ensure project coordination (Appendix A). Several materials will be removed from Pit 30 for barrier construction, including pea gravel, graded-filter media, and drainage gravel.

2.3 BASALT RIPRAP FUNCTION

Each layer of the HISB (Figure 2-1) contributes a specific and important function to the overall performance of the barrier system. The prototype HISB contains a 1.5-m-thick (4.9-ft) layer of basalt riprap that serves two important functions: one as a bio-intrusion impediment layer and the second as a primary component for construction of barrier side slopes.

The quantity of basalt within the numerous outcrops on the Hanford Site and surrounding region make basalt an ideal choice for use as a component in barrier construction. The size and nature of the basalt riprap in the HISB make it a formidable obstruction to burrowing animals and an impediment to inadvertent human intrusion. Additionally, the angular nature of the riprap allows the stones to interlock with other pieces of riprap, which provides stability for the side slopes. These qualities make basalt riprap superior to other natural materials, such as smooth cobbles, which are not as stable on steep slopes (e.g., 2H:1V).

Obtaining enough cobbles (at the specified gradation) from Hanford soils would be difficult. Although cobbles and gravels are commonly found in many parts of Hanford, vast areas of land would have to be stripped to secure the millions of cubic yards with a gradation of 25 cm (10 in.) minus with a D_{50} of 10 cm (4 in.). Considering the environmental focus at Hanford, this option is neither reasonable nor in the best interest of Hanford, because large tracts of land would have to be reclaimed.

2.3.1 Biointrusion Impediment

The basalt riprap layer protects the HISB layer of asphaltic concrete/fluid-applied asphalt by impeding the biointrusion of animals, humans, and plants. Protecting the integrity of the asphalt layer and ultimately the waste form is extremely important. This asphalt layer is the final impediment between the waste form and infiltrating water. If the integrity of the asphalt layer were compromised, the potential for a moisture front reaching the waste form is greatly increased should water percolate to the depth of the asphalt. Holes and cracks created by animals or plants in the gently sloping asphalt layer would act as a point or line sink for water moving across the top of the of the asphalt layer.

2.3.2 Side Slope Stability

The prototype HISB design incorporates a side slope composed of basalt riprap (Buckmaster, 1993). The basalt stabilizes the side slopes against the detrimental effects of wind and water erosion. Wind and water can easily scour and transport small soil particles, such as silt and sand, from exposed surfaces. Over time, enough material could be removed from a fine-textured side slope to cause side slope failure, compromising barrier performance. However, because the side slopes are constructed of riprap instead of fine-textured materials, they will withstand erosional forces from the most severe elements that can be expected at Hanford.

3.0 BARRIER BASALT VOLUME REQUIREMENTS

3.1 BARRIER BASALT VOLUME REQUIREMENTS STATUS

Basalt volume requirements for all protective surface barrier applications at Hanford is not known as of this writing. However, unpublished estimates exist for several configurations of the protective surface barrier that may be implemented at the proposed ERDF and can be used to assist in determining overall volume requirements.

A single trench over 3,105 m (10,000 ft) long and over 386 m (1,266 ft) wide is one configuration that has been proposed for the ERDF. Material volume calculations indicate this trench will require nearly 2.3 million m^3 (3 million yd^3) of riprap using the HISB design. The size and configuration for the ERDF may change over time; however, this configuration will be used for the basis of estimating riprap volumes in this SER.

Many issues must be resolved before accurate volume requirements can be established for barrier materials such as the basalt riprap. Issues requiring further resolution include the following:

- Defining and finalizing the overall long-term waste disposal strategy, particularly for the 200 East and 200 West Areas
- Determining where protective surface barriers will be implemented
- Finalizing the design, configuration, and size of barriers for the sites identified as requiring surface barrier isolation.

3.2 FUTURE BASALT VOLUME ESTIMATE

Although basalt riprap volume requirements are not known for other future barrier applications, some order-of-magnitude approximations can be made using surface-area estimates of known burial grounds and tank farms in the 200 East and 200 West Areas. A considerable quantity of potential protective surface barrier applications exist in the 200 Areas, such as large burial grounds, numerous existing tank farms, future double-shell tank farms, disposal cribs, and process trenches. Locations and descriptions of active and inactive waste sites in the 200 East and 200 West Areas are given in Stenner (1988).

An order-of-magnitude estimate establishes an upper bound for future riprap volume requirements based on actual waste disposal site information. If the area of the waste sites selected for protective surface barrier construction increases or decreases from the assumptions in this SER, the volume calculations can be easily adjusted to accommodate the change.

3.2.1 Assumptions for Future Volume Requirements

To establish a base from which to estimate riprap volume requirements for protective surface barrier construction, the following generalized assumptions were made. These assumptions simplify what otherwise would be a complicated task for determining material volumes for several graded barrier designs applied to hundreds of potential candidate waste sites. Also, these assumptions do not prescribe a barrier implementation strategy and are for the sole purpose of estimating, within an order-of-magnitude, riprap volume requirements.

- All wastes will be disposed of in 200 East, 200 West, or the ERDF (i.e., there will be no protective surface barrier applications requiring basalt riprap in the 100 Areas).
- Estimates for barrier riprap volumes are based on the HISB configuration because it is the most thoroughly tested and documented protective surface barrier design and is the only surface barrier to have completed the entire engineering design process at Hanford.
- All burial grounds and tank farms will be covered by a protective barrier to provide long-term isolation and protection.
- Large barriers will be used to cover all contiguous waste sites in a given area (i.e., adjacent tank farms and burial grounds) rather than small, individual barriers for each waste site.
- Waste forms existing in the 200 Areas that are in an area not identified to be covered by one of the large surface barriers will be moved to a location in an area that will be covered by a barrier appropriate for that waste form.

3.2.2 Basalt Volume for 200 East and 200 West

Calculations for riprap volume for the 200 East and 200 West Areas were made using the assumptions outlined in the previous section. Seven barriers were configured in the 200 Areas, including five in 200 East and two in 200 West. Additional details for these barrier configurations are included in Appendix B. Calculations for ERDF riprap volumes were made assuming a trench with dimensions of 3,105 m x 386 m (10,000 ft x 1,266 ft).

Volume calculations were made using a spreadsheet programmed by the HISB development team members to determine material volume requirements and costs for constructing the HISB. The spreadsheet calculations were written assuming the site prepared to receive the surface barrier is level graded over the entire barrier footprint. Calculations in this spreadsheet are based upon the core barrier dimensions entered by the user. The core dimension is the rectangular measurement (length and width) of the waste site to be covered by the barrier, plus 10 m (33 ft) overhang added to each side (i.e., 20 m [66 ft] total added to the length and width of the waste site). Riprap side slopes project outward from the edge of each side and corner of the barrier at a 2H:1V slope (user specified) from the top of the barrier surface downward to the surrounding level ground surface. The spreadsheet calculates basalt volume requirements for a barrier with a horizontal core riprap layer thickness of 1.5 m (4.9 ft) and with basalt riprap side slopes (2H:1V) on all sides.

An estimated 12.4 million m^3 (16.2 million yd^3) of basalt riprap will be required for the 200 Areas protective surface barriers. These are order-of-magnitude numbers only and are meant to establish a riprap material volume based on an estimated surface area of actual 200 Areas waste sites that have potential barrier applications. The actual volume of basalt required for constructing future barriers cannot be determined until the issues presented in Section 3.1 are resolved. Tasks requiring detailed material volume requirements for future barrier applications should use numbers from more detailed analyses based on information resulting from the finalization of barrier sites and finalized barrier configuration and design.

The 200 Area basalt riprap requirements plus the riprap requirements for the ERDF barrier yield a total requirement of 14.5 million m^3 (19.0 million yd^3).

3.2.3 Other Basalt Requirements

In addition to the basalt required for use in surface barrier construction, other construction projects across the Hanford Site may require basalt materials. A variety of road construction projects on the site may require basalt material for road bed top course and aggregate for the asphaltic concrete road surface. Future road construction projects that may require basalt materials include the possible widening of SR 240, construction of barrier material haul roads, and construction of a road from the 100 Areas to the 200 Areas plateau that will be used to transport reactor blocks for disposal. The volume of basalt riprap required for these projects is not known, but each may require

765,000 m^3 (1 million yd^3) or more. Basalt materials for these projects can be handled through expansion of the quarry selected for development.

4.0 SITE SELECTION CRITERIA

The following sections describe qualifying criteria and engineering criteria used during the evaluation process in this SER for identifying candidate sites for basalt quarry development. DOE-RL Order 4320.2C (DOE-RL, 1990) was used for guidance in establishing these criteria. This order lists factors that should be considered for site evaluation and categorizes them into two groups: (1) environmental, safety, and security factors, and (2) engineering/economic factors.

4.1 ENVIRONMENTAL, SAFETY, AND SECURITY FACTORS

DOE-RL Order 4320.2C lists six environmental, safety, and security factors. These factors are listed below along with their applicability and relevance to the basalt quarry siting process.

- Terrestrial, aquatic, and archaeological factors.

  Applicable. Biological and cultural resources must be assessed. Aquatic factors are not expected to be impacted by quarry development. Cultural resource surveys and T&E species surveys will be conducted at the quarry site and issues will be resolved before operations begin.

- Aesthetics

  Applicable. The aesthetics of the site after quarry operations are completed must be considered. This factor is considered during evaluation of the Land Reclamation engineering criterion.

- Separation distance and buffer zones

  Applicable. Buffer zones must be considered prior to quarry development. These zones may be required for biological resources protection, cultural resources protection, separating quarry activities from public corridors (roads), and for protecting structures or power lines. Required buffer zones will be specified in a Mitigation Plan resulting from cultural resource surveys or T&E species surveys or may be specified in the quarry operations or safety plans.

- Limited or protected areas

  Not Relevant. None of the Hanford Site candidate quarries are located in limited areas. Quarries located within Hanford boundaries are in remote portions of property protection areas (600 Area) only. This factor does not apply to off-site candidate quarries.

- Long-range planning and compliance

  Applicable. The ICF KH Site Planning organization has been and will continue to be involved in the siting activities of barrier materials. Site Planning is aware of proposed and planned construction and infrastructure activities across the Hanford Site and is the point of contact for implementing barrier material borrow site requirements and infrastructure into the master plan. Compliance with regulatory requirements will be assured by involving regulatory personnel in the planning process and at the appropriate stages as the project advances.

- Special Design Requirements

  Not Relevant. No design requirements out of the ordinary are expected.

4.2 ENGINEERING/ECONOMIC FACTORS

DOE-RL Order 4320.2C lists ten engineering/economic factors. These factors are listed below along with their applicability and relevance to the basalt quarry siting process.

- Total Energy Consumption

  Applicable. Total energy consumption will be a significant factor of the quarry operations and barrier construction. The largest single contributor to energy consumption is transporting the riprap from the quarry to the barrier construction site. This is dependent on the transportation factor listed below and is evaluated, in general terms, in the Haul Distance engineering criterion.

- Site Services

  Not Relevant. No additional site services out of the ordinary (such as patrol or fire) are expected to be required. Services at the quarry (electrical generation, potable water, sanitation services, etc.) will be the responsibility of the contractor in charge of quarry operations.

- Topography, geology, and hydrology

  Applicable. Because the quarry will alter the landscape, the topography and hydrology of the local area must be considered. The geology of the site (specifically, the location of the basalt) will control how the quarry is developed. However, because the basalt formations are very large, quarry development is not expected to require any extraordinary efforts from an operations perspective. Specific quarry development details are not part of this SER, but will be included in a separate operations development plan. This factor is related to those considered during evaluation of the Expansion Potential and Land Reclamation engineering criteria.

- Decontamination and Decommissioning

  Not Applicable. All on-site and off-site candidate quarry sites are located in clean areas and are far removed from any process related structures or facilities that may be contaminated by radioactive, hazardous, or mixed waste constituents.

- Utilities

  Not Applicable. No site utilities are expected to be required for the quarry operations. All required electrical generators, potable water, cellular phones, and other such necessities will be provided by the contractor in charge of quarry operations.

- Meteorology and Climatology

  Applicable. Meteorology and climatology should be considered. The primary consideration will be control of wind-borne dust - runoff is not expected to be a major problem in Hanford's arid climate. Specific dust control procedures are not part of an SER but should be incorporated into the quarry operations development plan. However, blowing dust is a consideration for the safety criterion (mainly the proximity to public roads) in Chapter 5 and borrow operations consideration as discussed in Chapter 6 of this SER.

- Transportation

  Applicable. Transportation (related to total energy consumption listed previously) is a significant consideration. The greater the transportation distance from the quarry to the barrier construction site, the greater the costs and energy input for moving the riprap. This factor is evaluated, in general terms, when applying the Haul Distance engineering criterion.

- Removals/Relocations

  Applicable. Although no facilities or buildings are near the Hanford Site candidate quarries, there may be power or utility poles that require relocation or a buffer zone to be established to isolate them from quarry activities. This is a secondary consideration during evaluation of the Safety engineering criterion.

- Relationship to nearby facilities

  Not Relevant. There are no nearby facilities or buildings in the area of the Hanford Site candidate quarries.

- Expansion

  Applicable. A reasonable area for quarry expansion must be considered a factor for the candidate quarry site in order to meet unaccounted future needs. This is considered during evaluation of the Expansion Potential engineering criterion.

4.3 QUALIFYING CRITERIA

Qualifying criteria are used to determine if a given site warrants further consideration for quarry development (i.e., application of the engineering criteria). After the qualifying criteria are satisfied, the engineering criteria can be applied, and each site can be evaluated. The qualifying criteria are described in detail in the subsections that follow.

Historic, archaeologic, and cultural resource impacts are normally used as a qualifying criterion in an SER. This criterion establishes that historic, archaeologic, and cultural resource impacts must be investigated and considered during the evaluation process. However, because only about half of each Hanford Site candidate quarry has been surveyed, the database for historic, archaeologic, and cultural properties is incomplete and, therefore, cannot be used as a qualifying criterion at this time. Before quarry operations begin, the historic, archaeologic, and cultural resources for on-site and off-site quarry developments must be fully assessed and evaluated for listing on the National Register.

If it is determined that these resources will be impacted at a candidate quarry site, a Mitigation Plan must be developed that outlines the procedures for mitigating the resources of concern. It is also possible that mitigation is economically prohibitive or is not an option at all. Development of the Mitigation Plan will include assessment and reporting of significant historic, archaeologic, and cultural findings and dialogue, through the DOE-RL, with the State Historic Preservation Officer (SHPO) and Native American stakeholders.

If a significant issue pertaining to any of the qualifying criteria arises, the DOE-RL must provide direction on whether or not to pursue a given site. If a site is eliminated from consideration for development as a quarry, the next highest ranking site (see Chapter 5) will become the preferred quarry for development.

4.3.1 Hanford Site Proximity

This criterion establishes the need to locate candidate quarry sites near the Hanford Site, preferably within Hanford boundaries and close to the 200 Areas where many barrier applications are expected. Identifying candidate quarries as close to the 200 Areas as possible will minimize costs associated with transporting large quantities of riprap from the quarry to the barrier construction site. Transporting riprap from off-site will increase transportation costs considerably (likely by hundreds of millions of dollars). Locating a source of basalt within Hanford Site boundaries also eliminates the costs associated with purchasing riprap from private owners. However, as a contingency, off-site sources should be considered a viable alternative to on-site sources.

4.3.2 Basalt Availability

This criterion establishes that a site under consideration must be known to have, or, using the best available information, be believed to have a sufficient quantity of basalt (near-surface or outcrop) to justify development of a new quarry or use of an existing quarry. To be considered in this SER, a candidate quarry site must have the potential for producing at least 7.6 million m^3 (10 million yd^3) of competent basalt riprap, which is approximately half of the basalt requirement estimated in Chapter 3. Because geologic logs are not available for many areas at Hanford or the off-site sources, judgement by and consultation with geologists familiar with basalt formations and characteristics at the Hanford Site were used to identify candidate quarry sites. Off-site quarry basalt volumes and availability were determined through conversation with the appropriate commercial quarry operators.

4.3.3 Suitability of Basalt

This criterion establishes a requirement for the basalt riprap to be suitable for use as a barrier component. To meet this objective, the basalt source must be physically competent and must have the capacity to produce the desired size fraction of 25 cm

(10 in.) minus with a D_{50} of 10 cm (4 in.). Historical quarry production (for existing quarries) and known characteristics of local basalt formations can be used to determine suitability. Consultations with geologists familiar with basalt characteristics and formations on the Hanford Site were used to determine likely locations of suitable basalt.

In general, mechanical properties of basalt, such as compressive strength, vary with location in a flow. Dense interior basalts usually exhibit a relatively high compressive strength, while flow-top or weathered basalts exhibit relatively low compressive strength (DOE-RL, 1988). Basalt riprap used in protective surface barrier construction should be composed of high-compressive-strength interior basalts instead of flow-top or highly weathered material. Weaker flow-top and weathered basalt material is considered unsuitable for use in barrier construction at this time because of its porous nature and tendency to crumble into smaller pieces relative to the dense competent basalt. However, the quality or minimum standards for riprap required for a particular barrier construction project should be noted in the barrier construction specifications.

Interior basalt will form angular pieces with many rough edges during blasting and crushing operations at the quarry. The angular nature and roughness of the end product is required because these properties provide a means for the basalt pieces to interlock within the riprap layer, creating a layer that is more stable than one composed of smooth cobbles. The interlocking action of riprap may provide a bridging effect that would act as a buffer against barrier surface subsidence should there be minor settling or deterioration of the underlying waste form.

4.3.4 Threatened and Endangered Species Impacts

Each candidate quarry site must be surveyed for flora and fauna species that reside in and use the area of concern. An ecological assessment will document any plant or wildlife species that are federal or state listed as T&E and will make note of other species of concern in the area of impact. If a federal or state listed threatened or endangered species is found at a candidate site, a T&E species Mitigation Plan would need to be developed to address what is required before operations can proceed. Based on the nature of the circumstances and information from the T&E species Mitigation Plan, DOE-RL can provide direction on whether to pursue the given site for quarry development. A T&E species survey has been performed for each of the Hanford Site candidate quarries. Findings from ecological surveys for T&E species at the candidate basalt quarry sites are documented in Appendix C. This appendix contains a list of all flora and fauna species observed at each quarry site and specifically calls out species of special concern observed during the surveys. The ecological surveys found no federal or state listed T&E flora or fauna species at any of the Hanford Site candidate quarries. Required T&E species surveys at off-site quarries will be conducted as needed.

4.4 ENGINEERING CRITERIA

Candidate sites that satisfy the qualifying criteria will be evaluated against the set of engineering criteria listed below. The engineering criteria will determine which site is the most suitable for development of a quarry to produce riprap for barrier construction. These criteria are as follows:

- Haul Distance
- Safety
- Expansion Potential
- Land Reclamation.

A weight will be assigned to each engineering criteria to indicate its relative importance toward selecting a site for quarry development. Numerical values ranging from 1 to 10, in increments of one unit, will be used to accommodate the weighting scheme. The significance of the numerical value assigned to each of the engineering criteria is described below.

- **10 - Extremely Significant.** A criterion with this weighting carries the highest level of influence and project impact and is of the highest degree of importance and consideration to the given candidate quarry site.

- **8 - 9 = Very Significant.** A criterion with this weighting is influential and important to the given candidate quarry site, but is not of the highest degree of importance.

- **4 - 7 = Significant.** A criterion with this weighting merits special consideration and has some impact on the given candidate quarry site, but is of secondary importance in one or more aspects.

- **1 - 3 = Slightly Significant.** A criterion with this weighting holds only secondary importance and has minimal impact on the given candidate quarry site.

4.4.1 Haul Distance (Weight = 10)

Costs for transporting the basalt riprap from the quarry to the barrier construction site will be a significant component of the overall project costs. The magnitude of this issue is clarified when considering if 15.3 million m^3 (20 million yd^3) of basalt riprap must be transported at \$0.27 per t-km (\$0.40 per ton-mi)[2], the cost is approximately \$8.2 million/km (\$13.2 million/mile). Haul distance must be minimized to prevent transportation costs from becoming prohibitive. Another factor that is given some consideration for this criterion is whether or not costs will be accrued for constructing new roads, maintaining existing roads, building rail spurs, or placing conveyor systems. For example, if public highways are used by the haul trucks, it is assumed costs will be accrued for maintenance and repairing damage to the road surface caused by the extensive hauling operation. Also, road upgrades and maintenance are assumed to be required for all Hanford roads used by the haul trucks. Detailed costs are not calculated for these maintenance and upgrade factors, but are analyzed from the perspective of whether they will likely be needed for the given haul routes. A detailed transportation and infrastructure study will be required to identify specific costs for the transportation and haul route alternatives.

4.4.2 Safety (Weight = 10)

Each site must be evaluated for safety issues and potential dangers associated with site operations and transportation routes used for moving riprap from the quarry to the barrier construction site. The degree of interaction with highway traffic and the likelihood of quarry operations distracting motorists (via dust, general operations, etc.) will be considered for this criterion. Because safety issues (i.e., equipment and dangers) related to quarry operations tend to be a constant from site to site, they tend not to affect the overall rating for the candidate sites. However, it is very important to minimize danger and risk and maximize personnel and public safety wherever the quarry is developed and to apply ARAR at all times.

4.4.3 Expansion Potential (Weight = 6)

Each site will be evaluated for its expansion potential beyond the minimum qualifying riprap volume of 7.6 million m^3 (10 million yd^3) and beyond the perceived upper bound of 15.3 million m^3 (20 million yd^3). This criterion holds significance to the overall project because a potential for new applications that will require the use of basalt riprap (or other basalt products) always exists, or a significant expansion of protective surface

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(2) t = metric ton (1,000 kg) and ton = short ton (2,000 lbs)

barrier applications may develop. Value ratings for expansion potential for Hanford Site candidate quarries are based on the estimated lateral extent of the basalt formation in the desired area and the estimated yield-per-unit depth of excavation below a baseline at each candidate site. The baseline is the horizontal plane through the boundaries of the quarry at a given elevation (refer to Section 5.0). A large lateral extent is considered more desirable than a small lateral extent because the depth of excavation to obtain a unit volume of basalt riprap can be minimized with the former. The rating for expansion potential for the off-site quarries is based upon conversation with the appropriate commercial quarry operators.

4.4.4 Land Reclamation (Weight = 5)

DOE Order 4320.2C (DOE-RL, 1990) lists aesthetics and impact to the environment as criteria for evaluating candidate sites for a proposed project. Impacts to the surrounding landscape and natural resources by quarry development and related activities should be minimized when feasible. Therefore, land reclamation is considered a criterion with some significance to the quarry siting process. Land reclamation will have varying degrees of success, depending on the nature and characteristics of the quarry site. Minimizing physical impact to the land will lessen costs required to restore the land to a given level. Although the degree of restoration required is not known at this time, those standards may be determined by regulatory requirements or through negotiation with various state agencies, federal agencies, and Native Americans.

The primary consideration for evaluating the candidate site against this criterion is how much effort is believed to be required to return the site to a condition similar to that which existed before quarry operations. The location of the quarry, type of quarry, and nature of the surrounding environment will affect the value given to a candidate site for this criterion. Although this criterion is open to individual interpretation, it is assumed for this SER that success for a given level of reclamation is more likely at a quarry in a basalt outcrop than at a near-surface basalt source. The latter quarry will tend to be developed as an open pit, which generally will be more difficult to reclaim in such a manner that it blends with the surrounding environment; i.e., a large open pit will remain after quarry operations and reclamation are complete.

5.0 ANALYSIS

5.1 DESCRIPTION OF CANDIDATE SITES

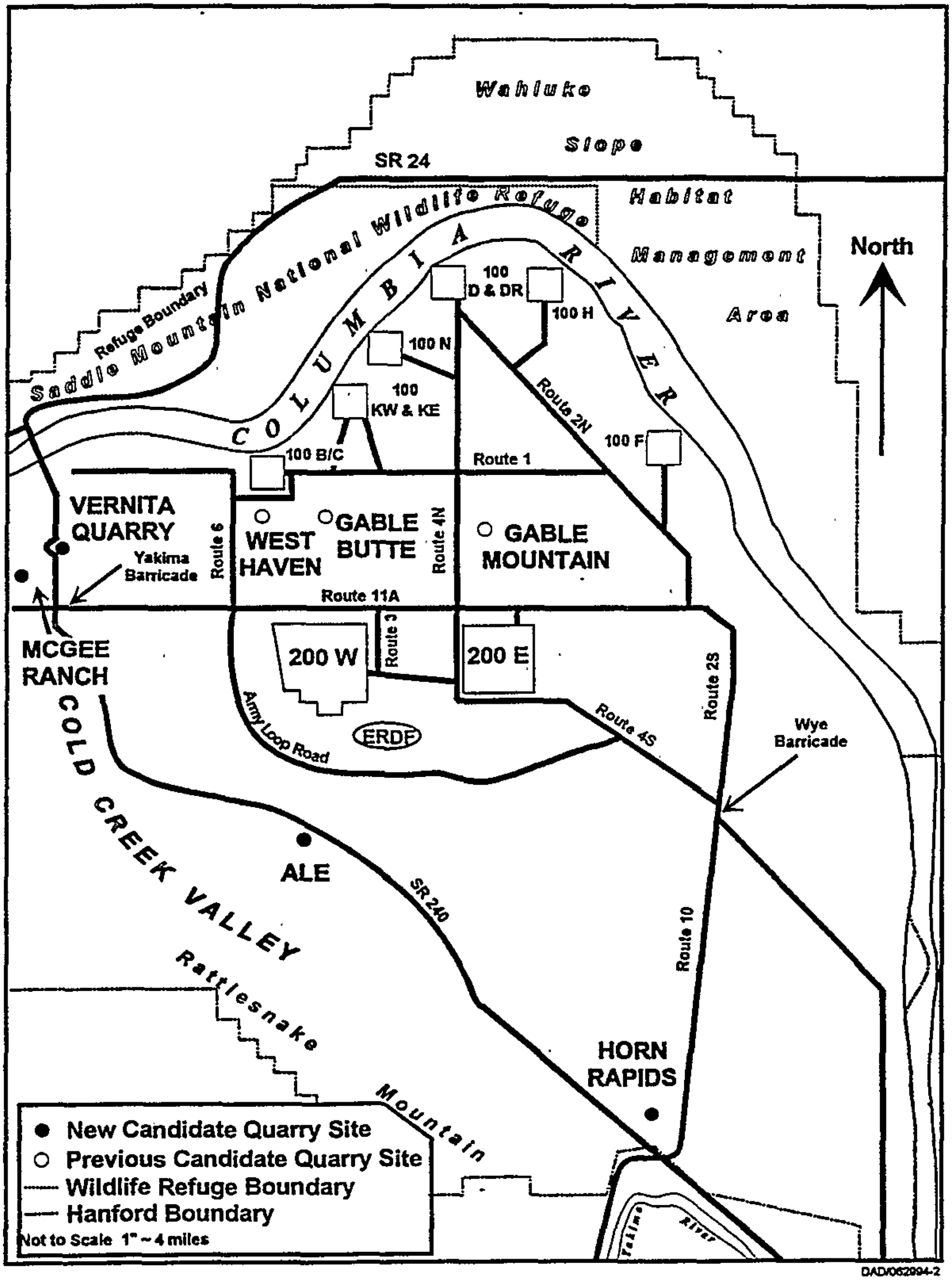
To include the broad range of possibilities for quarry development, four new on-site candidate quarries (Figure 5-1) and three off-site privately operated quarries (see Figures 5-9, 5-10, and 5-11 in section 5.2.1) have been selected for evaluation in this SER. Of the four new on-site candidate quarries, one is an exposed basalt outcrop, and the other three consist of basalt sources at or slightly below grade. Additionally, Gable Mountain, Gable Butte, and West Haven, originally evaluated in Myers (1985), will be included in this SER to provide a uniform evaluation of all candidate sites considered for quarry development in recent years.

To reach useable basalt, some overburden material may need to be removed from the area to be mined at the near-surface sites. The overburden can be stockpiled for use in reclamation after the quarry mining operations are complete. Overburden material would consist of soils and other debris overlying the basalt source. Flow-top basalt is sometimes composed of weak basalt and is commonly found on top of many basalt flows. This flow-top basalt is the product of rapid cooling of the basalt during its molten stage, sometimes associated with rain or surface water. This weakened, weathered zone of basalt may also need to be removed from the near-surface basalt sites if it is determined to be unsuitable for use in the surface barrier in which the riprap is required. Specific construction specifications should outline the grade of riprap required for each barrier. If removal of the weakened basalt is required, it could be accomplished by using a ripper and blade on a large dozer or other appropriate equipment. Weakened flow-top material could be as thick as 3 m (10 ft) or greater, so a considerable quantity of material may need to be removed and stockpiled at each site if it cannot be used in barrier construction.

Talus slopes are associated with a number of outcrops identified for candidate quarries. Much of the talus material exists in a riprap form and appears to be useable as a surface barrier component. If only small quantities of riprap are needed for surface barrier projects, it may be desirable to extract the talus material from around the outcrops rather than removing part or all of the actual outcrop, thus minimizing physical impacts to the landscape.

Adequate geologic logs do not exist to characterize the basalt flows, talus slopes, or the extent of weakened and competent basalt at these sites. However, weakened basalt may have an application in some barrier construction projects, depending on the surface barrier material specifications. Because of the potential cost savings, the barrier

Figure 5-1. New Candidate Basalt Quarry Sites.



construction project engineer should determine if weakened or weathered basalt is suitable for the particular application in which basalt material is required.

Estimates of basalt volumes for the Hanford Site candidate quarries are included in Appendix D. Volume estimates for off-site sources are based upon conversations with those respective quarry operators or representatives. Figures are included in this appendix for the Hanford Site sources to show the approximate quarry footprint on the outcrop that will be developed to obtain the necessary basalt resources. Additionally, the approximate area of impact for the quarry operation is shown. The area of impact includes the basalt quarry plus additional surface area for operations, stockpiling, equipment parking, and office trailers. These details will be the responsibility of the respective quarry operators for the off-site basalt sources and are not included in this SER.

5.1.1 Vernita Quarry

An existing basalt quarry (Vernita Quarry), located off the east side of SR 24 near Vernita Bridge, has been identified as a suitable source to supply riprap required for use in constructing protective surface barriers at Hanford. The location of the tract of land for this candidate site is given in Table 5-1 at the end of Section 5.1. The original quarry at this site probably supported highway construction, although no documentation has been found. The *National Environmental Policy Act* (NEPA) documentation, including a T&E species survey and a cultural resource survey, was prepared to support removing a small quantity of basalt from this quarry. Approximately 10,700 m^3 (14,000 yd^3) of riprap was removed in March 1994 for use in constructing the prototype HISB over the B-57 crib in the 200-BP-1 operable unit (OU).

5.1.1.1 Site Characteristics. The existing quarry at the Vernita Site is located in the Umatilla flow of the Saddle Mountain Basalt. The Umatilla flow at this location is composed of a single colonnade, locally characterized by columns 0.9 to 1.2 m (3.0 to 4.0 ft) wide. A bench approximately 12 to 15 m (40 to 50 ft) thick exists at the current quarry site and extends eastward as part of a series of benches that correspond to eroded basalt flows along the valley of the Columbia River. The Pomona flow overlies the Umatilla flow and crops out approximately 300 m (1,000 ft) east of the existing quarry. The Pomona flow, like the Umatilla flow, locally comprises a single colonnade (or columnar entablature) with columns generally less than 0.6 m (2.0 ft) wide. Because the Pomona basalt columns are smaller, less effort (i.e., blasting and crushing) should be required to produce the desired size fraction of 25.4 cm (10 in.) minus with a D_{50} of 10 cm (4 in.) as specified for the basalt riprap of the HISB (Buckmaster, 1993). The larger columns of the Umatilla flow probably would require more effort (i.e., hotter blasting and/or supplementary crushing) to produce the desired riprap size fraction.

Table 5-1. Land Tract Locations for Candidate Quarry Sites.

Candidate Quarry Name	USGS Quadrangle (WA)	Land Parcel Location
Vernita	Riverland	• S2/3, SE1/4, Section 18, T13N, R25E • SW1/4, Section 17, T13N, R25E
Horn Rapids	Horn Rapids Dam	• W1/2, Section 34, T11N, R27E
ALE[a]	Riverland	• N1/4, Section 25, T12N, R25E • SE1/4, SE1/4, Section 22, T12N, R25E • S1/4, Section 23, T12N, R25E
McGee	Emerson Nipple Riverland	• SE1/4, Section 24, T13N, R24E • NE1/4, NE1/4, Section 25, T13N, R24E • SW1/4, SW1/4, Section 19, T13N, R25E • N1/2, NW1/4, Section 30, T13N, R25E
Gable Mountain	Gable Butte	• E1/2, SW1/4, Section 15, T13N, R26E • W1/2, SE1/4, Section 15, T13N, R26E
Gable Butte	Gable Butte	• W1/2, NW1/4, Section 19, T13N, R26E • W2/3, S2/3, Section 18, T13N, R26E • NE1/2, Section 24, T13N, R25E • NE1/4, Section 24, T13N, R25E
West Haven	Riverland	• S1/2, N1/2, Section 14, T13N, R25E
Section 9	Vantage	• E3/4, Section 9, T16N, R23E
D'Atli	Benton City	• W1/2, NW1/4, Section 13, T9N, R27E
Mahaffey	Kennewick	• SW1/4, SE1/4, Section 23, T8N, R28E

[a]Arid Lands Ecology Reserve

No federally listed T&E flora or fauna species were observed at the Vernita Quarry. However, two state plant species of concern, the Crouching milkvetch and the Stalked-pod milkvetch, were observed at this site (see Appendix C). A listing of all flora and fauna species observed at this site during the ecological surveys is also included in this appendix.

5.1.1.2 Quarry Development. Several options exist for development of the Vernita Quarry to obtain suitable material for construction of protective barriers. One option is to develop the Umatilla flow beginning at the existing quarry. Development of the Vernita Quarry could proceed from the existing quarry toward the east where the Pomona Flow overlies the Umatilla flow. After the Pomona Flow is reached, it could be developed separately, or in conjunction with the underlying Umatilla flow.

A second option is to develop a new quarry in the Pomona Flow and obtain as much basalt as possible before developing the Umatilla flow. The advantage of this option is that less effort would be required initially to obtain a considerable quantity of suitable material because of the smaller Pomona Flow columns. Borrowing from the Pomona Flow could continue as long as it is available, after which the underlying Umatilla flow would be developed.

In both cases, consideration must be given to the overhead power lines at the Vernita Site during quarry activity planning. One set of lines runs parallel to SR 24 near the west side of the quarry, and another set of lines (high voltage) crosses the northeast corner of the proposed quarry boundaries. Arrangements must be made to safeguard these lines from debris during blasting, from heavy equipment, and from excavations that may compromise the stability and integrity of the power line tower.

5.1.2 McGee Ranch

A near-surface basalt source consisting of Pomona Flow basalts exists to the interior north portion of the McGee Ranch site, northwest of the McGee well. The location of the tract of land for this candidate site is given in Table 5-1 at the end of Section 5.1.

Another portion of McGee Ranch is also the designated borrow site for fine-textured soils that will be used in barrier construction. This would make it possible to use some of the same infrastructure to support both the fine-soil borrow pit and basalt quarry development activities.

5.1.2.1 Site Characteristics. Basalt characteristics for this site are not well known because surfaces or benches are not exposed. This formation exists as a knoll with approximately 15 to 30 m (50 to 100 ft) of vertical relief. Thickness of the overburden and weaker basalt is not known.

No federally listed T&E flora or fauna species were observed at the McGee Ranch site. However, two state plant species of concern, the Crouching milkvetch and Scilla onion; one federal and state wildlife species of concern, the Loggerhead shrike; and one state wildlife species of concern, the Sage sparrow, were observed at this site (Appendix C). A listing of all flora and fauna species observed at this site during the ecological surveys is also included in this appendix.

5.1.2.2 Quarry Development. The most likely scenario for developing a quarry at this site would be to begin mining on the east end of the ridge. Quarry development would proceed to the west in blocks that span the width of the formation, while maintaining grade above the 274-m (900-ft) contour level. If additional basalt is required, excavation could proceed below this contour level.

5.1.3 ALE Site

Part of the Elephant Mountain Flow crops out immediately south of and along the edge of SR 240, between gates 116 and 117, on the ALE reserve. No geologic logs exist for this site, so detailed information pertaining to the flow at this site is not available. The location of the tract of land for this candidate site is given in Table 5-1 at the end of Section 5.1. Historically, there have been no major earth work activities on the ALE reserve, and because it is an ecological research area, it may be unavailable for quarry development. This "land use" issue is unique to the ALE reserve and does not exist with the other candidate sites.

5.1.3.1 Site Characteristics. Little is known about the Elephant Mountain Flow at this site because of limited exposures. The nearest outcrop with any exposure is at a small gravel pit nearby. This flow was exposed in the Dry Creek drainage in the Cold Creek Valley and runs roughly parallel to SR 240.

No federally listed T&E flora or fauna species were observed at the ALE site. However, one state plant species of concern, the Stalked-pod milkvetch and two state wildlife species of concern, the grasshopper sparrow and Sage sparrow, were observed at this site (Appendix C). A listing of all flora and fauna species observed at this site during the ecological surveys is also included in Appendix C.

5.1.3.2 Quarry Development. The most probable scenario for developing a quarry at this site would be to begin mining on the east end of the exposure and advance westward up the drainage.

5.1.4 Horn Rapids Site

Another outcrop and potential borrow area of the Elephant Mountain Flow exists 900 m (3,000 ft) north of the Horn Rapids Dam. The location of the tract of land for this candidate site is given in Table 5-1. As with the Elephant Mountain Flow on the ALE site, no geologic logs are known to exist for the Elephant Mountain Flow at the Horn Rapids Site, so detailed information about the basalt flow here is not available. The exposed portion of this particular outcrop is the most aerially extensive of the three near-surface sources identified (Horn Rapids, ALE, and McGee Ranch).

5.1.4.1 Site Characteristics. Characteristics for this site are not well known because few benches are exposed. Observation generally indicates the top of this formation is relatively flat with abundant scattered basalt rocks in places.

No federally listed T&E flora or fauna species were observed at the Horn Rapids site. However, one federal and state wildlife species of concern (two pair of Long-billed curlew) were observed at this site (Appendix C). A listing of all flora and fauna species observed at this site during the ecological surveys is also included in Appendix C.

5.1.4.2 Quarry Development. The flow top is relatively flat at the 152-m (500-ft) contour. However, some vertical relief exists near the south end and near the center on the west side of the outcrop. These two locations may provide the most suitable locations to begin quarry operations.

5.1.5 Gable Mountain Site

Part of the Pomona Flow crops out immediately on the west end of Gable Mountain. No geologic logs exist for this site, so detailed information pertaining to the flow at this site is not available. The location of the tract of land for this candidate site is given in Table 5-1.

5.1.5.1 Site Characteristics. A small quarry already exists at this site, and observation of exposed basalt there indicates that a suitable quality of basalt exists throughout the west end of Gable Mountain. A considerable quantity of naturally occurring talus slope material exists at Gable Mountain that could possibly provide many thousands of cubic meters of riprap. Also, several large piles (thousands of cubic meters) of human-made riprap exist in the old quarry site.

No federally listed T&E flora or fauna species were observed at the Gable Mountain. However, two state plant species of concern, the Stalked-pod milkvetch and Crouching milkvetch; one federal and state wildlife species of concern, the Loggerhead shrike; and one state wildlife species of concern, the Prairie falcon, were found at this site (Appendix C). A listing of all flora and fauna species observed at this site during the ecological surveys is also included in Appendix C.

5.1.5.2 Quarry Development. Development of a quarry at Gable Mountain would begin at the far west end of the mountain and proceed east. Elevation of the west end of Gable Mountain ranges from about 91 m (300 ft) to 304 m (1,000 ft), and the quarry would excavate about 914 m (3,000 ft) into the mountain from the west.

5.1.6 Gable Butte Site

Parts of the Pomona Flow and Elephant Mountain Flow crop out west of the railroad grade at Gable Butte. These outcrops exist immediately west of Gable Butte proper. No geologic logs exist for this site, so detailed information pertaining to the flow at this site is not available. The location of the tract of land for this candidate site is given in Table 5-1.

5.1.6.1 Site Characteristics. Numerous outcrops exist at this site that will provide suitable quality and quantities of basalt. A considerable quantity of naturally occurring talus slope material exists at these outcrops that could possibly provide many thousands of cubic meters of riprap.

No federally listed T&E flora or fauna species were observed at the Gable Butte site. However, two state plant species of concern, the Stalked-pod milkvetch and Crouching milkvetch, and one federal and state wildlife species of concern, the Loggerhead shrike, were found at this site (Appendix C). A listing of all flora and fauna species observed at this site during the ecological surveys is also included in Appendix C.

5.1.6.2 Quarry Development. Development of a quarry at the Gable Butte Site would begin at the south end of the area of interest. Plenty of room is available for stockpiling material and for parking equipment in the southern portion of this area. The outcrops of interest range in elevation from about 152 m (500 ft) to 182 m (600 ft).

5.1.7 West Haven Site

Part of the Pomona Flow crops out immediately east of Route 6 and west of Gable Butte. No geologic logs exist for this site, so detailed information pertaining to the flow at this site is not available. The location of the tract of land for this candidate site is given in Table 5-1.

5.1.7.1 Site Characteristics. A single large outcrop has been identified at the West Haven Site for quarry development. A considerable quantity of naturally occurring talus slope material exists at this site that could possibly provide many thousands of cubic meters of riprap.

No federally listed T&E flora or fauna species were observed at the West Haven Site. However, two state plant species of concern, the Crouching milkvetch and the Stalked-pod milkvetch, were found at this site (Appendix C). A listing of all flora and fauna species observed at this site during the ecological surveys is also included in Appendix C. .

5.1.7.2 Quarry Development. Development of a quarry at the West Haven site would begin at the south end of the area of interest. Plenty of room is available for stockpiling material and for parking equipment in the southern portion of this area. The outcrops of interest range in elevation from about 152 m (500 ft) to 182 m (600 ft).

5.1.8 Section 9 Quarry

This is a privately owned quarry located north of Wanapum Dam. This quarry has supplied basalt materials for a number of projects in the Tri-Cities and has considerable quantities of basalt in-place that could be blasted and crushed to produce the desired riprap. Quarry development would be the responsibility of the quarry operator. Status of T&E species and cultural resources at this site is not known. The location of the tract of land is given in Table 5-1.

5.1.9 D'Atli Quarry

This is a privately owned quarry located on the old highway 12, about 6.7 km (4.2 mi) east of Benton City, Washington. This site has supplied basalt materials for a number of local Department of Transportation projects. Quarry development would be the responsibility of the quarry operator. Status of T&E species and cultural resources at this site is not known. The location of the tract of land is given in Table 5-1.

5.1.10 Mahaffey Quarry

This is a privately owned quarry located on Clodfelter Road about 5.5 km (3.4 mi) from the intersection with Clearwater Avenue in Kennewick, Washington. This site has supplied basalt materials for a number of local projects. Quarry development would be the responsibility of the quarry operator. Status of T&E species and cultural resources at this site is not known. The location of the tract of land is given in Table 5-1.

5.2 EVALUATION OF CANDIDATE SITES - QUALIFYING CRITERIA

Each candidate quarry must meet the intent of the qualifying criteria to be considered and evaluated against the engineering criteria. Each site included in this SER has met the intent of the qualifying criteria as summarized in the following sections.

5.2.1 Hanford Site Proximity

All ten sites qualify as being located in the vicinity of the Hanford Site. Seven of the candidate quarry sites are located within the boundaries of the Hanford Site and three are located outside these boundaries. The off-site candidate quarries are all located within a 52-km (32-mi) radius of the 200 Areas plateau.

5.2.2 Basalt Availability

All ten sites are located in basalt formations that are known (or believed to be) suitable for producing the riprap required for surface barrier construction. Of the seven on-site candidate quarries, two (Vernita Quarry and Gable Mountain) have been used in the past for obtaining basalt materials. The remaining on-site candidate quarries are located on basalt outcrops or near-surface basalt formations. All three off-site quarries are currently producing (or have recently produced) riprap and other basalt materials for a number of construction projects in the region. The availability of quality basalt on the Hanford Site is limited only by economics, outstanding ecological and cultural resource issues, and the current regulatory framework.

5.2.3 Suitability of Basalt

Geologic logs are not available for many of the basalt formations at the candidate quarries. However, based on nearby development of small quarries and known characteristics of surrounding basalts, all candidate quarries are assumed to be located in formations that will produce a quality product that will meet or exceed the requirements for constructing surface barriers. There are no limitations expected on the availability of the quality of basalt required for the barriers. Consultation with geologists familiar with Hanford basalt formations resulted in the identification of outcrops and near-surface flows to ensure good potential for quarry development. Where geologic logs do not exist to characterize the nature of the basalt, it is assumed the basalt in the given flow is similar to that flow in other locations across the Hanford Site.

5.2.4 Threatened and Endangered Species Impacts

Ecological surveys for T&E species were conducted at each Hanford Site candidate quarry. No federal or state T&E species were observed at these sites, although several federal and state species of concern were observed (see Appendix C for details of the ecological survey). Ecological surveys were not conducted at the three privately operated commercial quarries for several reasons. First, the off-site quarries are considered low priority (relative to the on-site candidate quarry sites) because of the long haul distance. Second, if a privately operated commercial quarry were used, it would be selected through the competitive bid process; therefore, at this time it is unknown which would be used. Surveying the site selected is less expensive than surveying all three quarries. The contract would be awarded contingent upon successful conclusion and mitigation of the T&E species survey (assuming all other aspects of NEPA have been satisfied). For purposes of this SER, it was assumed that the currently operating commercial quarries do not contain any federal or state T&E species.

5.3 EVALUATION OF CANDIDATE SITES - ENGINEERING CRITERIA

Each of the new and previously identified candidate quarry development sites are evaluated against the conditions outlined in the engineering criteria. A numerical value ranging from 0 to 10, in increments of one unit, is assigned to each site to reflect how well that particular site meets the conditions outlined in each engineering criterion. Numerical values used in this evaluation are defined below.

