MAKAH INDIAN RESERVATION

DRAFT
WARMHOUSE BEACH DUMP CLOSURE PLAN

PREPARED FOR THE

MAKAH TRIBAL COUNCIL

632845

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Prepared for the
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Prepared by
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TABLE OF CONTENTS

EXECUTIVE SUMMARY v

1.0 INTRODUCTION 1
- 1.1 Background and History 1
- 1.2 Project Objective 3
- 1.3 Design Criteria 3
- 1.4 Previous Studies and Site Characterization Efforts 3

2.0 DESIGN CONSIDERATIONS 5
- 2.1 Site Description 5
- 2.2 Hazardous Waste or Substance Contamination 5
- 2.3 Geotechnical Evaluation 7
- 2.4 Ground Water 8
- 2.5 Surface Water 8
  - 2.5.1 Hydrologic Analysis 8
  - 2.5.2 Hydraulic Analysis 9
- 2.6 Percolation 9
- 2.7 Landfill Gas Generation 10
- 2.8 Sensitive Environments 10
- 2.9 Adjacent Land Use, Traffic, and Access 11
- 2.10 Site Utilities 11

3.0 CIVIL ENGINEERING DESIGN 11
- 3.1 Description of Dump Closure Action 11
- 3.2 Design Elements 11
  - 3.2.1 Limited Clearing 12
  - 3.2.2 Surface Debris Removal and Waste Consolidation 12
  - 3.2.3 Seismic Risks and Tsunamis 12
  - 3.2.4 Surface Water Control 13
  - 3.2.5 Landfill Cover Design 13
  - 3.2.6 Percolation System 16
  - 3.2.7 Landfill Gas Control Measures 16
  - 3.2.8 Site Grading and Erosion Control 16
  - 3.2.9 Site Revegetation and Site Rehabilitation 17
  - 3.2.10 Site Access and Access Control 18

4.0 ALTERNATIVE COVER CONFIGURATIONS 18
- 4.1 Alternative Cover Concept 1 – The Slope Option 18
  - 4.1.1 Description 18
  - 4.1.2 Residual Effects 19
  - 4.1.3 Considerations for Habitat Rehabilitation 20
  - 4.1.4 Evaluation of Effectiveness and Implementability 20
  - 4.1.5 Estimate of Probable Costs 22
- 4.2 Alternative Cover Concept 2 – The Ravine Option 22
  - 4.2.1 Description 22
  - 4.2.2 Residual Effects 23
  - 4.2.3 Considerations for Habitat Rehabilitation 23

4.2.4 Evaluation of Effectiveness and Implementability 24
4.2.5 Estimate of Probable Costs 25
4.3 Summary of Option Evaluation 25

5.0 SITE MONITORING AND MAINTENANCE REQUIREMENTS 26

6.0 REFERENCES 28

LIST OF TABLES

Table 1. Summary of Waste Types in Warmhouse Beach Dump
Table 2. Summary of Hazard Scoring
Table 3. Summary of Precipitation Hydrologic Parameters and Peak Flow Rates
Table 4. Special Status Species on the Makah Reservation
Table 5. Summary of HELP Modeling Results for Cover Alternatives
Table 6. Summary Evaluation of Alternative Cover Concept 1 – The Slope Option
Table 7. Estimate of Probable Cost of Alternative Cover Concept 1 – The Slope Option
Table 8. Summary Evaluation of Alternative Cover Concept 2 – The Ravine Option
Table 9. Estimate of Probable Cost of Alternative Cover Concept 2 – The Ravine Option
Table 10. Summary Comparison of Cover Alternatives
Table 11. Summary of Post-Closure Monitoring and Maintenance Requirements

LIST OF FIGURES

Figure 1. Location Map
Figure 2. Existing Site Conditions
Figure 3. Typical Cover Cross-Section
Figure 4. Final Grading Plan – Alternative Cover Concept 1 – The Slope Option
Figure 5. Typical Cross-Section for Concept 1
Figure 6. Final Grading Plan – Alternative Cover Concept 2 – The Ravine Option
Figure 7. Typical Cross-Section for Concept 2