- **10 = Excellent.** The candidate site meets the intent of all the conditions outlined in the engineering criteria.
- **8 - 9 = Good.** The candidate site meets the intent of most of the conditions outlined in the engineering criteria but does have some minor shortcomings.
- **4 - 7 = Average.** The candidate site meets the intent of some of the conditions outlined in the engineering criteria but does not fully meet the intent of others. However, the conditions that are met are more important than those that are not.

- **1 - 3 = Poor.** The candidate site does not meet the intent of most of the conditions outlined in the engineering criteria.

- **0 - Very Poor.** The candidate site does not meet the intent of the conditions outlined in the engineering criteria.

At the beginning of each of the following sections is a table containing the numerical value rating for each candidate site for the respective engineering criteria. A discussion of the engineering criteria, as they apply to each site, follows the ratings in each section.

5.3.1 Haul Distance

On-Site Source	Vernita Quarry	McGee Ranch	ALE	Horn Rapids	Gable Mtn	Gable Butte	West Haven
Rating	8	8	10	4	9	10	9
Off-Site Source	**Section 9 Quarry**	**D'Atli Quarry**	**Mahaffey Quarry**				
Rating	2	3	2				

Haul distance estimates are based on the distance from a given quarry site to the center of the 200 East Area, 200 West Area, and the ERDF site. These distances are estimated by measuring road segment lengths on a blueline drawing of the Hanford Site (WHC, 1989), and USGS topographic maps using a digital plan measure. The destination for the ERDF materials was assumed to be in an area south of the 609A Fire Station and east of the 200 West Area. Distance and rough haul cost estimates are compiled in Tables 5-2a and 5-2b for the candidate sites, and alternate routes are discussed below. The cumulative volume-distance to the three barrier construction sites from each candidate quarry is given in the last column in each of these tables. Cumulative volume-distance is calculated by multiplying the assumed volume of riprap hauled to each site by the loaded haul distance. The lowest cumulative volume-distance total is preferable from a haul distance perspective. For consistency in characterizing the relative costs among the candidate quarry alternatives, it was assumed that the full 15.3 million m^3 (20 million yd^3) would be hauled from each quarry even though the D'Atli Quarry and Mahaffey Quarry may not be able to supply this volume.

Table 5-2a. Loaded-Truck Distance and Transportation Costs for Route Alternatives - Metric Units

Quarry Site	Distance, Costs, and Volume Requirements for Potential Barrier Sites (Metric Units). 200 West Barriers Transport 6.6 E+06 m^3 Distance (km)	200 West Costs ($ million) @ $ 0.24 per t-km	200 West Costs ($ million) @ $0.27 per t-km	200 East Barriers Transport 5.7 E+06 m^3 Distance (km)	200 East Costs ($ million) @ $ 0.24 per t-km	200 East Costs ($ million) @ $0.27 per t-km	ERDF Transport 2.1 E+06 m^3 Distance (km)	ERDF Costs ($ million) @ $ 0.24 per t-km	ERDF Costs ($ million) @ $0.27 per t-km	Total Transportation Costs ($ million) @ $0.24 per t-km	Total Transportation Costs ($ million) @ $0.27 per t-km	Cubic Meter km (x10 E6)
Gable Mountain:												
West End	12.2	38	44	7.9	21	24	9.7	10	11	69	79	146
East End	17.7	55	63	10.5	28	32	18.3	18	21	102	116	215
Gable Butte:	5.3	17	19	11.7	32	36	10.5	10	12	59	67	124
West Haven Area:	8.9	28	32	16.1	43	50	14.8	15	17	86	98	181
Vernita Quarry:												
Alternate Route A	11.7	37	42	19.3	52	59	16.9	17	19	106	121	223
Alternate Route B	11.7	37	42	19.3	52	59	16.9	17	19	106	121	223
Alternate Route C	11.9	37	43	19.5	52	60	17.1	17	19	107	122	225
McGee Ranch:												
Alternate Route A	10.5	33	37	18.2	49	56	15.6	16	18	97	111	205
Alternate Route B	10.0	31	36	17.7	48	54	15.1	15	17	94	107	199
Alternate Route C	10.5	33	37	18.2	49	56	15.6	16	18	97	111	205
Alternate Route D	10.3	32	37	17.9	48	55	15.4	15	18	96	109	202
Horn Rapids:												
Alternate Route A	31.9	100	114	25.9	70	80	27.4	27	31	197	225	415
Alternate Route B	25.4	80	911	31.1	84	96	24.5	24	28	187	214	396
ALE:												
Alternate Route A	20.8	65	74	28.5	77	88	25.9	26	29	167	191	354
Alternate Route B	7.7	24	28	11.6	31	36	4.2	4	5	60	68	126
Section 9 Quarry:												
SR 243	58.4	183	209	66.1	178	204	63.6	63	72	424	485	896
D'Atli Quarry:												
Old Highway 12	59.5	186	213	53.6	144	165	55.0	55	63	385	440	814
Mahaffey Quarry												
Alternate Route A	66.9	209	239	61.2	165	188	62.4	62	71	436	499	922
Alternate Route B	73.9	231	264	68.1	183	209	69.5	69	79	483	553	1,022

Table 5-2b. Loaded-Truck Distance and Transportation Costs for Route Alternatives - Standard Units

Quarry Site	Distance, Costs, and Volume Requirements for Potential Barrier Sites (Standard Units).									Total Transportation Costs ($ million)		Cubic Yard Miles (x10 E6)
	200 West Barriers Transport 8.7 E+06 yd³			200 East Barriers Transport 7.5 E+06 yd³			ERDF Transport 2.8 E+06 yd³					
	Distance (miles)	Costs ($ million) @ $ 0.35 per ton-mi	Costs ($ million) @ $0.40 per ton-mi	Distance (miles)	Costs ($ million) @ $ 0.35 per ton-mi	Costs ($ million) @ $0.40 per ton-mi	Distance (miles)	Costs ($ million) @ $ 0.35 per ton-mi	Costs ($ million) @ $0.40 per ton-mi	@ $ 0.35 per ton-mi	@ $0.40 per ton-mi	
Gable Mountain:												
West End	7.6	38	44	4.9	21	24	6.0	10	11	69	79	120
East End	11.0	55	63	6.5	28	32	11.4	18	21	102	116	176
Gable Butte:	3.3	17	19	7.3	32	36	6.5	10	12	59	67	102
West Haven Area:	5.5	28	32	10.0	43	49	9.2	15	17	86	98	149
Vernita Quarry:												
Alternate Route A	7.3	37	42	12.0	52	59	10.5	17	19	105	121	183
Alternate Route B	7.3	37	42	12.0	52	59	10.5	17	19	105	121	183
Alternate Route C	7.4	37	43	12.1	52	60	10.6	17	19	107	122	185
McGee Ranch:												
Alternate Route A	6.5	33	37	11.3	49	56	9.7	16	18	97	111	168
Alternate Route B	6.2	31	36	11.0	48	54	9.4	15	17	94	107	163
Alternate Route C	6.5	33	37	11.3	49	56	9.7	16	18	97	111	168
Alternate Route D	6.4	32	37	11.1	48	55	9.6	15	18	96	109	166
Horn Rapids:												
Alternate Route A	19.8	100	114	16.1	70	80	17.0	27	31	196	225	341
Alternate Route B	15.8	79	91	19.3	84	95	15.2	24	28	187	214	325
ALE:												
Alternate Route A	12.9	65	74	17.7	77	88	16.1	26	29	167	191	290
Alternate Route B	4.8	24	28	7.2	31	36	2.6	4	5	59	68	103
Section 9 Quarry:												
SR 243	36.3	183	209	41.1	178	203	39.5	63	72	424	484	735
D'Atli Quarry:												
Old Highway 12	37.0	186	213	33.3	144	165	34.2	55	62	385	440	667
Mahaffey Quarry												
Alternate Route A	41.6	209	239	38.0	164	188	38.8	62	71	436	498	756
Alternate Route B	45.9	231	264	42.3	183	209	43.2	69	79	483	552	838

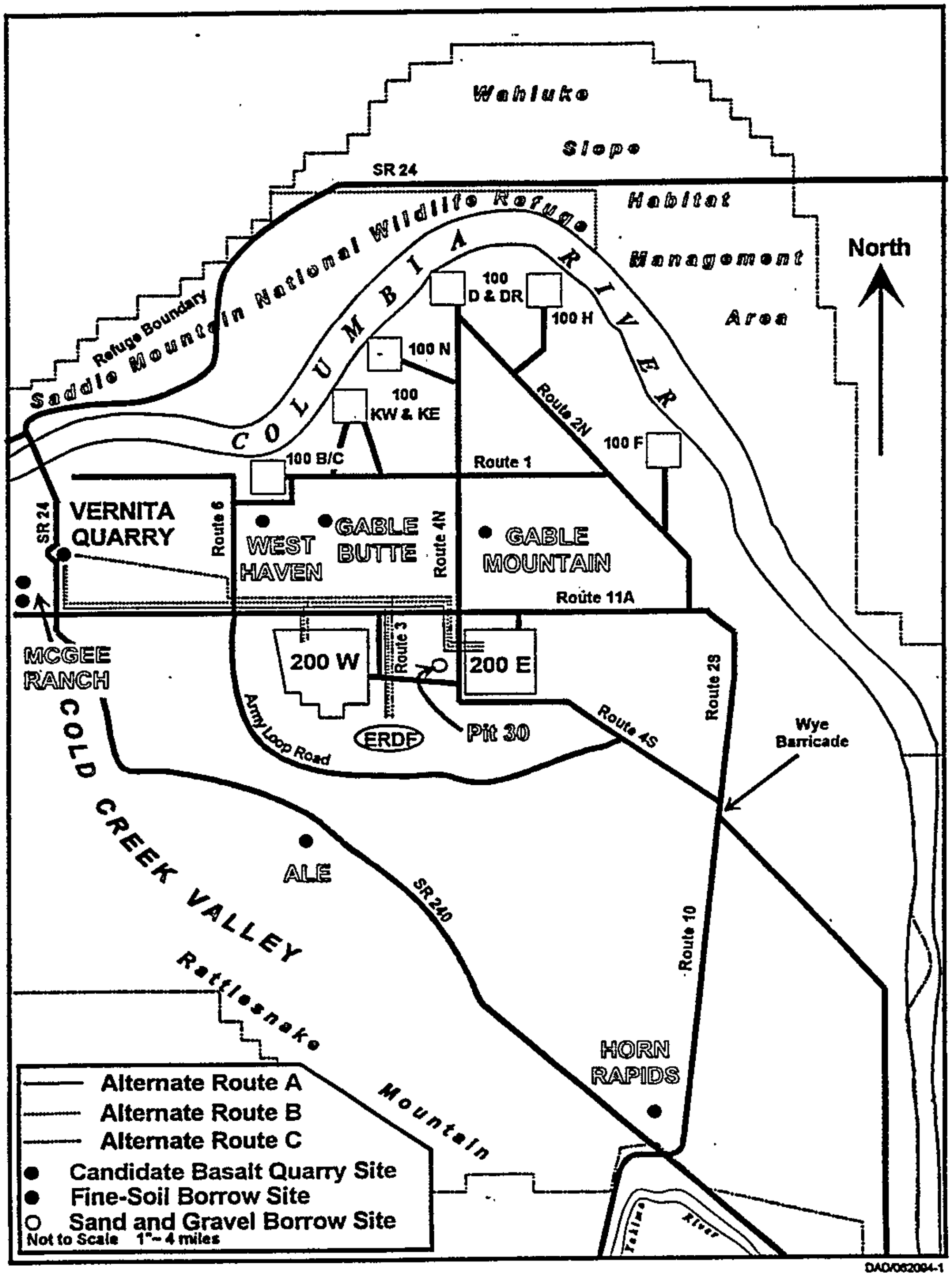
Transportation costs are estimated for each haul route alternative assuming costs of $0.24 and $0.27 per t-km ($0.35 and $0.40 per ton-mile, respectively). These calculations are based on loaded-truck distance, and the return trip (empty truck) from the barrier construction site to the quarry is factored into these costs. This table clearly demonstrates that significant differentials exist for total transportation costs among the various candidate quarries and haul route alternatives.

For this report, it is assumed that highway licensed haul trucks will be used for moving the riprap from the quarry to the barrier construction site. Although route options described in the following sections may propose the use of short conveyor segments to move basalt across highway sections, trucks remain the primary method for transporting basalt to the barrier construction site in this report. Hauling by conveyor and rail require stockpiling the riprap in dumping pockets at some location where it could be loaded into trucks, which would transfer the material to the construction site. Handling the material more than once will add to the costs of moving the riprap from the quarry to the construction site. However, after the specifics are known regarding the quantity of barrier materials required and the time frame in which they are needed, a detailed transportation infrastructure study can be performed to determine the cost/benefit and optimum mode of transport and handling of the riprap. This transportation infrastructure study would investigate all modes of transportation and associated costs of moving the riprap and could make a recommendation based upon data that is more solid than that available as of this writing. Clearly, existing rail line and/or rail grades could be used as part of the infrastructure to transport riprap from the off-site quarries and several on-site quarries to the 200 Area plateau.

5.3.1.1 Vernita Quarry. The Vernita Quarry is located off SR 24 approximately 3.2 km (2 mi) north of the Yakima Barricade on Hanford property. Three haul route alternatives have been identified for moving material from Vernita Quarry to the barrier construction site (Figure 5-2). Vernita Route B is considered the most feasible for transporting large volumes of basalt over several decades, primarily because of safety, and is used to evaluate the haul distance criterion for the Vernita Quarry. This route has a cumulative volume-distance of 223 million m^3-km (183 million yd^3-mi).

5.3.1.1.1 Vernita Route A: State Route 24. Alternate Route A uses SR 24 beginning at Gate 122A, where trucks would enter and exit Vernita Quarry. From the quarry, the trucks would progress to the Yakima Barricade and follow Route 11A to Route 3 and Route 3 to the barrier construction site. Distance estimates are 11.7 km (7.3 mi) to 200 West, 19.0 km (12.0 mi) to 200 East, and 16.9 km (10.5 mi) to the proposed ERDF site. Considerable wear would be expected on the 2,800-m (9,300-ft) segment of SR 24 road surface between the quarry and the Yakima Barricade. The DOE would be liable for repair and maintenance of this segment of SR 24, in addition to the affected roads on the Hanford Site.

Figure 5-2. Vernita Quarry Route Alternatives.



5.3.1.1.2 Vernita Route B: State Route 24 Frontage Road. Alternate Route B will follow a new paved frontage road, starting from the top of the Vernita Quarry near the pavement of the old highway. This road would parallel SR 24 on Hanford property and would merge with Route 11A near the Yakima Barricade. As with alternate Route A, Route 11A would be followed to Route 3 and Route 3 to the barrier construction site. Distance estimates are the same as those described in the previous alternative. Capital money would have to be allocated for constructing approximately 3,300 m (11,000 ft) of frontage road along SR 24.

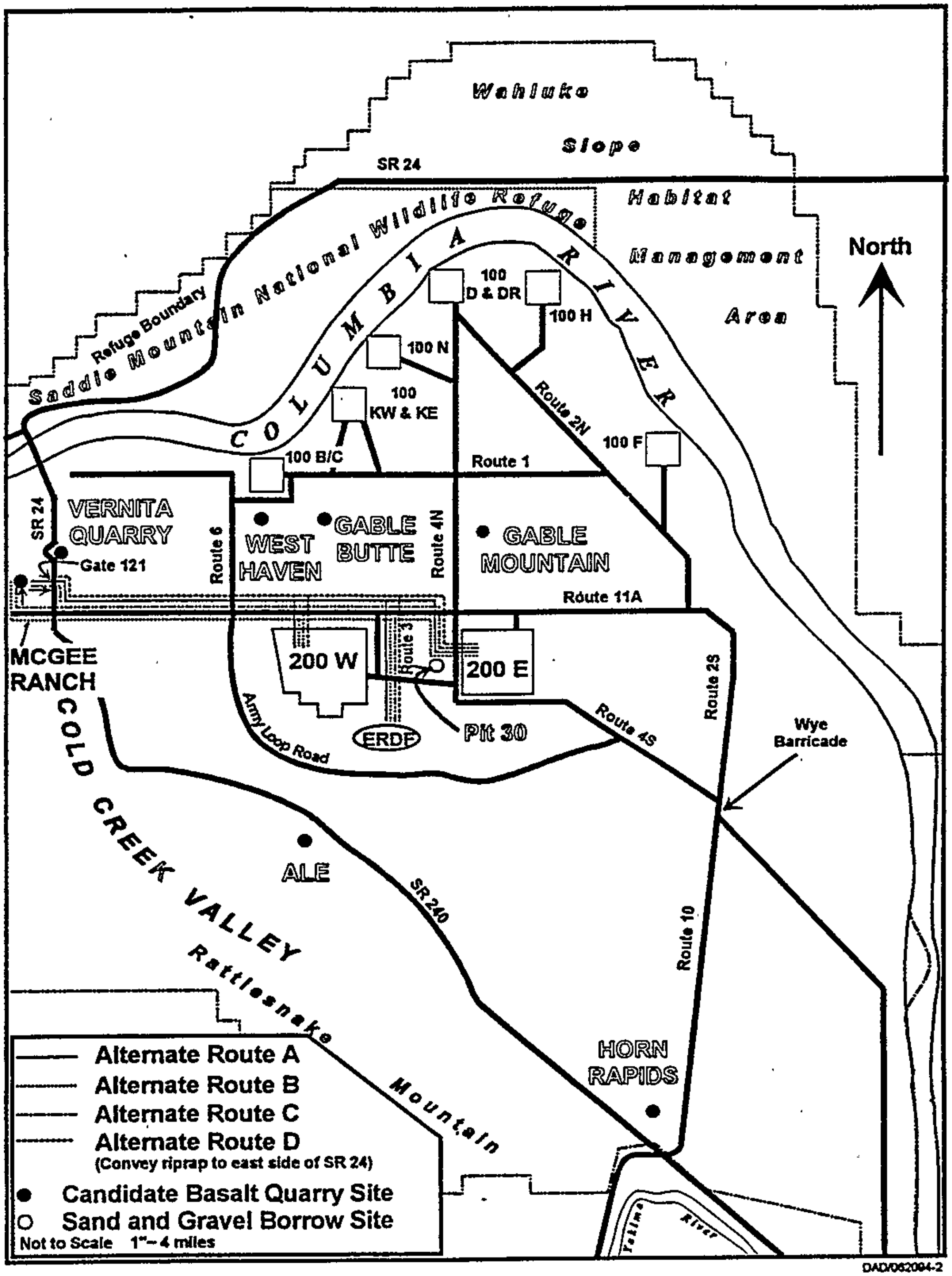
5.3.1.1.3 Vernita Route C: Power Line Road. Alternate Route C would follow a new road that would be constructed from Vernita Quarry to Route 6, along the general vicinity where the current transmission power-line maintenance road is located. From Route 6, the trucks would progress to Route 11A, to Route 3, and finally to the barrier construction site. Estimated distances are 11.9 km (7.4 mi) to 200 West, 19.5 km (12.1 mi) to 200 East, and 17.1 km (10.6 mi) to the proposed ERDF site. Capital money would need to be allocated for constructing about 5,200 m (17,000 ft) of road and upgrading affected Hanford Site roads. Greater construction costs will be realized for building this road than the road proposed in Alternative 2, because it is roughly 1,800 m (6,000 ft) longer and would require more preparation to compensate for the relatively uneven terrain.

5.3.1.2 McGee Ranch. A near-surface basalt source is located on a knoll within the interior portion of McGee Ranch and northwest of the McGee well. Four route alternatives (Figure 5-3) are discussed below. McGee Route D is considered the preferred route at this time because trucks would not have to merge and exit the highway traffic because the riprap is conveyed to a stockpile on the east side of SR 24. This route has a cumulative volume-distance of 202 million m^3-km (166 million yd^3-mi). Because a fine-soils borrow site will also be located at McGee Ranch, a subsequent study may show that a haul route or method that combines the two operations may be preferred.

5.3.1.2.1 McGee Route A: North-South State Route 24. Alternate Route A would enter the north-south stretch of SR 24, roughly 500 m (1,600 ft) north of Gate 121 (or through Gate 121), proceed to the Yakima Barricade, follow Route 11A to Route 3, and proceed on Route 3 to the barrier construction site. Distance estimates are 10.5 km (6.5 mi) to 200 West, 18.2 km (11.3 mi) to 200 East, and 15.6 km (9.7 mi) to ERDF. Maintenance liability will be incurred for roughly 1,200 m (4,000 ft) of SR 24 used by the trucks in addition to the affected Hanford roads.

5.3.1.2.2 McGee Route B: West-East State Route 24. Alternate Route B would enter the west-east stretch of SR 24 and cross the intersection of SR 240 and SR 24 and proceed through the Yakima Barricade on Route 11A to Route 3 and follow Route 3 to the barrier

Figure 5-3. McGee Ranch Route Alternatives.



construction site. Distance estimates are 10.0 km (6.2 mi) to 200 West, 17.7 km (11.0 mi) to 200 East, and 15.1 km (9.4 mi) to the proposed ERDF site. Maintenance liability will be incurred for roughly 800 m (2,700 ft) of SR 24 used by the trucks and for upgrading the affected Hanford roads. A road about 1.6 km (1 mi) long will need to be constructed to connect the basalt quarry with SR 24; however, this portion of the haul road would also be used by the fine soils borrow operation at McGee Ranch.

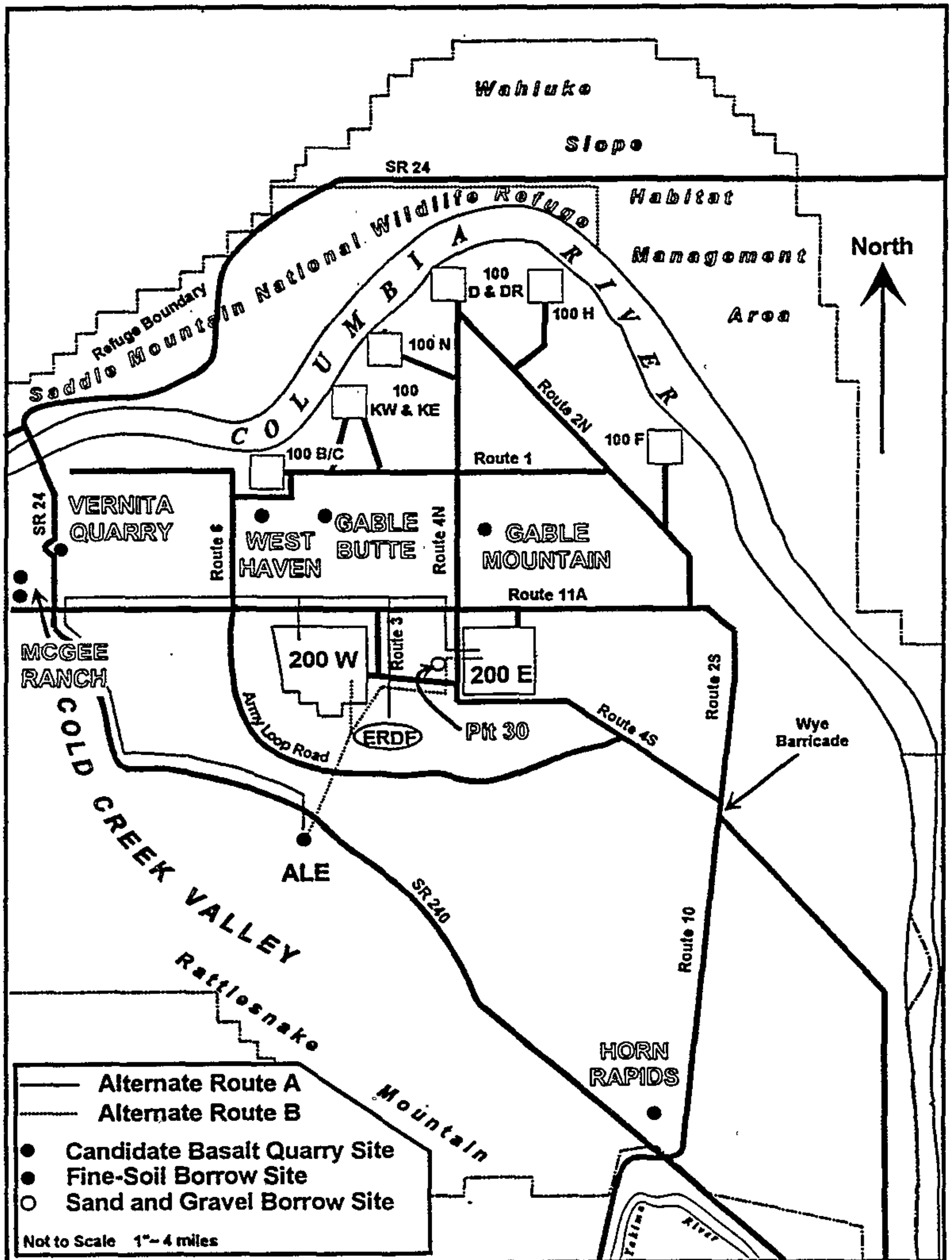
5.3.1.2.3 McGee Route C: State Route 24 Loop. The third alternate route for hauling riprap from McGee Ranch is a combination of the Alternate Routes A and B described previously. Trucks would enter McGee Ranch off the west-east stretch of SR 24 and proceed on a road leading directly to the quarry. Trucks would leave the quarry by entering the north-south stretch of SR 24. Distance is 10.5 km (6.5 mi) to 200 West, 18.2 km (11.3 mi) to 200 East, and 15.6 km (9.7 mi) to the proposed ERDF site. Maintenance liability will be incurred for roughly 2,000 m (6,700 ft) of SR 24 used by the trucks and for the affected Hanford roads.

5.3.1.2.4 McGee Route D: State Route 24 Frontage Road. Alternate Route D would use a frontage road that would be constructed parallel to and east of SR 24. A conveyor system crossing SR 24 would move riprap from the quarry to a stockpile east of SR 24, near the new frontage road. Distances are 10.3 km (6.4 mi) to 200 West and 17.9 km (11.1 mi) to the proposed ERDF site. Capital costs would be incurred for constructing roughly 1,400 m (4,600 ft) of frontage road along the east side of SR 24 from the riprap stockpile to the Yakima Barricade. Additional capital expenses would be incurred for implementing and maintaining the conveyor system. If the conveyor system were to break down, the stockpile east of SR 24 might not be replenished in a timely manner; however, trucks could be loaded at the quarry in the interim while the conveyor is under repair.

5.3.1.3 Arid Lands Ecology Reserve. A near-surface basalt source is located on the ALE approximately 305 m (1,000 ft) off SR 240, near Gate 116. Two route alternatives (Figure 5-4) for transporting basalt riprap from this quarry to the barrier construction sites are discussed below. ALE Route B with the conveyor option is the preferred route because trucks would not have to use SR 24 or SR 240. This route has a cumulative volume-distance of 126 million m^3-km (103 million yd^3-mi).

5.3.1.3.1 ALE Route A: State Route 240. Alternate Route A follows SR 240 to the Yakima Barricade, Route 11A to Route 3, then Route 3 to the barrier construction site. Distance estimates are 20.8 km (12.9 mi) to 200 West, 28.5 km (17.7 mi) to 200 East, and 25.9 km (16.1 mi) to the proposed ERDF site. Maintenance liability would be incurred for SR 240 and the affected Hanford roads.

Figure 5-4. ALE Route Alternatives.



5.3.1.3.2 ALE Route B: Army Loop Crossing. Alternate route B would cross SR 240 from the ALE quarry, then tie into the new Hanford access road linking SR 240 and 200 West, and continue to the barrier construction site. Distance estimates are 7.7 km (4.8 mi) to 200 West, 11.6 km (7.2 mi) to 200 East, and 4.2 km (2.6 mi) to the proposed ERDF site, which are among the shortest of all the sites considered. Another option for this alternative is to use a conveyor system to transport the riprap from the ALE Quarry to a stockpile north of SR 240. This will eliminate the need for trucks to cross two lanes of highway traffic on SR 240. Capital costs will be incurred for implementing and maintaining the conveyor system and for upgrading and maintaining affected Hanford roads. If the conveyor system breaks down, the stockpile north of SR 240 may not be replenished in a timely manner. In this case, trucks would have to haul the riprap directly from the quarry.

5.3.1.4 Horn Rapids Site. A near-surface basalt source is located on Hanford property at the corner of Route 10 and SR 240 about 1,070 m (3,500 ft) north of Horn Rapids Dam. Two route alternatives (Figure 5-5) for transporting riprap from this quarry to the barrier construction sites are discussed below. Horn Rapids Route B would be the first choice because traffic at the Wye Barricade and along Route 4 South would be avoided. This route has a cumulative volume-distance of 396 million m^3-km (325 million yd^3-mi).

5.3.1.4.1 Horn Rapids Route A: Hanford Route 10. A route would follow Route 10 through the Wye Barricade, then Route 4 South to Route 3 to the barrier construction site. Estimated distances are 31.9 km (19.8 mi) to 200 West Area, 25.9 km (16.1 mi) to 200 East Area, and 27.4 km (17.0 mi) to the proposed ERDF site. Route 10 and Route 4 South will need to be improved and maintained to handle the wear that will be caused by frequent heavy truck traffic.

5.3.1.4.2 Horn Rapids Route B: State Route 240. Alternate Route B would follow SR 240 to the SR 240 spur road, through the Rattlesnake Barricade, and into 200 West Area. Distance estimates are 25.4 km (15.8 mi) to 200 West Area, 31.1 km (19.3 mi) to the 200 East Area, and 24.5 km (15.2 mi) to the proposed ERDF site. Maintenance liability would exist for the affected segment of SR 240 and Hanford roads that would receive considerable wear from the heavy truck traffic.

5.3.1.5 Gable Mountain. Gable Mountain is 1.6 km (1.0 mi) north of Route 11A between Route 4 North and Route 2 South. One route (Figure 5-6) has been identified to serve quarries at either end of Gable Mountain. This route has a cumulative volume-distance of 146 million m^3-km (120 million yd^3-mi) from the west end of the mountain.

5.3.1.5.1 Gable Mountain Route A: Route 11 A. This route would tie into Route 11A from the east end of the mountain or via Route 4 North from the west end. Distance estimates from the east end are 17.7 km (11.0 mi) to 200 West, 10.5 km (6.5 mi) to

Figure 5-5. Horn Rapids Route Alternatives.

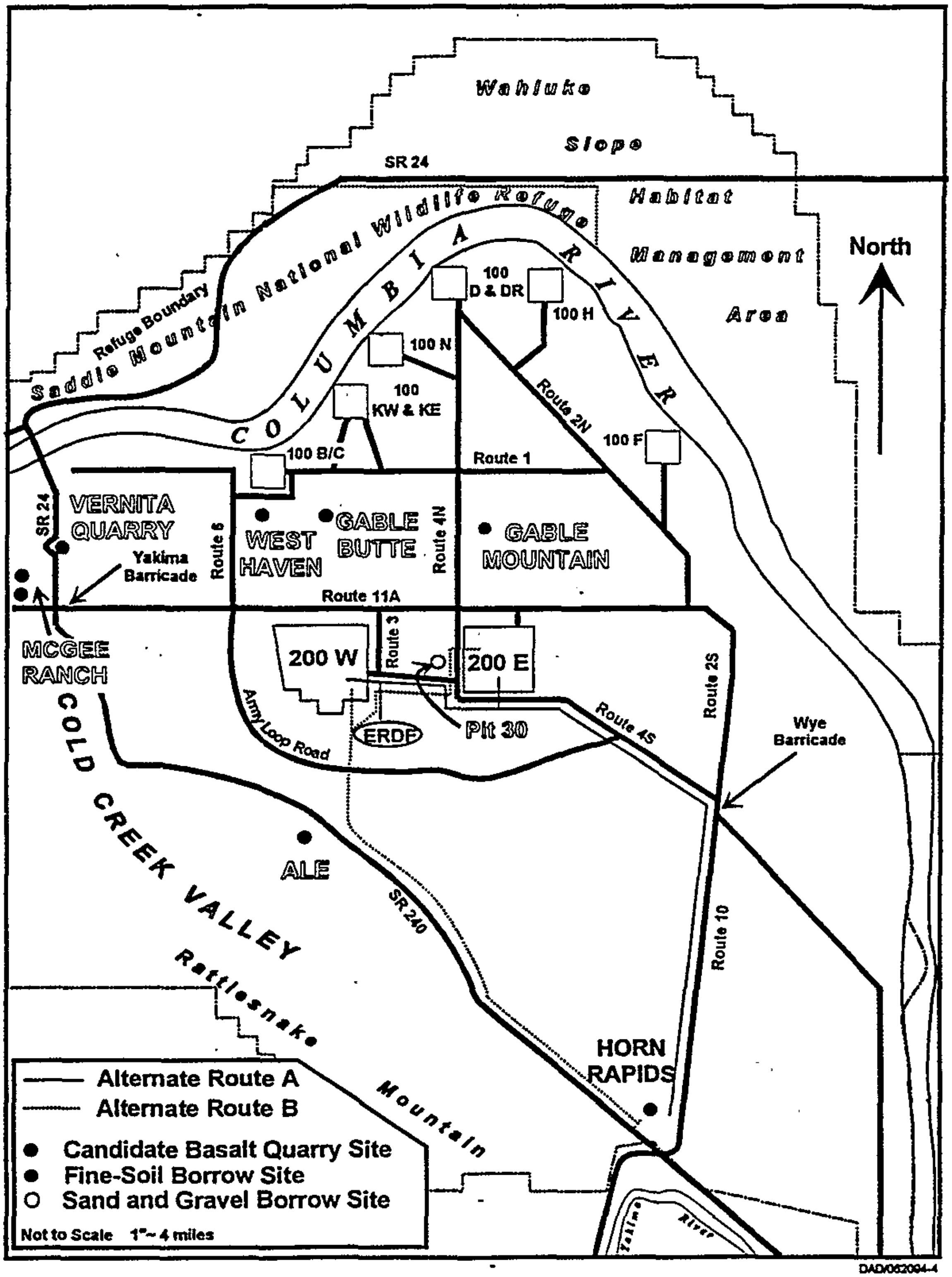
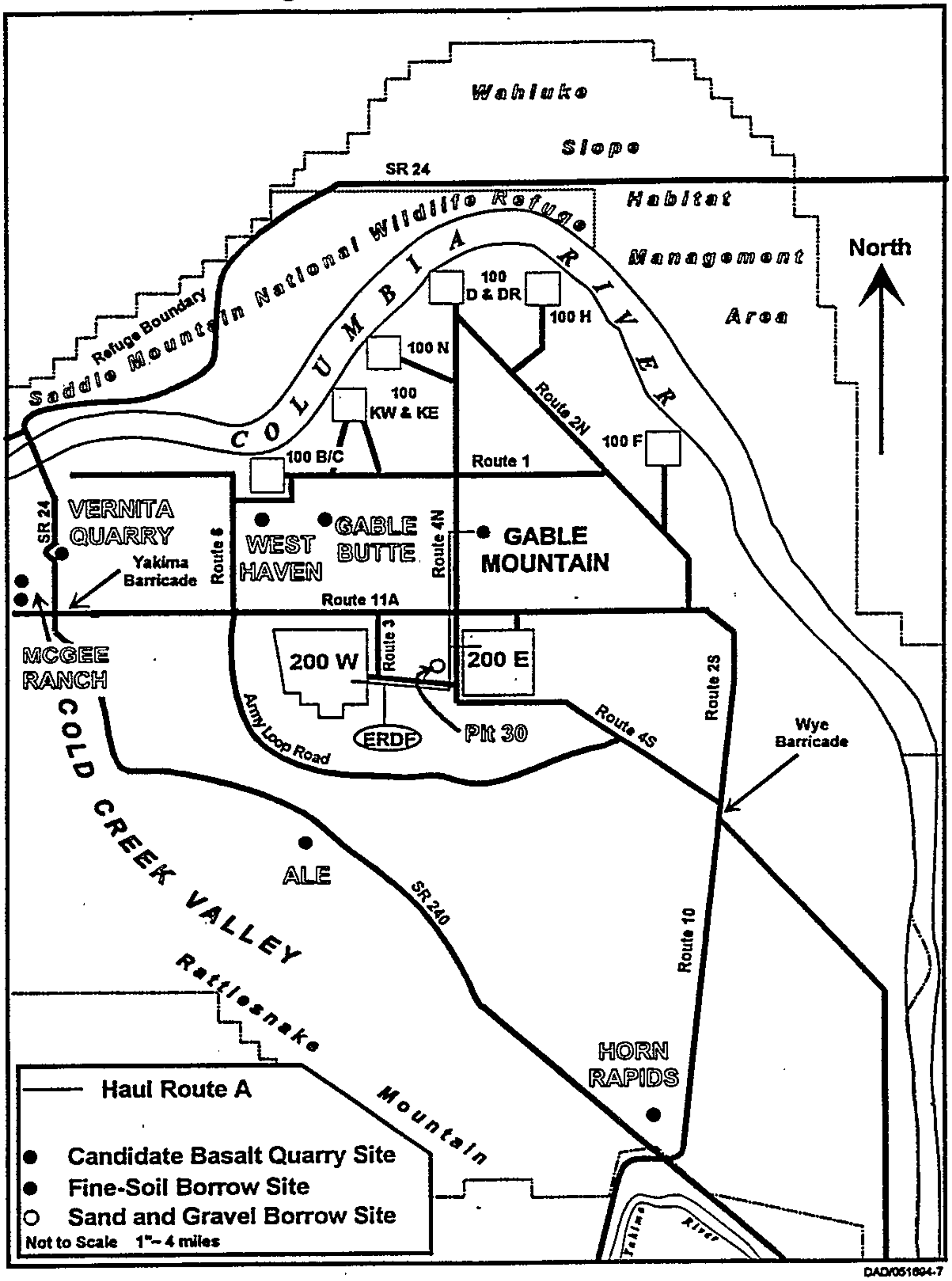


Figure 5-6. Gable Mountain Route.



200 East, and 18.3 km (11.4 mi) to the proposed ERDF site. From the west end of Gable Mountain, the distances are 12.2 km (7.6 mi) to 200 West, 7.9 km (4.9 mi) to 200 East, and 9.7 km (6.0 mi) to the proposed ERDF site. Maintenance and upgrades would be required for the affected portions of Route 4 North and Route 11A.

5.3.1.6 Gable Butte. Gable Butte is centrally located 2.4 km (1.5 mi) north of Route 11A and 0.8 km (0.5 mi) south of the 100 C cut-off road. One route (Figure 5-7) has been identified for hauling riprap to the barrier construction sites from this quarry. This route has a cumulative volume-distance of 124 million m^3-km (102 million yd^3-mi).

5.3.1.6.1 Gable Butte Route A: Route 11A. Approximately 2.4 km (1.5 mi) of new road would be constructed from the Gable Butte quarry to Route 11A to the south. Distance estimates are 5.3 km (3.3 miles) to 200 West Area, 11.7 km (7.3 mi) to 200 East Area, and 10.5 km (6.5 mi) to the proposed ERDF site. This route will parallel the existing railroad spur from the Susie Switch to Route 11A. Costs will be incurred for constructing the road and for upgrading affected portions of Hanford Site roads.

5.3.1.7 West Haven. West Haven is located 1.21 km (0.75 mi) south of the 100 B&C Areas and 0.80 km (0.50 mi) east of Route 6. One route (Figure 5-8) has been identified for hauling riprap to the barrier construction sites from this quarry. This route has a cumulative volume-distance of 181 million m^3-km (149 million yd^3-mi).

5.3.1.7.1 West Haven Route A: Route 6. About 0.80 km (0.50 mi) of road would be constructed from the quarry to Route 6. Route 6 will be followed to Route 11A to the barrier construction sites. Distance estimates for this haul route are 8.9 km (5.5 mi) to 200 West, 16.1 km (10.0 mi) to 200 East Area, and 14.8 km (9.2 mi) to the proposed ERDF site. Costs will be incurred for constructing an access road to the quarry and for upgrading affected portions of Hanford Site roads.

5.3.1.8 Section 9 Quarry. Section 9 Quarry is located approximately 2.4 km (1.5 mi) north of Wanapum Dam. One route (Figure 5-9) has been identified for hauling riprap to the barrier construction sites from this quarry. This route has a cumulative volume-distance of 896 million m^3-km (735 million yd^3-mi).

5.3.1.8.1 Section 9 Quarry Haul Route: SR 243. About 40 km (25 mi) of SR 243 would be followed from the Section 9 Quarry to the intersection with SR 24 at the Vernita Bridge. SR 24 would be followed for 8 km (5 mi) to the Yakima Barricade after which Route 11A would be followed to the 200 Area plateau. Distance estimates for this haul route are 58.4 km (36.3 mi) to 200 West, 66.1 km (41.1 mi) to 200 East, and 63.6 km (39.5 mi) to the proposed ERDF site. Costs will be incurred for road maintenance for roughly 50 km (31 mi) on SR 243 and SR 24, in addition to Hanford Site roads.

Figure 5-7. Gable Butte Route.

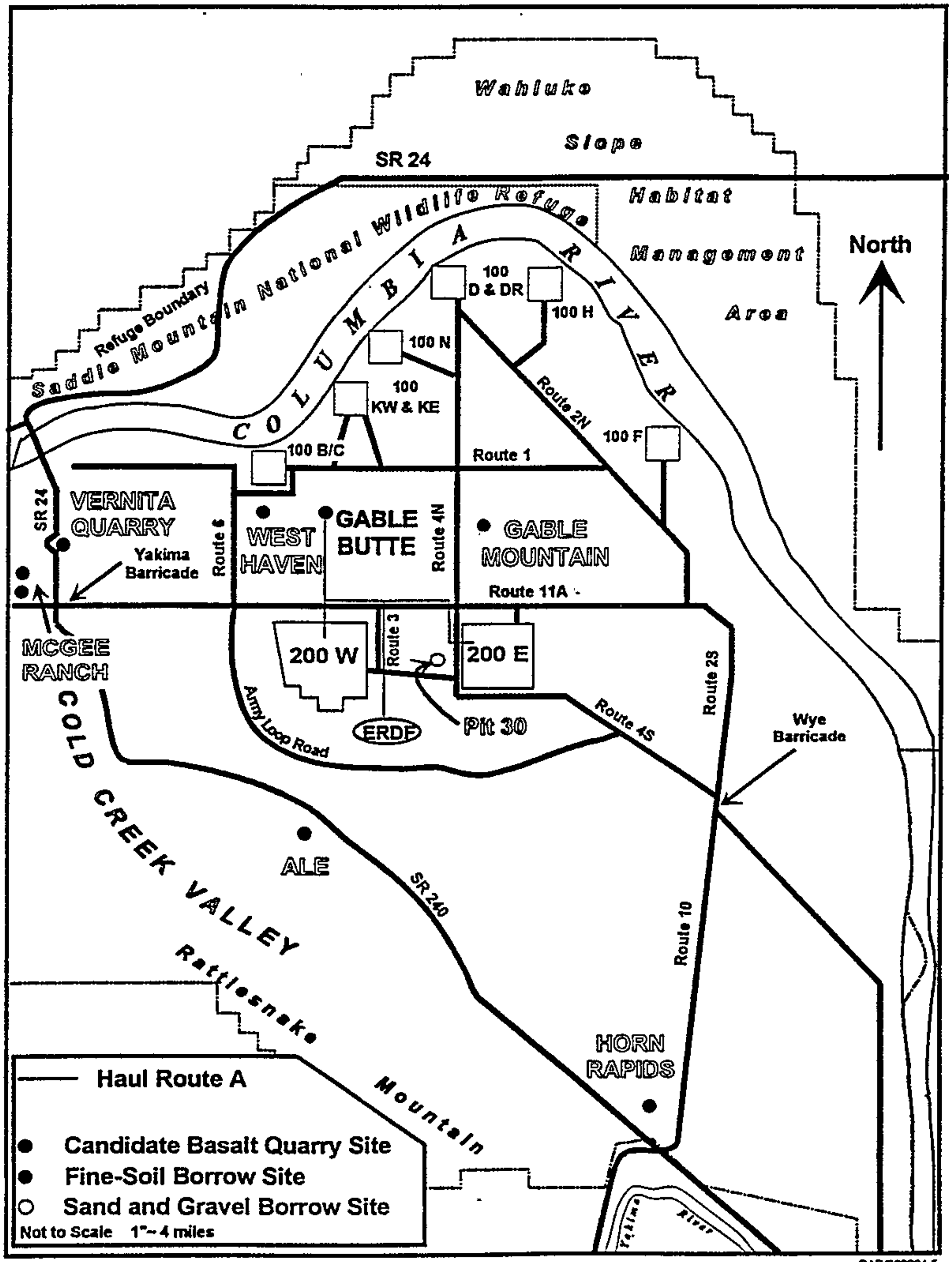


Figure 5-8. West Haven Route.

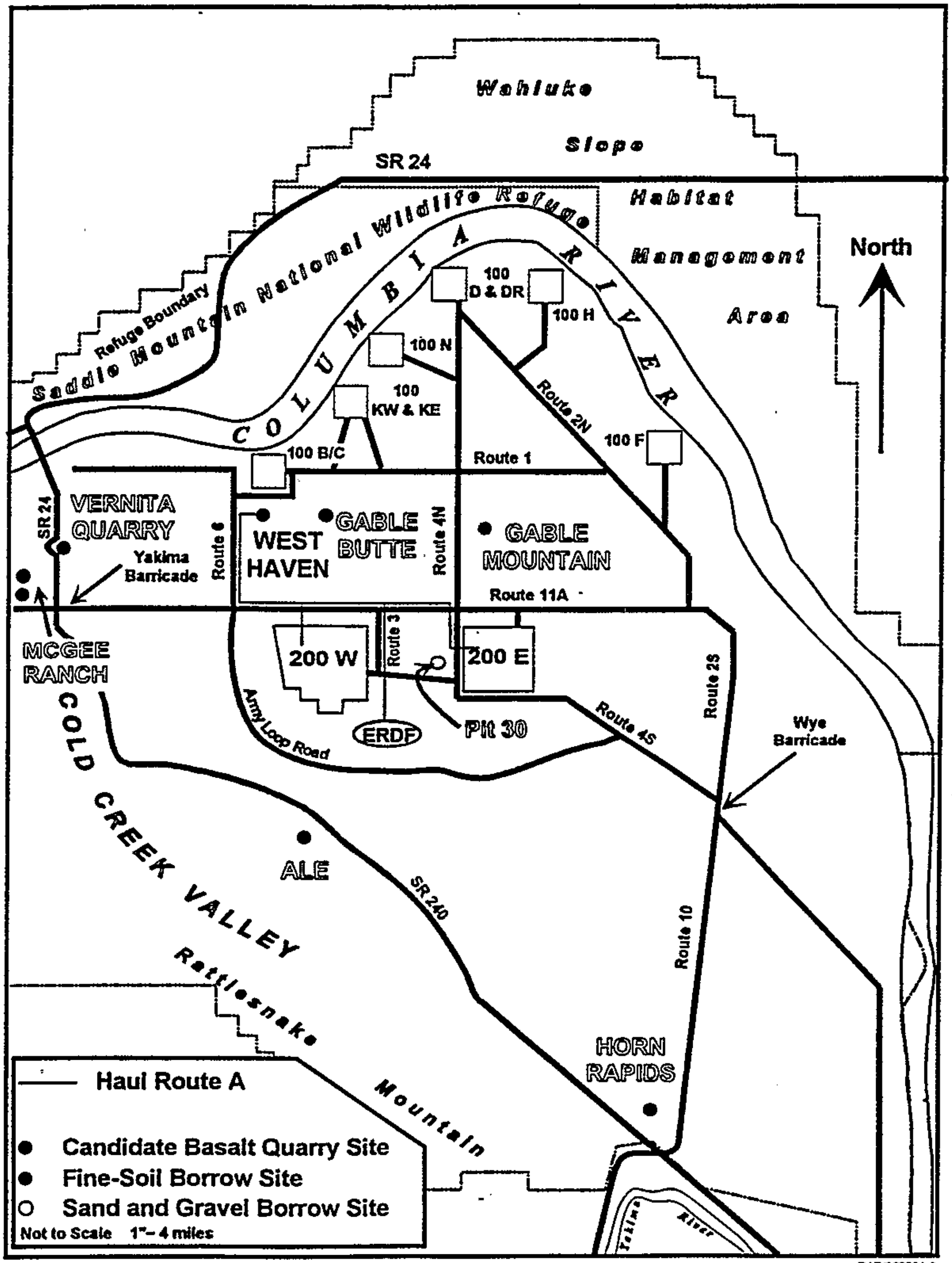
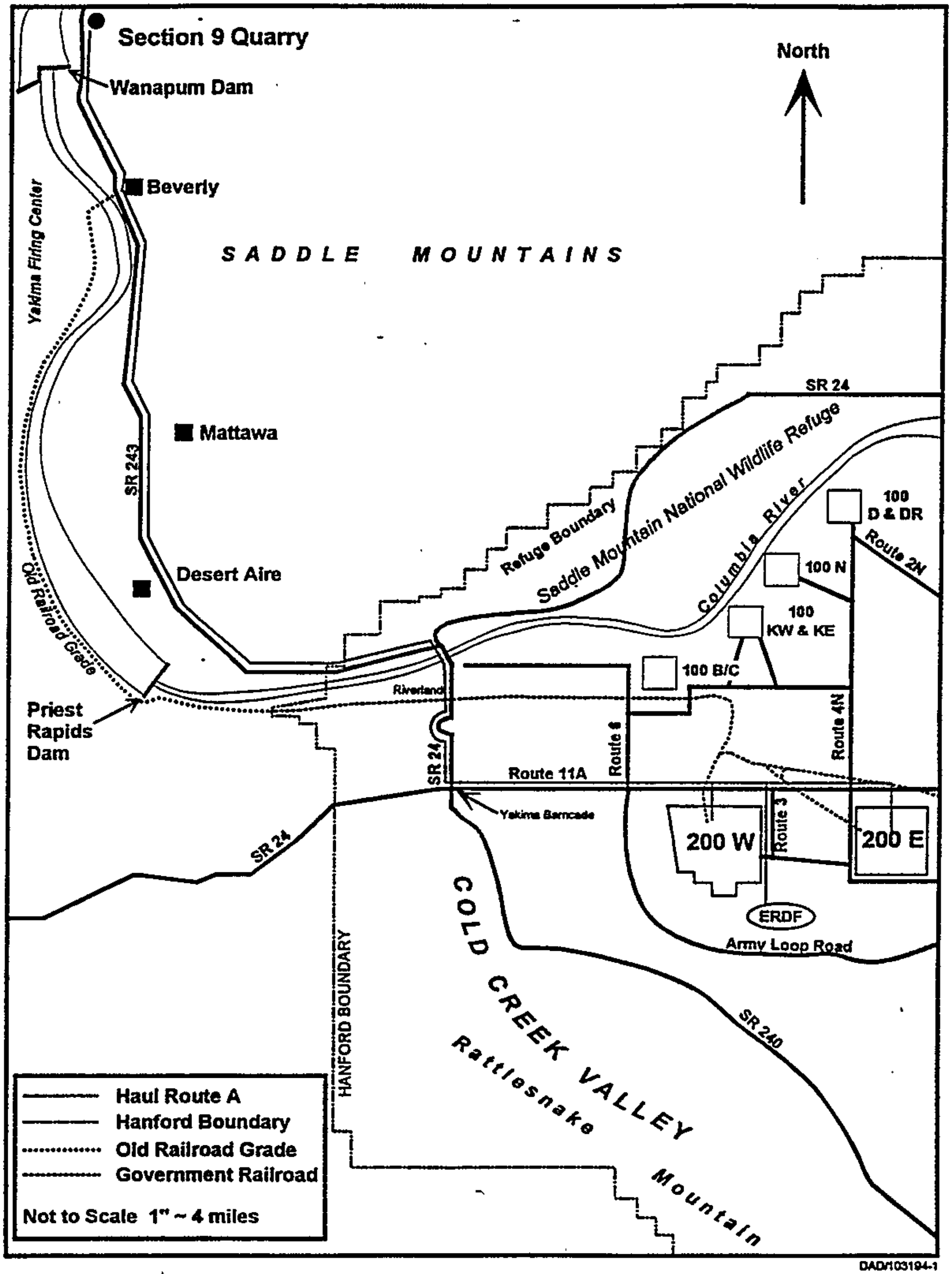


Figure 5-9. Section 9 Quarry Haul Route.



5.3.1.9 D'Atli Quarry. The D'Atli Quarry is located about 6.7 km (4.2 mi) east of Benton City, Washington. One route (Figure 5-10) has been identified for hauling riprap to the barrier construction sites from this quarry. This route has a cumulative volume-distance of 814 million m^3-km (667 million yd^3-mi) assuming the full 15.3 million m^3 (20 million yd^3) of riprap can be obtained here.

5.3.1.9.1 D'Atli Quarry Haul Route: Old Highway 12. This haul route will follow Highway 12 from the quarry to the bypass highway, and the bypass highway to Stevens Drive to the Wye Barricade, a total of about 38 km (24 mi). Distance estimates for this haul route are 59.5 km (37.0 mi) to 200 West, 53.6 km (33.3 mi) to 200 East, and 55.0 km (34.2 mi) to the proposed ERDF site. Costs will be incurred for road maintenance for the 38 km (24 mi) of Highway 12, the bypass highway, and Stevens Drive in addition to the Hanford Site roads.

5.3.1.10 Mahaffey Quarry. The Mahaffey Quarry is located southwest of Kennewick, Washington, on Clodfelter Road about 5.5 km (3.4 mi) from the intersection with Clearwater Avenue. Two routes (Figure 5-11) have been identified for hauling riprap to the barrier construction sites from this quarry. Route A has a cumulative volume-distance of 922 million m^3-km (756 million yd^3-mi) assuming the full 15.3 million m^3 (20 million yd^3) of riprap can be obtained here. With the same assumption, Route B has a cumulative volume-distance of 1,022 million m^3-km (838 million yd^3-mi). Although Route A has the shorter haul distance of the two alternatives, it is considered too hazardous from a safety perspective (see Section 5.2.2) because of the interaction between haul trucks and other motorists on a routinely heavily congested Columbia Center Boulevard and SR 240. Therefore, Route B will be selected as the preferred route in this SER.

5.3.1.10.1 Mahaffey Quarry Haul Route A: Clodfelter Road to Clearwater Avenue. This haul route will follow Clodfelter Road to Clearwater Avenue, then to Columbia Center Boulevard, and then to SR 240. SR 240 will be followed via the bypass highway to Stevens Drive, then out to the Hanford Site. This route is 66.9 km (41.6 mi) to 200 West, 61.2 km (38.0 mi) to 200 East, and 62.4 km (38.8 mi) to the proposed ERDF. Costs will be incurred for road maintenance for the affected portions of Clodfelter Road, Columbia Center Boulevard, SR 240, the Bypass Highway, Stevens Drive, and the Hanford Site roads.

Figure 5-10. D'Atli Quarry Haul Route.

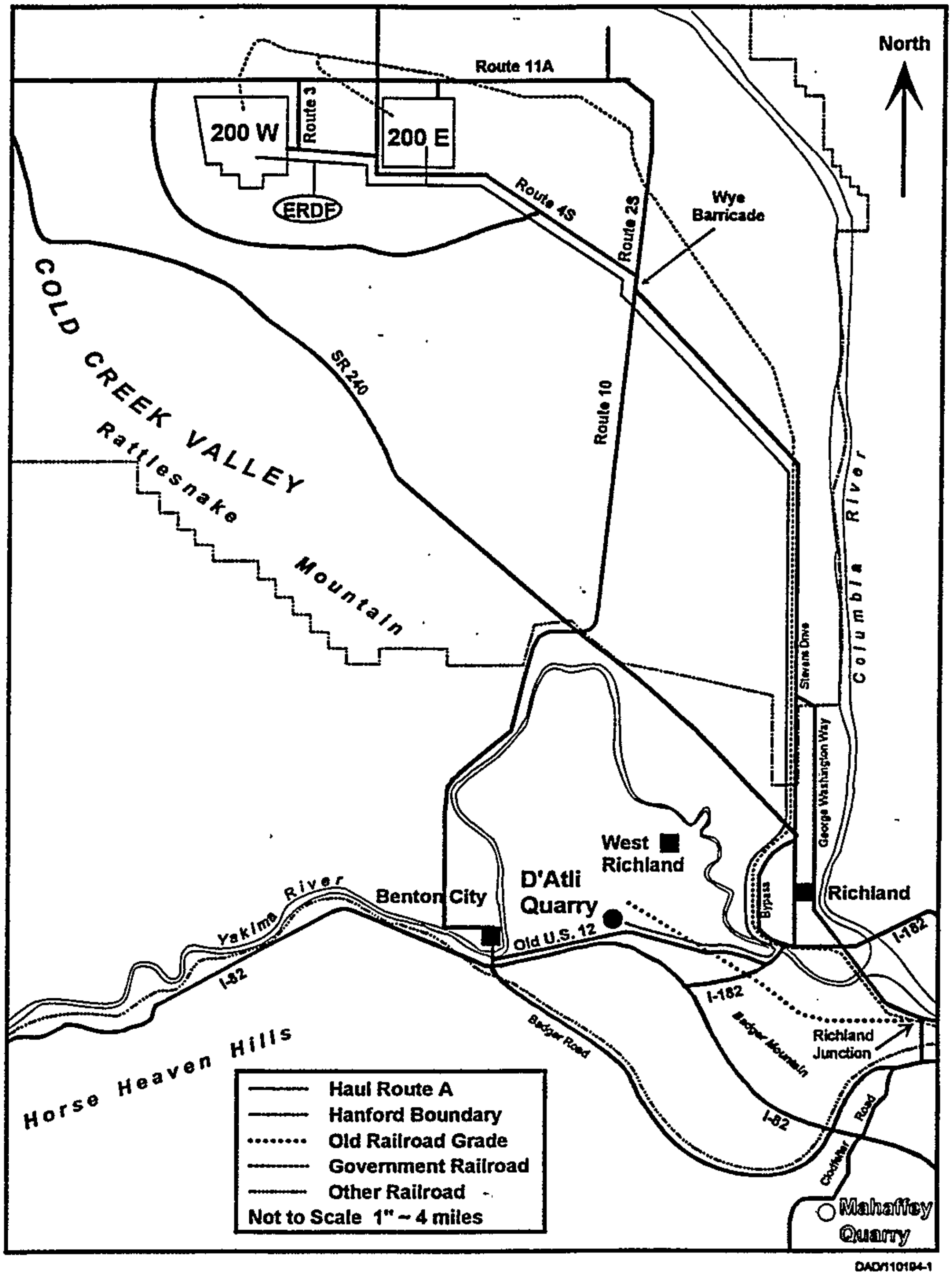
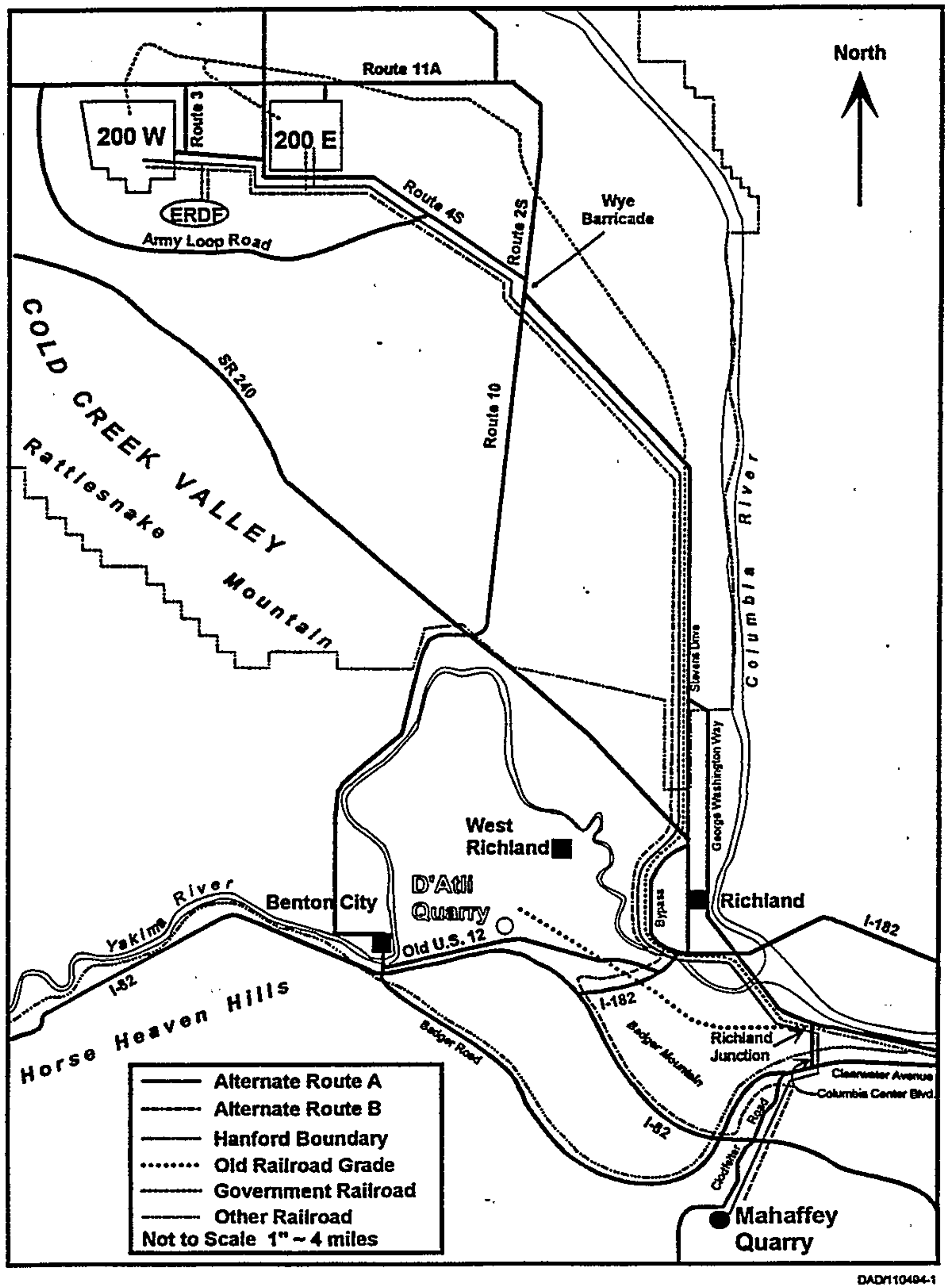


Figure 5-11. Mahaffey Quarry Haul Routes.



5.3.1.10.2 Mahaffey Quarry Haul Route B: Clodfelter Road to Badger Road. This route will follow Clodfelter Road to the intersection with Badger Road and will follow Badger Road to I-82, proceeding west on the interstate highway. The trucks will exit I-82 onto I-182 and will follow this highway to the Bypass Highway, then to Stevens Drive and onto the Hanford Site. This route is 73.9 km (45.9 mi) to 200 West, 68.1 km (42.3 mi) to 200 East, and 69.5 km (43.2 mi) to the proposed ERDF. Costs will be incurred for road maintenance for 53 km (33 mi) of Clodfelter Road, Badger Road, I-82, I-182, the Bypass Highway, and Stevens Drive to the Wye Barricade in addition to the Hanford Site roads.

5.3.2 Safety

On-Site Source	Vernita Quarry	McGee Ranch	ALE	Horn Rapids	Gable Mtn	Gable Butte	West Haven
Rating	8	6	5	6	9	9	9

Off-Site Source	Section 9 Quarry	D'Atli Quarry	Mahaffey Quarry
Rating	3	3	3

The main safety consideration for each candidate site is the transportation corridor used to move riprap from the quarry to the construction site and the associated interactions with public highway and Hanford Site traffic. (For a description of the route alternatives evaluated for safety in the following sections, refer to the Haul Distance Section.) Additionally, the proximity of the quarry to public highways is deemed an important safety consideration because activity of heavy equipment and quarry operations could distract motorists and could create traffic problems associated with dust and noise emanating from the quarry. Weighing the risk associated with the actual quarry operations at each candidate site tends not to affect the value rating of this engineering criterion because such risk should be roughly the same, regardless of the site evaluated. Additional considerations include the proximity of power or utility poles in relation to quarry activities. This is a minor consideration though, because with proper planning, the power and utility poles and lines can be relocated or quarry operations can be modified to include buffer zones around such hazards.

The haul route selected for evaluation against the safety criterion is the preferred haul route selected in the Haul Distance Section. Considerable improvements in the safety score would be realized if rail haulage is used where possible, especially for the three off-site quarries. Rail haulage will eliminate most of the direct interaction with traffic on roads and highways. The one exception is where the rail line crosses roadways; however, the safety benefits far outweigh the disadvantages because specific controls (warning lights and cross arms) can be placed at the railroad crossings.

5.3.2.1 Vernita Quarry. Alternative Route B was selected the most feasible in the Haul Distance Section for transporting large volumes of basalt over several decades and is used for evaluating the safety criterion of the Vernita Quarry. The quarry site is fairly close to SR 24, but development could begin slightly east of the existing quarry to minimize impacts to highway traffic. Also, as the quarry is developed, it will progress to the east and will be farther removed from SR 24.

This alternative includes a safe route that would be constructed parallel to SR 24 on Hanford property. This route would not interfere with traffic on SR 24, thereby removing risk involved with trucks entering traffic moving at near highway speeds. A gravel road could create large amounts of dust that might interfere with SR 24 traffic; a paved road would not. A gravel road is feasible but would have to include a plan to monitor and control dust. Significant warning signs and signals would not have to be maintained on SR 24 or SR 240.

A disadvantage is that slow haul trucks would be entering Route 11A near the Yakima Barricade, which has some moderate commuter traffic. Transportation schedules may have to be adjusted slightly to avoid commuter traffic in the morning and early evening.

5.3.2.2 McGee Ranch. Alternative Route D was selected the most feasible in the Haul Distance Section for transporting large volumes of basalt over several decades and is used for evaluating the safety of the McGee Ranch Quarry. Because the quarry site is 900 m (3,000 ft) from SR 24, the immediate distractions to motorists associated with quarry operations are minimized.

The advantage is that trucks would not have to enter or exit SR 24 because the riprap is conveyed to a stockpile on the east side of the highway. This eliminates the need to cross a lane of highway traffic at the entrance and exit of the quarry, which will reduce the probability of a collision with motorists using SR 24.

Disadvantages include distraction to motorists caused by a conveyor passing over SR 24, and a greater risk of traffic/personnel accidents during normal use, maintenance, or repair of the overhead conveyor system. This greater risk is associated with repairing the conveyor over the highway or with the possibility of material (riprap or conveyor parts) falling from an improperly maintained or operated conveyor system.

5.3.2.3 ALE Reserve. Alternative Route B was selected the most feasible in the Haul Distance Section for transporting large volumes of basalt over several decades and is used for evaluating the safety of the ALE Reserve Quarry. Alternate Route B would use a conveyor to move riprap across SR 240 to a stockpile. Trucks would haul riprap from the stockpile to the barrier construction sites using the spur road linking SR 240 and 200 West.

This alternative offers the advantage of using a conveyor system to move the riprap to a stockpile located on the north side of SR 240. This eliminates the potential for an accident between trucks and rapidly moving highway traffic on SR 240.

Disadvantages include the fact that the quarry operation would be located very close to SR 240, which could distract highway motorists and increase the potential for accidents. Trucks will encounter morning and afternoon commuter traffic on the spur road linking SR 240 and 200 West and may have to adjust their hauling schedules accordingly. Dust from quarry operations and haul trucks could interfere with traffic flow on SR 240, and extra dust-control measures may be necessary. A conveyor passing over SR 240 could distract motorists, and a greater risk of traffic/personnel accidents exists during normal use, maintenance, or repair of the overhead conveyor system. This greater risk is associated with repairing the conveyor over a highway or with the possibility of material (riprap or conveyor parts) falling from an improperly maintained or operated conveyor system.

5.3.2.4 Horn Rapids. Alternative Route B was selected the most feasible in the Haul Distance Section for transporting large volumes of basalt over several decades and is used for evaluating the safety of the Horn Rapids Quarry. The quarry site is located near SR 240 and Route 10, which could create some hazards to motorists using these roads. However, much of this problem could be alleviated by developing the quarry near the center and on the west side of the basalt formation, which is more removed from public roads.

The biggest advantage of this alternative stems from the fact that heavy commuter traffic along Route 10, the Wye Barricade, and Route 4 South would be avoided. Also, this will not impose the same degree of transportation schedule restrictions that may otherwise be required to avoid peak commuter traffic.

The disadvantage is that trucks would have to enter public traffic moving at highway speeds on SR 240, which increases the potential for an accident. Traffic control measures would have to be in place to reduce the speed of highway traffic and to warn motorists of truck crossings.

5.3.2.5 Gable Mountain. One route (Route A) has been identified for moving riprap from Gable Mountain to the barrier construction sites. This haul route primarily uses Route 4 North and Route 11A north of the 200 Areas.

The advantages of this route include no interaction with public traffic and use of only short portions of Route 4 North and Route 11A. Normally, Route 4 North receives little traffic, and Route 11A receives only moderate traffic compared to other Hanford roads such as Route 4 South. This establishes a safe transportation corridor for haul trucks moving between Gable Mountain and the barrier construction sites. Another advantage is that the quarry operation at Gable Mountain is far removed from frequently used Hanford roads, so dust, noise, and operations activities will not distract motorists as readily as quarries located near frequently used roads and highways.

Disadvantages include some moderate commuter traffic along Route 11A during the early morning and late afternoon commute. Some relatively heavy traffic may be encountered along Route 3 during the same time period; however, this would only be a concern for trucks bringing materials to the ERDF site.

5.3.2.6 Gable Butte. One haul route (Route A) has been identified for moving riprap from Gable Butte to the barrier construction sites. This haul route uses Route 11A north of the 200 Areas.

Advantages of this haul route are similar to those described for Gable Mountain. No interference with public traffic would exist, and only short portions of Route 11A would be used. Route 11A normally receives only moderate traffic compared to other Hanford roads such as Route 4 South. A safe transportation corridor is established for haul trucks moving between Gable Butte and the barrier construction sites. Another advantage is that the quarry operation at Gable Butte is far removed from Hanford roads, so dust, noise, and operations activities will not distract motorists as readily as quarries located near frequently used roads and highways.

Disadvantages include the fact that some moderate commuter traffic will be encountered along Route 11A, particularly during the early morning and late afternoon commute. Some relatively heavy traffic may be encountered along Route 3 during the same time period; however, this would only be a concern for trucks bringing materials to the ERDF site.

5.3.2.7 West Haven. One route has been identified for moving riprap from West Haven to the barrier construction sites. This route uses Route 11A north of the 200 Areas.

Advantages with this haul route are much the same as those described for Gable Mountain and Gable Butte. There will be no interference with public traffic, and only Route 6 and short portions of Route 11A will be used. As of this writing, Route 6 is closed to through traffic, and Route 11A normally receives only moderate traffic compared to other Hanford roads such as Route 4 South. A safe transportation corridor is established for trucks moving between West Haven and the barrier construction sites. Another advantage is that the quarry operation at West Haven is far removed from currently used Hanford roads, so dust, noise, and operations activities will not distract motorists as readily as quarries located closer to frequently used roads and highways.

A disadvantage is that some moderate commuter traffic will be encountered along Route 11A, particularly during the early morning and late afternoon commute. Some relatively heavy traffic may be encountered along Route 3 during the same time period; however, this would only be a concern for trucks bringing materials to the ERDF site.

5.3.2.8 Section 9 Quarry. One route has been identified for moving riprap from the Section 9 Quarry to the barrier construction sites. This route follows SR 243 and SR 24.

This is the only route that haul trucks can use for moving riprap from this quarry. The primary disadvantage with this route is a considerable portion of the route uses public highways. SR 243 and SR 24 are two-lane highways, which will create hazards for motorists passing slow moving haul trucks or haul trucks passing slow moving motorists. A potentially high volume of haul truck traffic will compound this hazard.

Considerable improvements in safety (and in the safety score) would be realized if a rail line is installed on the existing railroad grade that runs from Beverly, over the Columbia River to the West, and south along the river through Riverland and onto the Hanford Site (see the USGS Washington State quadrangles Beverly, Priest Rapids, Priest Rapids NE, Emerson Nipple, and Riverland). A detailed cost/benefit analysis of the transportation infrastructure would need to consider the costs for several items including rail haulage, installation of new rail line, improving the existing rail grade as necessary, truck hauling, and road maintenance and upgrades before the most efficient means of transportation can be determined.

5.3.2.9 D'Atli Quarry. One route has been identified for moving riprap from the D'Atli Quarry to the barrier construction sites. This route follows Highway 12 to the bypass highway.

The primary disadvantage with this route is a considerable portion of the route uses public highways. Highway 12 is a two-lane highway, which will create hazards for motorists passing slow moving haul trucks or haul trucks passing slow moving motorists. The bypass highway has four lanes; however, heavy commuter traffic will be encountered in the early morning and late afternoon hours. Haul schedules may have to be adjusted accordingly to avoid heavy commuter traffic in the morning and late afternoon on these roads. A potentially high volume of haul truck traffic will compound hazards along this route.

Considerable improvements in safety (and in the safety score) would be realized if a rail line is installed on the existing railroad grade that runs about 900 m (3,000 ft) north of the quarry. This rail line would connect with existing track at the Richland Junction, south of SR 240 near Columbia Center Boulevard (see the USGS Washington State quadrangles Benton City, Richland, Badger Mountain, and Kennewick). A detailed cost/benefit analysis of the transportation infrastructure would need to consider the costs for several items including rail haulage, installing rail line, improving the existing rail grade as necessary, truck hauling, and road maintenance and upgrades before the most efficient means of transportation can be determined.

5.3.2.10 Mahaffey Quarry. Route B has been identified for moving riprap from the Mahaffey Quarry to the barrier construction sites. The quarry is located near Clodfelter Road, about 5.5 km (3.4 mi) from the Clearwater Avenue intersection near Kennewick, Washington.

The primary disadvantage with this route is that most of it uses several heavily travelled public roads and highways. Of primary concern is the use of the Bypass Highway for hauling large material volumes. (Even though this haul route is longer than the Alternative A, it is believed to be much safer than using Columbia Center Boulevard, which is heavily congested during morning and late afternoon commutes and moderately congested during the rest of the day.) Haul schedules may have to be adjusted accordingly to avoid heavy commuter traffic along the bypass highway in the morning and late afternoon on these roads. A potentially high volume of haul truck traffic will compound hazards along this route.

Considerable improvements in safety (and in the safety score) would be realized if the riprap is moved by conveyor system or truck to the nearby rail line in Badger Canyon. The length of the conveyor system will depend upon the location of the land near the rail line that is acquired for the dumping pocket and transfer yard, in this case, at least 3.2 km (2 mi). The distance of truck haulage to the rail line would be around 8 km (5 mi), also depending on the location of the land acquired for the dumping pocket and transfer yard. This rail line connects with track at the Richland Junction, south of SR 240 near Columbia Center Boulevard (see the USGS Washington State quadrangles Badger Mountain, Richland, and Kennewick). A detailed cost/benefit analysis of the transportation infrastructure would need to consider the costs of rail haulage, the costs of installing rail line, costs for improving the existing rail grade as necessary, the costs for truck hauling, and associated road maintenance costs before the most efficient means of transportation can be determined.

5.3.3 Expansion Potential

On-Site Source	Vernita Quarry	McGee Ranch	ALE	Horn Rapids	Gable Mtn	Gable Butte	West Haven
Rating	10	5	3	8	10	10	10
Off-Site Source	Section 9 Quarry	D'Atli Quarry	Mahaffey Quarry				
Rating	10	3	3				

Value ratings for expansion potential are assigned based on the extent of the basalt formation at the candidate sites. Although all the candidate sites could be mined deeper to accommodate future expansion, there is an added cost to doing so. A basalt formation covering a large surface area could yield more riprap per unit depth of excavation than a formation covering a relatively small area. These factors are used to evaluate each candidate site for expansion potential.

5.3.3.1 Vernita Quarry. Vernita Quarry is located in an extensive basalt outcrop parallel to the Columbia River. A considerable volume of basalt exists outside of the immediate area identified for quarry development at this candidate site. Additional overburden per unit area may be encountered on parts of this outcrop if it were expanded beyond the currently identified boundaries (see Appendix C); however, the potential volume of useable basalt makes expansion here a feasible option.

5.3.3.2 McGee Ranch. The basalt source identified at McGee Ranch comprises a large knoll that may not supply all the necessary material. Deeper excavation in this basalt formation could yield more basalt. Also, there are likely other sources of basalt at McGee Ranch, but they may not be continuous with the existing formation in the same manner as the basalt found at the Vernita Quarry that allows for uninterrupted quarry advancement. Further geologic surveys would be necessary to verify the extent of this formation as well as other formations at McGee Ranch.

5.3.3.3 ALE Reserve. The near-surface portion of the basalt formation identified at this site is fairly limited aerially compared to the other sites. The potential for continuing quarry operations to accommodate expansion at this site is not known but appears to be the most limited of the candidate sites investigated in this report. The quantity of basalt at this site is large, and expansion likely could be accommodated through deeper excavation of the flow. However, further geologic surveys would need to be conducted to verify the extent of this formation and the depth of overburden and weak flow-top material.

5.3.3.4 Horn Rapids. The near-surface source at the Horn Rapids Site is fairly expansive and could accommodate future expansion. This site does not have the same expansion potential as the Vernita Quarry but likely exceeds that of the McGee Ranch and ALE sites. Further geologic surveys would need to be conducted to verify the extent of this formation.

5.3.3.5 Gable Mountain. Gable Mountain is a prominent geologic feature north of Route 11A and north to northeast of the 200 East Area. A quarry that exists on the west end of this mountain has the capacity to supply all basalt needs at Hanford. This quarry has excellent expansion potential by advancement eastward into the mountain as demand for basalt resources materializes. Also, talus slopes along the base of Gable Mountain have the capacity to supply significant quantities of basalt that is already broken into riprap-sized material that may be suitable for barrier construction.

5.3.3.6 Gable Butte. Gable Butte is a prominent geologic feature north of Route 11A and north of the 200 West Area. Gable Butte and a number of outcrops have the capacity to meet all basalt needs at Hanford. The outcrops immediately west of Gable Butte provide excellent opportunities for quarry expansion. Also, talus slopes at the base of these outcrops have the capacity to supply significant quantities of basalt that is already broken into riprap-sized material that may be suitable for barrier construction.

5.3.3.7 West Haven. West Haven and nearby outcrops have the capacity to supply significant quantities of basalt material that could meet all of Hanford's need for such material. Although West Haven is not as large as Gable Mountain or Gable Butte, it has good expansion potential. Also, talus slopes at the base of many of the outcrops in the West Haven area have the capacity to supply significant quantities of basalt that is already broken into riprap-sized material that may be suitable for barrier construction.

5.3.3.8 Section 9 Quarry. The Section 9 Quarry and surrounding basalt formation can easily supply the upper bound volume estimate of 15.3 million m^3 (20 million yd^3) of riprap[3]. Bank reserve volumes at this quarry site far exceed the Hanford Site basalt materials requirement.

5.3.3.9 D'Atli Quarry. The D'Atli Quarry and surrounding basalt formation could supply an estimated basalt bank volume of 7.6 million m^3 (10 million yd^3)[4] from this 24-ha (60-acre) site. This translates to approximately 11.6 million m^3 (15.2 million yd^3) of loose riprap.

5.3.3.10 Mahaffey Quarry. An area of 5.7 ha (14 acres) of 16 ha (40 acres) is currently permitted for the Mahaffey Quarry operations[5]. Total reserve estimates at this site are not known at this time. Much of the basalt is subsurface with as much as 2.4 m (8 ft) of topsoil in places. For this SER, the reserve estimate for this site is assumed to be similar to that of the 24-ha (60-acre) D'Atli Quarry.

5.3.4 Land Reclamation

On-Site Source	Vernita Quarry	McGee Ranch	ALE	Horn Rapids	Gable Mtn	Gable Butte	West Haven
Rating	8	5	3	7	8	8	8
Off-Site Source	**Section 9 Quarry**	**D'Atli Quarry**	**Mahaffey Quarry**				
Rating	8	8	3				

Consideration must be given to the relative impact to natural resources by developing a basalt quarry in a given area and the relative effort required to reclaim the land after

[3] Personal conversation (10/26/94) with Billy Fulleton, Section 9 Quarry representative.

[4] Personal conversation (10/26/94) with John Hjatalin, D'Atli Construction representative.

[5] Personal conversation (11/3/94) with Fred Mahaffey, Mahaffey Enterprises representative.

quarry closure. It is not the scope of this SER to outline detailed plans necessary for quarry reclamation; however, it is prudent to assume that some degree of land reclamation will be required at the quarry site, either through regulatory obligation or negotiation with appropriate parties.

Some guidelines pertaining to quarry reclamation and plant species mitigation are included in Appendix E. This appendix is included as a tool and guide for planning reclamation and mitigation activities, but is not meant to dictate or establish policy. There are no legally binding requirements for mitigating candidate or monitor plant species; however, a level of effort to protect such species could be expended in proportion to the degree of concern for that specie in order to improve reclamation quality. For example, this may involve transplanting a few samples out of a given population of a candidate or monitor specie that can be used later during reclamation activities. If a T&E specie is found, additional and more stringent efforts would need to be expended during the mitigation process because T&E species are legally protected.

Ultimately, cost/benefit analyses should be conducted among several reclamation and/or mitigation alternatives in order to select the most effective option for the dollars spent. This SER will not outline detailed plans necessary for quarry reclamation; however, major considerations pertaining to reclamation that may be important to the siting process will be presented. Some guidelines pertaining to quarry reclamation are included in Appendix E. The degree of success for reclamation for this SER is measured by how well the reclaimed land conforms with the surrounding landscape and could vary greatly depending on the type of quarry developed at a given site.

5.3.4.1 Exposed Basalt Outcrops. Extensive exposed basalt outcrops can be found on the Hanford Site north of the 200 Areas, parallel to the Columbia River. These outcrops include Vernita Quarry, West Haven, Gable Butte, and Gable Mountain. Basalt outcrops are ideal sources for acquiring riprap because the mining operation is simpler than that associated with an open-pit mine on a near- surface basalt source. Outcrops also have the advantage of using gravity to bring the riprap down to grade during a blasting operation; i.e., the material does not have to be hauled out of an open-pit mine.

5.3.4.1.1 Area of Impact. The area of impact for developing a quarry on a basalt outcrop includes the area of the outcrop secured for quarry development and an operations area for various facilities, equipment, parking, and stockpiling. Operations facilities and equipment space includes that necessary for portable office structures and space for quarry equipment such as haul trucks, loaders, dozers, water trucks, screens, conveyors, and crushers. Parking will be necessary for vehicles belonging to quarry operations personnel and for other quarry equipment. Stockpiles may include graded basalt riprap, screened gravel, unusable flow-top material, topsoil, or other overburden materials from the bench top. The exposed bench will advance farther into the basalt formation as it is mined, leaving behind an area at grade that can be used for future or expanding stockpiles and operations facilities.

Visual and aesthetic results of reclaiming a quarry developed in an existing outcrop may more successfully blend with the surrounding undisturbed landscape than an open-pit mine. A quarry operation in an exposed bench of an outcrop could be conducted in such a manner to ensure that an exposed bench remains once quarry development is complete and to ensure that materials are not removed from below the grade of the surrounding undisturbed landscape. In essence, the topographical outline of the bench face would be translocated back into the original outcrop, thereby maintaining many of its original topographical features and its appearance. It would also be relatively simple to grade the approach to the new bench face so it will blend into the surrounding undisturbed terrain. Overburden and spoil materials from quarry operations should be used during the reclamation process.

5.3.4.2 Near-Surface Basalt Sources. Because no convenient exposed outcrops associated with the near-surface basalt sources exist, they would have to be developed similar to open-pit surface mines. Basalt would have to be moved from the pit to the surface using trucks or conveyors. Crushing, screening, and stockpiling operations will take place outside of the pit, where plenty of maneuvering and working room is available.

5.3.4.2.1 Area of Impact. The area of impact for developing a quarry on a near-surface basalt source will include the surface area of the bank volume basalt to be mined; a safety buffer zone encompassing the basalt source that incorporates any side slopes and that provides a safe working zone at grade; and an operations area that includes space for operations facilities, equipment, parking, and stockpiling.

The footprint of an open-pit surface mine can cover an extensive area of land because of the need to maintain a safe side slope for unconsolidated overburden above the desired basalt. Slopes of 1.5:1 (horizontal to vertical) are normally required at Hanford for stabilization of side slopes in excavations of unconsolidated materials, unless approved shoring methods are used. Trucks and/or loaders will need to enter and exit the open pit on ramps linking the surface and the pit.

Although land reclamation has been successful in surface mines, reclaiming an open-pit mine so that it will blend with the surrounding environment would be extremely difficult. After quarry closure and reclamation, a large depression will remain - a topographical feature will be evident that is out of character with the surrounding land formations.

5.3.4.3 Candidate Sites. Vernita Quarry is located in an exposed bench that could be reclaimed fairly successfully from a physical and topographic perspective. As described previously, the bench will be translocated into the original outcrop, and when the quarry operations are complete, an exposed bench will remain. The approach to the new bench could be graded so that there is a natural transition to the surrounding terrain. It can be revegetated to further enhance the transition between undisturbed and disturbed areas.

The candidate site at McGee Ranch is a knoll that could be developed similarly to an exposed outcrop. However, the reclaimed landscape will not blend with the surrounding landscape to the same degree as the Vernita Quarry Site. The knoll at McGee Ranch has several drainages running lengthwise on either side. After quarry operations are complete, these drainages will not exist because the basalt formation that formed them with the surrounding terrain will be removed. Also, a pit will be created if the formation is mined below the grade of the surrounding landscape to provide additional basalt materials. A revegetation program may help the quarry area partially blend with the surrounding landscape and camouflage the quarry.

The site at the ALE Reserve probably would be developed similarly to a surface mine because no major exposed benches exist. After reclamation, a large topographical depression will be evident that is out of place with the surrounding landscape. Additional issues are likely to be encountered in the future if development of a quarry were proposed on the ALE site. Because the ALE Reserve is an ecology reserve that, for the most part, has remained untouched by large development activities, a large-scale basalt quarry does not fit historical or current use designations for the ALE Reserve.

The Horn Rapids Site could be developed like the basalt formation at Vernita. Although there is not a well developed and exposed bench at the Horn Rapids Site, there is enough vertical relief at the south end to develop a 9- to 12-m (30- to 40-ft) bench. Reclamation at this site should be fairly successful from a physical and topographic perspective because the quarry operation could maintain a grade with the surrounding terrain, and therefore not create an open pit. However, if additional basalt is required beyond that contained in the portion of the formation above grade, a pit may have to be developed.

Gable Mountain, Gable Butte, and West Haven contain extensive exposed basalt benches that are well suited for quarry development. Additionally, extensive quantities of riprap exist in the many talus slopes at the base of these outcrops. Considering the quantity of basalt contained within these outcrops, there will be no need to develop open pit mines unless restrictions are placed on quarry expansion. Land reclamation at these sites should be very successful in blending the quarry with the surrounding landscape.

Because the Section 9 Quarry, the D'Atli Quarry, and the Mahaffey Quarry are privately operated, restoration of the site will be the owner's responsibility. However, as indicated on USGS topographic maps, the Section 9 Quarry and the D'Atli Quarry sites exist along outcrops or bluffs similar to the Vernita Quarry. The Mahaffey Quarry is more similar to a near-surface quarry in nature when the potential basalt volume that may be removed is considered. For evaluation purposes, the relative success of reclamation at the Section 9 Quarry and the D'Atli Quarry are assumed to be equivalent to the Vernita Quarry site, while that for the Mahaffey Quarry is assumed to be similar to the ALE candidate quarry site.

5.4 WEIGHTED MATRIX

Tables 5-3a, 5-3b, and 5-3c contain a synopsis of the scores assigned to each candidate site through the engineering criteria. The tables contain the weight assigned to each engineering criterion, the score assigned to each candidate quarry site for each engineering criterion, and the total relative score. The total relative score is the product of the criterion weight and the candidate quarry site score.

5.5 RECOMMENDATIONS FOR CANDIDATE SITE DEVELOPMENT

The candidate quarry sites evaluated in this study include the three sites considered in Myers (1985), four new Hanford Site candidates quarries, and three off-site quarries. Tables 5-2a and 5-2b clearly indicate that hauling basalt from Gable Butte would save nearly $50 million compared to hauling from the Vernita Quarry (the highest ranking new site), $150 million over the Horn Rapids site, and at least $300 million compared to the three off-site quarries. Both the Safety and Haul Distance criteria have equal importance to the rating process; however, the primary factor affecting a candidate site score is the haul distance. Additional issues pertaining to the ecological reserve status of the ALE candidate site will likely prevent, or at least further complicate and/or delay, approval for any such development of this site as a quarry, which realistically makes it a less likely alternative.

The following recommendations for quarry site development priority are based on results from the evaluation of each candidate site against the set of engineering criteria presented in this SER.

Table 5-3a. Weighted Matrix Synopsis

		On-site Sources							
		Vernita Quarry		McGee Ranch		ALE		Horn Rapids	
Criterion	Weight	Value Rating	Relative Score	Value Rating	Relative Score	Value Rating	Relative Score	Value Rating	Relative Score
Transportation	10	8	80	8	80	10	100	4	40
Safety	10	8	80	6	60	5	50	6	60
Expansion Potential	6	10	60	5	30	3	18	8	48
Land Reclamation	5	8	40	5	25	3	15	7	35
TOTAL SCORE		260		195		183		183	

Table 5-3b. Weighted Matrix Synopsis (continued)

		On-site Sources					
		Gable Mountain		Gable Butte		West Haven	
Criterion	Weight	Value Rating	Relative Score	Value Rating	Relative Score	Value Rating	Relative Score
Transportation	10	9	90	10	100	9	90
Safety	10	9	90	9	90	9	90
Expansion Potential	6	10	60	10	60	10	60
Land Reclamation	5	8	40	8	40	8	40
TOTAL SCORE		280		290		280	

Table 5-3c. Weighted Matrix Synopsis (continued)

		Off-site Sources					
		Section 9 Quarry		D'Atli Quarry		Mahaffey Quarry	
Criterion	Weight	Value Rating	Relative Score	Value Rating	Relative Score	Value Rating	Relative Score
Transportation	10	2	20	3	30	2	20
Safety	10	3	30	3	30	3	30
Expansion Potential	6	10	60	3	18	3	18
Land Reclamation	5	8	40	8	40	3	15
TOTAL SCORE		150		118		83	

5.5.1 Preferred Site - Gable Butte

The results from evaluating each site against the set of weighted engineering criteria demonstrate that Gable Butte is the optimum candidate site for developing a quarry to produce basalt riprap for barrier construction. Gable Butte received a total score of 290 points from the evaluation process.

Gable Butte is located closer to potential barrier construction sites than any other candidate quarry site. This reduces the haul distance, which could save hundreds of millions of dollars over the life of barrier construction at Hanford. Existing rail line immediately next to the candidate quarry could also be used for transporting the riprap. Because this proposed site consists of several exposed basalt outcrops, the material will not have to be hauled out of an open pit. There is ample of room for screening, crushing, and stockpiling basalt on land near Gable Butte. Quarry activities and fugitive dust will not distract motorists because the quarry operations are not located next to frequently used roadways.

5.5.2 First Alternate - West Haven

With a total score of 280, West Haven is the first alternate site to Gable Butte. West Haven is located near Route 6 to facilitate truck transport to the nearby 200 Areas. Because it is located close to the 200 Areas, hundreds of millions of dollars will be saved for transportation costs over the life of barrier construction (compared to the more distant alternatives). Additionally, this site contains large quantities of basalt in exposed outcrops that will easily facilitate development of a quarry.

5.5.3 Second Alternate - Gable Mountain

Gable Mountain is the second alternate site to Gable Butte with a total score of 280 points. Gable Mountain provides excellent expansion potential and a relatively short transportation distance from the west end of the mountain. A small quarry is already established on the west end of the mountain and would provide an ideal location for further development.