ACRONYMS AND ABBREVIATIONS

AFS	Air Force Station
ASCE	American Society of Civil Engineers
BA	Biological Assessment
BIA	Bureau of Indian Affairs
CCC	USEPA Recommended Water Quality Criteria for Fresh Water – Criteria Maximum Concentration
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
cfs	cubic feet per second
CMC	USEPA Recommended Water Quality Criteria for Fresh Water – Criteria Maximum Concentration
COD	chemical oxygen demand
cy	cubic yard
DoD	Department of Defense
FAA	Federal Aviation Administration
FML	flexible membrane liner
FHWA	Federal Highway Administration
GCL	geosynthetic clay liner
GPM	gallons per minute
HAZWOPER	hazardous waste operations and emergency response
HDPE	high-density polyethylene
HEC	Hydrological Engineering Center (USACE)
HELP	Hydrologic Evaluation of Landfill Performance
IHS	Indian Health Service
IWMP	Integrated Waste Management Plan
LEL	lower explosive limit
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
msl	mean sea level
NA	Not Applicable
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Agency
NWTPH-Dx	Northwest Total Petroleum Hydrocarbon – diesel range
NWTPH-Gx	Northwest Total Petroleum Hydrocarbon – gasoline range
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
O&M	operation and maintenance
OSHA	Occupational Safety and Health Administration (US)
OSWER	Office of Solid Waste and Emergency Response (USEPA)
PCB	polychlorinated biphenyl
pcf	pounds per cubic foot
PEL	NOAA Screening Quick Reference for Freshwater Sediments – Probable Effects Level
PID	photoionization detector
PPE	personal protective equipment
PRG	USEPA Region 9 Preliminary Remediation Goals

RCRA	Resource Conservation and Recovery Act
SCL	Model Toxics Control Act Soil Cleanup Level
SCS	Soil Conservation Service (now Natural Resource Conservation Service)
SPIP	Strategic Project Implementation Plan
SVOC	semivolatile organic compound
SWMP	Solid Waste Management Plan
TAL	Target Analyte List
TCLP	toxicity characteristic leaching procedure
TERO	Tribal Employment Rights Office
TPD-DX	total petroleum diesel
TPH	total petroleum hydrocarbons
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USDC	U.S. Department of Commerce
USDHHS	U.S. Department of Health and Human Services
USDOD	U.S. Department of Defense
USDOE	U.S. Department of Energy
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
USWB	U.S. Weather Bureau
UW	University of Washington
VOC	volatile organic compound
WADOE	Washington Department of Ecology
WRCC	Western Regional Climate Center

EXECUTIVE SUMMARY

This Warmhouse Beach Dump Closure Plan contains a description of design concepts for closing the Warmhouse Beach Dump (Dump) and discusses considerations affecting Dump closure. The plan was developed in compliance with United States Environmental Protection Agency's (USEPA) Guidelines for Cleanup and Remediation of Open Dumps and Other Contaminated Sites (USEPA, 1995). Closing the Warmhouse Beach Dump is one of the primary objectives identified by the Makah Tribal Council, the Indian Health Service (IHS) and the USEPA during development of the Makah's Solid Waste Management Plan (Makah, 2002a).

The Dump currently serves a community of about 1,500 people, or 492 households, receiving both solid and hazardous wastes. The Dump is unlined, uncovered, and does not meet federal or Tribal environmental standards. During the past six years, the USEPA, U.S. Department of Defense, IHS, and other federal agencies have evaluated this site. The site is included in the IHS' report on open dumps on Indian lands and is listed in the IHS Sanitation Deficiency System as Number WA05344-0301 (IHS, 1995). This site has also been evaluated using the scoring system established by the Tribal Solid Waste Interagency Workgroup. The Warmhouse Beach Dump scored 60 points; sites with scores over 30 are considered to have high hazard potential. In its Solid Waste Management Plan, the Makah Tribe of Indians identified closing the Warmhouse Beach Dump as the highest priority.

The Warmhouse Beach Dump poses a high degree of risk to human health and the environment and is considered by many to be the largest single environmental challenge on the Makah Reservation. The objective of the Warmhouse Beach Dump Closure Project is to permanently close the Warmhouse Beach Dump, reduce the release and threat of release of hazardous substances from the site, and thereby reduce risks to human health and the environment.