5.5.4 Third Alternate - Vernita Quarry

The third alternate site is Vernita Quarry with a score of 260. This basalt formation is quite extensive and has the capacity to provide basalt materials for an extended period of time. Minimal overburden and flow-top material exists over much of the Vernita Quarry site identified for development. The colonnade structure observed along the face of this outcrop suggests that this material is very suitable for use in protective surface barrier construction and will supply the desired size fraction of riprap. Observation of the exposed portion of the outcrop also indicates the basalt is structurally competent and will meet and exceed the expectation of the riprap to serve as an internal structural component of the protective surface barrier. This basalt formation is quite extensive and therefore has the capacity to provide basalt materials for an extended period of time.

Haul roads can be built on Hanford property so trucks transporting basalt from the Vernita Quarry to the barrier construction site will not have to use state highways, eliminating the potential for an accident with motorists using SR 24.

Aesthetic land reclamation will be more successful at the Vernita Quarry than at the remaining near-surface site options. Because the outcrop face will be translated southward and eastward into the existing basalt, much of the original appearance and character of the area can be maintained. The disturbed portion of land from which basalt material is removed could be graded to blend with the surrounding undisturbed landscape.

5.5.5 Fourth Alternate Site - McGee Ranch

The fourth alternate site is McGee Ranch with a score of 195. McGee Ranch has some expansion potential, but its location presents additional safety concerns because haul trucks will have to use portions of SR 24.

5.5.6 Fifth Alternate Site - Horn Rapids

With a score of 183, the Horn Rapids site is the fifth alternate for securing basalt material for the 200 Area plateau. The relatively low score primarily results from the long haul distance from the quarry to the barrier construction sites. However, this quarry site may be valuable if barriers are ever built in the 300 Area or other nearby sites. The Horn Rapids Site consists of an extensive formation of Elephant Mountain Basalt on the southern edge of the Hanford boundary that should supply ample basalt material.

Because this site is far removed from the 200 Areas, transportation costs for hauling the basalt riprap will be significantly greater than those associated with the Vernita Quarry, McGee Ranch, and ALE. The haul distance is at least 16 km (10 mi) longer from the Horn Rapids site to the 200 Areas than the longest route alternative for all the other sites. Assuming 15.3 million m^3 (20 million yd^3) of basalt riprap will be hauled at $0.27 per metric ton-km ($0.40 per ton-mile) using highway licensed trucks, transport costs would amount to $160 million more than the Gable Butte site.

5.5.7 Sixth Alternate Site - ALE

The sixth alternate site is ALE with a total score of 183. Because this basalt source is located on the ALE reserve, it is likely that a multitude of land use issues involving a number of groups would have to be negotiated to gain approval for using this area. These issues have the potential of severely limiting or completely suspending plans for expanding a quarry located there. Additionally, expansion potential is somewhat limited at this site. However, it does provide the second shortest transportation route of all the sites considered. Only Gable Butte has a shorter transportation route.

5.5.8 Seventh Alternate Site - Section 9 Quarry

The seventh alternate site is the Section 9 Quarry with a total score of 150. The low score for this site results from the long haul distance from the quarry to the 200 Area plateau. A number of safety issues also exist for hauling the material by truck on public highways. However, many of the safety issues can be.alleviated by installing new rail track on existing railroad grades and using existing rail track.

5.5.9 Eighth Alternate Site - D'Atli Quarry

The eighth alternate site is the D'Atli Quarry with a total score of 118. This site scores low because of the long haul distance and somewhat limited expansion potential.
A number of safety issues also exist for hauling the material by truck on public highways. However, many of the safety issues can be alleviated by installing new rail track on existing railroad grades and using existing rail track.

5.5.10 Ninth Alternate Site - Mahaffey Quarry

The ninth alternate site is the Mahaffey Quarry with a total score of 83. This site scores low because of the long haul distance and somewhat limited expansion potential.
A number of safety issues also exist for hauling the material by truck on public highways. However, many of the safety issues can be alleviated by moving the basalt to a dumping pocket and transfer yard next to the nearby rail line in Badger Canyon.

6.0 ADDITIONAL CONSIDERATIONS

6.1 BORROW OPERATIONS

This section presents generic borrow site considerations that apply to all of the candidate basalt quarries outlined in the previous sections. Many of these issues should be addressed in a quarry development plan and/or a safety plan that can be written once the quarry site is selected.

- ARAR. Applicable or relevant and appropriate requirements must be applied at all times.
- WARNING SIGNS. As appropriate, proper warning signs, flashing lights, flags, and flaggers must be maintained in accordance with Washington State Department of Transportation regulations for all public roads and all Hanford Site roads used by haul trucks transporting basalt riprap to the protective surface barrier construction site. These warning signs should alert motorists of slow trucks merging and exiting highway traffic, reduced speed limits, and passing restrictions.
- DUST CONTROL. Ensure sufficient dust control measures are in place at the quarry and along haul routes to prevent dust from becoming a nuisance or impediment to safe driving conditions to highway or Hanford Site motorists and also from becoming a nuisance to the environment surrounding the quarry.
- QUARRY HAZARDS. Maintain a high level of awareness for objects and people surrounding the general quarry area that could potentially be affected by blasting work and quarry activities. This includes motorists, site personnel, highway surfaces, power transmission lines, power transmission line towers, and utility poles. Precautions must be taken to ensure all quarry operations (drilling, blasting, crushing, screening, loading, and handling) are conducted safely.
- PERSONNEL SAFETY. Ensure that all personnel working in the quarry are properly trained for the assigned job function and that they are provided with the proper safety equipment in accordance with state and federal regulations. Before entering the quarry, all personnel and visitors must read, understand, and sign the job safety analysis located in the site superintendent's office for that quarry. In addition, visitors must obtain permission from the quarry site superintendent before entering the quarry.

- ACCESS CONTROL. Control access to the quarry and operations area as well as all stockpile areas to prevent unauthorized access and to ensure personnel and public safety as well as property protection.

- REGULATIONS. Subcontractors shall ensure adherence to all applicable state and federal regulations and directives as well as Hanford Site safety practices (on-site subcontractors) for all phases and aspects of quarry operation activities.

6.2 CULTURAL, HISTORIC, AND ARCHAEOLOGIC RESOURCES

Findings from Cultural Resource Surveys (CRS) must be considered for each site. A CRS documents any findings that are deemed significant from a cultural, historic, or archaeologic perspective. These findings may be significant to a number of organizations, including Native Americans, state agencies, and federal agencies. Significant findings will be forwarded to the SHPO for determination of eligibility for listing on the National Register. Cultural resource findings may preclude a candidate site from being developed as a quarry. A candidate site will be precluded from consideration for development as a basalt quarry upon direction from the DOE-RL.

Appendix F contains a CRS summary report from the Hanford Cultural Resources Laboratory (HCRL) for the candidate basalt quarry sites discussed in this SER. In particular, this CRS summary focuses on the Gable Butte, Horn Rapids, and ALE candidate quarry sites. The purpose for the CRS was to bring the same relative level of understanding from a cultural, historic, and archaeologic resource perspective to all seven Hanford Site candidate quarries . Surveys will be conducted at the off-site quarries as required if it is determined they will be used.

Using documentation and information from past surveys, the HCRL concluded that the three sites mentioned previously lacked the quantity of cultural, historic, and archaeologic resource information that was available for the remaining four Hanford candidate sites (Gable Mountain, West Haven, Vernita Quarry, and McGee Ranch). As a result, at the Gable Butte, Horn Rapids, and ALE candidate sites, a 50 percent pedestrian survey was conducted to document cultural, historic, and archaeologic resources. The 50 percent pedestrian survey assessed the cultural, historic, and archaeologic resources on roughly half the land area selected for quarry development at these three sites. The portions surveyed included those believed to most likely contain cultural, historic, and archaeologic resources.

The survey report in Appendix F concludes by recommending the ALE and Horn Rapids candidate quarry sites be given first consideration for quarry development. These two sites are the least sensitive from a cultural resource perspective. However, these sites are among the least favorable from an engineering perspective for various reasons. The Horn Rapids site is the farthest removed from the 200 Areas where the riprap will be required and, therefore, would incur the greatest transportation costs . The ALE site is close to the 200 Areas via the Rattlesnake Barricade into the 200 West Area, so haul distance is not an issue. However, because the ALE candidate quarry is located on the ALE reserve, an essentially untouched zone historically dedicated to ecological studies, a number of difficult issues will certainly arise if a large-scale open-pit quarry were proposed for development there. The issues surrounding the ALE candidate quarry are further complicated by the fact that it is unknown with what entity the ALE reserve will reside once quarry operations are ready to begin.

Before any of the candidate quarry sites are developed, a CRS must be completed on the remaining unsurveyed tracts of land at the given site. Additionally, significant findings from the final survey would be submitted to the SHPO for determining eligibility for listing on the national register. Following this, a Mitigation Plan or Programmatic Agreement must be developed that will explain if, and how, the adversely impacted cultural resources can be mitigated.

6.3 OFF-SITE BASALT SOURCES

Off-site sources of basalt material for use in constructing protective surface barriers should be considered as the last option. However, if sufficient quantities of riprap cannot be secured on Hanford property, the only remaining option is to contract off-site commercial sources such as the Section 9 Quarry, the D'Atli Quarry, or the Mahaffey Quarry.

Transportation and procurement costs for securing off-site basalt material will add significantly to the total barrier construction costs. For example, assuming a haul cost of \$0.27 per t-km (\$0.40 per ton-mile), and hauling 14.5 million m^3 (19 million yd^3), haul costs from the Mahaffey Quarry will be at least \$500 million, not including the purchase price of the material, maintenance for 64 km (40 mi) of road surface, and other costs. The transportation cost for this off-site source is well over \$250 million more than the most expensive on-site truck haulage alternative considered in this SER.

6.4 RECOMMENDATIONS

The following recommendations should be considered concerning the development of a basalt quarry in support of the construction of protective surface barriers.

1. DOE-RL must provide direction regarding which candidate site should be pursued for development as a basalt quarry.

2. Determine the waste disposal strategy for the Hanford Site and determine where surface barriers will be used. Conduct a cost/benefit analysis on definitive surface barrier designs to select the most appropriate barrier that will function and perform at the desired level for the given waste sites. This will establish the material volumes required to construct the surface barriers.

3. Conduct a geologic investigation at the first and possibly second choice candidate quarry sites to determine the nature and quantity of overburden, flow-top basalt, and interior basalt. This will provide information on what quantity of acceptable basalt is present and how much overburden and flow-top basalt must be removed (i.e., dollars spent) to expose it. The first and second choice sites should be the top two ranking sites after direction from DOE-RL is received on the candidate quarry sites that should be pursued for development.

4. Conduct a detailed transportation infrastructure analysis to identify the most efficient means of moving the riprap from the quarries to the barrier construction site. This investigation should consider the alternatives of moving the basalt by rail systems, highway licensed trucks, off-road trucks, and conveyor systems. Costs associated with building new roads, maintaining and upgrading affected public highways and Hanford roads, placing rail track on existing railroad grades, using existing rail track, maintaining conveyor systems (considering impacts from conveyor system downtime), and other pertinent transportation infrastructure details should be included in this analysis.

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APPENDIX A

SITE PLANNING DSI (AND DRAWING) REGARDING PIT 30 EXPANSION

DON'T SAY IT -- WRITE IT!

DATE: December 3, 1993

TO: W. A. Skelly H6-03

FROM: E. T. Trost (6-8949)
Site Planning

cc:

C. A. Augustine	G6-02
M. A. Cahill	S4-57
D. R. Doman	B5-24
D. A. Duranceau	H4-14
V. J. Lindberg	S2-31
E. C. Oedewaldt	B5-24
K. E. Peterson	H4-14
S. W. Seiler	B4-64
J. C. Sonnichsen	H4-14
R. S. Weeks	H6-26
N. R. Wing	H4-14
J. G. Woolard	H6-05
E. F. Yancey	B4-64

SUBJECT: PIT #30 EXPANSION FOR LONG-TERM BARRIER CONSTRUCTION MATERIALS

The present plan is to obtain gravel and other soils for subject project by expanding the west portion of Borrow Pit #30 to the north and west as shown on the attached drawing. The expansion area will be fairly extensive consisting of about 320 acres. This project has been incorporated into the master planning process for the TWRS Complex to assure that all of the projects in the area are coordinated. Some of the advantages of obtaining borrow materials from this site are:

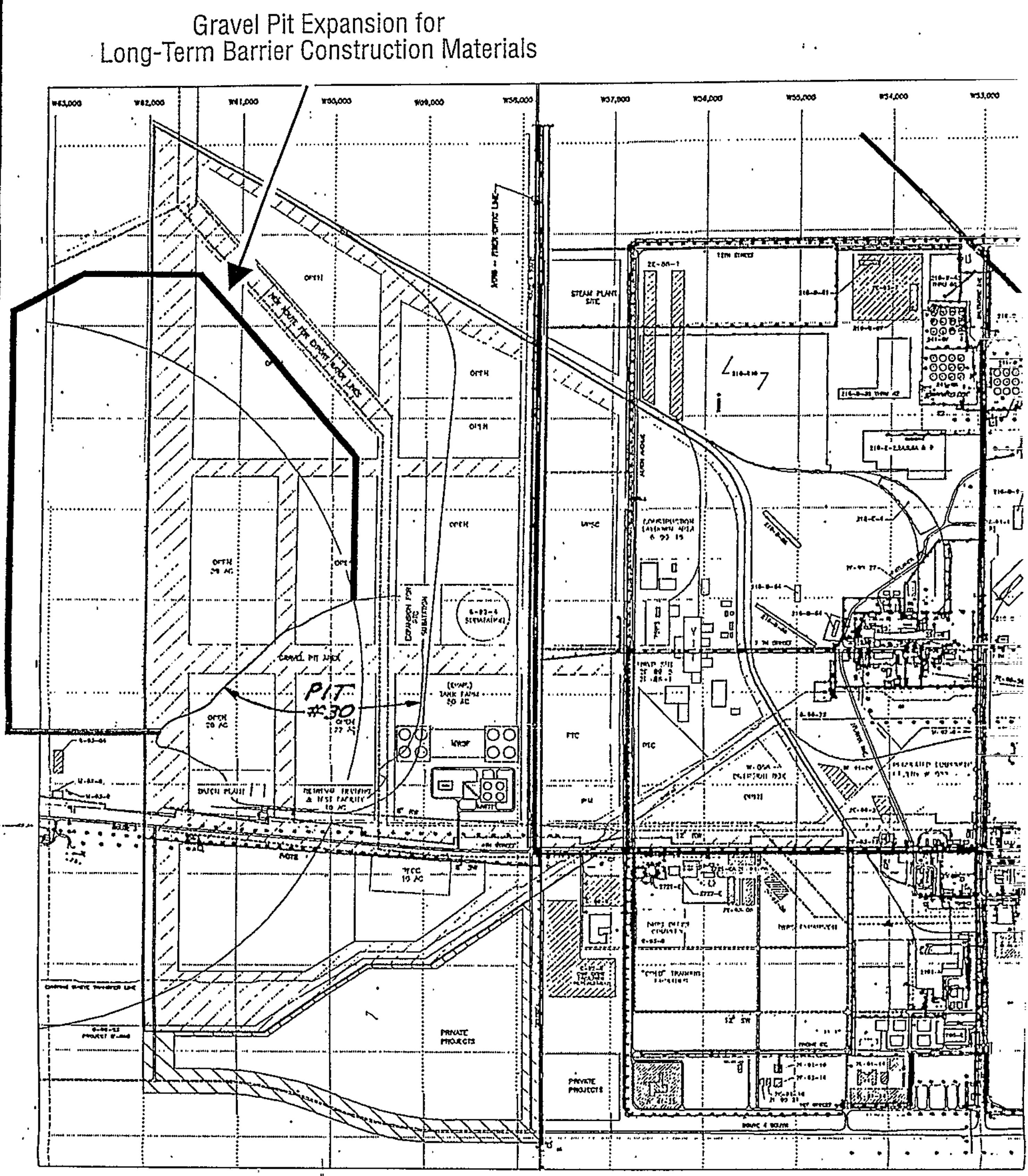
- Borrow Pit #30 is an existing established borrow pit, centrally located with respect to 200 Areas long-term barrier construction. Haul distances for borrow materials will be kept to a minimum

- The earthwork can be managed so that unreclaimed portions of the existing borrow pit could be backfilled with excess clean soils that would be compacted to allow for future development.

- The excavated areas of the expanded borrow pit could possibly provide a good location for low-level storage facilities and/or vaults.

To eliminate a potential conflict with the export water lines, the borrow pit expansion area has been located to the west of the proposed relocated export water lines. The most desirable way to expand the borrow pit would be to start operations on the east side and proceed to the west. This would allow the excavated areas to be used for future low waste storage facilities.

If you have any questions about this issue contact me on 376-8949.



EXPORT WATER
SANITARY WATER
RAW WATER
STEAM
TELECOMMUNICATIONS
13.8 KV LINE
2.4 KV LINE
SERIES LIGHTING
POWER POLES

TWRS COMPLEX BOUNDARY
TWRS CORRIDORS
PROPOSED SITE
APPROVED SITES

A-3/A-4

SITE PLAN

SCALE: 1:14000

0 140 280 560 840 1120 METERS

0 574 1148 1722 2296 2870 4019 5167 FEET

DRA

APPENDIX B

200 AREAS BASALT VOLUME REQUIREMENT ESTIMATION

Figures B-1 and B-2 show a potential configuration of protective surface barriers over burial grounds and tank farms in 200 West and 200 East. These configurations were used to estimate future basalt riprap volume requirements using a spreadsheet developed to calculate material volume requirements for the HISB. These numbers represent an upper bound volume for what will actually be required.

Potential dimensions, area, and riprap volume for each barrier are given in Table B-1. The barrier core dimension is assumed to be the length and width of the horizontal layers of the fine-soil portion of the barrier extended 10 m (30 ft) beyond the perimeter of the waste site to be covered. The total riprap volume requirement is the sum of the riprap volume required for the horizontal layers and the side slopes.

Figure B-1. 200 West - Potential Barrier Configuration.

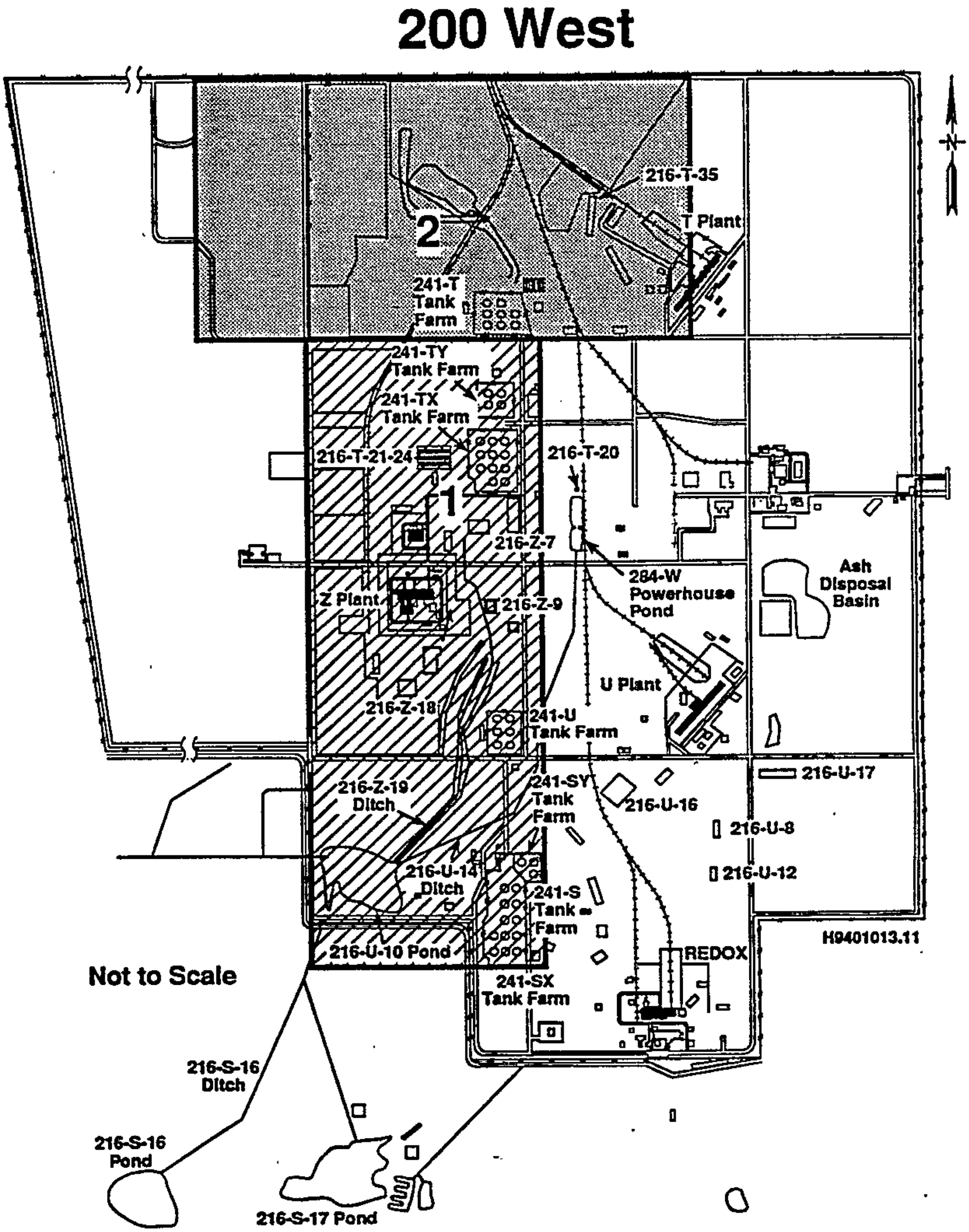


Figure B-2. 200 East - Potential Barrier Configuration.

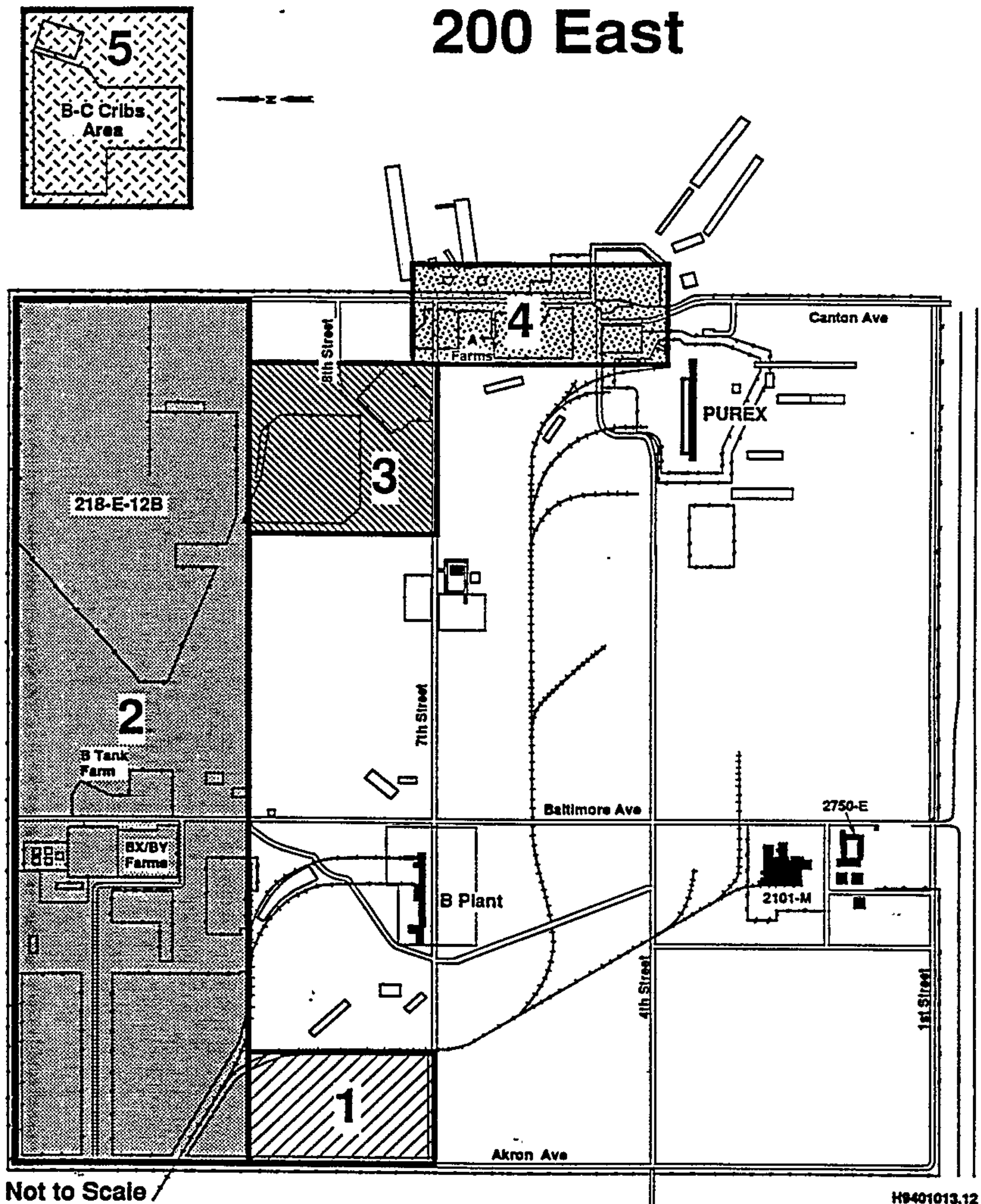


Table B-1. Potential Barrier Dimensions and Riprap Volumes for the 200 Areas.

Barrier Location	Barrier Core Dimensions m (ft)	Barrier Core Area m^2 (ft^2)	Barrier Footprint hectares (acres) (Includes side slope)	Total Riprap Volume Requirement m^3 (yd^3)
200 East Area				
Barrier 1	599 x 416 (1,965 x 1,365)	249,184 (2,682,225)	28.2 (69.8)	468,212 (612,398)
Barrier 2	721 x 2,885 (2,365 x 9,465)	2,080,085 (22,384,725)	219.5 (542.3)	3,449,180 (4,511,357)
Barrier 3	599 x 569 (1,965 x 1,867)	340,831 (3,668,655)	37.9 (93.6)	619,538 (810,325)
Barrier 4	752 x 355 (2,467 x 1,165)	266,960 (2,874,055)	30.3 (74.9)	503,209 (658,173)
Barrier 5	508 x 752 (1,667 x 2,467)	382,016 (4,112,489)	42.3 (104.5)	689,785 (902,205)
200 West Area				
Barrier 1	2,489 x 843 (8,166 x 2,756)	2,098,227 (22,505,496)	220.4 (544.6)	3,451,157 (4,514,483)
Barrier 2	1026 x 1,910 (3,366 x 6,266)	1,959,660 (21,091,356)	205.3 (507.3)	3,207,854 (4,195,714)

APPENDIX C

ECOLOGICAL SURVEY RESULTS

Because this appendix appears as originally distributed, the list referenced in the "Plants Observed" section of each ecological survey report does not appear on the page number(s) stated. Although the page numbers stated are incorrect, the list referenced closely follows.

**Westinghouse
Hanford Company**

**Internal
Memo**

ES94-600-6

From: Geotechnology and Landfill Technology
Phone: 376-1038 H4-14
Date: June 30, 1994
Subject: ECOLOGICAL SURVEYS AT BARRIER MATERIALS BORROW SITES

To: D. A. Duranceau H4-14

cc: R. A. Bechtold	H6-01	S. W. Seiler	G3-10
K. A. Gano	X0-21	W. A. Skelly	H6-03
A. R. Johnson	H6-30	J. C. Sonnichsen	H4-14
D. S. Landeen	H4-14	M. B. Strope	H6-26
R. M. Mitchell	H6-01	R. S. Weeks	H6-26
D. J. Moak	N3-05	N. R. Wing	H4-14
D. R. Myers	H4-14	ES File/LB	
M. R. Sackschewsky	K6-63		

The attached ecological surveys summarize the results of the flora and fauna surveys conducted at the proposed Barrier Materials Borrow Sites.

D. S. Landeen

D. S. Landeen, Team Leader
Biological Sciences

mjm

Attachment

ECOLOGICAL SURVEY FORM

REPORT #: ES94-600-5a **LOCATION:** T11N R27E S

PROJECT: Barrier Materials Borrow Sites

SITE: Horn Rapids Near Surface Basalt Site

PLANT SURVEY DATE: 04/20/94 **INVESTIGATOR:** M. R. Sackschewsky

ANIMAL SURVEY DATE: 04/20/94 **INVESTIGATOR:** D. S. Landeen

FEDERALLY LISTED THREATENED AND/OR ENDANGERED SPECIES:

PLANTS: No
WILDLIFE: No

SPECIES OF SPECIAL CONCERN OBSERVED:

PLANTS: No
WILDLIFE: Long-billed curlew (2 pairs)

IS THE AREA UNDER VEGETATION MANAGEMENT: No

DESCRIPTION OF AREA: This area has basalt outcrops mixed with shrubs and grasses. This area was burned in 1984 but shrubs such as sagebrush and bitterbrush are coming back. There are still lots of open areas dominated by grasses and flowering plants. The understory is primarily cheatgrass with some areas supporting large populations of prickly pear cactus.

PLANTS OBSERVED: (See pages 2 and 3 of Attachment for list of plants observed at the Horn Rapids near Surface Basalt Site.)

WILDLIFE OBSERVED: Bird species observed included the western meadowlark, horned lark, and long-billed curlew. Mammals known to utilize the area include mule deer, coyotes, badgers, and Great Basin pocket mice.

SUMMARY AND CONCLUSIONS: A bird species observed that is designated as a species of concern by the state and federal governments was the long-billed curlew. Long-billed curlews are classified as a federal candidate three (FC_3) species and as a state monitor (SM) species. Long-billed curlews nest and forage in open grassland areas.

REFERENCES:

Washington Department of Wildlife, Sept. 1993. Priority Habitats and Species.

Washington Department of Wildlife, Oct. 1993. Species of Special Concern in Washington State and Federal Status.

PLANTS OBSERVED AT HORN RAPIDS NEAR SURFACE BASALT SITE	
SPECIES	COMMON NAME
SHRUBS	
Artemisia tridentata	Big sagebrush
Chrysothamnus nauseosus	Gray rabbitbrush
Chrysothamnus viscidiflorus	Green rabbitbrush
Eriogonum sphaerocephalum	Rock buckwheat
Purshia tridentata	Antelope bitterbrush
GRASSES	
Agropyron sibericum	Siberian wheatgrass
Agropyron spicatum	Bluebunch wheatgrass
Bromus tectorum	Cheatgrass
Oryzopsis hymenoides	Indian ricegrass
Poa sandbergii	Sandberg's bluegrass
Sitanion hystrix	Bottlebrush squirreltail
Stipa comata	Needle-and-thread
ANNUAL FORBS	
Amsinckia lycopsoides	Fiddleneck tarweed
Amsinckia tessellata	Tessellate tarweed
Cryptantha circumscissa	Matted cryptantha
Cryptantha pterocarya	Winged cryptantha
Eriogonum vimineum	Broom buckwheat
Erodium cicutarium	Cranesbill
Descurainia pinnata	Tansy mustard

PLANTS OBSERVED AT HORN RAPIDS NEAR SURFACE BASALT SITE	
SPECIES	COMMON NAME
Draba verna	Spring whitlowgrass
Gilia leptomeria	Great basin gilia
Gilia sinuata	Shy gilia
Holosteum umbellatum	Jagged chickweed
Mentzelia albicaulis	White stem stickleaf
Salsola kali	Russian thistle
Sisymbrium altissimum	Jim Hill mustard
PERENNIAL FORBS	
Achillea millefolium	Yarrow
Allium macrum	Rock onion
Balsamorhiza careyana	Carey's balsamroot
Brodiaea douglasii	Cluster lily
Chaenactis douglasii	hoary false yarrow
Crepis atrabarba	Hawksbeard
Comandra umbellata	Bastard toadflax
Cymopteris terebinthinus	Turpentine springparsley
Delphinium nuttallianum	Upland larkspur
Eriogonum niveum	Snowy buckwheat
Eriogonum strictum	Strict buckwheat
Erysimum asperum	Wallflower
Hymenopappus filifolius	Columbia cut-leaf
Lomatium macrocarpum	Large-fruit desert parsley

PLANTS OBSERVED AT HORN RAPIDS NEAR SURFACE BASALT SITE	
SPECIES	COMMON NAME
Machaeranthera canescens	Hoary aster
Oenothera pallida	Pale evening primrose
Opuntia polyacantha	pricklypear
Phacelia hastata	Whiteleaf scorpionweed
Phacelia linearis	Threadleaf scorpionweed
Phlox longifolia	Longleaf phlox
Psoralea lanceolata	Dune scurfpea
Stephanomeria tenuifolia	Bush wirelettuce
Tragopogon dubius	Salsify

ECOLOGICAL SURVEY FORM

REPORT #: ES94-600-5b **LOCATION:** T13N R25E S30

PROJECT: Barrier Materials Borrow Sites

SITE: McGee Knoll Near Surface Basalt Site

PLANT SURVEY DATE: 04/18/94 **INVESTIGATOR:** M. R. Sackschewsky

ANIMAL SURVEY DATE: 04/18/94 **INVESTIGATOR:** D. S. Landeen

FEDERALLY LISTED THREATENED AND/OR ENDANGERED SPECIES:

PLANTS: No
WILDLIFE: No

SPECIES OF SPECIAL CONCERN OBSERVED:

PLANTS: Crouching Milkvetch and Scilla onion
WILDLIFE: Loggerhead shrike and Sage sparrow

IS THE AREA UNDER VEGETATION MANAGEMENT: No

DESCRIPTION OF AREA: This area is located behind the McGee Ranch well and is composed of a wide variety of shrubs and flowering plants. This area has not been burned or otherwise disturbed and would be classified as shrub-steppe habitat which is listed as a priority habitat by the Washington Department of Wildlife. Large portions of this site are covered with a dense stand of Big sagebrush and Spiny Hopsage with a Sandberg's bluegrass understory and very little cheatgrass or other alien weeds.

PLANTS OBSERVED: (See pages 6 and 7 of Attachment for list of plants observed at the McGee Knoll near the Surface Basalt Site.)

WILDLIFE OBSERVED: Bird species observed were the western meadowlark, horned lark, common raven, loggerhead shrike, and sage sparrow. Mammal species which utilize the area include badgers, coyotes, Great Basin pocket mice, and mule deer.

SUMMARY AND CONCLUSIONS: Bird species observed that have been designated as species of concern by the state and federal governments were the sage sparrow and loggerhead shrike. Sage sparrows are classified as a state candidate (SC) species. Loggerhead shrikes are classified as a federal candidate two (FC_2) species and as a state candidate (SC) species. Loggerhead shrikes and sage sparrows rely on shrubsteppe habitat for nesting and raising young. Any time projects impact or destroy mature sagebrush stands these two species are detrimentally affected.

Both the crouching milkvetch and the scilla onion are listed as class 3 monitor plant species by the State of Washington. Species in this class typically were considered to be more threatened at some time in the past, however, they have since been found to be more abundant or less threatened than previously believed. In general, species in this category can be considered indicative of native or relatively undisturbed habitats.

REFERENCES:

Washington Department of Wildlife, Sept. 1993. Priority Habitats and Species.

Washington Department of Wildlife, Oct. 1993. Species of Special Concern in Washington State and Federal Status.

PLANTS OBSERVED AT THE McGEE KNOLL NEAR SURFACE BASALT SITE	
SPECIES	COMMON NAME
SHRUBS	
Artemisia tridentata	Big sagebrush
Artemisia rigida	Stiff sagebrush
Grayia spinosa	Spiny hopsage
GRASSES	
Bromus tectorum	Cheatgrass
Oryzopsis hymenoides	Indian ricegrass
Poa sandbergii	Sandberg's bluegrass
Sitanion hystrix	Bottlebrush squirreltail
FORBS	
Allium scillioides	Scilla onion
Amsinckia tessellata	Tessellate fiddleneck
Astragalus caricinus	Buckwheat milkvetch
Astragalus purshii	Wooly-pod milkvetch
Astragalus succumbens	Crouching milkvetch
Balsamorhiza careyana	Carey's balsamroot
Calochortus macrocarpus	Mariposa lily
Castilleja thompsonii	Thompson's indian paintbrush
Descurainia pinnata	Tansy mustard
Erigeron poliospermus	Cushion fleabane
Eriogonum thymoides	Thymeleaf buckwheat
Helianthus cusickii	Cusick's sunflower

PLANTS OBSERVED AT THE McGEE KNOLL NEAR SURFACE BASALT SITE	
SPECIES	COMMON NAME
Lomatium canbyi	Canby's desert parsley
Lomatium macrocarpum	Large-fruit desert parsley
Machaeranthera canescens	Hoary aster
Phlox longifolia	Longleaf phlox
Sphaeralcea munroana	Globemallow
Townsendia florifer	Showy townsend daisy
Tragopogon dubius	Salsify

ECOLOGICAL SURVEY FORM

REPORT #: ES94-600-5c

LOCATION: T12N 26E S4,5
T13N 26E S32,33

PROJECT: Barrier Materials Borrow Sites

SITE: Pit 30 Expansion

PLANT SURVEY DATE: 04/18, 20, 25/94

INVESTIGATOR: M. R. Sackschewsky

ANIMAL SURVEY DATE: 04/18, 20, 25/94

INVESTIGATOR: D. S. Landeen
J. G. Lucas

FEDERALLY LISTED THREATENED AND/OR ENDANGERED SPECIES:

PLANTS: No
WILDLIFE: No

SPECIES OF SPECIAL CONCERN OBSERVED:

PLANTS: Stalked-pod milkvetch
WILDLIFE: Loggerhead shrike and Sage sparrow

IS THE AREA UNDER VEGETATION MANAGEMENT: No

DESCRIPTION OF AREA: The pit 30 expansion area is composed of undisturbed shrubsteppe habitat which is designated as a priority habitat by the Washington Department of Wildlife. This area has not been burned. Shrub coverage is approximately 40 to 50% with an understory comprised of cheatgrass with some sandberg's bluegrass.

PLANTS OBSERVED: (See pages 10 and 11 of Attachment for list of plants observed at the Pit 30 Expansion Site.)

WILDLIFE OBSERVED: Bird species observed were the common raven, western meadowlark, horned lark, sage sparrow, and loggerhead shrike. Mammals known to inhabit the area include pocket mice, mule deer, coyotes, and badgers.

SUMMARY AND CONCLUSIONS: Bird species observed that have been designated as species of concern by the state and federal governments were the sage sparrow and loggerhead shrike. During the surveys, 8 pair of sage sparrow and 3 pair of loggerhead shrikes were observed. Sage sparrows are classified as a state candidate (SC) species. Loggerhead shrikes are classified as a federal candidate two (FC_2) species and as a state candidate (SC) species. Both these species rely on sagebrush habitat for nesting and foraging. Any destruction of sagebrush habitat is detrimental to these species.

The stalked-pod milkvetch is classified as a class 3 monitor plant species by the State of Washington. This classification includes species that are more abundant and/or less threatened than believed at some point in the past. The stalk-pod milkvetch is relatively common in sandy areas throughout the Hanford Site.

REFERENCES:

Washington Department of Wildlife, Sept. 1993. Priority Habitats and Species.

Washington Department of Wildlife, Oct. 1993. Species of Special Concern in Washington State and Federal Status.

PLANTS OBSERVED AT THE PIT 30 EXPANSION SITE	
SPECIES	COMMON NAME
SHRUBS	
Artemisia tridentata	Big sagebrush
Chrysothamnus nauseosus	Gray rabbitbrush
Chrysothamnus viscidiflorus	Green rabbitbrush
Grayia spinosa	Spiny hopsage
GRASSES	
Bromus tectorum	Cheatgrass
Oryzopsis hymenoides	Indian ricegrass
Poa sandbergii	Sandberg's bluegrass
Sitanion hystrix	Bottlebrush squirreltail
Stipa comata	Needle-and-thread
ANNUAL FORBS	
Ambrosia acanthicarpa	Bur ragweed
Amsinckia lycopsoides	Fiddleneck tarweed
Amsinckia tessellata	Tessellate tarweed
Cryptantha circumscissa	Matted cryptantha
Cryptantha pterocarya	Winged cryptantha
Eriogonum vimineum	Broom buckwheat
Descurainia pinnata	Tansy mustard
Descurainia sophia	flixweed
Holosteum umbellatum	Jagged chickweed
Lupinus pusillus	Prairie lupine

PLANTS OBSERVED AT THE PIT 30 EXPANSION SITE	
SPECIES	COMMON NAME
Mentzelia laevicaulis	Blazing star
Microsteris gracilis	pink gracilis
Salsola kali	Russian thistle
Sisymbrium altissimum	Jim Hill mustard
PERENNIAL FORBS	
Achillea millefolium	Yarrow
Astragalus caricinus	Buckwheat milkvetch
Astragalus sclerocarpus	Stalked-pod milkvetch
Balsamorhiza careyana	Carey's balsamroot
Brodiaea douglasii	Cluster lily
Calochortus macrocarpus	Mariposa lily
Chaenactis douglasii	hoary false yarrow
Crepis atrabarba	Hawksbeard
Comandra umbellata	Bastard toadflax
Conyza canadensis	Horseweed
Cymopteris terebinthinus	Turpentine springparsley
Delphinium nuttallianum	Upland larkspur
Epilobium paniculatum	Tall willowherb
Erigeron filifolius	Threadleaf fleabane
Erigeron poliospermus	Cushion fleabane
Erigeron pumilus	Shaggy fleabane
Erysimum asperum	Wallflower

PLANTS OBSERVED AT THE PIT 30 EXPANSION SITE	
SPECIES	COMMON NAME
Fritillaria pudica	Yellowbell
Lomatium macrocarpum	Large-fruit desert parsley
Machaeranthera canescens	Hoary aster
Oenothera pallida	Pale evening primrose
Orobanche fasciculata	clustered broomrape
Phlox longifolia	Longleaf phlox
Rumex venosus	winged dock
Sphaeralcea munroana	Munro's globemallow
Townsendia florifer	Showy townsend daisy
Tragopogon dubius	Salsify

ECOLOGICAL SURVEY FORM

REPORT #: ES94-600-5d

LOCATION: T13N R26E S15,22

PROJECT: Barrier Material Borrow Sites

SITE: Gable Mountain Basalt Quarry Site

PLANT SURVEY DATE: 04/26/94

INVESTIGATOR: M. R. Sackschewsky

ANIMAL SURVEY DATE: 04/26/94

INVESTIGATOR: D. S. Landeen

FEDERALLY LISTED THREATENED AND/OR ENDANGERED SPECIES:

PLANTS: No
WILDLIFE: No

SPECIES OF SPECIAL CONCERN OBSERVED:

PLANTS: Crouching milkvetch and stalked-pod milkvetch
WILDLIFE: Prairie falcon and loggerhead shrike

IS THE AREA UNDER VEGETATION MANAGEMENT: No

DESCRIPTION OF AREA: The southern portion of the site is dominated by a mixed shrub community consisting of Big sagebrush, Spiny hopsage, Prickly phlox, and Grey ball sage with a sandberg's bluegrass understory. Much of the area on top of the mountain was burned within the last 1 or 2 years. It has scattered rigid sage mixed with bluebunch wheatgrass and Thurber's needlegrass. The Northern and northwest portions of the proposed borrow site have coarse sands with Big sagebrush, needle-and-thread, cheatgrass, and sandberg's bluegrass.

PLANTS OBSERVED: (See pages 14 through 16 of Attachment for list of plants observed at the Gable Mountain Basalt Site.)

WILDLIFE OBSERVED: Bird species observed included the western meadowlark, horned lark, magpie, starling, rock dove, rock wren, canyon wren, common raven, American kestrel, loggerhead shrike, and prairie falcon. Mammals known to utilize the area include mule deer, coyotes, badgers, pocket gophers, and Great Basin pocket mice.

SUMMARY AND CONCLUSIONS: Bird species observed that have been designated as species of concern by the state and federal governments were the loggerhead shrike and prairie falcon. Loggerhead shrikes are classified as a federal candidate two (FC_2) species and as a state candidate (SC) species. Prairie falcons are classified as a state monitor (SM) species. There are few places at Hanford that support nesting prairie falcons and anything that might disturb these birds should be avoided during the nesting season.

Both the stalked-pod and crouching milkvetches are classified by the State of Washington as class 3 monitor species which indicates that they are either more common or less threatened than previously believed. Species in this class can often be considered as indicators of native or relatively undisturbed habitats.

REFERENCES:

Washington Department of Wildlife, Sept. 1993. Priority Habitats and Species.

Washington Department of Wildlife, Oct. 1993. Species of Special Concern in Washington State and Federal Status.

PLANTS OBSERVED AT THE GABLE MOUNTAIN BASALT SITE	
SPECIES	COMMON NAME
SHRUBS	
Artemisia rigida	Rigid sage
Artemisia tridentata	Big sagebrush
Chrysothamnus nauseosus	Gray rabbitbrush
Chrysothamnus viscidiflorus	Green rabbitbrush
Grayia spinosa	Spiny hopsage
Leptodactylon pungens	Prickly phlox
Salvia dorrii	Gray ball sage
GRASSES	
Agropyron spicatum	Bluebunch wheatgrass
Bromus tectorum	Cheatgrass
Hordeum jubatum	Squirreltail barley
Koeleria cristata	Prairie junegrass
Oryzopsis hymenoides	Indian ricegrass
Poa sandbergii	Sandberg's bluegrass
Sitanion hystrix	Bottlebrush squirreltail
Stipa comata	Needle-and-thread
Stipa thurberiana	Thurber's needlegrass
ANNUAL FORBS	
Ambrosia acanthicarpa	Bur ragweed
Amsinckia lycopsoides	Fiddleneck tarweed
Amsinckia tessellata	Tessellate tarweed

PLANTS OBSERVED AT THE GABLE MOUNTAIN BASALT SITE	
SPECIES	COMMON NAME
Cryptantha circumscissa	Matted cryptantha
Cryptantha fendleri	Fendler's cryptantha
Cryptantha pterocarya	Winged cryptantha
Eriogonum vimineum	Broom buckwheat
Erodium cicutarium	Crane's bill
Descurainia pinnata	Tansy mustard
Gilia leptomeria	Great basin gilia
Holosteum umbellatum	Jagged chickweed
Layia glandulosa	Tidy tips
Mentzelia albicaulis	Whitestem stickleaf
Nama densum	Purple mat
Oenothera contorta	contorted eveningprimrose
Phacelia linearis	Threadleaf scorpionweed
Plectritis macrocera	White cupseed
Salsola kali	Russian thistle
Sisymbrium altissimum	Jim Hill mustard
PERENNIAL FORBS	
Achillea millefolium	Yarrow
Antennaria dimorpha	Low pussytoes
Astragalus caricinus	Buckwheat milkvetch
Astragalus sclerocarpus	Stalked-pod milkvetch
Astragalus succumbens	Crouching milkvetch

PLANTS OBSERVED AT THE GABLE MOUNTAIN BASALT SITE	
SPECIES	COMMON NAME
Balsamorhiza careyana	Carey's balsamroot
Brodiaea douglasii	Cluster lily
Calochortus macrocarpus	Mariposa lily
Centaurea diffusa	diffuse knapweed
Chaenactis douglasii	hoary false yarrow
Crepis atrabarba	Hawksbeard
Comandra umbellata	Bastard toadflax
Conyza canadensis	Horseweed
Cymopteris terebinthinus	Turpentine springparsley
Delphinium nuttallianum	Upland larkspur
Epilobium paniculatum	Tall willowherb
Erigeron filifolius	Threadleaf fleabane
Erigeron linearis	Desert yellowdaisy
Erigeron poliospermus	Cushion fleabane
Erigeron pumilus	Shaggy fleabane
Eriogonum strictum	strict buckwheat
Erysimum asperum	Wallflower
Fritillaria pudica	Yellowbell
Lomatium canbyi	Canby's desert parsley
Lomatium macrocarpum	Large-fruit desert parsley
Machaeranthera canescens	Hoary aster
Microseris troximoides	False mountain dandelion

PLANTS OBSERVED AT THE GABLE MOUNTAIN BASALT SITE	
SPECIES	COMMON NAME
Oenothera pallida	Pale evening primrose
Orobanche fasciculata	clustered broomrape
Phlox longifolia	Longleaf phlox
Plantago patagonica	Indian wheat
Psoralea lanceolata	Dune scurfpea
Rumex venosus	winged dock
Sphaeralcea munroana	Munro's globemallow
Stephanomeria tenuifolia	Bush wirelettuce
Townsendia florifer	Showy townsend daisy
Tragopogon dubius	Salsify

ECOLOGICAL SURVEY FORM

REPORT #: ES94-600-5e

LOCATION: T13N R25E S24,13
T13N R26E
S18,19

PROJECT: Barrier Materials Borrow Sites

SITE: Gable Butte Near Surface Basalt Site

PLANT SURVEY DATE: 04/26/94 **INVESTIGATOR:** M. R. Sackschewsky

ANIMAL SURVEY DATE: 04/26/94 **INVESTIGATOR:** D. S. Landeen

FEDERALLY LISTED THREATENED AND/OR ENDANGERED SPECIES:

PLANTS: No
WILDLIFE: No

SPECIES OF SPECIAL CONCERN OBSERVED:

PLANTS: Stalked-pod milkvetch and crouching milkvetch
WILDLIFE: Loggerhead shrike

IS THE AREA UNDER VEGETATION MANAGEMENT: No

DESCRIPTION OF AREA: The tops of the basalt outcrops are dominated by rock buckwheat, strict buckwheat, and bluebunch wheatgrass. Areas around and between the outcrops are dominated primarily by cheatgrass, Sandberg's bluegrass, and patches of needle-and-thread with scattered shrubs, primarily Big sagebrush.

PLANTS OBSERVED: (See pages 19 through 21 of Attachment for list of plants observed at the Gable Butte near the Surface Basalt Site.)

WILDLIFE OBSERVED: Bird species observed were the western meadowlark, horned lark, common raven, chukar, rock wren, American kestrel, and loggerhead shrike. Mammal species which utilize the area include badgers, coyotes, Great Basin pocket mice, pocket gopher, and mule deer.

SUMMARY AND CONCLUSIONS: The only bird species observed that has been designated as species of concern by the state and federal governments was the loggerhead shrike. Loggerhead shrikes are classified as a federal candidate two (FC_2) species and as a state candidate (SC) species.

Both the stalked-pod and crouching milkvetches are classified by the State of Washington as class 3 monitor species which indicates that they are either more common or less threatened than previously believed. Species in this class can often be considered as indicators of native or relatively undisturbed habitats.

REFERENCES:

Washington Department of Wildlife, Sept. 1993. Priority Habitats and Species.

Washington Department of Wildlife, Oct. 1993. Species of Special Concern in Washington State and Federal Status.

GABLE BUTTE BASALT SITE	
SPECIES	COMMON NAME
SHRUBS	
Artemisia rigida	Rigid sage
Artemisia tridentata	Big sagebrush
Chrysothamnus nauseosus	Gray rabbitbrush
Chrysothamnus viscidiflorus	Green rabbitbrush
Eriogonum sphaerocephalum	Rock buckwheat
Grayia spinosa	Spiny hopsage
Leptodactylon pungens	Prickly phlox
Salvia dorrii	Gray ball sage
GRASSES	
Agropyron spicatum	Bluebunch wheatgrass
Bromus tectorum	Cheatgrass
Koeleria cristata	Prairie junegrass
Oryzopsis hymenoides	Indian ricegrass
Poa sandbergii	Sandberg's bluegrass
Sitanion hystrix	Bottlebrush squirreltail
Stipa comata	Needle-and-thread
ANNUAL FORBS	
Ambrosia acanthicarpa	Bur ragweed
Amsinckia lycopsoides	Fiddleneck tarweed
Amsinckia tessellata	Tessellate tarweed
Cryptantha circumscissa	Matted cryptantha
Cryptantha fendleri	Fendler's cryptantha
Descurainia pinnata	-Tansy mustard

GABLE BUTTE BASALT SITE	
SPECIES	COMMON NAME
Gilia leptomeria	Great basin gilia
Holosteum umbellatum	Jagged chickweed
Layia glandulosa	Tidy tips
Mentzelia albicaulis	Whitestem stickleaf
Microsteris gracilis	Pink gracilis
Phacelia linearis	Threadleaf scorpionweed
Plectritis macrocera	White cupseed
Salsola kali	Russian thistle
Sisymbrium altissimum	Jim Hill mustard
PERENNIAL FORBS	
Achillea millefolium	Yarrow
Antennaria dimorpha	Low pussytoes
Astragalus caricinus	Buckwheat milkvetch
Astragalus purshii	Wooly-pod milkvetch
Astragalus sclerocarpus	Stalked-pod milkvetch
Astragalus succumbens	Crouching milkvetch
Balsamorhiza careyana	Carey's balsamroot
Brodiaea douglasii	Cluster lily
Calochortus macrocarpus	Mariposa lily
Chaenactis douglasii	hoary false yarrow
Crepis atrabarba	Hawksbeard
Comandra umbellata	Bastard toadflax
Cymopteris terebinthinus	Turpentine springparsley
Delphinium nuttallianum	Upland larkspur

GABLE BUTTE BASALT SITE	
SPECIES	COMMON NAME
Epilobium paniculatum	Tall willowherb
Erigeron filifolius	Threadleaf fleabane
Erigeron poliospermus	Cushion fleabane
Erigeron pumilus	Shaggy fleabane
Eriogonum niveum	Snowy buckwheat
Eriogonum strictum	strict buckwheat
Erysimum asperum	Wallflower
Fritillaria pudica	Yellowbell
Lomatium canbyi	Canby's desert parsley
Lomatium macrocarpum	Large-fruit desert parsley
Lupinus sp.	Lupine
Machaeranthera canescens	Hoary aster
Microseris troximoides	False mountain dandelion
Oenothera pallida	Pale evening primrose
Orobanche fasciculata	clustered broomrape
Phlox longifolia	Longleaf phlox
Plantago patagonica	Indian wheat
Sphaeralcea munroana	Munro's globemallow
Stephanomeria tenuifolia	Bush wirelettuce
Tragopogon dubius	Salsify

ECOLOGICAL SURVEY FORM

REPORT #: ES94-600-5f

LOCATION: T13N R25E S13,14

PROJECT: Barrier Materials Borrow Sites

SITE: West Haven Site

PLANT SURVEY DATE: 05/09/94

INVESTIGATOR: M. R. Sackschewsky

ANIMAL SURVEY DATE: 05/09/94

INVESTIGATOR: D. S. Landeen
J. G. Lucas

FEDERALLY LISTED THREATENED AND/OR ENDANGERED SPECIES:

PLANTS: No
WILDLIFE: No

SPECIES OF SPECIAL CONCERN OBSERVED:

PLANTS: Crouching milkvetch and stalked-pod milkvetch
WILDLIFE: No

IS THE AREA UNDER VEGETATION MANAGEMENT: No

DESCRIPTION OF AREA: This area is similar to Gable Mountain and Gable Butte Sites. Overall shrub density is low with an understory composed of grasses such as Indian rice grass, needle-and-thread grass, Sandberg's bluegrass, and bluebunch wheatgrass.

PLANTS OBSERVED: (See pages 24 and 25 of Attachment for list of plants observed at the West Haven Site)

WILDLIFE OBSERVED: Bird species observed included horned larks, western meadow larks, rock wrens, and red-tailed hawks. Mammals that utilize the site include Great Basin pocket mice, northern pocket gopher, mule deer, coyotes, and badgers. A pair of red-tailed hawks were utilizing the basalt cliffs as a nesting site.

SUMMARY AND CONCLUSIONS: Any proposed activities at this site should be conducted before or after the nesting season for any raptor species that may be utilizing the cliffs as a nesting site.

Both the stalked-pod and crouching milkvetches are classified by the State of Washington as class 3 monitor species which indicates that they are either more common or less threatened than previously believed. Species in this class can often be considered as indicators of native or relatively undisturbed habitats.

REFERENCES:

Washington Department of Wildlife, Sept. 1993. Priority Habitats and Species.

Washington Department of Wildlife, Oct. 1993. Species of Special Concern in Washington State and Federal Status.

PLANTS OBSERVED AT THE WEST HAVEN BASALT SITE	
SPECIES	COMMON NAME
SHRUBS	
Artemisia tridentata	Big sagebrush
Chrysothamnus nauseosus	Gray rabbitbrush
Chrysothamnus viscidiflorus	Green rabbitbrush
Eriogonum sphaerocephalum	Rock buckwheat
Grayia spinosa	Spiny hopsage
Leptodactylon pungens	Prickly phlox
Salvia dorrii	Gray ball sage
GRASSES	
Agropyron spicatum	Bluebunch wheatgrass
Bromus tectorum	Cheatgrass
Oryzopsis hymenoides	Indian ricegrass
Poa sandbergii	Sandberg's bluegrass
Sitanion hystrix	Bottlebrush squirreltail
Stipa comata	Needle-and-thread
Vulpia octoflora	Sixweeks
ANNUAL FORBS	
Ambrosia acanthicarpa	Bur ragweed
Amsinckia lycopsoides	Fiddleneck tarweed
Chenopodium leptophyllum	Slimleaf goosefoot
Cryptantha circumscissa	Matted cryptantha
Descurainia pinnata	Tansy mustard

PLANTS OBSERVED AT THE WEST HAVEN BASALT SITE	
SPECIES	COMMON NAME
Holosteum umbellatum	Jagged chickweed
Microsteris gracilis	Pink gracilis
Salsola kali	Russian thistle
Sisymbrium altissimum	Jim Hill mustard
PERENNIAL FORBS	
Achillea millefolium	Yarrow
Antennaria dimorpha	Low pussytoes
Astragalus caricinus	Buckwheat milkvetch
Astragalus purshii	Wooly-pod milkvetch
Astragalus sclerocarpus	Stalked-pod milkvetch
Astragalus succumbens	Crouching milkvetch
Balsamorhiza careyana	Carey's balsamroot
Calochortus macrocarpus	Mariposa lily
Chaenactis douglasii	hoary false yarrow
Crepis atrabarba	Hawksbeard
Comandra umbellata	Bastard toadflax
Erigeron filifolius	Threadleaf fleabane
Erigeron poliospermus	Cushion fleabane
Erigeron pumilus	Shaggy fleabane
Eriogonum niveum	Snowy buckwheat
Eriogonum strictum	strict buckwheat
Fritillaria pudica	Yellowbell

PLANTS OBSERVED AT THE WEST HAVEN BASALT SITE	
SPECIES	COMMON NAME
Lomatium canbyi	Canby's desert parsley
Lomatium macrocarpum	Large-fruit desert parsley
Lupinus sp.	Lupine
Machaeranthera canescens	Hoary aster
Phlox longifolia	Longleaf phlox
Sphaeralcea munroana	Munro's globemallow
Stephanomeria tenuifolia	Bush wirelettuce
Townsendia florifer	Showy Townsend daisy
Tragopogon dubius	Salsify

ECOLOGICAL SURVEY FORM

REPORT #: ES94-600-5g **LOCATION:** T12N R25E S22-26

PROJECT: Barrier Material Borrow Sites

SITE: ALE Basalt Quarry Site

PLANT SURVEY DATE: 05/10/94 **INVESTIGATOR:** M. R. Sackschewsky

ANIMAL SURVEY DATE: 05/10/94 **INVESTIGATOR:** D. S. Landeen
J. G. Lucas

FEDERALLY LISTED THREATENED AND/OR ENDANGERED SPECIES:

PLANTS: No
WILDLIFE: No

SPECIES OF SPECIAL CONCERN OBSERVED:

PLANTS: Stalked-pod milkvetch
WILDLIFE: Sage sparrow and grasshopper sparrow

IS THE AREA UNDER VEGETATION MANAGEMENT: No

DESCRIPTION OF AREA: There are two distinct habitats in the area that was surveyed. Part of the area is composed of sagebrush with an understory of cheatgrass and tumbleweeds. The remainder of the area was burned in the 1980s and is now dominated by cheatgrass, tumbleweeds, and mustard species.

PLANTS OBSERVED: (See pages 28 and 29 of Attachment for a list of plants observed at the ALE Basalt Quarry Site)

WILDLIFE OBSERVED: Bird species observed included the horned lark, western meadow larks, American kestrel, magpie, sage sparrow, and grasshopper sparrow. Mammals that utilize the site include Great Basin pocket mice, northern pocket gopher, mule deer, elk, coyotes, and badgers.

SUMMARY AND CONCLUSIONS: Bird species observed that have been designated as species of concern by the state and federal governments were the sage sparrow and grasshopper sparrow. Sage sparrows are classified as a state candidate (SC) species. Grasshopper sparrows are classified as a state monitor (SM) species. Loggerhead shrikes which were not observed but could reside in the sagebrush are classified as a federal candidate two (FC_2) species and as a state candidate (SC) species. Loggerhead shrikes and sage sparrows rely on shrubsteppe habitat for nesting and raising young. Any time projects impact or destroy mature sagebrush stands these two species are detrimentally affected. Grasshopper sparrows prefer more open areas for nesting and foraging.

The stalked-pod milkvetch is classified by the State of Washington as class 3 monitor species which indicates that it is either more common or less threatened than previously believed. Species in this class can often be considered as indicators of native or relatively undisturbed habitats.

REFERENCES: Washington Department of Wildlife, Sept. 1993. Priority Habitats and Species.

Washington Department of Wildlife, Oct. 1993. Species of Special Concern in Washington State and Federal Status.

PLANTS OBSERVED AT THE ALE NEAR SURFACE BASALT SITE	
SPECIES	COMMON NAME
SHRUBS	
Artemisia tridentata	Big sagebrush
Chrysothamnus nauseosus	Gray rabbitbrush
Chrysothamnus viscidiflorus	Green rabbitbrush
Grayia spinosa	Spiny hopsage
GRASSES	
Agropyron sibericum	Siberian wheatgrass
Bromus tectorum	Cheatgrass
Oryzopsis hymenoides	Indian ricegrass
Poa bulbosa	Bulbous bluegrass
Poa nevadensis	Nevada bluegrass
Poa sandbergii	Sandberg's bluegrass
Sitanion hystrix	Bottlebrush squirreltail
Stipa comata	Needle-and-thread
Vulpia octoflora	Sixweeks
ANNUAL FORBS	
Ambrosia acanthicarpa	Bur ragweed
Amsinckia lycopsoides	Fiddleneck tarweed
Chenopodium leptophyllum	Slimleaf goosefoot
Cryptantha circumscissa	Matted cryptantha
Cryptantha pterocarya	Winged cryptantha
Descurainia pinnata	Tansy mustard

PLANTS OBSERVED AT THE ALE NEAR SURFACE BASALT SITE	
SPECIES	COMMON NAME
Eriogonum vimineum	Broom buckwheat
Holosteum umbellatum	Jagged chickweed
Lupinus pusillus	Prairie lupine
Mentzelia albicaulis	Whitestem stickleaf
Mentzelia laevicaulis	Blazingstar
Microsteris gracilis	Pink gracilis
Salsola kali	Russian thistle
Sisymbrium altissimum	Jim Hill mustard
Tiquilia nuttallii	Desert mat
PERENNIAL FORBS	
Achillea millefolium	Yarrow
Astragalus caricinus	Buckwheat milkvetch
Astragalus sclerocarpus	Stalked-pod milkvetch
Balsamorhiza careyana	Carey's balsamroot
Calochortus macrocarpus	Mariposa lily
Chaenactis douglasii	hoary false yarrow
Crepis atrabarba	Hawksbeard
Cymopteris terebinthinus	Turpentine springparsley
Erigeron filifolius	Threadleaf fleabane
Erigeron linearis	Desert yellowdaisy
Erigeron poliospermus	Cushion fleabane
Erysimum asperum	Wallflower

PLANTS OBSERVED AT THE ALE NEAR SURFACE BASALT SITE	
SPECIES	COMMON NAME
Fritillaria pudica	Yellowbell
Lomatium macrocarpum	Large-fruit desert parsley
Machaeranthera canescens	Hoary aster
Oenothera pallida	Pale evening primrose
Orobanche fasciculata	Clustered broomrape
Penstemon acuminatum	Sand beardtongue
Phlox longifolia	Longleaf phlox
Townsendia florifer	Showy Townsend daisy
Tragopogon dubius	Salsify

ECOLOGICAL SURVEY FORM

REPORT #: ES94-600-5h **LOCATION:** T13N R25E S17-20

PROJECT: Barrier Material Borrow Sites

SITE: Vernita Basalt Quarry Site

PLANT SURVEY DATE: 05/10/94 **INVESTIGATOR:** M. R. Sackschewsky

ANIMAL SURVEY DATE: 05/10/94 **INVESTIGATOR:** D. S. Landeen
C. J. Kemp

FEDERALLY LISTED THREATENED AND/OR ENDANGERED SPECIES:

PLANTS: No
WILDLIFE: No

SPECIES OF SPECIAL CONCERN OBSERVED:

PLANTS: Crouching milkvetch and stalked-pod milkvetch
WILDLIFE: No

IS THE AREA UNDER VEGETATION MANAGEMENT: No

DESCRIPTION OF AREA: The areas on top of the basalt cliffs have very low shrub density, primarily both the Big and the rigid sagebrushes. Grasses such as Sandberg's blue grass and bluebunch wheatgrass are relatively common. Sandy areas between and below the cliffs have approximately 30 to 40 % shrub coverage, primarily Big sagebrush with some spiny hopsage and prickly phlox.

PLANTS OBSERVED: (See pages 32 through 34 of Attachment for a list of plants observed at the Vernita Basalt Quarry Site)

WILDLIFE OBSERVED: Bird species observed included the horned lark, western meadow larks, common raven, red-tailed hawk, and violet green swallow. Mammals that utilize the site include Great Basin pocket mice, northern pocket gopher, mule deer, coyote, and badger.

SUMMARY AND CONCLUSIONS: A pair of red-tailed hawks utilize the cliff face for nesting activities. At least one young hawk was observed in the nest. Activities that could disrupt nesting activities should be avoided in the spring and early summer if these hawks continue to use this area.

Both the stalked-pod and crouching milkvetches are classified by the State of Washington as class 3 monitor species which indicates that they are either more common or less threatened than previously believed. Species in this class can often be considered as indicators of native or relatively undisturbed habitats.

REFERENCES:

Washington Department of Wildlife, Sept. 1993. Priority Habitats and Species.

Washington Department of Wildlife, Oct. 1993. Species of Special Concern in Washington State and Federal Status.

PLANTS OBSERVED AT THE VERNITA BASALT QUARRY SITE	
SPECIES	COMMON NAME
SHRUBS	
Artemisia rigida	Rigid sage
Artemisia tridentata	Big sagebrush
Chrysothamnus nauseosus	Gray rabbitbrush
Chrysothamnus viscidiflorus	Green rabbitbrush
Grayia spinosa	Spiny hopsage
Leptodactylon pungens	Prickly phlox
GRASSES	
Agropyron spicatum	Bluebunch wheatgrass
Bromus tectorum	Cheatgrass
Elymus cinereus	Giant wildrye
Oryzopsis hymenoides	Indian ricegrass
Poa nevadensis	Nevada bluegrass
Poa sandbergii	Sandberg's bluegrass
Sitanion hystrix	Bottlebrush squirreltail
Stipa comata	Needle-and-thread
Vulpia octoflora	Sixweeks
ANNUAL FORBS	
Ambrosia acanthicarpa	Bur ragweed
Amsinckia lycopsoides	Fiddleneck tarweed
Cryptantha circumscissa	Matted cryptantha
Cryptantha pterocarya	Winged cryptantha
Eriogonum vimineum	Broom buckwheat
Erodium cicutarium	Crane's bill

PLANTS OBSERVED AT THE VERNITA BASALT QUARRY SITE	
SPECIES	COMMON NAME
Descurainia pinnata	Tansy mustard
Gilia leptomeria	Great basin gilia
Holosteum umbellatum	Jagged chickweed
Lactuca serriola	Prickly lettuce
Layia glandulosa	Tidy tips
Lepidium latifolium	Broadleaf pepperweed
Mentzelia albicaulis	Whitestem stickleaf
Nama densum	Purple mat
Phacelia linearis	Threadleaf scorpionweed
Plectritis macrocera	White cupseed
Salsola kali	Russian thistle
Sisymbrium altissimum	Jim Hill mustard
PERENNIAL FORBS	
Achillea millefolium	Yarrow
Antennaria dimorpha	Low pussytoes
Astragalus caricinus	Buckwheat milkvetch
Astragalus purshii	Wooly-pod milkvetch
Astragalus sclerocarpus	Stalked-pod milkvetch
Astragalus succumbens	Crouching milkvetch
Balsamorhiza careyana	Carey's balsamroot
Calochortus macrocarpus	Mariposa lily
Castilleja thompsonii	Thompson's paintbrush
Chaenactis douglasii	hoary false yarrow
Crepis atrabarba	Hawksbeard

PLANTS OBSERVED AT THE VERNITA BASALT QUARRY SITE	
SPECIES	COMMON NAME
Comandra umbellata	Bastard toadflax
Cymopteris terebinthinus	Turpentine springparsley
Erigeron filifolius	Threadleaf fleabane
Erigeron poliospermus	Cushion fleabane
Erigeron pumilus	Shaggy fleabane
Eriogonum strictum	strict buckwheat
Erysimum asperum	Wallflower
Gnaphalium palustre	Lowland cudweed
Lomatium canbyi	Canby's desert parsley
Lomatium macrocarpum	Large-fruit desert parsley
Machaeranthera canescens	Hoary aster
Microseris troximoides	False mountain dandelion
Oenothera pallida	Pale evening primrose
Orobanche fasciculata	clustered broomrape
Phlox longifolia	Longleaf phlox
Plantago patagonica	Indian wheat
Sphaeralcea munroana	Munro's globemallow
Thelypodium laciniatum	Cutleaf ladysfoot
Townsendia florifer	Showy townsend daisy
Tragopogon dubius	Salsify
Verbena bracteata	Bracted verbena

APPENDIX D

BASALT SOURCE VOLUME ESTIMATION

Volumes for the potential basalt quarry sites were estimated by calculating the volume of cross sections drawn on 7.5 minute USGS topographic maps containing the quarry sites. Cross section volumes were calculated on either 30.5 m (100.0 ft) or 61.0 m (200.0 ft) intervals. Contour intervals on the topographic maps were 3 m (10 ft) or 6 m (20 ft).

For the volume calculations that follow, it was assumed that the entire bank volume in each quarry contained basalt that was acceptable for use in barrier construction. In reality, however, the top 1.0 m (3.3 ft) or more may consist of soil, plant debris, and other unusable material. The extent of the unusable overburden and flow top material cannot be determined until several geologic cores are secured and analyzed for each of the sites.

Vernita Quarry. A parcel of land, approximately 45 ha (110 acres), has been identified for potential development near an existing quarry. This parcel of land extends about 1220 m (4000 ft) east of the existing quarry and about 366 m (1200 ft) south of the existing outcrop face (see Figure D-1).

The identified land parcel at the Vernita Quarry contains a bank volume of about 7.9 million m^3 (10.3 million yd^3). Using a bank volume basalt density of 2966 kg/m^3 (5000 lb/yd^3) and a loose basalt density of 1958 kg/m^3 (3300 lb/yd^3) (Caterpillar, 1992) this bank volume converts to 11.9 million m^3 (15.6 million yd^3) of loose riprap.

These volume estimations include both the Umatilla Flow and the Pomona Flow members. The bench comprising the Umatilla Flow has an elevation ranging from the 198 to 204 m (650 to 670 ft) elevation contour and an exposed north face that extends downward to approximately the 180 m (590 ft) elevation contour. The Pomona Flow bench top ranges from about the 183 m (600 ft) elevation contour at the west edge of the flow to the 168 m (550 ft) contour at the east edge of the parcel. This bench face extends downward to roughly the 152 m (500 ft) elevation contour.

Deeper excavation in the area of the Umatilla Flow would yield additional basalt beyond that calculated for the Vernita Quarry Site. This quarry bench could be mined toward the south to secure additional riprap material because the outcrop is quite extensive. Extending the quarry to the east is also a possibility, however, consideration would have to be given to the close proximity of the power transmission line towers near the east end of this parcel.

McGee Ranch. A near-surface source made up of a Pomona Flow member basalt is located on a knoll, northwest of the McGee well, in the central portion of McGee Ranch. This parcel comprises approximately 47 ha (116 Acres) at a planar slice through the knoll at the 290 m (950 ft) elevation contour. This basalt source takes on a rough elliptical shape with a major axis length of 1370 m (4500 ft) and a minor axis length of 400 m (1300 ft) at the 290 m (950 ft) elevation contour (see Figure D-2).

Using the bank volume and loose volume densities given above, the bank volume of basalt above the 290 m (950 ft) elevation contour is estimated to be 3.2 million m^3 (4.2 million yd^3) or 4.9 million m^3 (6.4 million yd^3) of loose riprap. Assuming the surface area of 47 ha (116 acres), each 1.0 m (3.3 ft) depth of excavation below the 290 m (950 ft) elevation contour will yield a bank volume of approximately 470,000 m^3 (615,000 yd^3) or 650,000 m^3 (850,000 yd^3) of loose riprap. Excavation would be required to proceed 16.0 m (52 ft) below the 290 m (950 ft) elevation contour to acquire 15.3 million m^3 (20 million yd^3) of riprap material.

Arid Land Ecology Reserve (ALE). A near-surface source of the Elephant Mountain basalt flow is located roughly 152 m (500 ft) immediately south of SR 240 on the (ALE) Reserve between gates 116 and 117. This parcel of land comprises roughly 38 ha (93 acres) at a planar slice through the 180 m (590 ft) elevation contour (see Figure D-3).

The bank volume of basalt above the 180 m (590 ft) contour is an estimated 1.9 million m^3 (2.5 million yd^3), which converts to 2.9 million m^3 (3.8 million yd^3) of loose riprap material. Every 1.0 m (3.3 ft) depth of excavation below the 180 m (590 ft) contour will yield a bank volume of 346,000 m^3 (452,000 yd^3) or 524,000 m^3 (685,000 yd^3) of loose riprap. In order to acquire 15.3 million m^3 (20.0 million yd^3) of riprap, the quarry would need to be excavated 24 m (78 ft) below the 180 m (590 ft) contour.

Horn Rapids. A near-surface basalt source belonging to the Elephant Mountain Flow is located approximately 900 m (3000 ft) north of Horn Rapids Dam and 610 m (2000 ft) west of Hanford Route 10. This parcel comprises 84 ha (207 acres) at a planar slice through the 152 m (500 ft) elevation contour level (see Figure D-4).

The basalt bank volume estimate above the 152 m elevation contour is 2.9 million m^3 (3.8 million yd^3), which converts to 4.3 million m^3 (5.6 million yd^3) of loose riprap. Every 1.0 m (3.3 ft) depth of excavation below the 152 m (500 ft) elevation contour will yield a bank volume of 765,000 m^3 (1 million yd^3) or 1.1 million m^3 (1.5 million yd^3) of loose riprap material.

Because this particular quarry alternative covers an extensive area, only about 9 m (30 ft) of excavation below the 152 m (500 ft) elevation contour would be required to yield the 15.3 million m^3 (20.0 million yd^3).

Gable Mountain, West Haven, and Gable Butte. Because of the extent of Gable Mountain, West Haven, and Gable Butte, the volume of basalt at these sites is considered unlimited in terms of the quantity of riprap that may be required for protective surface barrier construction. Each of these sites is capable of supplying the 15.3 million m^3 (20 million yd^3) of riprap calculated for the upper bound volume. These sites are shown in Figures D-5 and D-6, respectively.

Section 9 Quarry and D'Atli Quarry. These two quarries are located off the Hanford Site and are privately operated. USGS topographic map (Vantage, WA Quadrangle) indicates the area around the Section 9 Quarry, (located in Section 9, T16N, R23E), consists of a bluff overlooking the Columbia River with 76 - 91 m (250 - 300 ft) of relief. This site essentially contains an unlimited supply of basalt material[1] considering the upper bound volume calculated for surface barriers at Hanford. USGS topographic map (Benton City, WA Quadrangle) indicates the D'Atli Quarry basalt formation is characterized locally with about 30 m (100 ft) of relief. An estimated bank volume of 7.6 million m^3 (10 million yd^3) exists at this 24 ha (60 acre) site[2]. Because these quarries are privately operated and will be developed by a private operator, figures are not given that show where the basalt material will be extracted from the quarry. Refer to Figures 5-9 and 5-10 for the general location of these quarries.

[1] Personal conversation (10/26/94) with Billy Fulleton, Section 9 Quarry representative.

[2] Personal conversation (10/26/94) with John Hjatalin, D'Atli construction representative.

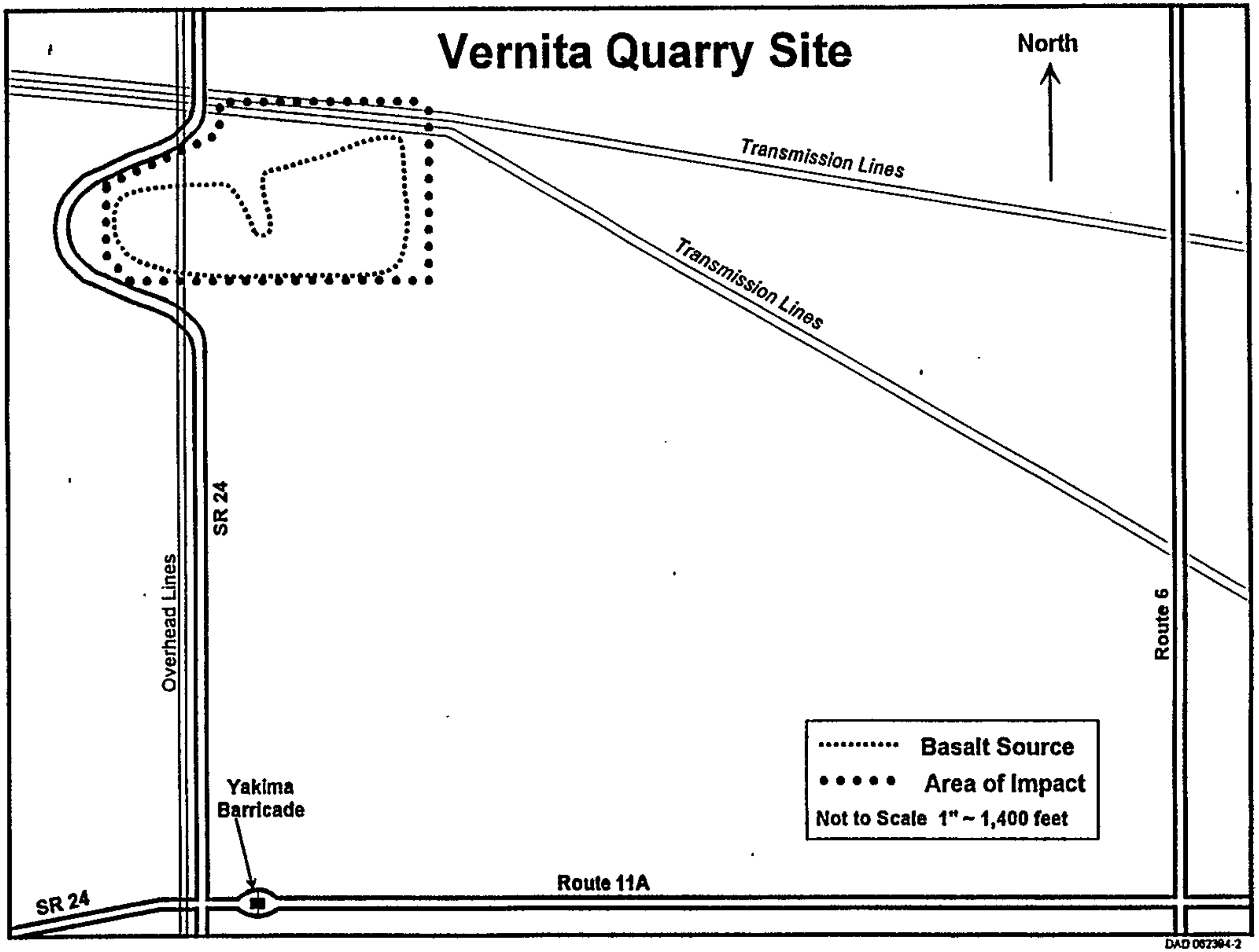


Figure D-1. Vernita Quarry Site.

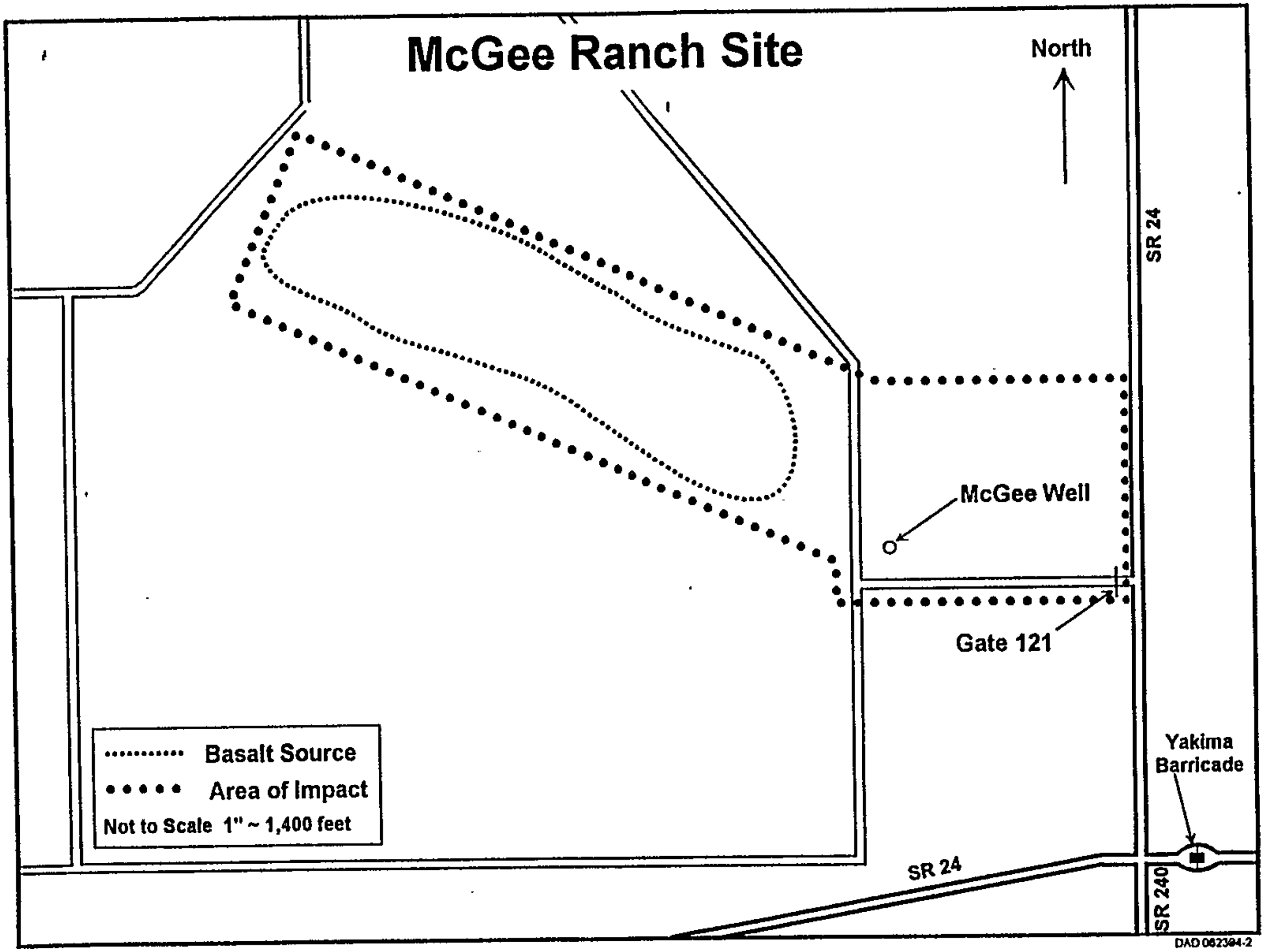


Figure D-2. McGee Ranch Quarry Site.

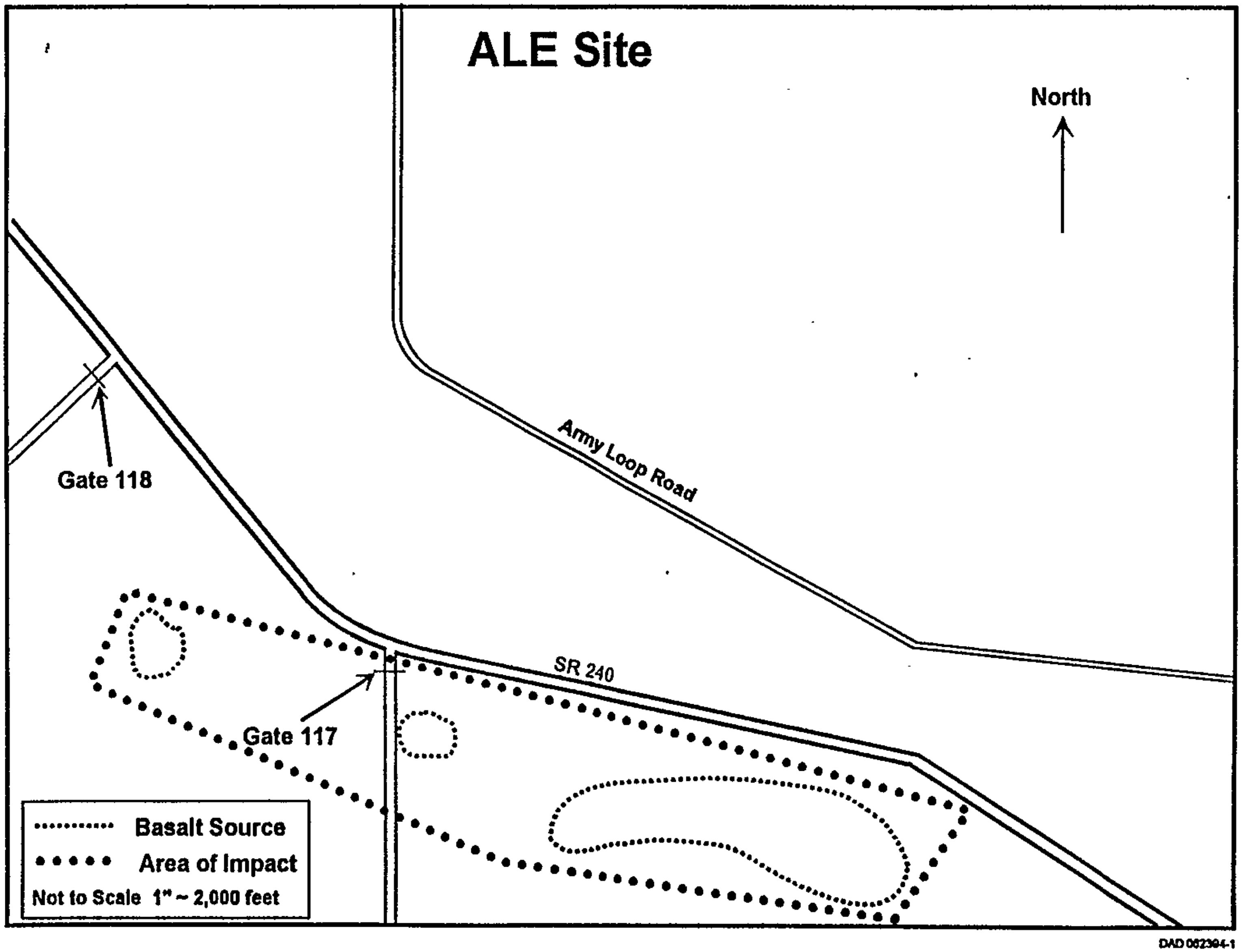
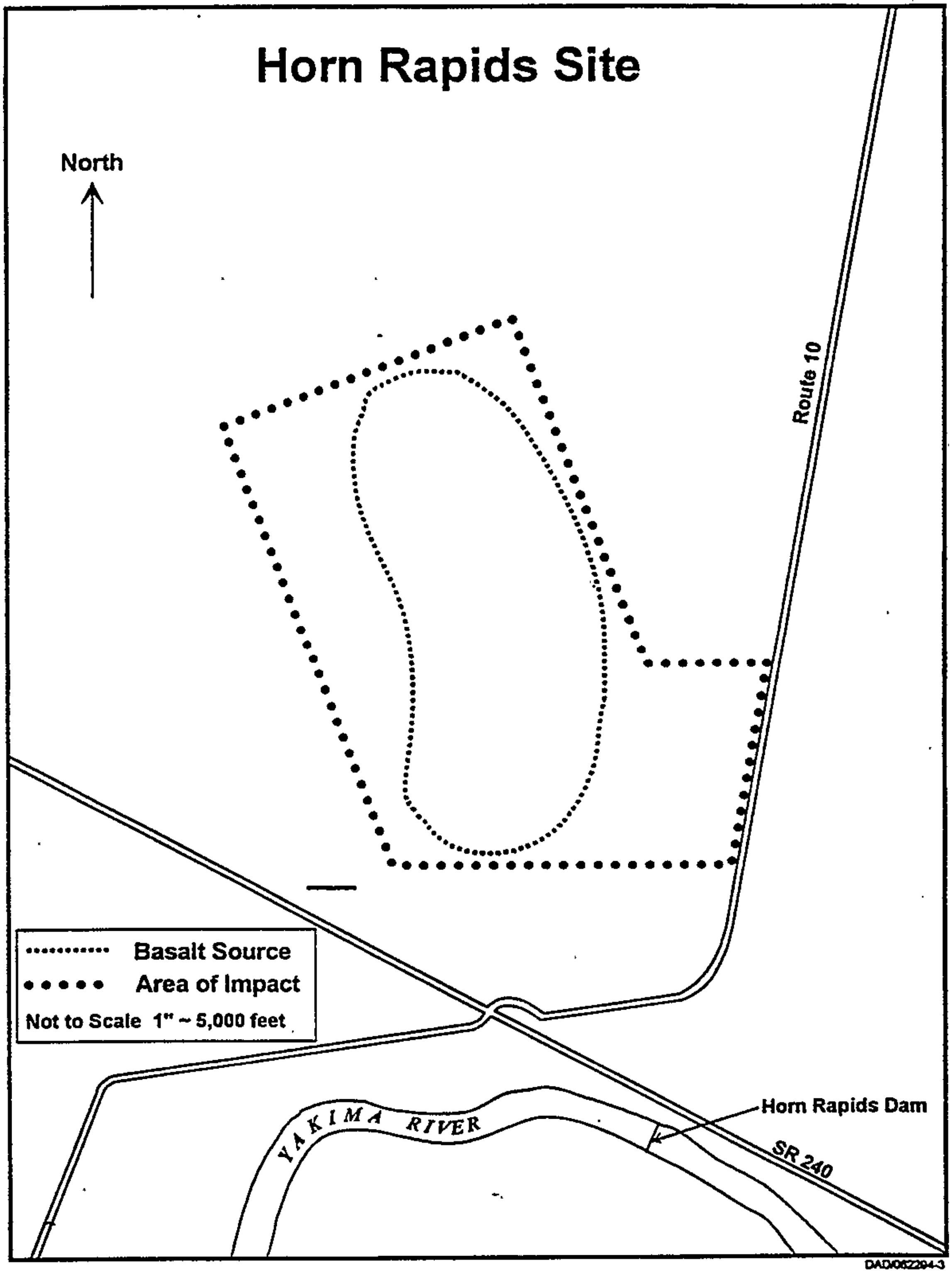


Figure D-3. ALE Quarry Site.

Figure D-4. Horn Rapids Quarry Site.