The active portion of the Dump consists of about 7 acres at the top of a ridge, with a majority of the waste presently located within a deep ravine. At an approximate elevation of 260 feet above mean sea level, the northernmost extent of the Dump is approximately 800 feet inland from the shoreline of Warmhouse Beach. The Dump is generally aligned east-west along an existing rock slope and is generally oval-shaped. The average dimensions of the surface portion of the dump are about 500 feet in width by 250 feet in length by up to at least 40 feet in height. In the ravine at the toe of the Dump, the waste extends below the surface to a depth of at least 22 feet (White Shield, 1995). The current surface of the Dump occupies about 3 acres. There is scattered debris along the access road to the Dump, and metal drums, tires, and other debris in the ravine west of the access road. Based on local waste projection rates and population estimates, the waste volume is likely between 55,000 and 65,000 cubic yards as of early 2003 (Ridolfi, 2002b).

This closure plan builds on previous studies that evaluated various closure options for the Dump and recommended waste consolidation and closure-in-place. Two alternative cover configurations were explored for the final shape of the waste containment facility: a "Slope Option", where the waste is simply regraded to a more stable slope, and the "Ravine Option", where the waste is consolidated within the existing ravine.

The **Slope Option** assumes that the waste from along the road and the existing hillside would be consolidated along the existing south slope of the landfill. The waste from the east and west edges of the landfill would also be consolidated into this area. Approximately 22,000 cubic yards of waste material and contaminated soils located outside of the containment footprint

would be excavated and placed on the existing waste pile along the hillside. The waste would be graded and compacted to form a 3H:1V slope from the top edge of the hillside across the ravine to existing elevation at the south side of the ravine. Forming a waste-wedge against the hillside. A 12-feet wide access road and drainage channels would placed along about 500 feet of the southern toe of the slope. The configuration would be one large oval-shaped hilltop with an adjacent valley. The containment under this option would have a final surface area of a little under an acre, and an estimated initial capital cost of $836,100. This Option has advantages of less material handling, and a more natural looking final shape, but may not allow as much area for post-remedial use. Figure 4 is a plan view of the concept for the Slope Option, and Figure 5 is a typical cross section that shows this concept.

The **Ravine Option** assumes that the waste from along the road, the channels and the existing hillside would be consolidated on top of the other waste within the existing ravine due south of the active landfill face. The waste from the east and west edges of the landfill would also be consolidated into this area. More waste would be relocated under this option – approximately 28,000 cubic yards of waste material and contaminated soils located outside of the containment footprint would be excavated, placed in the Ravine, and graded and compacted to a final surface. The waste would be graded and compacted to form a 3 percent top slope from a crown along the center of the ravine. The top elevation of the containment is estimated to be about 20 feet higher than the existing elevation in this area. The containment would slope to meet existing ground at the eastern and western edges at about a 3:1 slope. The waste would form a pentagon-shaped shaped wedge against inside the ravine. The containment under this option would have a final surface area of a little under a half an acre an estimated initial capital cost of $949,700. This Option requires more material handling, and thus has a higher cost; however, more of the site is cleaned up rather than capped. Figure 6 is a plan view of the concept for the Slope Option, and Figure 7 is a typical cross section that shows this concept.

Both options include site drainage and access control measures, and site stabilization. A multimedia-engineered cover would be installed over the consolidated and compacted waste materials. This cap includes an internal drainage layer, a passive gas venting system, a geosynthetic barrier layer and a layer with growth media to support vegetative growth. Modeling for this type cover predicts a 99.6 percent reduction of the precipitation percolating through the waste in the Warmhouse Beach Dump Closure containment.

Both cover options meet the project objectives and meet USEPA Guidance for landfill closure. Both effectively isolate the waste to reduce the risks to human health and the environment. And both options would support future beneficial uses of the Dump site by the Makah Tribe.

1.0 INTRODUCTION

This document has been prepared to support the Warmhouse Beach Dump Closure Project for the Makah Tribe of Indians, a federally recognized Indian Tribe. The Makah Indian Reservation lies in the extreme northwest corner of the Olympic Peninsula, on Cape Flattery, in Clallam County, Washington. Neah Bay, which is located about 70 miles west of the county seat of Port Angeles, Washington, is the only incorporated town on the Reservation. The Reservation is bordered on the south and west by the Pacific Ocean and on the north by the Strait of Juan de Fuca (Figure 1).

The Warmhouse Beach Dump is located about 2 to 3 miles northwest of Neah Bay, off a gravel road from the road to Koitlah Point, at Latitude 48° 23'20" North and Longitude 124° 39'24" West in the Northwest _ of Section 4, Township 33 North, Range 15 West of the Willamette Meridian. The active portion of the Dump consists of about 7 acres at the top of a ridge, with a majority of the waste presently located within a deep ravine. At an approximate elevation of 260 feet above mean sea level (msl), the northernmost extent of the Dump is approximately 800 feet inland from the shoreline of Warmhouse Beach.

This Warmhouse Beach Dump Closure Plan contains a description of the design concepts for closing the Warmhouse Beach Dump (Dump) and discusses considerations affecting the Dump closure. The plan was developed in compliance with United States Environmental Protection Agency's (USEPA) Guidelines for Cleanup and Remediation of Open Dumps and Other Contaminated Sites (USEPA, 1995a). Closing the Warmhouse Beach Dump is one of the primary objectives identified by the Makah Tribal Council, the Indian Health Service (IHS) and the USEPA during development of the Makah's Solid Waste Management Plan (Makah, 2002a).

The Dump Closure Plan is based on conditions observed on the surface of the site during investigations conducted in summer of 2001 and Fall 2002, and on a topographic survey completed in November 1995 (White Shield, 1995). The subsurface conditions, including depth of the wastes, ground water level, areal extent of the waste below ground surface, and locations of subsurface bedrock, have been approximated within the limits of the field measurements taken during site reconnaissance, investigation, and surveying.

This Dump Closure Plan is not intended for use in construction. Because closure of the Warmhouse Beach Dump and construction of the site features described in this document are not expected to begin for at least 2 years, this Dump Closure Plan recognizes that pre-construction investigations and engineering will be needed to support final design and the preparation of construction documents. Pre-construction engineering will likely include geotechnical, geologic, and possibly additional hydrogeologic investigations and analyses. The engineering data, design information, and closure plan presented in this document are intended to provide a foundation for the final design and construction of the site features that will be needed to contain the waste material within the dump and to control the sources of contamination within the site.

1.1 Background and History

The Warmhouse Beach Dump began as a dump that supported U.S. Defense activities on the Reservation, and then was later used by other Federal agencies, and the Tribe. The USAF and Navy began using the Warmhouse Beach Dump for waste disposal in the 1940s as well as other

dumps at Koitlah Point, Cape Flattery, and at the breakwater. Department of Defense (DoD) records indicate that the Warmhouse Beach Dump was more actively used after the Koitlah Point Dump was closed in the mid-to-late 1960s (Ridolfi, 2001a).

The Makah Air Force Station (AFS), which operated on the Reservation from World War II until 1988, used the Dump for disposal of solid waste, including household and hazardous wastes, during its operations (Ridolfi, 2001a). A site assessment report prepared for the DoD indicated that "Hazardous waste is known to have been disposed of by DoD in the landfill" (Tecumseh, 1998, as cited in Ridolfi, 2001a). In addition to household wastes, various hazardous materials including PCBs and asbestos are known to have been disposed at the site (Ridolfi, 2001a). Table 1 includes a summary of waste types identified in the Dump.

Table 1. Summary of Waste Types in Warmhouse Beach Dump

Potentially Hazardous Materials	Estimated Percent by Volume	
Batteries	Less than 0.1%	
Used motor oil (or unknown material)	Less than 0.1%	
Hypodermic needles	Less than 0.001%	
Tires	7 to 10%	
Appliances (may contain ammonia)	(included in metals)	
Roofing and construction material	Less than 1.0%	
Other Waste	**Percent by Volume**	
Unidentifiable organic material and household waste	20 to 30%	60-75% of this material could be reusable
Metal (car bodies, appliances, framework)	20 to 30%	85-100% of this material could be recyclable
Glass	20 to 30%	85-100% of this material could be recyclable
Data Source: White Shield, 1995		

The active dump has been used by the Army, Air Force, the Bureau of Indian Affairs (BIA) and IHS since the 1960s. As early as 1963, the Makah Solid Waste Management Department recommended that the Warmhouse Beach Dump be closed (Ridolfi, 2001a). However, the Dump remains in operation, and is currently used by the Tribe for municipal solid waste (MSW) disposal. Current waste disposal is primarily a mix of materials, including MSW, roofing and other construction materials, and animal carcasses. Barrels of lubricants, and other petroleum-based products have been also been noted at this site (White Shield, 1995).

Initially, waste materials were dumped into a ravine that runs east and west through the site. As the ravine was filled in with waste material, a road was constructed over the top of the waste material and across the ravine. Waste materials are now dumped on the ridge top, burned to a limited extent, and pushed down the south slope of the ridge toward the ravine. Figure 2 shows a general layout of the existing dump. An estimate of the current volume of solid waste material was developed based on waste generation rates and population. As of the end of 2002, in-place waste volumes at the Dump are estimated to be between 50,000 and 60,000 cubic yards (Ridolfi, 2002a).