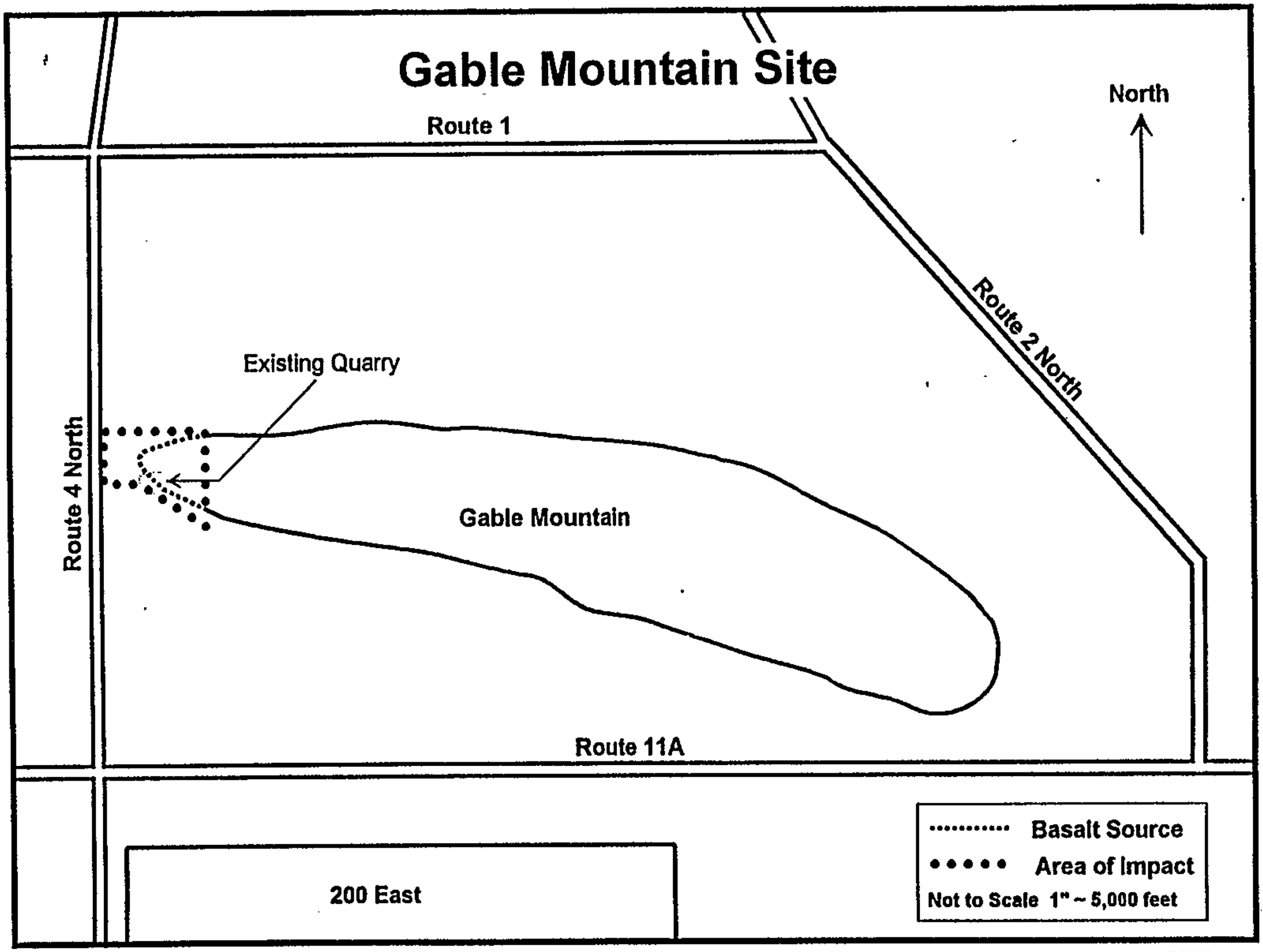


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Figure D-5. Gable Mountain Quarry Site.

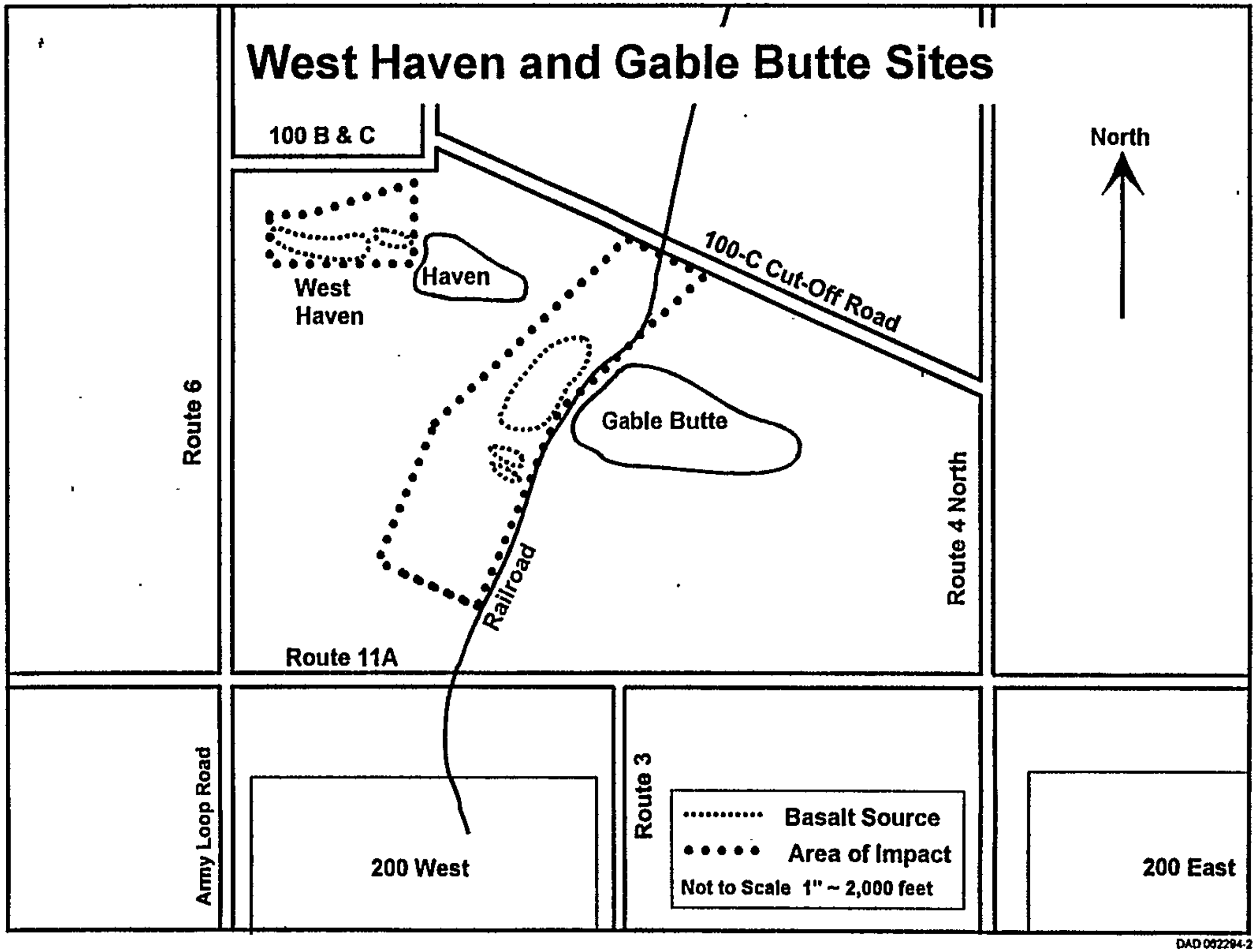

Figure D-6. West Haven and Gable Butte Quarry Sites.

APPENDIX E

QUARRY RECLAMATION GUIDELINES

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Battelle
Pacific Northwest Division
P.O. Box 999
Richland, Washington U.S.A. 99352
Telephone (509) 372-2554

August 31, 1994

David A. Duranceau
IT Hanford, Co.
450 Hills Street
Door #5, H4-14
Richland, WA 99352

Dear Mr. Duranceau:

Subject: Completion of Mitigation Plan for Piper's Daisy and Guidelines for Reclamation of Barrier Materials Borrow Sites.

Westinghouse Hanford Company (WHC) and IT Hanford Company provided a statement of work to Pacific Northwest Laboratory (PNL), under work order ED4754 to provide two documents in support of the Site Evaluation Report for Basalt Quarries, and the Operations Plan for the McGee Ranch fine-soils borrow site. The requested supporting documents have been completed and have been appended to this letter. Attachment 1 is the "Mitigation Plan for Piper's Daisy (*Erigeron piperianus*)". Attachment 2 is the "Guidelines for Reclamation of Barrier materials Borrow Sites".

The submittal of these documents to IT Hanford, Inc. fulfills the requirements as outlined in the statement of work for work order ED4754. If you have any additional questions or comments you may contact me on 372-2554.

Sincerely,

Michael R. Sackschewsky, Ph.D.
Research Scientist
Terrestrial Ecology Group
Pacific Northwest Laboratory

:tle

CC: CJ Kemp, H4-14
DR Myers, H4-14
C. Schaeffer, B2-68
WA Skelly, H6-30
NR Wing, H4-14
File/LB

ATTACHMENT 1.

Mitigation Plan for Piper's Daisy (*Erigeron piperianus*)

MITIGATION PLAN FOR PIPER'S DAISY
(*ERIGERON PIPERIANUS*)

1.0 INTRODUCTION

This report provides an overview of the current status and distribution of Piper's Daisy (*Erigeron piperianus)* and describes procedures that should be followed in the event that this species is encountered at any of the sites selected as borrow location for the construction of isolation barriers or other environmental restoration activities on the Hanford site. These procedures have been prepared specifically for Piper's daisy, but the same or similar procedures should be followed in the event that any other plant species of concern are discovered at material borrow areas. This plan is focused on Piper's daisy because it has been documented within Pit 30, one of the proposed borrow sites, and it could reasonably be expected at all of the other proposed borrow locations. The intent of this mitigation plan is to define a set of guidelines, prior to the initiation of borrow activities, in order to minimize budget and schedule impacts that could ensue if a population of Piper's daisy or any other plant species of concern is encountered at a selected site.

2.0 CURRENT STATUS OF PIPER'S DAISY

2.1 STATE AND FEDERAL LISTING STATUS

Piper's daisy is currently listed a "sensitive" by the Washington Natural Heritage Program (WNHP, 1994); it is not currently listed as a Federal threatened or endangered species, nor is it a candidate for federal listing. The WNHP "Sensitive" category is the third listing level for plant species of concern in the State of Washington behind "Endangered" and "Threatened". A plant is listed as sensitive "... when it is vulnerable or declining and could become endangered or threatened in the state without active management or removal of threats" (WNHP 1994). Based on this definition, loss of populations from historically protected areas such as the Hanford Site could form a basis for raising the listing status for "sensitive" to one of the higher categories.

2.2 DISTRIBUTION PATTERNS

Piper's daisy is typically found in dry, open areas, often with sagebrush (*Artemisia tridentata*) throughout south-central washington State (Hitchcock et al. 1955). As with many native species of the Columbia basin, the amount of suitable habitat within its original range has been greatly reduced due to the conversion of the original shrub steppe to agriculture.

On the Hanford Site, Piper's daisy has been found at a number of locations, including both disturbed and non-disturbed sites near the 200 areas, and disturbed sites in the 100 areas (Sackschewsky 1992). The populations in the 200 and 100 areas are typically small (usually fewer than 25 individuals) and they appear to be short lived or ephemeral. Many of the populations reported in the past are no longer present. The species is present in larger and more stable populations on Umtanum ridge and on Rattlesnake mountain.

Surveys were conducted during the spring of 1994 at sites proposed as potential borrow sites for permanent isolation barrier materials. These sites included potential basalt quarry sites, as well as sites that could provide sand, gravel, and fine soil materials. Piper's daisy was among a number of plant and animal species of concern that were specifically searched for during these surveys. No plant species of concern were found at any of the proposed basalt quarry sites, although all of them constitute suitable habitat for this species - especially McGee Knoll, Vernita, West Haven, Gable Butte, and Gable Mountain. The McGee Knoll and Vernita sites are of special concern because of their close proximity to known population of Piper's daisy on Umtanum ridge. These sites are less than 2 miles from the known populations and contain similar habitats. The ALE and Horn Rapids near surface basalt sites are the least likely to harbor large populations of Piper's daisy. The McGee Ranch fine soil borrow area has been surveyed several times since the mid 1980's; Piper's daisy was not documented during any of these surveys. However, there is no reason *per se* that this species would not be found in the future, especially in the native shrub portions of the site.

A population of approximately 25 Piper's daisy individuals was discovered at Pit 30 in the spring of 1993. These individuals were not found during the spring of 1994 survey, even though no major disturbances of the soil substrate were apparent. During a separate 1994 survey, one individual was located on the eastern edge of Pit 30, outside the area proposed for expansion to support barrier construction activities. The demise of the population may be due to the unusually low amounts of precipitation during the winter and spring of 1994. Another population near B-pond, approximately 4 miles east of pit 30, also disappeared during the same time frame. Although only one individual was observed in Pit 30 in 1994, there is a high probability that the population could be re-established in future years from viable seed remaining in the seed bank. Therefore, mitigation procedures should be in place prior to initiation of the pit 30 expansion. The same holds true for other material borrow sites because populations of Piper's daisy or other plant species of concern could become established at any of the sites prior to the initiation of borrow activities.

3.0 MITIGATION PROCEDURES

In the event that a population is found there are several approaches to mitigation that can be followed, depending on the specific circumstances under which it is found. The three general approaches are: selection of an alternative site, administrative controls, and physical relocation of all or part of the affected population. Each of these approaches are described in greater detail in the following sections, and various combinations of these approaches may be adopted.

3.1 ALTERNATIVE SITE SELECTION

From a population protection perspective, the selection of a different site for development may be the optimal approach for rare species conservation, and one that would preclude the need for any additional mitigation measures. However, there are many circumstances that may detract from the attractiveness of this option. For one, the development of an alternative site may result in the loss of greater quantities or higher quality habitat for many other species, and could have a net negative impact on the ecosystem as a whole that may out-weigh the impact on a single population of one species. Second, if the original site selection process is conducted appropriately, the choice of a particular site is made at least partially on the basis of the least overall environmental impact, and implies that other concerns (i.e. quantity and/or quality of materials, haulage costs, etc.) outweigh the projected environmental impacts. Third, a population may not be discovered until after significant resources have been committed on a particular site, or even after several years of site utilization, which could make development of an alternative site impractical.

Therefore, selection of an alternative borrow site should be the first option considered if a population of Piper's daisy or any other plant species of concern is discovered at a selected borrow site. However, selection of alternative sites should be made in light of all other environmental impacts that may result from such an action.

3.2 ADMINISTRATIVE CONTROLS

In many situations the use of administrative controls would be the preferred means of protecting a rare plant population. This can be accomplished by simply restricting access in the vicinity of the population, and leaving the area around the population intact and undisturbed. The area under administrative control should be roped off to prevent inadvertent entry by people or vehicles, and site workers should be informed about the nature and importance of the administratively controlled zone.

The quantity of land cordoned off should be large enough to support the present population, and provide enough undisturbed habitat to allow for population expansion. The area should also be large enough to prevent adverse impacts to the population that could occur in close proximity to high traffic areas, sites under active excavation, or areas that may receive herbicide drift. Designation of administratively control boundaries should be made in consultation with biologists familiar with the species in question.

3.3 RELOCATION

In certain situations it may prove impractical to select an alternative borrow site and the use of administrative controls to protect an entire population may remove excessive amounts of the selective borrow site from production. Under these circumstances it may be appropriate to relocate all or part of the population. However, this option should be considered a last resort, to be used only when the other mitigation alternatives are considered impractical or would result in greater harm to the ecosystem as a whole.

If the relocation option is selected, both mature plants and seeds should be included in the relocation effort. Use of both mature plants and seeds will increase the probability of successful relocation and will help preserve the locally adapted genetic traits of both the individuals and the populations. Plants that are intended for relocation should be identified, marked, and provided with temporary protection through administrative controls. Once the plants have set seed the seeds should be collected, and then the mature plants can be carefully excavated and replanted at a preselected site. Transplanting mature plants should be delayed until after seed set because the physical shock of transplantation can result in negligible seed production, or in a worst case the plant may die without setting seed, resulting in no plant material being available for relocation. Waiting until after seed set also has the advantage that the plants will be transplanted during a quiescent or dormant period, during which the water and nutrient requirements are low.

The selection of a site to receive the transplants will depend on a number of factors, including the specific circumstances present at the site. In most cases it is preferable to relocate the population to an area that is geographically similar and near the site of the original population center. If most of a population is to be protected solely by administrative controls, outlying individuals should be transplanted to within the controlled zone. If an entire population is to be relocated, the transplantation can be part of the borrow site restoration program if appropriate and practical, or if not, they may be relocated elsewhere. If the borrow site is to be used over a period of years, the restoration of the previously excavated areas should proceed concurrently with ongoing excavation. In this case it would be appropriate to replant the population within the same geographic area that it originally came from. If the borrow area has just been opened, or if appropriate sites are not reconstructed to support the population, or if other uses of the land are planned post-excavation, the population would have to be relocated elsewhere. This may be a nearby undisturbed community, or it may be another area on the Hanford site that is undergoing restoration and is ready to receive the transplants. The overriding criteria for transplant site selection is that the new site must be left undeveloped and undisturbed.

The seeds that are collected prior to relocating the mature plants should be transferred to an organization with the facilities and the experience required to germinate the seeds and nurture the seedlings until they are ready to be returned to the field. In some cases, PNL may be capable of providing this support. Other options include private nurseries (preferably those that specialize in native plants) and nurseries operated by Native American tribes, such as the one set up for the EMSL site restoration. In most cases, the germination and nursing of the seedlings should be timed to allow for early spring transplantation. The seedlings should be used to replace or expand the population affected by the borrow site activities at or near the original site. If large numbers of seedlings are produced, some may be introduced to other restoration sites, or to other parts of the Hanford Site that will not be affected by later Site activities. The same criteria used to select sites to receive the mature plants are appropriate for the seedlings.

When transplanting either mature plants or seedlings, water should be provided at planting and on a regular basis thereafter, until it can be determined that the plants have taken root, and can survive without supplemental irrigation.

4.0 SUMMARY

This mitigation plan is designed to provide general guidelines that should be followed in the event that a rare plant population is encountered during the development of a barrier materials borrow site. The same general protocols are applicable to other site operation and environmental restoration activities. This mitigation plan specifically addresses Piper's daisy because this species has been documented within Pit 30, the proposed borrow site for gravel, sand, and backfill materials. Although this plan is specific for Piper's daisy, the same procedures are applicable if any other plant species of concern is encountered.

If a species of concern is encountered at a selected borrow site, mitigation options should be considered in this order:

1) Select an alternative site for borrow materials.

2) Introduce administrative controls or access restrictions to protect and preserve the population in place, while continuing to utilize other portions of the borrow site.

3) Relocate all or part of the population.

These guidelines are general in nature because the exact specifications for mitigation will depend on the particular circumstances that are encountered in the field. The discovery of a plant species of concern would be likely to impact both the budget and the schedule for borrow site activities. However, if the general guidelines described here are followed, the impacts to the project should be minimized to the greatest extent possible.

5.0 REFERENCES

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ATTACHMENT 2.

Guidelines for Reclamation of Barrier Materials Borrow Sites

GUIDELINES FOR RECLAMATION OF BARRIER MATERIALS BORROW SITES

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1.0 Introduction

The construction of barriers for the long term isolation of radioactive and hazardous wastes will require the use of large amounts of earthen materials. The types of materials required include basalt rip-rap, gravel, sands, and silts. Borrow sites will be required for each of these materials and the development of these borrow sites will, by necessity, result in large scale disturbance of natural plant communities and wildlife habitats. Therefore, the selected borrow sites must be restored to some sort of permanent, self sustaining condition once the excavation has be completed.

The actual endpoint or goal of the reclamation effort will be highly dependant on the planned future use of each site. Several different terms are used to describe the reconstruction of a plant community on disturbed lands these were defined by the National Academy of Sciences (NAS 1974) as the following:

- "Restoration" implies that the conditions of the site at the time of disturbance will be replicated after the action.
- "Reclamation" implies that the site is made habitable to organisms that were originally present or others that approximate the original inhabitants,
- "Rehabilitation" implies that the land will be returned to a form and productivity in conformity with a prior land use plan, including a stable ecological state that does not contribute substantially to environmental deterioration and is consistent with surrounding aesthetic values.

Using these definitions, restoration would imply that all of the pre-disturbance conditions are recreated, including site contours, drainage patterns, and the complete plant community the was present prior to disturbance. Because the drastic nature of the disturbance that will result from the removal of thousands or millions of cubic meters of material, complete restoration as a goal will most likely be impractical. The actual endpoint of restoration may also be unclear. For instance, if the borrow site is located in an area presently dominated by invasive aliens such as cheatgrass, should the site be restored to an alien community, or should it be restored to a pristine condition. If the latter is selected, we may not be able to determine the true structure of the pristine plant community. For these reasons, the concept of reclamation rather than restoration will be the guiding principle behind this report.

Reclamation, which is the generic term that will be used throughout this report, implies that the site will be returned to pre-disturbance conditions to the greatest extent possible, but allows for some latitude in determining what endpoints and goals are practical or achievable. However, specific site reclamation plans must acknowledge that many of the original site conditions cannot be recovered, or it may be impractical or perhaps even undesirable to do so. For instance, if the pre-disturbance plant community consists primarily of weedy aliens, it may be highly undesirable to restore that condition after cessation of site activities. It may be much more desirable to reproduce something resembling the native or pristine conditions of the site which would allow for more diverse future uses such as wildlife habitat and recreation. Site reclamation should result in an environment that is suitable for wildlife, and should have community productivity at least equivalent to the pre-disturbance conditions.

The concept of rehabilitation, as differentiated from restoration or reclamation, is important and points to the need to have land use planning incorporated into the overall goals of the site reconstruction effort. In some cases, it may be highly desirable to utilize a disturbed area such as a borrow pit for something other than the pre-disturbance purpose. In this case, it would not be cost efficient to attempt to restore the site to some other land use such as wildlife habitat if it will be re-disturbed at a later time. Examples of alternative future land uses that may be considered include the siting of new facilities, and the use of the land for grazing or for agriculture. The rehabilitation goals of each of these land uses would be quite different, and the methods used to produce the reconstructed landscape would vary accordingly. For instance, if the site is intended to be used for grazing a mixture of grasses and forbs with high forage value would be a desired revegetation endpoint, whereas the re-creation of wildlife habitat may entail the establishment of native shrubs as well as a mixture of grasses and forbs that may be quite different from that used for grazing purposes.

These reclamation guidelines have been prepared under the assumption the reclaimed land will be utilized primarily for wildlife habitat and limited recreation. With this in mind, the reclamation goals and methodologies should be integrated into the operational plans for the borrow site activities, and should be pursued from the outset. It is imperative that future land use plans be in place prior to the implementation of the reclamation procedures. Likewise, it is important that the excavation and borrow process be conducted so as to facilitate a rapid and successful ecosystem recovery. Most of the pertinent research on reclamation and revegetation of semi-arid, shrub steppe has been performed in conjunction with the reclamation of mining sites, especially coal mines. Hanford Site specific information concerning many phases of the reclamation process, such as topsoiling, soil reconstruction, planting methods, species selection, fertilization, and irrigation is limited to small test plots, to sites with unusual conditions, or to programs aimed at interim stabilization rather than long-term plant community reconstruction. Therefore, controlled, comparative tests of various techniques should be conducted in conjunction with, and as part of, ongoing reclamation activities. This will allow for the development of procedures that are optimized for the specific conditions encountered at the Hanford Site.

The following sections of this report provide general discussions of the integration of borrow site operations with the reclamation process, site and soil preparation, and revegetation procedures. Following these general discussions are specific recommendations for each of the different types of borrow sites that are currently planned, including the McGee Ranch fine soil borrow site, the Pit 30 sand and gravel borrow site, and the proposed basalt quarries.

2.0 Integration of Operational and Reclamation Activities

Proper integration of reclamation procedures with the normal operation procedures of a borrow site offers the advantages of reduced costs and increased probability of successful reclamation. Whenever possible, materials removed from an newly opened portion of the borrow site should be directly applied to previously utilized portions of the same site. This offers several advantages, including:

- Minimization of handling costs, because the materials would only be moved once.
- Maintains the overall topsoil health, especially the microbial populations.
- Maintains the native seed bank in the soil, which allows for both an increase in the number and diversity of plants that can re-establish on the reclaimed land.

Many aspects of site operations can be integrated with the reclamation procedure, including the collection and handling of plant materials, initial grubbing and clearing, and the handling of topsoil.

2.1 Plant Material Collection and Handling

If the plant community present at a site represents a native or at least semi-native stand or shrub steppe, the plant material that is present at the site can be a valuable commodity that will help to increase both the speed and success of the reclamation effort. The extant plant material can serve as a source for both seed and mature plants that can be transplanted onto other reclamation sites, and the remaining material can be utilized as a soil amendment to aid in the re-creation of topsoil. This would not be true if the plant community present at a site consists primarily of weedy or alien species. In that case the plant material should be removed and destroyed in order to reduce the likelihood of re-infesting the reclaimed areas with undesirable plant species.

Prior to the initiation of grubbing and clearing activities, plant materials should be selected for transfer to areas undergoing reclamation. These materials can be both seeds and mature plants, including shrubs, bunchgrasses, and forbs. Use of direct transplants will increase the species diversity within the reclaimed areas, help to inoculate soils with beneficial micro-organisms, and provide a self sustaining seed source for the transplanted species. Transplanting relatively large shrubs can also provide immediate habitat for wildlife species that are dependant on the presence of mature shrubs. The number of mature plants collected will depend on both the species in question and the amount of surface area available to receive the transplants. Section 4.0 of this report provides addtional planting guidelines.

Seed collected from the site can either be directly sown in current reclamation areas, or it may be planted in a nursery to produce seedlings for later transplant. The collection and utilization of local seed will be especially useful for increasing the forb species diversity in the reclaimed sites because seeds for most of the native herbaceous species are not available commercially. Little is known about the germination and establishment requirements for most native species of the Hanford Site, therefore techniques for both direct sowing and seedling transplants should be developed using comparative trials on a species by species basis.

2.2 Grubbing and Clearing

From a reclamation perspective, it is preferable to perform grubbing and clearing on relatively small sections of land, and to clear the land only as it is needed, rather than clearing off the entire projected borrow site in a single step. A multi-step approach offers several advantages for reclamation purposes, and each of the following considerations will contribute to overall cost savings for the reclamation program:

- Materials salvaged from the site, such as topsoil and plant materials, can be directly applied to areas that are being closed down and actively reclaimed. This offers the potential to reduce material handling costs, as well as increasing the probability of successful revegetation and site reclamation.

- The introduction of invasive weeds in fallow areas will be minimized, as will the costs associated with physically or chemically controlling the weeds.

- Nuisance dust generation will be minimized because less soil surface area will be exposed to erosive forces. The need for interim dust control measures, such as planting cover crops, applying chemical soil fixatives, or continually providing water trucks would also be eliminated.

- The overall habitat integrity will be better preserved because of the maintenance of local, native seed sources that will aid in the natural recolonization of reclaimed sites.

- The potential that areas will be cleared, but never utilized, will be reduced. All of the cleared land will ultimately require reclamation, regardless of whether or not borrow materials are removed.

Once the native seeds have been collected form a site, and the selected mature plants have been removed and transplanted, the remaining portion of the newly opened site can be grubbed and cleared. This operation will include both the removal of the remaining extant vegetation, and the stripping of the topsoil.

The plant material that is grubbed off of the site should be stockpiled, and eventually chipped or shredded. The resulting organic mater can then be applied to the reclamation areas as a portion of the topsoil re-creation process. Use of this material in the topsoil will increase the organic matter, act as a bulking agent, will provide a native seed source and, if root material is included, it will provide a natural soil inoculum for mycorrhizae and other micro-organisms. Other soil amendments will probably also be required, but the use of the chipped or shredded plant material will more closely mimic the native organic matter present in the local soils.

2.3 Scraping and Handling of Topsoil

The topsoil present at a site is usually substantially different from the underlying soil material in many factors, including fertility, water holding capacity, cation exchange capacity, and structure. For these reasons the topsoil is a more suitable growth medium than the underlying materials that will be excavated for barrier construction purposes, or the residual soil that will remain on the surface after the excavation is completed. Therefore, the topsoil should be stripped off and salvaged before the underlying materials are borrowed for other purposes. "This one activity may do more for restoring ecosystem function on disturbed lands than any other reclamation procedure (DePuit and Rendente 1988) ".

Once the vegetation cover has been removed from a site, the upper soil layers can be stripped off and used in areasthat are being reclaimed. The topsoil should be respread immediately following removal from a site, which will not only saves in material handling costs, but also preserves the fertility of the soil, the microbiological activity, and the viability of the soil seed bank (DePuit 1988). Jastrow et al. (1984) showed that overall plant community productivity and canopy coverage were significantly reduced in plots that had received topsoil that had been stockpiled for 2 years, compared to plots that had directly received fresh topsoil. The differences were especially apparent in the shrub component of the plant community.

The depth of topsoil that should be salvaged will depend on the amount of area available to receive the soil and the type of plant community that will be re-established in the reclaimed area. If the area being reclaimed is larger than the area that is being cleared off, as much topsoil as possible should be salvaged, and then spread evenly over the entire reclaimed area. Because the depth of this topsoil layer may be insufficient for proper community development in the reclaimed area, additional soil enhancement and reconstruction efforts will be required. Guidelines for soil enhancement are described in more detail in section 3.2. If the area being reclaimed is smaller than the area being cleared, all of the topsoil should be spread on the reclaimed area and only minor additional soil enhancements may be required. The type of plant community desired in the reclaimed area will also influence the amount of topsoil required. Barth and Martin (1984) found that cool-season grasses had greater productivity with increasing topsoil depth over mine spoils, especially over acidic or sodic spoils. They found that grass productivity increased with soil depth to depth of about 50 cm over 'generic' spoils but greater than 100 cm of topsoil was required for maximum productivity over acidic spoils. Redente et al. (1982) found that overall species diversity is greater, but overall productivity was lower in sites with a thin (30 cm) topsoil layer compared to sites with thicker (90- 100 cm) topsoil layers. Shrub productivity increased with increasing topsoil depth, whereas forb biomass was negatively effected by increasing soil depth. Grasses benefitted from increasing soil thicknesses up to a intermediate depth (60 cm) and were unaffected by thicker layers. Therefore, if shrub re-establishment with a perennial grass understory is desired, approximately 1 meter of topsoil will be required on the reclaimed sites. In general, it is preferable to have native topsoil constitute as much of this meter as possible. If the residual material on the borrow pit surface has good structure and chemical composition, slightly less topsoil may be required. However, comparative studies of the effects of replaced topsoil depth on plant community development have not been conducted at the Hanford Site, and should be pursued in conjunction with on-going reclamation efforts.

There is some disagreement about the necessity to separate the "true" topsoil or A-horizon from the sub-soil or B-horizon. DePuit (1988) suggests that soil profile segregation is usually not required for rangeland reclamation. Biondini et al. (1985) found that mixing the upper soil layers did not result in significantly different communities compared to non-mixed soils, and they found that reversing the order of the soil layers resulted in a community with a higher shrub cover compared to un-mixed and uniformly mixed soils. However, Bradshaw and Chadwick (1980) recommend the practice of separate removal, storage, and reapplication of the topsoil and sub-soil, and recommend that the materials be reapplied so as to reconstruct the layering of the original soil profiles. Obviously, this would greatly increase both the complexity and the cost of the reclamation effort. Therefore, initial efforts should be focused on utilizing a mixture of the A and B horizons, with a few small plots with segregated soil profiles used for comparative purposes, to determine if there would be a significant benefit associated with soil profile segregation.

3.0 Site and Soil Preparation

The interface between the excavation and the revegetation efforts occurs at the site and soil preparation stage. This is when the transition from removing to replacing materials occurs. Proper integration of the reclamation goals with the excavation operational procedures can produce cost savings due to reduced efforts involved with site contouring, grading, and materials handling.

3.1 Site Contouring

Site contouring is an important step in returning a site to some semblance of its original physical and topographical state. The site should be recontoured so as to meld with the surrounding landscape. Obviously, the physical layout will be dependant on the specifics encountered at each individual site, and The physical stability and erosion potential of each site should be evaluated by a civil engineer prior to final design and layout. Therefore, only general guidelines and considerations are provided here.

Slopes should be minimized whenever possible in order to reduce erosion. Specific slope inclinations will depend on the overall topography of the site, the soil characteristics, and the type of soil amendments that will be incorporated into the topsoil. Topographic variation should also be included in the overall site contouring design as long as it fits with the surrounding terrain. This will create a wider range of microhabitat sites that will aid in the creation of a more diverse plant community. Contouring should take into account the natural topography and drainage patterns of the site. This will minimize the potential for both ponding in low areas, and the creation of gullies on the side slopes. If long slopes are unavoidable, benches and drainage structures should be incorporated into the contouring design. The drainage structures should be lined with materials such as rip-rap or fiber matting to minimize erosion of the structures. Revegetation can be used in conjunction with fiber matting. Contouring should be performed prior to the replacement of topsoil or topsoil reconstruction, but in some situations, these can be performed concurrently.

3.2 Seed Bed Preparation

Once the site has been recontoured, soil preparation can begin. Steps include analysis of the residual subsoils on the surface, application of additional topsoil, incorporation of amendments, and final soil surface and compaction manipulations.

3.2.1 Soil Preparation

The soil present on the surface after the site is recontoured will most likely consist entirely of subsoils that were originally buried well below the topsoil. These subsoils generally will not be suitable as a plant growth medium due to low organic matter, fertility, and water holding capacity. Because the availability of replacement topsoil will usually be limited, the first step in soil preparation should be an analysis of the surface soils present after site contouring. These analyses should include fertility (both macro- and micro-nutrients), organic matter content, particle size, and bulk density. In most cases, field portable instruments may be satisfactory for these analyses. The results of these tests will help to determine the utility of the soil as a plant growth medium, and can point to what types of amendments would most useful and cost effective for soil improvement. In general, if there is very little topsoil available for reapplication the subsoils will require more substantial compensatory improvements. If relatively large quantities of topsoil are available, then there may be little or no need for subsoil modifications.

As discussed in section 2.3, the depth of soil suitable for plant growth will depend on the type of plant community that is ultimately desired. In most cases on the Hanford Site, a shrub community (mainly sagebrush - *Artemisia tridentata*) with a perennial bunchgrass understory will be the desired revegetation endpoint. For this type of community, a relatively thick (90 - 100 cm) soil layer will be required. Ideally, as much of this soil volume as possible should consist of salvaged topsoil, but in many cases the existing substrate will require modification in order to provide the required soil depth. The first step in this process is to determine if the residual soil is structurally similar to the topsoil that was originally present and that will be replaced on the surface. Care should be taken during the process of material removal to ensure that a sufficient depth of soil is left in place above any underlying layers of structurally different material. For instance, if a layer of gravel or cobbles underlies the sand or silt borrowed from a site, a minimum of one meter of soil should be left in place above that underlying layer to allow for a suitable rooting depth.

3.2.2 Soil Amendments

Various amendments can be added to either (or both) the subsoils and the replaced topsoil. Amendment of the subsoil is especially important if insufficient quantities of topsoil are available for the site. In this case, an artificial "topsoil" can be created by amending the subsoils with organic materials. Even if relatively large amounts of topsoil are available, amendment of the subsoil may still be required if it is severely depauperate in nutrients. Amendment of the topsoil itself can be performed both to increase the soil organic matter and nutrient status of the soil and to provide surface erosion protection. A number of soil amendment options are available, including:

- Shredded plant material salvaged from the reclamation sites
- Sewage sludge
- Composts
- Straw and Hay Mulches
- Chemical Fertilizers

There is limited information regarding the use of many of these materials for revegetation purposes at the Hanford Site and most of this information is from relatively small test beds, except for straw, which has been used extensively in the interim stabilization program. At this point, a single recommendation cannot be made, and undoubtedly different materials will be optimal depending on the specifics of the site. Large scale tests of various materials and combinations of materials should be incorporated into the overall reclamation procedures. The timing of application of these materials in relation to the time of seeding also varies. Sludges and composts are usually incorporated into the soil prior to seeding, straw and hay mulches are often applied after seeding, and chemical fertilizers are often co-applied with the seed through a separate feed box on the seed drill.

Plant biomass salvaged during the initial opening of a borrow site can be a very cost effective source of soil amendment material. Although it will probably not be as balanced as some of the other amendment options in terms of overall nutrient suitability, it does comprise the mixture of plant material that would naturally be incorporated into the soil via normal senescence and decay processes. Schlatterer and Tisdale (1969) found that litter of sagebrush and rabbitbrush (*Chrysothamnus viscidiflorus*) inhibited the germination of several bunchgrass species, but once established, the grasses had higher growth rates in the presence of the litter than controls without litter. They attributed the higher growth rate to increased nitrogen content in the seedlings, at least in the case of the sagebrush litter. If root material is included with the salvaged biomass, it would also provide for inoculation of the soil with native mycorrhizae and other desirable soil microbes. In addition to these benefits, there would be no material acquisition costs, and minimal haulage costs. The volume of material that should be applied to a site will, in most instances, be limited only by the amount of material available. In most cases, shredded native biomass will be a useful addition to the soil, but additional amendments will normally be required. The use of shredded biomass can reduce the overall cost associated with some of the more expensive alternatives.

Sewage sludge had been used as a soil amendment for at least 100 years (Jones 1981). This material is a by-product of municipal sewage treatment plant operations, and is normally available at relatively low cost. It is normally available in a dewatered form, although liquid forms are also available. Application rates typically range up to approximately 500 metric tons (dry weight)/ ha. Sewage sludges contain a complete compliment of the macro- and micronutrients required for plant growth, and also have beneficial effects on soil pH and water holding capacity (Brandt and Hendrickson 1990). Sewage sludge also has the added benefit of increasing soil microbial activity. Aldon (1982) and Fresquez and Lindemann (1982) found a significant increase in both the number and variety of microbes and fungi in soils amended with sludge as compared with commercial fertilizers. Sewage sludge has been found to be very beneficial as an aid in re-establishing vegetation on disturbed lands (Bradshaw and Chadwick 1980), and many specific examples are available. For instance, Pietz et al (1989) found that sludge significantly increased plant coverage and biomass on acidic coal refuse. Primary concerns associated with the use of municipal sewage sludge are the potential for build up of pathogens and heavy metals in the soil. Both of these concerns are most acute in situations where the material is applied to food crops and when repeatedly applied to the same site. Survival of infectious pathogens in the soil will depend of factors such as pH, soil moisture, and soil organic content, but the maximum half-life for pathogen survival in soil is typically less than 10 to 20 days (Sorber and Moore 1986). Many sewage sludges have elevated levels of various heavy metals, including copper, zinc, cadmium, and chromium. The concentrations will depend on the source of the sludge, and is especially related to the amount of heavy industry in the area that contributes waste water to the local sewage treatment plant. The levels of heavy metals within the sludge is rarely at a toxic level, but an analysis of the material should be requested with each order. Even if the metal concentrations are well below toxicity limits, there is still the potential of accumulation in the soil, and eventual adverse accumulation in plants. This should not be a problem in most reclamation settings, when the material is only applied at the time of initial revegetation.

Composts are also a useful means of increasing the bulk organic matter content of soils. Composts can be derived from a variety of sources, including yard waste, wood chip and other lumber mill waste, feedlot wastes, mushroom growth media, and municipal sewage sludge. While each of these forms have slightly different combinations of nutrients and organic matter, they all provide for slow release of nitrogen, increase the tilth and water holding capacity of the soil, and help to bind the soil, resulting in lower surface erosion rates (Brandt and Hendrickson 1991). Compost amendments have been used successfully as aids in revegetation with native grass species at the Hanford Site. Sackschewsky et al. (1993) found that the addition of a municipal sewage sludge / wood chip compost greatly increased biomass production and soil moisture content compared to plots without compost. They applied a 11.4 cm layer of compost that was disked into a sandy loam soil in the 200 East area. Brandt et al. (1993) reported that an artificial topsoil made up warden silt loam and compost (with or without additional wood fiber) was superior to either no compost or to a compost top-dressing. They found an increase in the density of perennial grasses and a decrease in density of both cheatgrass and russian thistle when using the artificial topsoil compared to a straw mulch or a compost topdressing. Their results suggest that the compost should be well mixed into the soil whether as an artificial topsoil using imported material or incorporated into the *in situ* surface soil. The volume of compost that should be applied to the site will depend on the particular soil type and nutrient conditions of the particular site. However, if the compost is to be incorporated into the soil in situ, then a relatively small amount, on the order of a 7.5 cm layer (750 m^3 compost/ha) should normally be sufficient because it can be difficult to uniformly incorporate the material to sufficient depths with tillage equipment that is normally available. At the test plots constructed by Sackschewsky et al. (1993) the compost plots had a considerable amount of residual compost on the surface after disking. The material should be uniformly mixed into the upper 30 - 40 c m of soil.

A number of other materials have also been traditionally used as mulches for revegetation and reclamation. These materials include wheat or barley straw, grass hay, and wood chips or fibers. The primary advantage of these materials is a significantly reduced cost compared to other alternatives such as sludge or compost. Straw and hay are utilized as much for erosion protection as for soil enhancement. They are normally applied at rates of 4000 to 5000 Kg/ha, and are then crimped or pressed into the soil surface. Because erosion protection is a primary reason for using straw or grass hay, they are usually spread and crimped after the seeds have been sown. This will leave the materials on the surface, and form an artificial stubble that will minimize wind erosion. Straw is usually the least expensive alternative. The disadvantages of straw include a high carbon to nitrogen ratio, the introduction of volunteer crop plants, and a tendency to wick moisture out of the soil. Grass hay normally has a slightly lower carbon to nitrogen ratio, and it can provide a supplemental seed source for desirable species. Large round bales of native grass hay are preferable to small rectangular bales because the long grass culms can be crimped several times, increasing the utility in prevention of soil erosion. Alfalfa hay is an alternative to straw and grass hay that should be further explored. Alfalfa has a much lower carbon to nitrogen ratio than either straw or grass hay, and therefore supplies significantly more nutrients as well as comparable erosion protection. Initial data (Kemp and Sackschewsky, unpublished) suggest that the incorporation of alfalfa into both fine and coarse soils greatly increases the overall biomass production and perennial grass density compared to straw mulches. The values in alfalfa plots were comparable to those amended with compost. Alfalfa can be incorporated after seeding, but may be better applied and incorporated via disking or rototilling prior to seeding. With the use of any of these materials, it is important to use certified weed-free material to prevent the inadvertent introduction of undesirable alien weed species that would compete with the seeded species and limit the success of the revegetation effort. Wood fibers are usually applied as part of a hydromulch. Other hydromulch materials include coconut fibers, paper, and straw. A tackifier, and often a nutrient solution, are also mixed into the hydromulch to bind the mulch materials together and to the soil surface. Hydromulches are used extensively in a number of situations, but are probably most useful in steep or rocky terrain where other types of equipment cannot be used. Bark chips can be used similarly to other organic amendments. Scholl and Pase (1984) found that decomposed pine bark, applied at rates of approximately 18 metric tons/ha significantly increased the density and biomass production of wheatgrasses on sodic coal spoils, compared to straw mulch and no amendment treatments.

Chemical fertilizers offer an easy and inexpensive means of increasing soil fertility. Fertilizer can either be incorporated into the soil prior to seeding, or it can be co-applied with a seed drill. The amount and form of fertilizer will depend on the initial nutrient status of the soil. At the Hanford Site a simple fertilizer, with N:P:K ratios of 21-0-0 or 16-16-16, at a rate of approximately 20 - 50 Kg N/ha is usually sufficient. Other materials such as 15:30:15 applied at rates up to 84 Kg/ha have also been reported (Brandt et al. 1992). Selection of the type of chemical fertilizer and the application rate should be determined based on an analysis of the soil at each specific site. In general, fertilizers have been found to be beneficial for the establishment of perennial grasses. Brandt et al. (1993) reported that fertilizer treatments increased the density and cover of perennial grasses, but had little or no effect on cheatgrass, shrubs, russian thistle, or native forbs. These results are similar to those of Doerr and Redente (1983) and Redente et al. (1984) who found that fertilizer increased initial grass production but had relatively little effect on shrubs. They also found that forb production was negatively effected by fertilization. However, the also found that after four years there was no difference between stands that were initially fertilized and those that were not initially fertilized.

3.2.3 Final Soil Preparation

Final adjustments in soil compaction and surface configuration can either be made during the incorporation of soil amendments and mulches, or after the materials have been applied and incorporated. The repeated passes of large equipment inherent to the processes of recontouring, grading, applying topsoil, and applying and incorporating amendments can compact the soil surface (Barnhisel 1988). A compacted surface may decrease the water infiltration rate, and may inhibit seedling root elongation (Glinski and Lipiec 1990). Depending on the degree and depth of compaction, this can be corrected by rippers, chisel plows, or disks.

4.0 Revegetation Procedures

The selection of plant materials and the procedures used to introduce them to a site will influence the ultimate plant community that will develop. The intended land use of the site will determine the choice of plant material, and could also influence the type and level of effort used to introduce vegetation to a reclaimed site. For the purposes of these reclamation guidelines, it is assumed that the recreated plant communities will be designed to be similar in structure and composition to the native shrub-steppe vegetation of the mid Columbia basin. The resulting community should be productive, aesthetically pleasing, and provide habitat for indigenous wildlife that rely on shrub steppe habitat. The creation of this type of plant community may require a multi-year effort, and will include both direct seeding and transplantation of a variety of native grasses, forbs, and shrub species. If other land uses are planned for a site, the revegetation may be as simple as drill seeding of cover crops to minimize erosion until the alternative land use can be implemented.

4.1 Selection and Planting of Native Species

The desired end point for the reclamation effort will usually be a productive and diverse plant community that resembles natural communities in physiognomy, composition, and diversity. To meet this goal, all of the principle components of the community should be included in the revegetation effort. These components include the perennial grasses, the forbs, and the shrubs.

4.1.1 Perennial Grasses

In the native shrub steppe of the mid Columbia Basin, perennial bunchgrasses are the principle understory species, and the presence or absence of these species is normally a very good indicator of the overall condition of the plant community. In native plant communities on the Hanford Site, canopy coverage of perennial bunchgrasses can be up to 50% (Daubenmire 1970, Downs et al. 1993). For the purposes of revegetation, the introduction of perennial bunchgrasses will be the initial step, and will form the overall background for the community reconstruction. A number of species should be considered, depending on the location of the site, the soil type, and the nature of the surrounding plant community. Important perennial grass species to consider are listed in Table 1.

Table 1 - Hanford Site Perennial Bunchgrasses

Species	Common Name
Poa sandbergii	Sandberg's Bluegrass
Sitanion hystrix	Bottlebrush squirreltail
Oryzopsis hymenoides	Indian ricegrass
Stipa comata	Needle-and-thread grass
Sporobolus cryptandrus	Sand dropseed
Elymus cinereus	Basin wildrye
Koleria cristata	Prairie junegrass
Agropyron dasystachyum	Thickspike wheatgrass
Psuedoregneria spicata	Bluebunch wheatgrass

Ideally, seed used for revegetation should be collected locally because local seed is expected to be best adapted to the specific conditions of that site. However, if large amounts of seed are required, it may be impractical or prohibitively expensive to collect enough seed of each species to revegetate large areas. In that case, the next best option is to use commercially available seed. In most cases it is possible to purchase seed harvested from near the Hanford Stie in south-central Washington. Every effort should be made to obtain seed from the local region as this will help to ensure that the introduced plants will be more genetically adapted to Hanford Site conditions, will minimize the dilution of the native gene pool, and it can have the side benefit that contaminant seed will be of other desirable native species. Most species should be sown at rates of 5 - 15 Kg pure live seed (PLS) /ha when drill seeded, and up to double that amount when broadcast seeded. Most can be planted at depths of between 1 and 2 cm, but some, especially Indian ricegrass should be planted deeper, between 5 and 7 cm (Wasser 1982).

In many cases, it may be optimal to use a combination of locally collected material and commercially purchased seed. In many plant communities on the Hanford site, Sandberg's bluegrass is the primary native grass, and a number of other species that are important for overall community structure and diversity are present at lower densities. To recreate this mixture, one can drill seed commercially available Sandberg's bluegrass to create the overall base, and then use locally collected seeds or transplants of other grasses to increase the richness and diversity of the grass component of the community. These minor components of the mixture can be co-drilled with the sandberg's bluegrass throughout the entire area being planted, broadcast seeded or drill interseeded in specific areas to create islands within the larger site, or they can be introduced to specific areas within the site via transplantation of adults and seedlings.

4.1.2 Native Forbs

The introduction of forbs into a reconstructed plant community will greatly increase the species diversity, and will provide additional food material for wildlife. Unfortunately virtually no research on revegetation with native forb species has been performed on the Hanford Site. In most cases both seed and mature individuals of selected forb species should be collected from the areas thatwill be grubbed and cleared for development. The seeds can then be either planted directly into the reclaimed areas, or they may be germinated in controlled conditions and the seedlings planted on site at a later date. Likewise, the mature plants can be either directly transplanted to the reclaimed areas, or they may be transferred to a nursery for planting at a later date. The diversity of collected species should be as broad as possible, and should represent as many genera and species as are present in the borrow site areas. The specific species that may be collected will be highly dependant on the specific location. A listing of some important annual species is provided in Table 2, and important native perennial species are listed in Table 3. In many cases, much of the diversity of a plant community may be due to non-native species. This is not entirely bad, and a species should not necessarily be left out of the revegetation process simply because it is not "native". The primary concern that should be addressed when selecting and collecting plants for revegetation purposes is that they not be considered noxious weeds, or have the potential to become serious weedy pests. Many non-native species are important components of extant local plant communities.

Table 2 - Hanford Site Native Annual Forb Species

Species	Common name
Camissonia species	Desert primroses
Cryptantha species	Cryptanthas
Epilobium species	Willow-herbs
Eriogonum viminium	Broom buckwheat
Gilia species	Gilias
Plantago patagonica	Indian wheat
Plectritis macrocera	White cupseed
Tiquilia nuttallii	Desert mat

Table 3 - Hanford Site Native Perennial Forb Species	
Species	Common Name
Achillea millefolium	Yarrow
Astragalus species	Milkvetchs
Erigeron species	Fleabanes
Eriogonum species	Buckwheats
Chaenactis douglasii	Hoary false yarrow
Brodiaea douglasii	Cluster lily
Fritellaria pudica	Yellowbell
Allium species	Onions
Balsamorhiza careyana	Carey's balsamroot
Phlox longifolia	Long leaf phlox
Cymopteris terebinthinus	Turpentine springparsley
Helianthus cusickii	Cusick's sunflower
Sphearalcea munroana	Munroe's globemallow
Penstemon accuminatus	Sand beardtongue
Phacelia hastata	Whiteleaf scorpionweed
Phacelia linearis	Threadleaf scorpionweed
Lupinus species	Lupines
Lomatium species	Desert parsleys
Delphinium nuttalianum	Upland larkspur
Crepis atrabarba	Hawksbeard
Psoralea lanceolata	Dune scurfpea
Oenothera pallida	Pale eveningprimrose

4.1.3 Shrubs

Shrubs are a very important component of the native plant communities in the Columbia basin. Shrubs typically provide for as much as 20 - 30% of the total canopy coverage (Daubenmire 1970) and a significant portion of the above ground biomass production. They also provide the physiognomic structure to the community on which many species of wildlife depend. They also provide shading for other plant species. Throughout most of the Hanford Site big sagebrush is the dominant shrub. Species such as spiny hopsage, antelope bitterbrush, and gray rabbitbrush are important components of some communities. Table 4 provides a listing of the important shrubs, as well as less common shrubs and sub-shrubs.

Table 4 - Shrubs and Sub-Shrubs of the Hanford Site

Species	Common Name
Principle Shrubs:	
Artemisia tridentata	Big Sagebrush
Purshia tridentata	Antelope bitterbrush
Grayia spinosa	Spiny hopsage
Chrysothamnus nauseosus	Gray rabbitbrush
Chrysothamnus viscidiflorus	Green rabbitbrush
Other Shrubs and Subshrubs:	
Salvia dorrii	Grayball sage
Artemisia rigida	Rigid sage
Ceratoides lanata	winterfat
Sarcobatus vermiculatus	Greasewood
Leptodactylon pungens	Prickly phlox
Eriogonum sphearocephalum	Rock buckwheat
Eriogonum niveum	Snowy buckwheat

The native shrubs are all slow growing, and the replacement of large shrubs, especially sagebrush, will be one of the most important means of returning a site to a pre-disturbance type of plant community. Many of the sagebrush dependent wildlife species such as the Loggerhead shrike and the Sage Sparrow require the presence of relatively large individuals. Very little work has been performed at the Hanford Site on transplanting mature sagebrush. It is expected that it will be possible to transplant relatively large individuals using equipment commonly in use in the landscaping industry, such as tree shovels. Typical shrub-steppe communities on the Hanford Site have sagebrush densities up to 2000 shrubs/ha (Brandt et al 1991). Obviously, it would be exceedingly expensive to transplant that many mature shrubs. However, a significant benefit may be derived from transplanting a relatively low number of mature shrubs (collected from areas currently under development), interspersed with a much larger number of smaller transplants that could be directly transplanted, or obtained from a nursery as seedlings or tublings. Brandt et al. (1991) reported some success in transplanting tublings of sagebrush, gray rabbitbrush, and antelope bitterbrush. Not all of the sites on which they transplanted shrubs were considered successful, but enough of the shrubs survived to validate the utility of the procedure. Work is continuing on the general problem of shrub introduction at the Hanford Site.

4.2 Planting Considerations

Grasses should be planted in the fall, preferably in October, to take advantage of the winter precipitation (November through February) that makes up 54% of the normal annual precipitation (Hoitink and Burk 1994). Most of the grasses germinate in late fall, over winter as seedlings and then continue growth the next spring. When possible, the revegetation effort should be planned to occur sequentially over 2 or more years. The first year, grasses can be seeded, and some grass transplanting can be performed. Shrubs and forbs should not be planted the first year. This will allow for the control of broadleaf annual weeds, such as russian thistle (*Salsola kali*) and Jim Hill Mustard (*Sisymbrium altissimum*) with the use of selective herbicides. This may help to increase the survival of the grasses through the first year. Annual weeds are common early successional components on disturbed sites, and normally will become minor components of the community after several years (Allen 1988, Biondini et al. 1985). However, the use of selective herbicides may help to speed up the successional process. Evans et al. (1970) showed that germination and survival of intermediate wheatgrass was greatly increased when herbicides were used to control annual weeds. They attributed this increase in survival to a greater amount of soil moisture available to the wheatgrass seedlings.

Most of the native forbs of the Hanford Site germinate or resprout in the spring, therefore, that would be the preferable time to introduce these species to the reclamation site. If a multi-year planting schedule is followed, the forbs should be introduced in the spring of the second year of grass growth. The timing of shrub transplants is not clear. Brandt et al. (1991) transplanted tublings of several shrub species, including big sagebrush, hopsage, and gray rabbitbrush. Most of the transplants were performed in November, but several sites were transplanted in March; no significant differences in shrub survival due to planting date were observed. They did observe that the seedlings, especially hopsage, were highly susceptible to grazing by jack-rabbits. Initially, both spring and fall transplants should be attempted until it can be determined which time period would be optimal for shrub survival.

Irrigation can greatly increase the survival rate of seeded or transplanted plants. Several studies (Young and Rennick, 1982; Doerr and Redente, 1983; Rennick and Munshower 1985) have shown that irrigation for 1 to 3 months following seeding increases the total grass production in reseeded communities. This may be especially helpful at the Hanford site because of the low long-term average precipitation, and the high variation in natural precipitation from year to year (Hoitink and Burk 1994).

4.3 Site Monitoring

A continuing monitoring program should be developed to determine whether or not the plant communities on reclaimed sites are developing as intended. A monitoring program will also allow for early detection of problems, and can point to remedies that can be instituted before the entire plant community fails. The monitoring program need not be complex, and will typically consist of quarterly evaluations during the first year, and annual or semi-annual evaluations over the following several years, until the it can be determined with confidence that the plant community has developed within the bound of the initial site objectives. Parameters that should be evaluated include perennial grass coverage and diversity, forb survival and diversity, and shrub survival, density, and growth. The reclamation objectives for grass coverage, forb diversity, and shrub density should be determined at the start of the reclamation process. These objectives will usually be determined in relation to native plant communities in the vicinity of the reclamation site. For many areas, this information may be collected from the available literature on Hanford Site vegetation (i.e. Brandt et al. 1990, Downs et al. 1993). In other cases, the necessary data may need to be collected in the field.

5.0 Special Borrow Site Considerations

Reclamation of each of the different types of borrow sites (silt, sand/gravel, and basalt) will have different inherent reclamation problems. While the general considerations and guidelines that have been presented in the preceding sections of this report are applicable to all borrow sites, special considerations should be given to the unique problems that will be encountered in the conditions found in the different borrow site settings.

5.1 Sand and Gravel Borrow Sites

The principle problems that will be encountered when attempting to reclaim sand and gravel borrow sites, such as Pit 30, will be the extremely coarse nature of the residual soil, low fertility, and low water holding capacity of the soil. Correction of these deficiencies can be accomplished using the soil enhancement techniques described in section 3 of this report. Topsoil salvaging would be very beneficial, but the subsoils will also require amendment with organic matter such as compost. If the residual surface is exceedingly rocky, additional sandy or silty soil may be need to be incorporated along with the soil amendments. These treatments will increase the water holding capacity, and make for a rooting medium that is more structurally conducive to plant rooting and growth. Fertility deficiencies can be addressed via the added organic matter, and through additional chemical fertilizers.

5.2 Silt Loam Borrow Sites

There are several reclamation problems that will be encountered at a silt loam borrow site such as McGee ranch. The silty soils will be highly susceptible to compaction, which may require a conscious effort to minimize vehicular traffic on the exposed surfaces, and special attention to plowing or chiselling of the subsoils prior to topsoil replacement. Soil water holding capacity will not be a serious concern in these sites, but organic amendments such as compost or alfalfa mulches may be required to enhance the soil nutrient status and friability. Special problems may develop if underlying sand or gravel lenses are left on the surface following excavation. The interface between these coarse materials and the replaced topsoil could function as a capillary break that would inhibit deep penetration of soil moisture. This could be quite beneficial to grasses and forbs, but it could ultimately inhibit the growth of shrubs. Therefore, approximately 1 meter of silt loam subsoil should be left in place above the underlying sands and gravels. Disturbed topsoils at McGee ranch are highly susceptible to invasion by annual weeds, especially in the old field portions of the site where cheatgrass is the dominant plant species. This is due both to the large seed source that will surround the borrow site, and to the large amount of seed present in the soil seed bank. Therefore, topsoil salvaged from the old field areas will function as a seed source for undesirable plant species. This can be marginally alleviated by mowing with a strong vacuum mower prior to topsoil salvaging to minimize the amount of new seed, but the seed already present in the soil may still result in strong competition with the desired grasses. Some chemical herbicides may be useful in preferentially inhibiting cheatgrass, and these should be investigated as part of the overall reclamation program. Although revegetation of the old field portions of McGee ranch will be constrained by competition with annual weeds, these areas should be utilized as borrow areas before the shrub portions of the site. Replacement of all of the components of a shrub community will be always be difficult and expensive, but will be required within the portions of McGee ranch currently dominated by shrubs. Failure to meet reclamation goals in the shrub areas will require repeated revegetation attempts, which will significantly increase the overall cost of the reclamation effort. In the old fields, every attempt should be made to establish a mixed shrub / perennial grass community, but if something less than the desired results are obtained, it would be no worse, and quite possibly better, than the cheatgrass monocultures that are currently present in the old fields.

5.3 Basalt Quarries

Basalt quarries will present unique problems that will not be encountered in any other type of borrow site. The over-riding problem will be the complete absence of residual subsoils on which to build a rooting medium. Compounding this problem is the fact that there may be very little native topsoil available for salvaging. The material used as topsoil will need to be borrowed from another location, and may require mixing of sands, silts, and organic matter to produce a productive soil. Creation of a deep soil layer over the residual basalt will be expensive, and therefore, in most cases, the depth of the soil over bedrock will be relatively shallow, probably 50 to 100 cm. This can be compensated for by careful landforming, and the use of plant species adapted to thin soils. The floor of the quarry should be graded in a concave shape, so as to prevent off-site run-off, and to allow precipitation to collect within the reclaimed area. This will increase the amount of water available to the plants. The plant species used for revegetation should be those thatare usually found on the lithosols on top of the basalt deposits. These may include several buckwheats, rigid sage, *Antennaria dimorpha*, *Haplopappus stenophyllus*, and several *Astragalus*, and *Erigeron* species as well as Sandberg's bluegrass and Bluebunch wheatgrass.

Basalt cliffs are used by raptors and other birds for nesting and roosting. Therefore, the rock face that remains after the quarry is closed should be left in a rough condition, with plenty of the basalt columns remaining in place to function as nesting sites.

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APPENDIX F

CULTURAL, HISTORIC, AND ARCHAEOLOGIC SURVEYS

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A CULTURAL RESOURCES INVENTORY OF PROPOSED BASALT QUARRY SITES AT THE DEPARTMENT OF ENERGY'S HANFORD SITE, BENTON COUNTY, WASHINGTON

FOR
BATTELLE PACIFIC NORTHWEST LABORATORY
P.O. BOX 999
Richland, Washington 99352

ATTN: Dr. Paul Nickens

Master Agreement 057970-A-P2
Task Order 246277-A-S1

BY
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September 30, 1994

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1.0 INTRODUCTION

Federal statutes, regulations, and directives require the Department of Energy (DOE) to preserve significant historical, archaeological, and cultural sites ("historic properties"); to protect archaeological and paleontological sites; and to avoid interference with the free practice of traditional Native American religions. Management of cultural resources is the responsibility of the Site Management Division of the DOE-Richland Operations (DOE-RL), which discharges that responsibility partially through the Hanford Cultural Resources Laboratory (HCRL), a component of the Batelle Memorial Institutes' Pacific Northwest Laboratory (PNL) at the Hanford Site (Chatters 1989:3.1).

PNL is assisting Westinghouse Hanford Company (WHC) in conducting cultural resource reviews and surveys of seven potential basalt quarry sites located at the Hanford Site [Figs. 1 and 2]. Under Master Agreement 057970-A-D1 between CH2M HILL and the Environmental Management Operations (EMO) program at Battelle Memorial Institute's Pacific Northwest Laboratory, CH2M HILL is providing cultural resources support services (Task Order 246277-A-S1). One or more quarries needs to be developed to supply basalt riprap and gravel for protective barrier construction projects expected to take place over the next several decades at Hanford. At Hanford, historic properties are categorized as archaeological "isolates", archaeological "sites", or "traditional cultural properties" [TCPs](cf. Chatters 1989).

The name, size, and cultural resource inventory status of each of the seven quarries (prior to the current inventory) is summarized in Table 1. About 50 percent of the four quarry sites (Gable Mountain, McGee Ranch, Vernita Quarry and West Haven) has been surveyed previously in connection with other projects or programs. A small portion of the Horn Rapids quarry has also been surveyed. To compare the seven potential quarry sites in terms of impacts to cultural resources, field surveys of three of the quarries were required to identify extant cultural resource properties within their boundaries. To assure a reasonable level of comparability (e.g., 50 percent sampling of each of the seven quarries), CH2M HILL conducted intensive cultural resource surveys of approximately half of the Arid Lands Ecology [ALE], Gable Butte, and Horn Rapids quarries (e.g., 263 acres of ALE, 167 acres of Gable Butte, and 253 acres of Horn Rapids). A comparative analysis of the relative cultural resource sensitivity of the seven quarries is presented in Section 4.1B of this report.

TABLE 1
Cultural Resource Status of Proposed Quarry Locations

Location	Total Acreage	Inventory Coverage Status	Historic Properties
ALE	525 acres	no previous survey	none known
Gable Butte	333 acres	no previous survey	none known
Gable Mtn.	194 acres	ca: 50% surveyed	1 isolate; 3 sites
Horn Rapids	506 acres	ca: 10% surveyed	1 site
McGee Ranch	415 acres	ca: 50% surveyed	9 isolates; 3 sites
Vernita Quarry	196 acres	ca: 50% surveyed	5 isolates; 7 sites
West Haven	261 acres	ca: 50% surveyed	8 sites

2.0 RESEARCH DESIGN
2.1 OBJECTIVES
2.1.1 Cultural Resource Context

A comprehensive cultural resource overview of the DOE Hanford Site is available in the Hanford Cultural Resources Management Plan (Chatters 1989). The history of cultural resource management activities at the Hanford Site has been reviewed by Chatters (1992). Subsequent to the publication of the management plan, project driven field investigations, conducted by the HCRL, have resulted in dramatic increases in the number and variety of cultural resource properties known at Hanford. In a recent National Environmental Protection Act [NEPA] characterization of the Hanford Site, Cushing (1992:4.85-4.93) presented a condensed cultural resource overview of which salient portions are repeated here to provide contextual background to the current study.

As of mid-1994, HCRL has records for 248 prehistoric and 202 historic archaeological sites (Cushing 1994:4.120; 4.123). Forty-seven of the prehistoric sites are listed in the National Register (two as single sites and the remainder in seven archaeological districts). At this time, over six percent of the 560 square-mile Hanford Site has been systematically inventoried for the presence of cultural resources (Cushing 1994:4.121). Recent work by HCRL, in connection with the 100-Areas CERCLA characterization, has been summarized by Chatters, Gard, and Minthorn (1992), and Wright (1993).

Human occupation of the Middle Columbia River region began at the end of the glacial period leaving extensive archaeological deposits along river shores (cf. Leonhardy and Rice 1970; Greengo 1982; Chatters 1989). In this arid lowland environment, well-watered inland areas have yielded evidence of human habitation and widespread hunting (cf. Chatters 1982, 1989; Daugherty 1952; Greene 1976; Leonhardy and Rice 1970; and Rice 1980). Decades of access restrictions at the

Hanford Site has resulted in *de facto* preservation of much of the archaeological resource base.

Archaeological sites include pithouse villages, open campsites, cemeteries along river banks (cf. Rice 1968a, 1980), spirit quest monuments (rock cairns), hunting camps, game drive complexes, quarries in mountains and rocky bluffs (Rice 1968b), hunting/kill sites in lowland stabilized dunes, and small temporary camps near perennial sources of water located away from the river (Rice 1968b). A reconnaissance of portions of Gable Mountain and Gable Butte was completed by Rice in 1986-1987 (Rice 1987).

Native American people of various tribal affiliations populated the Hanford reach of the Columbia River. The Wanapum and the Chamnapum band of the Yakama tribe dwelt along the Columbia from south of Richland upstream to Vantage (cf. Relander 1956; Spier 1936) and some of their descendants still live at Priest Rapids or on the Yakama and Umatilla Indian reservations. Palus people from the lower Snake River fished the Hanford Reach and inhabited the Columbia's east bank (cf. Trafzer and Scheuerman 1986). Walla Walla and Umatilla also fished the Columbia. Traditional secular and religious ties to the Hanford Site are recognized by DOE (see discussion in Chatters 1989:Appendix D). Landmarks such as Rattlesnake Mountain, Gable Mountain, Gable Butte and Goose Egg Hill, plus habitation, fishing, and burial sites along the Columbia are sacred to such groups as the Yakama, Umatilla, Warm Springs, and Nez Perce. Some of these locations are now registered as TCPs. Native American graves have been found in various settings and spirit quest monuments have been found on the high rocky summits of mountains and buttes (cf. Rice 1968a).

Euro-American visitation of the Hanford area began with Lewis and Clark during their 1803-1806 explorations and was followed by fur trappers passing through to lands up and down the river. By the 1860s, merchants had set up stores, a freight depot, and the White Bluffs Ferry on the Hanford Reach. Cattle ranchers, farmers, and Chinese miners soon followed, resulting in the late 19th and early 20th century settlements of Hanford, White Bluffs, and Ringold. These towns were razed in the early 1940s by the U.S. Government to accommodate the Manhattan Project within the newly created Hanford Nuclear Reservation (cf. Chatters 1989; Gerber 1992). Defense reactors 100-B, 100-D, and 100-F and associated processing facilities were constructed in 1943 as part of the Manhattan Project. Reactor 100-B, which produced plutonium for the first atomic explosion and the bomb that destroyed Nagasaki to end World War II, is listed in the National Register of Historic Places.

Important historic properties include the Allard Pumping Plant at Coyote Rapids, the Hanford Irrigation Ditch, the Hanford townsite, Wahluke Ferry, the White

Bluffs townsite, the Richmond Ferry, Arrowsmith townsite, a cabin at East White Bluffs ferry landing, the White Bluffs road, the old Hanford High School, and the Cobblestone Warehouse at Riverland (cf. Rice 1980). Historic archaeological sites such as the East White Bluffs townsite and associated ferry landings, assorted trash scatters, dumps, homesteads, corrals, riverbank gold mine tailings, and abandoned Army installations are scattered over the entire Hanford Site.

The Proposed Quarry Sites

The following discussion outlines all the known information, prior to our survey, about the seven quarry sites and identifies possible historic property types that could be encountered during field survey of these locations. Figures referenced in the text can be found in Appendix 1 of this report.

Arid Lands Ecology

The proposed ALE quarry would encompass 525 acres [Figs. 2 and 3]. No previous cultural resource work has been conducted within ALE. However, two archaeological sites (45BN170 and 45BN171) lie a short distance to the west and are included in the Rattlesnake Springs Archaeological District (cf. Rice 1980). Site 45BN170 is an open campsite consisting of scattered concentrations of fire-cracked rock and lithic debitage. This site is also the location of the Perkins Massacre which took place on or about July 10, 1878. Site 45BN171 is an open campsite located about 0.2 miles east of Rattlesnake Springs on the north bank of Dry Creek. It contains small quantities of fire cracked rock, scattered lithic debitage, and two leaf-shaped projectile points. Both sites have been severely eroded by wind deflation. The information from nearby Rattlesnake Springs Archaeological District suggests that prehistoric campsites or other short term occupation sites may be present within the ALE area.

Gable Butte

The proposed Gable Butte quarry would include a 333-acre area [Figs. 2 and 4]. Although parts of Gable Butte (and Gable Mountain) were subject to archaeological reconnaissance (cf. Rice 1987), the subject portion of Gable Butte proposed for quarry operations has never been inventoried for cultural resources.

Previous survey work at Gable Butte and Gable Mountain resulted in the discovery of several rock cairn sites thought to be related to the aboriginal practice of the Guardian Spirit Quest. Lithic scatters associated with a possible game drive and a small game trap used for subsistence procurement and processing were also found. The rock cairns, thought to be likely spirit quest vigil sites, are regarded as sacred by local Indian groups (Rice 1987:ii). The lithic scatters and game kill sites are relatively rare examples of cultural resource sites located away from the Columbia River on the Hanford Site (Rice 1987:ii). This information suggests that rock cairns and other rock features related to spirit quest or hunting activities as well as small task-specific sites (kill or butchery sites) may be present within the proposed Gable Butte quarry.

Gable Mountain

The proposed Gable Mountain quarry would encompass a 194 acre area [Fig. 2]. Previous work resulted in about a 50% inventory of the proposed quarry area. One isolate and three sites have been recorded to date. Isolate HT-87-016 is a single piece of lithic debitage. Site 45BN349 is a prehistoric site consisting of four rock cairns. Site 45BN402 is a sparse lithic scatter consisting of 10+ pieces of lithic debitage. Site 45BN403 is a prehistoric site consisting of 12 rock cairns. As noted above for Gable Butte, rock cairns are believed to be spirit quest vigil sites and the lithic scatters probably reflect small task-specific occupation sites related to hunting and processing wild game. The same archaeological property types found at Gable Butte may be encountered during surveys of Gable Mountain.

Horn Rapids

The proposed Horn Rapids quarry would include a 506-acre area [Figs. 2 and 5]. Previous work resulted in about a 10 percent inventory of the proposed quarry area. One site has been recorded to date (HT-90-016). Site HT-90-016 is a multi-component site (historic camp with prehistoric component). Artifacts and features present include a chert projectile point fragment, one crescent-shaped rock feature, soldered tin cans, and over 500 pieces of assorted glass (beverage bottle and light bulb fragments). One coke bottle fragment has a patent date of December 25, 1923. Anticipated archaeological properties in the Horn Rapids quarry include small prehistoric camp sites and historic or early 20th century Euro-American farm or ranch settlement sites.

McGee Ranch

The proposed McGee Ranch quarry would encompass 415 acres [Fig. 2]. Previous work resulted in about a 50 percent inventory of the quarry and the recordation of nine isolates and three sites. Prehistoric isolates include HI-88-022 (utilized flake), HI-88-023 (projectile point), HI-94-004 (two flakes), HI-94-005 (projectile point fragment), HI-94-006 (projectile point), HI-94-007 (two flakes), HI-94-008 (projectile point fragment), HI-94-012 (flake), and HI-94-013 (flake). HT-94-009 is a prehistoric site consisting of 4 flakes. Site HT-94-010 is either a historic or prehistoric rock feature. Site HT-94-015 is a multi-component site consisting of four flakes, one biface fragment, and one possible cairn along with three lengths of heavy wire, five milled wood fragments, downed fence posts, and fence jacks (supporting rock piles).

The McGee Ranch area is known to be sensitive for both prehistoric and historic sites. Future survey work in this area can be expected to result in the discovery of additional prehistoric isolates and sites as well as historic features related to the Euro-American settlement of the Hanford Reach and surrounding areas.

Vernita Quarry

The proposed Vernita Quarry encompasses 196 acres [Fig. 2]. Previous work resulted in about a 50 percent survey of the proposed quarry area and the recordation of five isolates and seven sites. Prehistoric isolates include HI-90-002 (two flakes), HI-90-004 (flake), and HI-90-014 (rock cairn). Historic isolates are HI-90-003 (one can, one cooking pot) and HI-90-015 (talus pit with bailing wire). Site 45BN452 is a large lithic scatter consisting of over 180 pieces of lithic debitage, one grinding stone, fire-cracked rock, tooth enamel and other faunal remains. Site HT-90-006 is a sparse lithic scatter consisting of over 40 pieces of lithic debitage, one projectile point, and one projectile point fragment. Site HT-90-007 is a prehistoric rock cairn. Site HT-90-009 is a historic can dump consisting of over 60 cans and scattered glass. Site HT-90-010 is a historic site consisting of a low density can scatter. Site HT-90-011 is either a historic or prehistoric site consisting of two rock alignments of unknown cultural affiliation. Site HT-90-012 is a multi-component site consisting of five historic cans and one flake.

The Vernita Quarry is known to be sensitive for both prehistoric and historic sites. Future survey work in this area can be expected to result in the discovery of additional prehistoric isolates and sites as well as historic features related to Euro-American settlement of the Hanford Reach and surrounding areas.

West Haven

The proposed West Haven quarry encompasses 261 acres [Fig. 2]. Previous work resulted in about a 50 percent survey of the proposed quarry area and recordation of eight sites. Site 45BN357 is a prehistoric site consisting of a game trap/hunting blind feature. Sites 45BN358, 45BN359, and 45BN360 are lithic scatters. Site 45BN361 is a prehistoric site consisting of rock cairns. Site 45BN362 (which lies just to the east of the proposed quarry) is a prehistoric site consisting of a game drive feature. Site 45BN363 is a prehistoric site composed of rock cairns. Site 45BN447 is a prehistoric site consisting of over 60 pieces of lithic debitage, two projectile points, fire-cracked rock and sheep faunal remains. These sites are discussed by Rice (1987). No historic sites have yet been detected in the West Haven quarry area.

The West Haven quarry is known to be sensitive for prehistoric sites and future survey work in this area can be expected to result in the discovery of additional prehistoric isolates and sites. The potential for Euro-American settlement sites at West Haven cannot be ruled out.

Consultations

Consultations with concerned tribes, local preservation officials, the Washington State Historic Preservation Officer [SHPO], and other federal agencies is routinely handled by HCRL (as authorized by DOE-RL) or is handled directly by DOE-RL (Paul Nickens, personal communication, 1994). These ongoing consultations should result in the approval of a draft Memorandum of Agreement among the Washington SHPO, DOE, various tribal organizations and others that will guide future Section 106 compliance at Hanford. Tribal consultations are currently being conducted under the terms of a Co-management Agreement between DOE-RL and four interested tribal entities (Umatilla, Yakama, Nez Perce, Wanapum). CH2M HILL has not been directed to conduct any tribal or agency consultations in connection with this project.

2.1.2 Environmental Context

Chatters (1989:C1-13) presents an overview of the ecology and geological history of the Hanford site, portions of which are presented below to provide an environmental context for this project.

The Hanford Site sits in an arid physiographic depression known as the Pasco Basin. The basal geology of the area consists of Columbia River basalts which erupted in the form of magma in massive sheetflows during the Miocene, 16.5 to 6 million years ago (Gaylord and Porter 1987). Overlying these basalts is the Ringold Formation, a fluvio-lacustrian sedimentary unit deposited during the late Miocene and early Pliocene. During the Pleistocene, glacio-fluvial activity deposited sediments over the Ringold formation across the Hanford site. These sediments have been divided into two distinctive textural facies: Pasco gravels, which range in size from boulders to fine sand (Brown 1975), and Touchet Beds, which are made up of rhythmically bedded sand, silt, and clay (Flint 1938). These facies are deposits resulting from the catastrophic floods associated with the failure of ice dams along the margins of the continental glacier in Montana, Idaho, northern Washington, and British Columbia (Tallman, et al. 1981).

During the late Pleistocene and early Holocene, eolian sediments began overlying older deposits across the Hanford site. These sediments are represented by the stable and semi-active dunes now present across the site. The cultural remains of Native American peoples are found within or upon Holocene depositions and often in association with the major perennial water sources - the Yakima and Columbia Rivers.

The proposed Gable Mountain, Gable Butte, and West Haven quarries are located on features classified as 'mid-basin buttes' by Chatters (1989:C.6). Vernita quarry and McGee Ranch are located on the eastern slopes of Umtanum Ridge. These features are anticlines resulting from the late Miocene deformation of Columbia River basalts. The elevations of these features range from approximately 500 feet near Gable Butte to over 2600 feet on Umtanum Ridge. Habitat types present include: sagebrush/grass (*Artemisia tridentata/Poa sandbergii or Artemisia rigida/Poa sandbergii),*and winterfat/grass (*Eurotia lanata/Poa sandbergii)*(Franklin and Dyrness, 1973). Other species identified on the sites include: bitterbrush (*Purshia tridentata*), rabbitbrush (*Chrysothamnus spp.*), and desert parsley (*Lomatium macrocarpum*). Characteristic fauna includes chukar partridge (*Alectoris chukar*), prairie falcon (*Falco mexicanus*), mule deer (*Odocoilleus hemionus*), coyote (*Canis latrans*), badgers (*Taxidea taxus*), and black-tailed hares (*Lepus californicus*).

The proposed Arid Lands Ecology quarry lies in the Cold Creek syncline, formed concurrently with the area's anticlines, during the late Miocene. An area of little relief, elevations in the proposed quarry area range from 590 feet to 660 feet. Portions of the quarry area are covered with stabilized dunes. Vegetational habitat types in the Cold Creek Valley include: *Artemisia tridentata/Poa sandbergii* and *Grayia spinosa/Poa sandbergii* (Rickard 1988). Recent fires have eliminated much of the Artemisia. Mammals in the area include elk (*Cervus canadensis*), mule deer, black tailed hare, and Townsend's ground squirrel (*Citellus townsendi*).

The proposed Horn Rapids quarry lies slightly north of the Yakima River in the inland flat area of the Hanford site. This area is the remnant of the late Pleistocene (Missoula flood) braidplain. The sediments are composed largely of Pasco gravels covered with a thin covering of eolian sediment. The proposed quarry area is dominated by a very low, rocky, north-south ridge. Relief does not exceed 70 feet. Maximum elevation in the quarry area is 547 feet. The Yakima River lies approximately 600 meters south of the quarry area. The primary plant community is *Artemisia tridentata/Poa sandbergii*. Vegetation observed includes desert parsley

(*Lomatium macrocarpum*), cheatgrass (*Bromus tectorum*), and prickly-pear cactus (*Opuntia fragilis*). Much of the sagebrush has been removed by recent fires.

2.2 METHODS

CH2M HILL was tasked to complete a cultural resource survey to cover 50 percent of the surface area of the ALE, Gable Butte, and Horn Rapids quarries in order to provide a sample comparable to the other four potential quarries which had been previously surveyed to about 50 percent coverage. A large block of land within each proposed quarry site was selected in consultation with HCRL staff on the basis of perceived cultural resource sensitivity. Areas with greater elevational relief and/or areas with more dependable (seasonal) water were judged to be areas where the presence of cultural sites was highly probable. These areas would have provided a greater diversity or abundance of needed food or other economic resources. Since previous survey work in four of the seven quarries focused on areas of high cultural resource sensitivity, and to ensure comparability of information for all seven quarries, CH2M HILL and HCRL selected the more sensitive half of the ALE, Gable Butte and Horn Rapids quarries for intensive survey [Figs. 3-5]. The eastern half of ALE (263 acres), the southern half of Gable Butte (167 acres) and the southern half of Horn Rapids (253 acres) were selected. Approximately 683 acres was designated for inventory.

Background research revealed that Gable Butte is an area of high archaeological sensitivity. Due to a lack of previous survey data for the proposed ALE and Horn Rapids quarries, their relative sensitivity could not be assessed prior to field work. Nevertheless, CH2M HILL estimated that the 683 acres would contain approximately 27 cultural sites. To ensure compatibility with the existing Hanford Site cultural resource database, field inventory and cultural resource recording followed Technical Procedure CR-1, Identification, Evaluation and Treatment of Cultural Resources (PNL 1994) and the Washington State Office of Archaeology and Historic Preservation Archaeological Survey and Reporting Guidelines (OAHP 1988).

CH2M HILL's work scope was limited to field survey and identifying and recording cultural resource properties. Although a preliminary evaluation of National Register eligibility is provided for the archaeological sites discovered during the survey (see Section 4.0 below), formal determination of National Register eligibility is beyond the scope of this project. No subsurface testing or auguring was included in the work scope and the field crew followed a no-collection policy. The work scope does require a brief comparative analysis of the seven quarries to identify which quarry sites if developed, would pose the least impact to known historic properties.

3.0 FIELD INSPECTION
3.1 BACKGROUND RESEARCH

Background research was conducted by Dr. James Bard (CH2M HILL) with the assistance of HCRL staff (Ms. Natalie Cadoret, Ms. Mona Wright, and Ms. Beth Crist). Specific information pertaining to each of the seven quarry areas is summarized above. Site and isolate record forms, previous reports, and other pertinent data on file at HCRL were reviewed prior to the inception of field work operations. Standard references and procedures were reviewed (e.g., Chatters 1989, PNL 1994). The results of the background research are summarized in the cultural resource and environmental context statements (see above).

3.2 ON-SITE INSPECTION

The field survey of the southern half of the proposed Gable Butte quarry (167 acres) was conducted on July 6-8, 1994 by Mr. James B. Cox, Mr. Robin McClintock, Mr. William Goss and Dr. Bard. The eastern half of the proposed ALE quarry (263 acres) was surveyed on July 8 and 13-14, 1994 by Cox, McClintock and Goss, while the southern half of the proposed Horn Rapids quarry (253 acres) was surveyed on July 14-16, 1994 by the same three individuals. Approximately 683 acres were inventoried.

The cultural resource field survey of ALE, Gable Butte, and Horn Rapids Dam quarry areas was accomplished by employing pedestrian parallel transects, maintained by a compass bearing, and spaced 20 meters apart. The crew members visually scanned the area five meters to either side of their respective transect center line. Ground surface visibility was greater than 20 percent in all three quarry areas. Had ground surface visibility dropped below 20 percent, standard procedure dictates scraping the plant cover from an area approximately 30 cm in diameter to expose mineral soil at intervals of about five meters along transect lines. Surface visibility did not drop below 20 percent, therefore, no surface scraping was performed. As each transect was walked, the outside surveyor would flag his line with biodegradable toilet paper. In this way, the inside surveyor on the next set of transects could easily maintain the correct spacing. No subsurface investigations were conducted. Opportunistic views of subsurface sediments were available in road cuts, ditches, and rodent backdirt piles.

In accordance with Technical Procedure CR-1 (PNL 1994), CH2M HILL recorded any group of two or fewer artifacts found within less than 10 m (33 feet) of each other, and/or greater than 20 m (66 feet) from a site as <u>isolates</u>. Likewise, any locus of concentrated human activity, indicated by the presence of artifacts in specified densities [tactically defined as artifacts found in groups of three or more with less than 10 m (33 feet) between objects, or groups of one or more features], as sites.

Prior to conducting field work , CH2M HILL conducted a "tool-box" safety meeting with Ms. Mona Wright (HCRL) to review PNL field safety procedures. The ALE, Gable Butte and Horn Rapids areas were not identified as areas with known toxic or radioactive contamination. Field safety procedures followed HCRL's Job Safety Analysis for conducting archaeological field surveys.

On average, the 3-4 person crew surveyed about 97 acres/day (32-33 acres/day/person) although it was anticipated that ground coverage would only average 80 acres/day (26-27 acres/day/person) due to high temperatures. The key variable in ground coverage rates was the relative abundance of cultural sites rather than terrain or weather conditions. Most of the cultural sites were discovered in the Gable Butte area where ground coverage was slowed considerably to allow for site or isolate recordation. In the ALE and Horn Rapids areas, where cultural sites were less frequent, ground coverage rates increased accordingly. Quarry-specific field survey methods are described below.

ALE [Fig. 3]

The eastern half of the ALE quarry was selected for survey. Highway 240 formed the northern boundary of the survey area. Another dirt road which meandered slightly but roughly parallel to the southern edge of the project area was used as the southern boundary. Western and eastern boundaries were delimited by using the U.S.G.S. map to scale distances from a north-south road leading to a borrow pit in the western half of the project area. Distances were calculated to the west edge of the survey area and to the east edge of the survey area. These distances were then measured using the vehicle odometer and west edge and east edge locations were flagged.

The survey began in the northeast corner. A 192° azimuth was surveyed to Dry Creek and a 12° azimuth was surveyed to the highway. Using the toilet paper flag line to maintain correct spacing, the remainder of the area was surveyed.

Gable Butte [Fig. 4]

The southern portion of Gable Butte quarry was selected for survey. The power transmission lines dissecting the area into roughly north-south halves was used as the northern boundary. The railroad grade which ran up the east side served as the eastern boundary. The western boundary was determined by an azimuth of 200° which was taken from the junction of a jeep trail with the powerline access road.

From the intersection of this western boundary with the 'old RR grade' [Fig. 4] an azimuth of 112° was taken to the eastern boundary. This line formed the southern boundary and closed the polygon defining the area to be surveyed.

Survey began in the northeast corner and proceeded west, then east, paralleling the powerline. The small area just east of the borrow pit at the southern edge of the project area was not surveyed due to the presence of several unidentified north/south trending trenches. These trenches appeared to be partially filled and were approximately 6 feet wide and 2 feet deep. The crew had been cautioned by HCRL staff against entering areas of disturbance that could not be identified because drums containing hazardous waste are sometimes found buried in unmarked trenches at the Hanford Site.

Horn Rapids [Fig. 5]

The southern half of the Horn Rapids quarry was selected for survey. The east/west running jeep trail between Hanford Road and Highway 240 was used to delimit the northern boundary. Hanford Road served as the eastern boundary. Using the U.S.G.S. map, a scaled distance was calculated from the intersection of jeep trails slightly west of the project area. This distance was then measured east along the jeep trail to locate the northwest corner of the survey area. From this point a 150° azimuth was taken and flagged. This line served as the western boundary of the survey area. The southern boundary was determined by using the U.S.G.S. map to scale a distance north from the intersection of Hanford Road and Highway 240 to the point where a westerly extension of the southern boundary intersected the highway. This distance was then measured using the vehicle odometer and marked with flagging as the line for the southern boundary.

Survey work began in the northeast corner of the survey area and proceeded west to the western boundary. The extreme southeast corner of the project area was not surveyed because the alignment of Hanford road had been moved slightly north, thus removing approximately 10 acres from the survey area.

4.0 RESULTS

4.1 FINDINGS OF FACT

Approximately 683 acres were inventoried in July 1994 by the CH2M HILL cultural resource field crew. This work resulted in the discovery and recordation of 22 historic sites or isolates (19 isolates and 3 sites) and the re-recording of one multicomponent site.

Three isolates were found in the ALE quarry: HI-94-032, -036, and -037. Thirteen isolates and three sites were found in the Gable Butte quarry: HI-94-020, -021, -022, -023, -024, -025, -026, -027, -028, -029, -030, -031, -035, HT-94-024, HT-94-025 and HT-94-026. Three isolates were found in Horn Rapids quarry: HI-94-038, -039, -040, and site HT-90-016 was re-located and re-recorded. With the completion of the July 1994 surveys, 50 percent of the ground surface in each of the seven potential quarry sites has now been subject to cultural resource inventory (see below). The frequency of cultural sites/acre, assuming that 100 percent of each quarry would be inventoried, is presented in Table 2.

Arid Lands Ecology

Three isolates were discovered in the ALE quarry (1 prehistoric and 2 historic). These cultural resources are summarized as follows:

Isolates:

HI-94-032	Two white crypto-crystalline silicate flakes.
HI-94-036	A historic "fence jack" -- a rock pile with the remains of a split rail.
HI-94-037	A large historic riveted metal collared cylinder.

Gable Butte

Thirteen isolates and three sites were discovered in the Gable Butte Quarry. These cultural resources are summarized as follows:

Isolates:

HI-94-020	A small rock ring of uncertain cultural affiliation. Believed to be of prehistoric Native American origin.
HI-94-021	Two historic tin cans.
HI-94-022	Two historic tin cans, ca. 1910 A.D.
HI-94-023	One historic tin can.
HI-94-024	One historic tin can, ca. 1910 A.D.
HI-94-025	A rock feature that might have once served as a hunting blind at the mouth of a small canyon pass. Rock wall is of uncertain cultural affiliation, but believed to be of prehistoric Native American origin. May be a hunting blind or related to prehistoric game drives.
HI-94-026	A low rock wall across a narrow U-shaped canyon pass of uncertain cultural affiliation, but believed to be of prehistoric Native American origin. May be an extensive hunting blind or related to prehistoric game drives.
HI-94-027	A proximal/medial section of a chalcedony thinning flake.
HI-94-028	A bottom and side fragment of a rectangular historic amethyst bottle.
HI-94-029	A four-foot high rock cairn of uncertain cultural affiliation, but may be of prehistoric Native American origin.
HI-94-030	Two historic tin cans.
HI-94-031	A small historic metal lamp fragment.
HI-94-035	A small compact rock cairn of uncertain cultural affiliation, but believed to be of historic origin. May have helped secure a fence post.

Sites:

HT-94-024 A historic can scatter, with condensed milk cans dating to ca. 1900 A.D.

HT-94-025 A historic can scatter.

HT-94-026 Three rock features (cairns) of uncertain cultural affiliation. A piece of milled lathe is lying across one of the cairns. A tobacco can was found within one of the cairns. At least one of the rock features is believed to be prehistoric but the presence of the milled lathe and a tin can suggest possible historic origin.

Horn Rapids

Three isolates were discovered and one site was re-recorded in the Horn Rapids quarry. These cultural sites are summarized below:

Isolates:

HI-94-038 A basalt cobble ring of uncertain cultural affiliation but believed to be of prehistoric Native American origin.

HI-94-039 A rock feature of uncertain cultural affiliation but believed to be of prehistoric Native American origin.

HI-94-040 A round aluminum historic tax token.

Sites:

HT-90-016 (Previously recorded in 1990) A multicomponent site with semi-circular rock wall, historic glass fragments and tin cans and prehistoric artifacts (could not be relocated).

TABLE 2
Revised Cultural Resource Status of Proposed Quarry Locations

Location	Total Acreage	Revised Inventory Coverage Status	Revised Inventory of Historic Properties	Sites/Acre
ALE	525 acres	ca. 50% surveyed	3 isolates	ca. 0.012
Gable Butte	333 acres	ca. 50% surveyed	13 isolates; 3 sites	ca. 0.096
Gable Mtn.	194 acres	ca: 50% surveyed	1 isolate; 3 sites	ca. 0.042
Horn Rapids	506 acres	ca: 50% surveyed	3 isolates; 1 site	ca. 0.016
McGee Ranch	415 acres	ca: 50% surveyed	9 isolates; 3 sites	ca. 0.058
Vernita Quarry	196 acres	ca: 50% surveyed	5 isolates; 7 sites	ca. 0.122
West Haven	261 acres	ca: 50% surveyed	8 sites	ca. 0.062

4.1.1 Functional Interpretation

The 23 historic properties identified above consist of archaeological sites and isolates of either Native American or Euro-American cultural affiliation. In some cases, particularly those where rock features were found, attribution of the site or isolate to either prehistoric Native American or historic Euro-american occupation is difficult. The functional interpretation of many of these rock features is also problematic.

At HT-90-016, the crescent-shaped rock feature could be an aboriginal hunting blind. The projectile point fragment found nearby supports the interpretation of the rock feature as prehistoric. The scatter of historic/early modern glass and other items can be interpreted as a historic/modern component to what otherwise would be viewed as a prehistoric site. Alternatively, Euro-Americans could have created the rock feature for some purpose and the projectile point then simply becomes an isolated find.

In the case of HT-94-026 where three rock features are present, a piece of milled wood lathe was found lying across one of the rock cairns. Also a tobacco can was found in one of the rock cairns. Since Euro-Americans are known to create "fence jacks" or survey monuments by piling up basalt boulders, field interpretation of the cultural origination of some rock features must rely on more subjective observations (e.g., presence/absence of uniform lichen coatings on rock stacks, presence/absence of aeolian deposition amongst the piled rocks, etc.).

Other rock features found include "rings". The function of these features is unclear. HI-94-020 is a rock ring located on the edge of a steep basalt cliff in the Gable Butte area and HI-94-038 is a ring located within the inland flats area near Horn Rapids.

In his report on the multi-year Mesa Project in the Columbia Basin of eastern Washington, William C. Smith (1977:70-71) reported that some 132 "basalt structures" were encountered during his fieldwork; most commonly cairns, crescent-shaped alignments, irregular alignments, and basalt mounds. H.I. Smith (1911) described a wide range of enigmatic basalt structures as "rock-slide graves", "terraces", "pits", "cremation circles", "tipi circles", "mounds", "game-drive fences", "rifle pits", "cache pits", "game blinds", and "fortifications". Citing ethnographic data for the Wishram (Spier and Sapir 1930) and for the Middle Columbia (Ray 1939 and 1942), Caldwell and Coulson (1954) argued that these stone works were constructed incident to the quest for spirit power. During the vision quest it was customary to assign tasks to the young such as piling stones in prescribed patterns. It was believed the structures constituted evidence of the physical and (by inference) mental application to the requirements of the quest. Such activities were carried out in areas remote from human activity, yet reasonably accessible from centers of habitation (Caldwell and Coulson 1954:442). Smith (1977:70) notes that the interpretation of such features as "vision quest monuments" is generally accepted and applys to the entire Plateau culture area.

In addition to functioning as possible vision quest sites, Osborne (1967:40-41) suggested that rock structures may represent at least three other major functions: ceremonial, fortification, and marking. Smith (1977:71) tested this multiple function hypothesis against his Mesa Project data using a generalized interpretive model where basalt features defined space either as monuments, walls, precincts, and vaults or chambers.

Smith (1977:71) suggests that cairns functioned as vision quest monuments since they are too small to contain or cover anything, their form is too limited geometrically to define space in any other way, they are often located in some prominent place such as along bluff or cliff edges, they are located some distance from camp sites, and that ethnographic data suggests a functional relationship of cairns to the vision quest. Smith (1977:71) suggests that crescentric alignments functioned to define space by dividing it and forming a screen or barrier between the occupant and the space beyond. Such features are usually located on the edge of the tabular zone of a mesa, overlooking a precipitous cliff of varying height (and providing their occupants with some real or imagined protection from falling while affording concealment and a vantage point from which to view the valley floor below). Smith (1977:73) argues for a utilitarian function to such crescentric alignments (e.g., "vantagepoints"). Irregular alignments are wall-like structures that divid space and would have been useful as barriers to the movement of people (or game). Smith (1977:73) interprets their function to be "barricades". Basalt mounds might have functioned as "caches" for the preservation of food or other materials or may have functioned as "burial caches" for disposal of the dead (e.g., "social precincts").

Cairns, crescentric alignments, and irregular alignments (walls) were found during the present survey. While the function of these rock features is still subject to debate, most of these features are probably prehistoric in age for reasons previously discussed and played an important role in the spiritual life and/or subsistence economy of former Native American inhabitants.

4.1.2 Comparative Analysis

As described earlier, previous projects at the Hanford Site have resulted in several of the seven potential quarries being subject to cultural resource inventory (see Research Design for a brief description of the cultural sites located in each quarry). With the completion of this survey, roughly 50 percent of the ground surface of all seven quarries has been surveyed for historic properties. Unfortunately, the field methodologies employed in previous years does not match current survey standards. Therefore, interpretation of relative cultural resource sensitivity between the quarries must be approached with caution.

For example, in his field investigation of Gable Mountain and Gable Butte, Rice (1987:5) implemented a "reconnaissance" level survey where the field crew spread out informally in places and congregated in others to check promising spots. While Rice (1987:5) noted that coverage was more systematic than this (with individual transects of 10 meters), the coverage is less comprehensive than current HCRL standards (PNL 1994). Eight archaeological sites were recorded by Rice (1987) in the West Haven area of the Gable Butte locality. Interestingly, the West Haven data suggests that isolates were either not recorded or overlooked in the attempt to find large sites during their reconnaissance. With these limitations in mind, a number of conclusions can be drawn from the analysis of the available survey data.

On quantitative basis, the seven quarries can be split into three groups: low, moderate, and high cultural resource sensitivity. ALE and Horn Rapids are the least sensitive quarries in terms of cultural resources. They have the lowest proportion of cultural sites (0.012 and 0.016 sites/acre respectively) and can be classified in the "low" category. Gable Mountain, McGee Ranch and West Haven have higher proportions of cultural sites (0.042, 0.058, and 0.062 sites/acre respectively) and can be classified in the "moderate" category. Gable Butte and Vernita quarry (0.096 and 0.122 sites/acre respectively) can be classified in the "high" category.

On an intuitive basis the seven quarries should probably be ranked as "low" (ALE and Horn Rapids) and "high" (Gable Butte, Gable Mountain, McGee Ranch, Vernita Quarry, and West Haven) since environmental conditions for human occupation would have been more favorable in the "high" sensitivity quarries than in the "low". The five quarries intuitively ranked as "high" are all located in areas that, in the absence of any ground survey data, would otherwise be considered as high probability areas for both prehistoric and historic archaeological sites and TCPs. This evaluation is based on the kinds of historic properties that have been found in these five "high" sensitivity quarries. From a management perspective, the "high" sensitivity quarries, if developed, could trigger a substantial amount of additional cultural resource investigative work including consultations with the interested tribes.

As noted by Rice (1987:5-16), historic properties found in the Gable Mountain and Gable Butte localities (including much of the proposed Gable Butte, Gable Mountain and West Haven quarries) include rock cairns that are believed to be of aboriginal origin (functionally associated with spirit quest religious activity) and lithic scatters presumed to be natural resource processing sites. Rock fences or linear rock features may be functionally related to game drives or hunting blinds. The McGee

Ranch and Vernita Quarries are similar topographically and can be expected to also contain these types of sites. The rock features documented by CH2M HILL in the proposed Gable Butte quarry appear to be consistent with site types described by Rice (1987) for this area. Rice's (1987:11) analysis provides the rationale for our "high" sensitivity ranking of the five proposed quarries in the Gable Butte and Gable Mountain areas. Of rock cairns Rice (1987:11) remarks:

> "As a group, the rock cairn sites stand out in this survey as the principal site type and they confirm that the Gable Butte–Gable Mountain localities were religious areas where guardian spirit quests were sought. Although these sites are simple in content, their context is more complex. Whereas they are in most cases recognized by small piles of fist-sized rocks [*e.g., cobbles*] on exposed bedrock ridges and peaks, they have other more subtle associations. [*Note: the rock cairns recorded by CH2M HILL are more boulder-sized than fist or cobble-sized*]. Most of the rock cairn sites are in close proximity to steep cliffs, over which rocks can be hurled for activity, and along which raptors soar. The elevated peaks and ridges are exposed to howling winds, they provide an overlook of the plains below, and they serve as perches to observe the rising and setting of the sun, moon, and the stars. The quality of visual experience at these sites is high, and this was evidently an integral part of the religious experience. Accordingly, it is not likely that all of the religious activities carried out in these localities would leave archaeological remnants, nor is it necessarily true that all religious activities were centered around the areas of the rock cairns."

Of lithic scatters and game trap/game drive sites, Rice (1987:11) observes:

> "The hunting sites...and... lithic scatters are regarded as functionally related sites. The lithic scatters are viewed as processing sites for the game trap/game drive sites. The existence of these sites shows that Gable Butte, because of its discontinuous linear configuration, served as an important hunting area. The problem for hunters in the Pasco Basin would be in aggregating populations of grazing animals on an unbroken steppeland plain. Gable Mountain and Gable Butte are the only natural barriers in this region that game animals would have to go around. Gable Butte was particularly useful in this respect because it provided both parallel constricting walls and narrow passages through which game animals could pass. These features provided the opportunity for hunters to trap game animals passing through these barriers and to aggregate animal herds using game drives bordered by basaltic cliff walls. The animals hunted would be initially processed close to where they were killed (the lithic scatters), but most of the remains were likely taken to villages along the Columbia River two or three miles distant (such as the Coyote Rapids area) where the remains would be fully processed into food, hides, tools, etc."

The Gable Mountain/Gable Butte Cultural District, which includes sites 45BN348-352, 45BN354-363, 45BN402-410, and 45BN447, has been nominated to the National Register of Historic Places (Cushing 1992:4.86; Chatters 1992:83) because of its religious importance and archaeological resources. Gable Mountain in particular is considered sacred in the world view of local Native Americans (Chatters 1992:84).

Because of the kinds of prehistoric sites that have been found within the five proposed "high" sensitivity quarries, if one or more of these five quarries is selected for development, considering TCPs and consulting with local tribes will play an important role in the Section 106 compliance program. The potential for TCPs in the ALE and Horn Rapids quarries is perceived to be considerably lower than for the proposed quarries in or near Gable Mountain and Gable Butte.

4.2 CONCLUSIONS

The intensive inventory of 683 acres within three proposed quarry sites resulted in the discovery and documentation of 22 sites and isolates and the re-recording of one site. The comparative analysis indicates that of the seven candidate quarry sites under consideration, the proposed ALE and Horn Rapids quarries are the least sensitive for historic properties (ca. 0.012 and ca. 0.016 sites/acre respectively). The remaining five quarry sites are much more sensitive ranging from Gable Mountain (ca. 0.042 sites/acre) to Vernita Quarry (ca. 0.122 sites/acre). Development of ALE quarry would likely result in harm to 1.2 historic properties per every 100 acres quarried, whereas development of Vernita Quarry would harm 12.2 historic properties per every 100 acres quarried.

It should be noted that the quality of previous survey work is not strictly comparable to survey work conducted within the last few years. Nevertheless, with approximately 50 percent of each quarry site sampled, the relative cultural resource sensitivity between ALE and Horn Rapids in comparison to the other five sites is dramatic. Not only are historic properties more plentiful at Gable Butte, Gable Mountain, McGee Ranch, Vernita Quarry and West Haven, the potential significance of those properties is also much higher. In many cases, historic properties in those areas are likely to be National Register eligible, either as archaeological sites or as TCPs. To date, only isolates have been found within ALE and, with the exception of one archaeological site, only isolates have been found within Horn Rapids. The other proposed quarry sites have a number of isolates and archaeological sites present within their boundaries.

National Register Evaluation

A preliminary evaluation of National Register eligibility status is provided here for the three archaeological sites and 19 isolates discovered by the CH2M HILL field crew. In the following tables E = eligible, NE = not eligible, and UN = eligibility undetermined.

Arid Lands Ecology

Three isolates were discovered in the ALE quarry (one prehistoric and two historic).

HI-94-032	Two flakes	NE
HI-94-036	Fence jack	NE
HI-94-037	Metal cylinder	NE

Gable Butte

Thirteen isolates and three sites were discovered in the Gable Butte quarry (one prehistoric, nine historic, and six of uncertain cultural affiliation).

HI-94-020	Rock ring	UN
HI-94-021	Tin cans	NE
HI-94-022	Tin cans	NE
HI-94-023	Tin can	NE
HI-94-024	Tin can	NE
HI-94-025	Rock feature	UN
HI-94-026	Rock wall	UN
HI-94-027	Thinning flake	NE
HI-94-028	Bottle fragment	NE
HI-94-029	Rock cairn	UN
HI-94-030	Tin cans	NE
HI-94-031	Lamp fragment	NE
HI-94-035	Rock cairn	NE

HT-94-024	Can scatter	NE

This site is a diffuse scatter of nine cans including a rectangular EVEREADY PRESTONE ANTI-FREEZE can and various crimped and soldered seam tin cans, some of which appear to be evaporated milk cans that date to ca. 1900 A.D. No other artifacts or features are present. The site appears to be a moderately large surface scatter of historic artifacts with little potential to contribute knowledge beyond that obtained through recordation. This site is judged to be ineligible for listing on the National Register of Historic Places.

HT-94-025	Can scatter	NE

This site is a can scatter and also contains four fragments of amethyst colored glass. The cans are predominantly condensed milk cans. No other artifacts or features are present. The site appears to be a small surface scatter of historic artifacts with little potential to contribute knowledge beyond that obtained through recordation. This site is judged to be ineligible for listing on the National Register of Historic Places.

HT-94-026 UN

This site consists of three rock features (cairns ?), each within five meters of each other and forming a rough triangle. Feature A is two meters in diameter, contains about 40 rocks and some cobbles up to 30 cm in diameter. Feature B is 0.45 meters in diameter, contains 10 rocks (the largest of which is 25 cm in diameter). A 16 inch long piece of milled wood lathe was found lying across this feature. It is not known if the lathe has any functional relationship with the feature. If the feature is prehistoric in origin, the lathe may only represent an effort to mark the feature for some purpose or may simply have been casually discarded on the feature by some earlier survey party. Feature C is 0.70 meters in diameter and contains about 25 rocks. A tobacco can with crimped ends and side seams was found within the cairn. The cultural affiliation of the features is unknown. Historic material associated with Features B and C suggest they may be historic, possibly related to construction of the nearby railroad or power transmission lines. However, the location of the site atop a cliff suggests that at least Feature A may be a Native American cairn. The National Register eligibility of this site cannot be determined based on available data.

Horn Rapids

Three isolates were discovered and one site was re-recorded in the Horn Rapids quarry (one historic and three of uncertain cultural affiliation).

HI-94-038	Rock ring	UN
HI-94-039	Rock feature	UN
HI-94-040	Tax token	NE
HT-90-016	Multi-component site	UN

Originally recorded in 1990 as being located just north of the Jeep Trail [see Fig. 5]. This site was re-located in the field by CH2M HILL but was found south of the same Jeep Trail. CH2M HILL's survey was confined to those lands south of this Jeep Trail and it is presumed that its mapped location in 1990 is erroneous. Site HT-90-016 is a multicomponent site consisting of a semicircular rock wall, approximately 1.5 feet high, located on the edge of a bench overlooking the surrounding plains. The cultural affiliation of the rock wall is uncertain but may be a historic hunting blind since the rock feature lacks lichen deposits, eolian soil deposition amongst the rocks, and appears to be freshly stacked. A single white crypto-crystalline silicate projectile point was observed in 1990 (but not relocated in 1994). Most of the cultural remains are historic or early modern. Over 500 pieces of glass were observed in 1990 as well as fragments of early Coca Cola bottles (patent date - December 25, 1923), light bulb sockets/filaments and soldered tin cans. Additional research would be required to assess the National Register eligibility of this site.

Discussion

As suggested above, our preliminary analysis indicates that archaeological sites HT-94-026 and HT-90-016 may be eligible for listing on the National Register of Historic Places and isolates HI-94-020, -025, -026, -029, -038, and -039 may also be eligible. In each case, additional research would be required to determine National

Register eligibility. Sites HT-94-024 and HT-94-025 and isolates HI-94-021, -022, -023, -024, -027, -028, -030, -031, -032, -035, -036, -037, and -040 are believed to be ineligible for National Register listing.

Some sites and isolates, while probably ineligible by themselves, when aggregated with other nearby sites and isolates, could qualify as contributing elements to an archaeological district. At Hanford, previous investigators have aggregated isolates and sites into archaeological districts. A number of thematically linked historic properties (mostly archaeological site clusterings) have been aggregated into districts [e.g., the Wooded Island, Savage Island, Hanford North, Locke Island, Ryegrass, Rattlesnake Springs, Snively Canyon, Wahluke, Coyote Rapids, and Gable Mountain-Gable Butte archaeological districts (cf. Cushing 1994:4.122)]. In fact, most of the known sites in the proposed West Haven quarry are contributing elements to the Gable Mountain-Gable Butte Archaeological District.

Cultural Values and TCPs

Some of the sites and isolates discovered in the proposed Gable Butte quarry could be aggregated as contributing elements to a larger TCP. In his evaluation of sites found in the Gable Mountain and Gable Butte locality, Rice (1987:15) noted that the archaeological finds have limited potential to contribute scientific knowledge regarding local or regional prehistory but they do, however, have key value in understanding aboriginal American Indian religion and subsistence hunting practices. Rice (1987:15) argues that it is the cultural value of these sites rather than their scientific value that is important and that the quality and integrity of the physical setting (as much as the rock cairn sites or game procurement sites themselves) that contributes to an understanding of aboriginal Plateau Indian religious and subsistence practices. It should be noted, however, that the integrity of the physical setting of the proposed Gable Butte quarry area may have been compromised by the construction of two powerlines, a road, the railroad, and the borrow pit [see Fig. 4].

It is noteworthy that Rice (1987) recognized the importance of the cultural value of these sites since his analysis predates the publication of National Register Bulletin 38 (Parker and King 1990) and more recent discussions of TCPs (Parker 1993). In 1987, Rice was mostly concerned about addressing the mandates of the American Indian Religious Freedom Act of 1978 and new policies such as the National Park Service's Native American Relationships Management Policy (52 Federal Register 35674-78 for September 22, 1987). With the publication of Bulletin 38, cultural resource managers now are better equipped to deal with TCPs within the Section 106 review process. From today's perspective, the National Register eligibility of Gable Mountain and Gable Butte, based on cultural importance, can be more firmly supported.

Although Rice (1987:15) could not ascertain the age of the Gable Mountain and Gable Butte sites, he notes that ethnohistoric references indicate that the religious sites are strongly associated with Late Period prehistory and the Historic Period up to the early 20th century (from ca. A.D. 1800 to 1920). He notes that hunting sites and camp sites may be earlier, but would be consistent with the cultural practices and occupations of Late Period prehistory. Bulletin 38 provides a mechanism for recognizing and evaluating TCPs and defines "traditional" as referring to "beliefs, customs, and practices of a living community of people that have been passed down through the generations, usually orally or through practice." Thus, a TCP is a property with significance to a community derived from "the role the property plays in a community's historically rooted beliefs, customs and practices" (Parker and King 1990:1). It would appear that Gable Mountain and Gable Butte meet this important criterion.

More importantly, properties that are deemed to qualify as TCPs can be listed on the National Register of Historic Places and afforded protection equivalent to that given archaeological and historic sites. Amendments to the National Historic Preservation Act (NHPA) in 1992 have increased the role of Native Americans. Specifically, Section 101(d)(6)(A), specifies that "properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization may be determined to be eligible for inclusion on the National Register." Regulations implementing Section 106 of the NHPA, promulgated by the Advisory Council on Historic Preservation, also provide for the participation of Native American groups in decisions regarding the identification and treatment of TCPs.

As a result of this new legislation, isolates and sites, particularly rock rings, rock cairns, rock fences and the like, may be viewed as manifestations of a larger pattern of prehistoric ritual and subsistence activities in the proposed quarry areas (e.g., as physical evidence of the presence of TCPs). Rice (1987) and others (cf. Chatters 1989, Cushing 1992) have documented the linkage between these prehistoric sites and spiritual beliefs and practices of the local tribes during the "ethnographic period" and have reported that these traditional belief systems continue into the modern era. The management implications of possible TCPs is discussed below.

4.3 RECOMMENDATIONS

Our findings suggest the ALE and Horn Rapids areas are the least sensitive in terms of cultural resources and that these proposed quarries should be given first consideration for development. The other five proposed quarries are considerably more sensitive and we recommend that their possible development be given a lower priority. Prior to developing either the ALE or Horn Rapids quarries, the selected quarry(s) should be subject to a complete (100 percent) inventory in accordance with Technical Procedure CR-1 (PNL 1994) and that all recorded sites and isolates be formally evaluated for their eligibility to be listed in the National Register of Historic Places.

In the event that rock quarrying is found to be infeasible at the ALE and Horn Rapids quarries and that one or more of the five remaining quarries must be developed, we recommend that the five quarries be subject to a complete (100 percent) inventory. Once a complete inventory has been accomplished, an objective determination of which of the five remaining quarries are less sensitive in relation to the others can be made. Once the quarry site(s) is selected and it has been subject to a complete archaeological inventory, all recorded sites and isolates should be formally evaluated for their eligibility for listing in the National Register of Historic Places.

National Register eligibility evaluations should also consider the presence of TCPs. Coordination and consultation with interested tribes will be a required element in the evaluation of prehistoric sites and isolates as physical evidence of TCPs.

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APPENDIX 1: FIGURES

FIGURE 1 Vicinity Map of the Department of Energy's Hanford Site, Washington

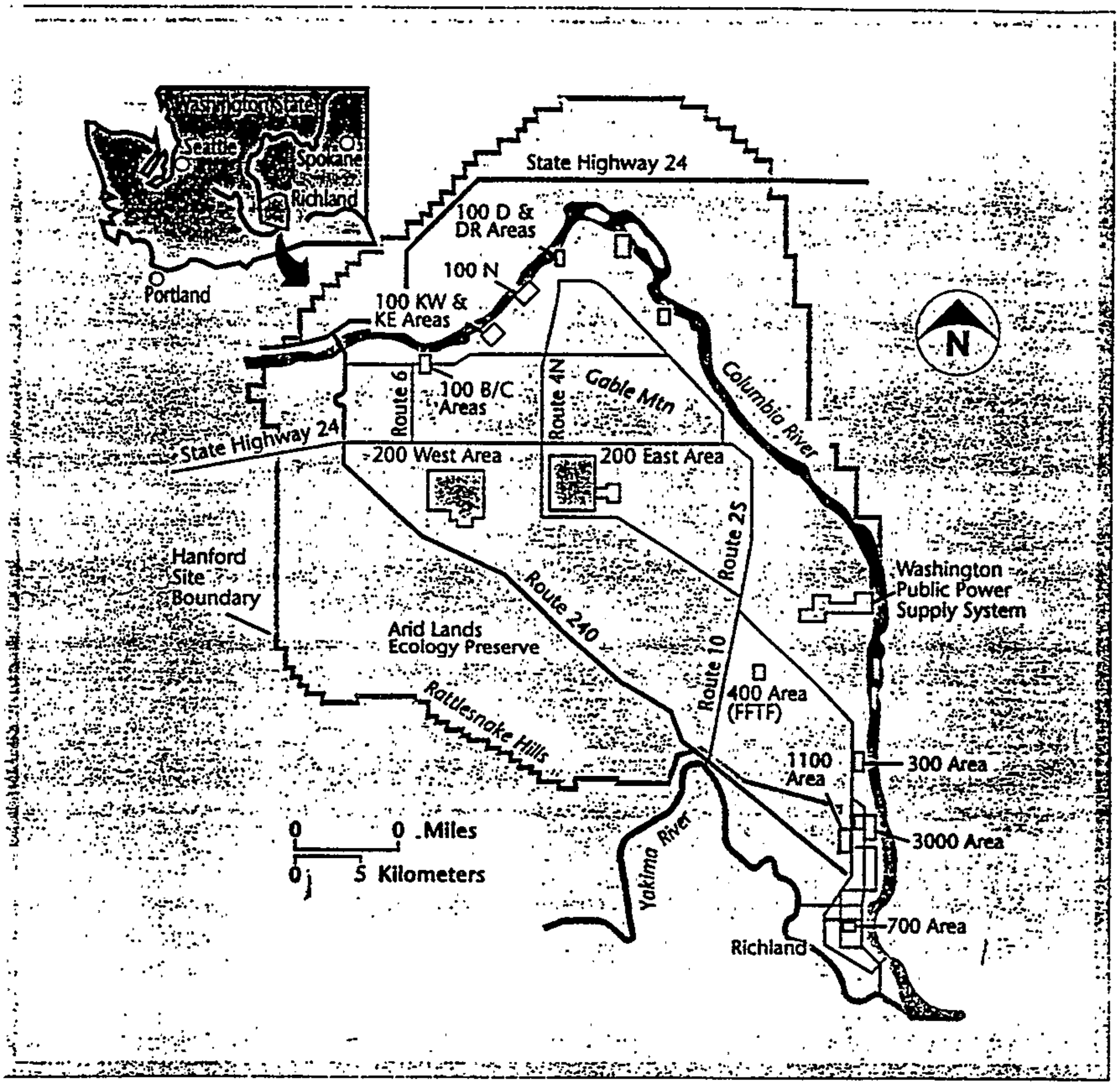


Figure 1
VICINITY MAP OF THE DEPARTMENT OF ENERGY'S HANFORD SITE, WASHINGTON

FIGURE 2 Hanford Site Vicinity Map Showing Locations of Seven Proposed Basalt Quarries

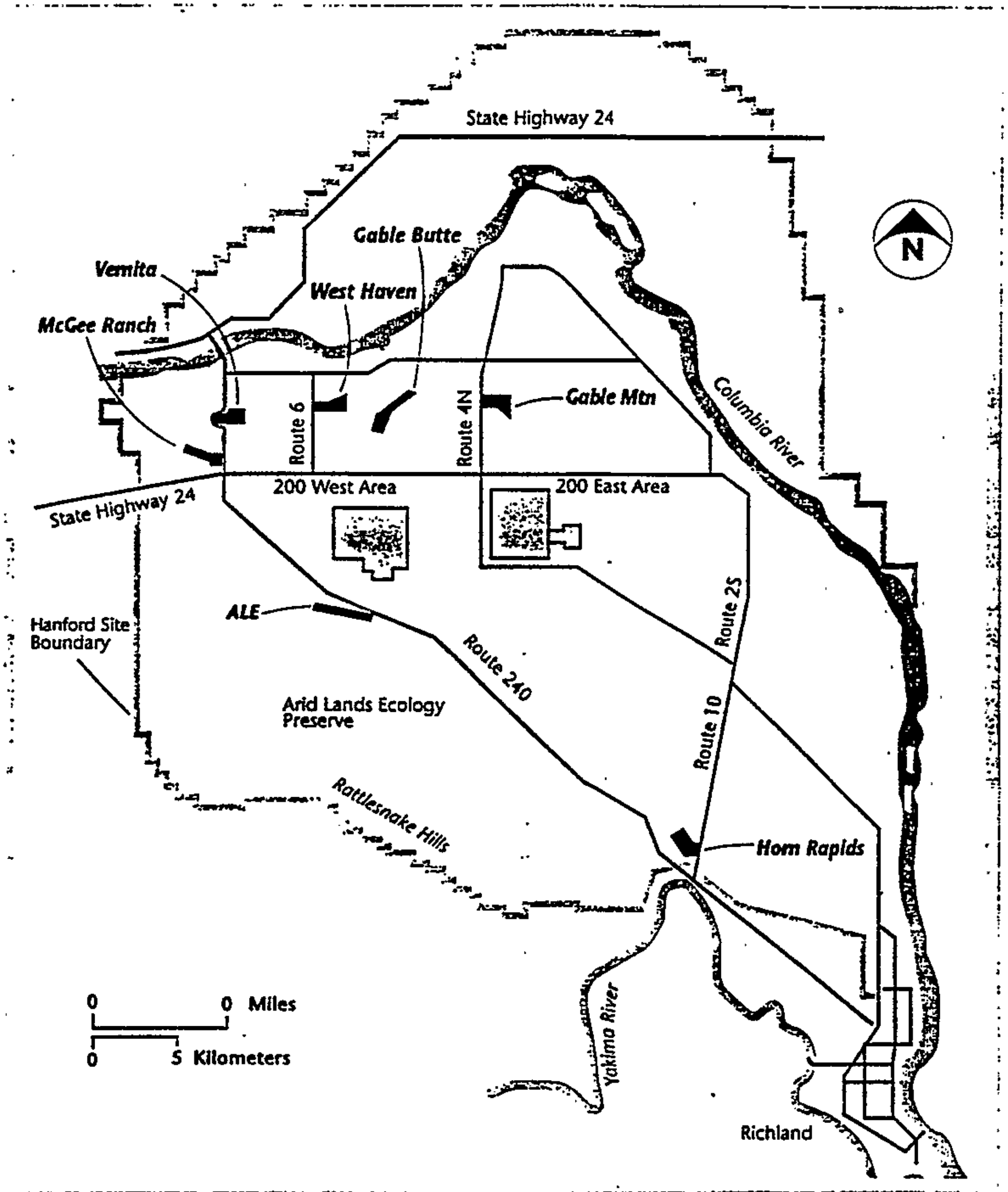
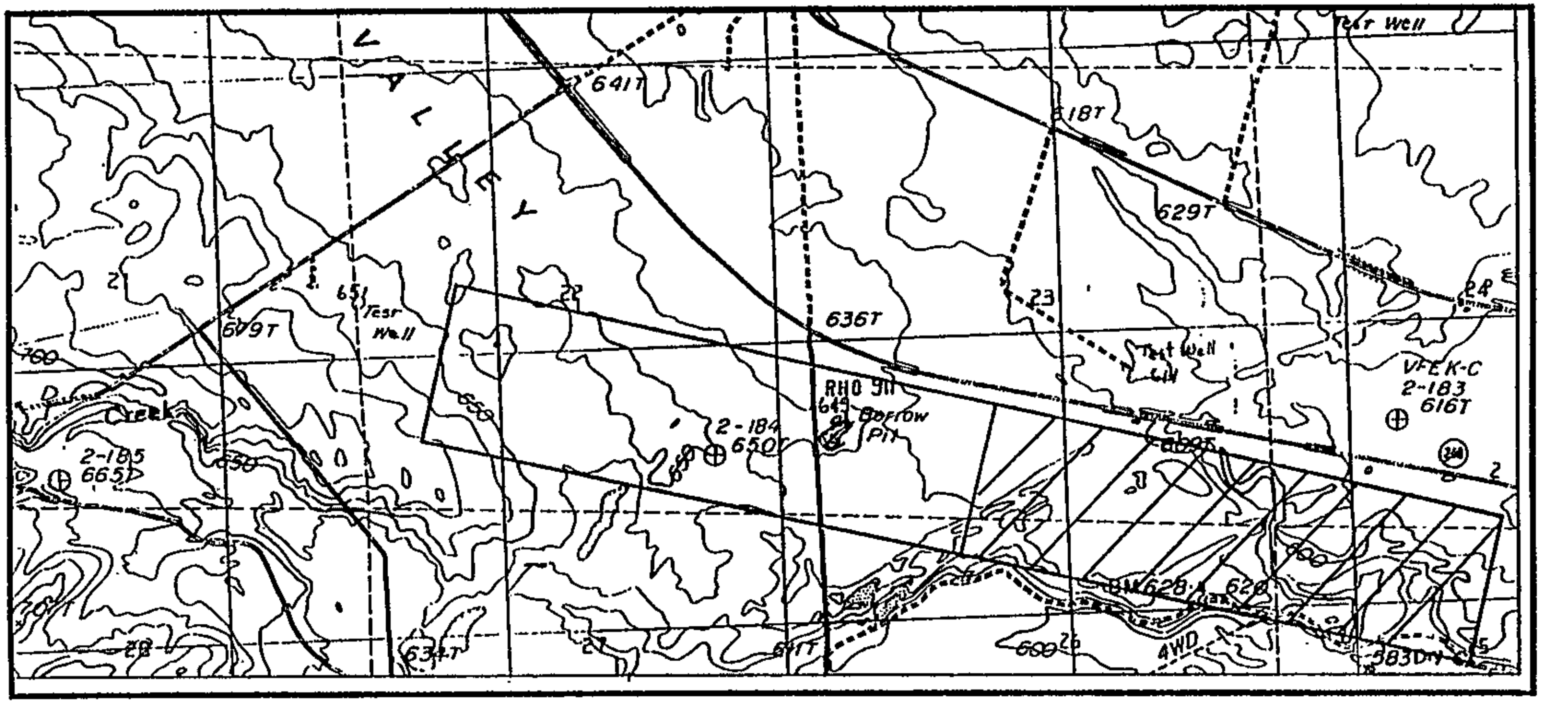


Figure 2
HANFORD SITE VICINITY MAP SHOWING LOCATIONS OF SEVEN PROPOSED BASALT QUARRIES

FIGURE 3 Proposed ALE Quarry Showing Area Surveyed



SCALE 1:24,000

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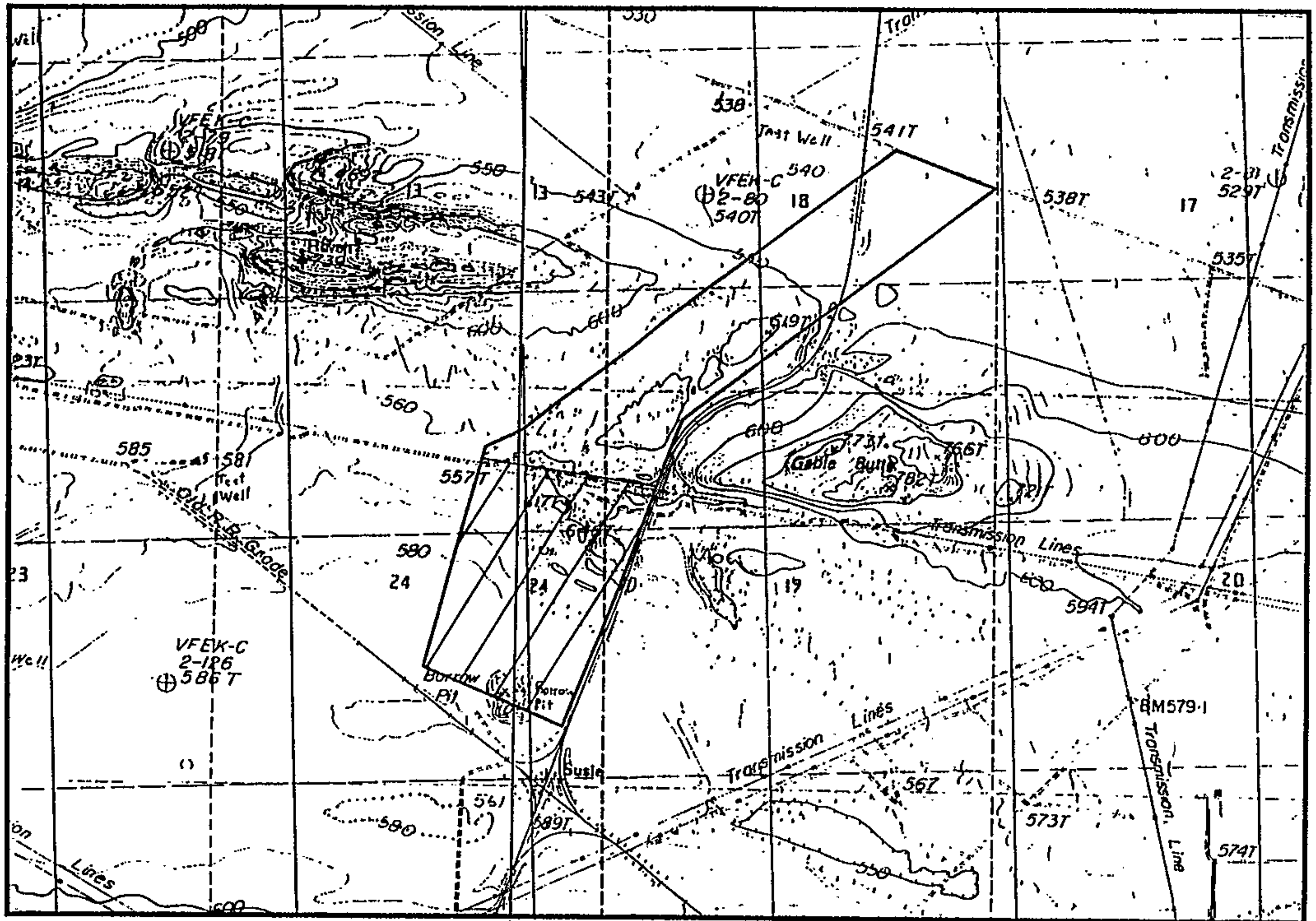
LEGEND

Surveyed Area

United States Geological Survey
Riverland Quadrangle
Washington-Benton Co.
7.5 Minute Series (Topo)
Provisional Edition 1986

Figure 3
PROPOSED ALE QUARRY

FIGURE 4 Proposed Gable Butte Quarry Showing Area Surveyed



United States Geological Survey
Riverland Quadrangle
Washington-Benton Co.
7.5 Minute Series (Topo)
Provisional Edition 1986

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LEGEND
Surveyed Area

United States Geological Survey
Gable Butte Quadrangle
Washington-Benton Co.
7.5 Minute Series (Topo)
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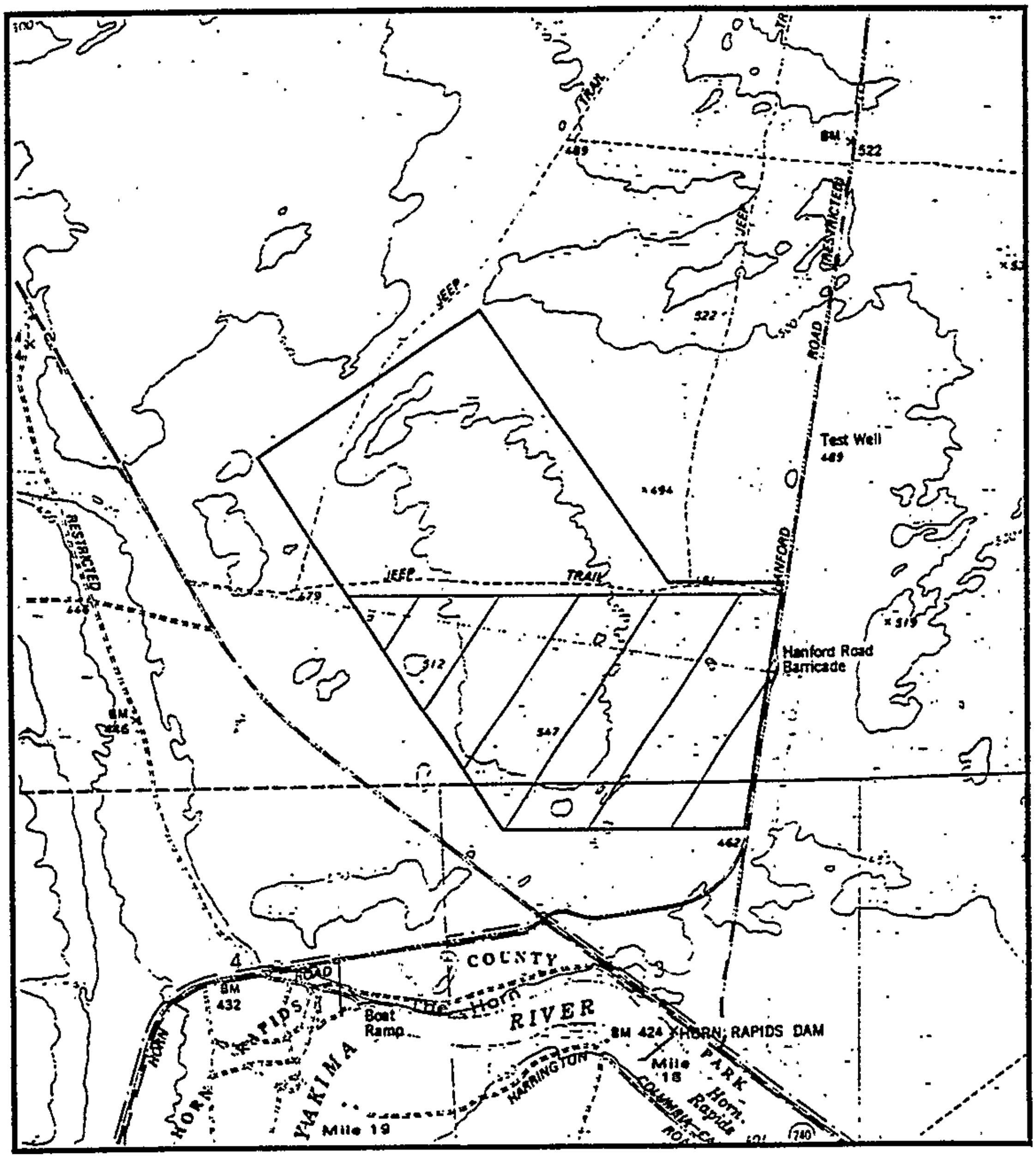
Figure 4
PROPOSED GABLE BUTTE QUARRY

FIGURE 5 Proposed Horn Rapids Quarry Showing Area Surveyed



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LEGEND

Surveyed Area

United States Geological Survey
Horn Rapids Dam Quadrangle
Washington-Benton Co.
7.5 Minute Series (Topo)
Provisional Edition 1986

Figure 5
PROPOSED HORN RAPIDS QUARRY

APPENDIX 2: PHOTOGRAPHS

PHOTO LOGS AND COLOR SLIDES

Hanford Cultural Resources Laboratory
Pacific Northwest Laboratory

Photo Log 7 Candidate Basalt Quarries

Color Slide x Color Print ___ B&W ___ ASA 100 Roll # 131

Exposure #	Project	Subject	Direction of View	Date	Photographer
1	HI-94-036	small rock pile		7/12/94	
2	HI-94-037	unidentified metal object		7/12/94	
3	HI-94-037	unidentified metal object		7/12/94	
4	HT-90-016	Rock Blind	west	7/13/94	
5	HT-90-016	Rock Blind	north	7/13/94	
6	HT-90-016	Rock Blind	northeast	7/13/94	
7	HI-94-038	Rock Ring	west	7/15/94	
8	HI-94-038	Rock Ring	east	7/15/94	
9	HI-94-039	Rock Pile	west	7/15/94	
10	HI-94-039	Rock Pile	southwest	7/15/94	
11					
12					
13					
14					
15					
16					
17					
18					

COMMENTS All photographs by Robin McClintock unless otherwise noted

Page 1 of 1

Hanford Cultural Resources Laboratory
Pacific Northwest Laboratory

Photo Log: Seven Candidate Basalt Quarries

Color Slide x   Color Print ___   B&W ___   ASA 100   Roll # 133

Exposure #	Project	Subject	Direction of View	Date	Photographer
1	Viewing west from top of bluff in Gable Butte project area				
2	Viewing east from top of bluff in Gable Butte project area				
3	HI-94-020-"Rock Ring."		north	7/06/94	
4	HT-94-024-Scatter of historic cans: east toward RR crossing. 7/06/94				
5	HT-94-024-Scatter of historic cans: west.			7/06/94	
6	HI-94-021-Isolated can: east toward RR crossing			7/06/94	
7	HI-94-022-Isolated cans		east	7/06/94	
8	HI-94-023-Isolated can		south	7/07/94	
9	HI-94-024-Isolated can		north	7/07/94	
10	HT-94-025-Historic can site: west toward crew and large outcrop. 7/07/94				
11	HT-94-025-Historic can site: south/southwest at grassy area below cliffs 7/07/94				
12	HI-94-025-Rock feature		north	7/07/94	
13	HI-94-026-Rock feature		north	7/07/94	
14	HI-94-026-Rock feature: west toward rock wall feature			7/07/94	
15	HI-94-026-Rock feature: east toward rock wall feature			7/07/94	
16	HI-94-026-Rock feature: east toward rock wall feature			7/07/94	
17	HI-94-026-Rock feature: south toward rock wall feature			7/07/94	
18	HI-94-027-Isolated flake		south	7/08/94	

COMMENTS   All photos by Robin McClintock

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Hanford Cultural Resources Laboratory
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Photo Log: Seven Candidate Basalt Quarries

Color Slide x   Color Print ___   B&W ___   ASA 100   Roll # 133

Exposure #	Project	Subject	Direction of View	Date	Photographer
19	HI-94-028-Glass fragment location			7/07/94	
20	HI-94-026-Rock wall feature, north from above			7/07/94	
21	HT-94-026-Rock feature "A."			7/07/94	
22	HT-94-026-Rock feature "B."			7/07/94	
23	HT-94-026-Rock feature "C."			7/07/94	
24	HI-94-035-Four rock feature.			7/07/94	
25	HI-94-029-Rock cairn with Jim Cox, north-northwest			7/07/94	
26	HI-94-030-Historic cans		north	7/07/94	
27	HI-94-031-Historic lamp			7/07/94	
28	HI-94-031-Historic lamp			7/07/94	
29	HI-94-032-Isolated flakes		south	7/07/94	
30	HI-94-033-Wooden pipe			7/08/94	
31	HI-94-034-Wooden pipe			7/08/94	
32					
33					
34					
35					
36					

COMMENTS All photos by Robin McClintock

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APPENDIX 3: INVENTORY FORMS

ALE Quarry:

HI-94-032
HI-94-036
HI-94-037

Gable Butte Quarry:

HI-94-020
HI-94-021
HI-94-022
HI-94-023
HI-94-024
HI-94-025
HI-94-026
HI-94-027
HI-94-028
HI-94-029
HT-94-024
HT-94-025
HT-94-026

Horn Rapids Quarry:

HI-94-038
HI-94-039
HI-94-040
HT-90-016

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