Average precipitation at this site is high; it is estimated to be over 100 inches per year. Rainfall from the adjacent hillsides drains into the Dump area and flows either over or through the

waste deposit in the ravine. A portion of this surface water flow is absorbed by the soils and thick vegetation, and a portion flows toward Warmhouse Beach. Warmhouse Beach is an important natural and cultural resource for the Makah Tribe of Indians. The Tribe makes cultural use of the streams, creeks, and plants of the area. Warmhouse Beach is a traditional summer fishing camp that has been used for many generations; however, deterioration of kelp beds and shellfish habitat may have occurred, and traditional Tribal harvesting of these natural resources may have been adversely affected as well. In addition, a historical fishing village of archaeological and cultural value may also have been impacted by materials from the Dump (Pendleton, 2002).

1.2 Project Objective

The objective of the Warmhouse Beach Dump Closure Project is to permanently close the Warmhouse Beach Dump, in order to reduce the release and threat of release of hazardous substances from the site, which will reduce risks to human health and the environment.

Closing the Dump is expected to improve water quality such that it meets standards protective of aquatic life, as practicable. Furthermore, closure is expected to reduce the risk of human and environmental exposures by isolating waste materials that contain hazardous substances. The desired result is a functioning waste containment facility that will protect Makah's important natural and cultural resources, with minimal long-term maintenance requirements.

1.3 Design Criteria

This plan has been developed to comply with applicable federal, state, and tribal design criteria related to the closure of abandoned open dumps. In addition, other relevant and applicable requirements, such as regulations governing work in and around waterways or near sensitive environments, have been considered.

1.4 Previous Studies and Site Characterization Efforts

This project has been identified as a high priority through several previous studies sponsored by different agencies working in concert with the Makah Tribal Council. These previous studies form the foundation for this closure plan and are briefly described below.

- **USEPA – Landfill Closure Plan for the Makah Reservation:** In 1993, the USEPA initiated an effort to develop engineering concepts for closing the dump. This effort included a brief site visit, and the development of three concepts for dump closure: *"minimal cover (soil), consolidation and capping, and excavation and haul to a conforming landfill"*. The report recommended consolidation and capping as an effective method of dump closure that would be protective of human health and the environment. The report also recommended developing an outline for closure plans and engineering design, as the first step towards dump closure (SAIC, 1993).

- **IHS/USDHHS Open Dump Inventory:** Under Public Law 103-399, the Indian Lands Open Dump Clean-up Act of 1994, the U.S. Department of Health and Human Services (USDHHS) and the IHS inventoried the Warmhouse Beach Dump in 1995. The Dump is listed on the IHS Sanitary deficiency System as Number WA05344-0301. These agencies have ranked the Dump as a high potential threat to human health and the environment (USDHHS and IHS, 1995).

- **Makah Landfill – Waste Delineation and Characterization Report:** In 1995, there was an effort to survey the dump and characterize the wastes and subsoil materials. A topographic survey of the immediate Dump area was obtained, and nine test pits were excavated into the waste. The results of this effort indicated that the Dump includes an estimated 3-acre deposit of mixed waste that varies in depth from scattered debris on the surface, to over 22 feet. Water was encountered in two of the down-gradient test pits. Samples were obtained of the wastes and subsurface soils; however, apparently no analyses on these samples were performed (White Shield, 1995).

- **Draft Makah Waste Management Plan:** In 1999, a draft plan for solid waste management on the Makah Reservation was developed. This plan included an evaluation of waste streams, a review of current and future regional disposal opportunities, and an evaluation of Dump closure alternatives. This report estimated that, as of the end of 1996, there were between 25,000 and 33,000 cubic yards of waste on-site at the Dump. The two alternatives for Dump closure were Consolidation and Closure-in-place, and Excavation and Export (Brown & Caldwell, 1999).

- **Biological Assessment for Industrial Development on the Makah Reservation:** In the spring of 2001, Tribal wildlife biologists prepared a Biological Assessment (BA) for several projects on the Reservation. This BA addressed projects in two primary areas: the first area included an existing rock quarry, construction site and wastewater treatment plant located off of Cape Flattery Road; the second area was a proposed log boom facility near Neah Bay. Even though the Dump is not located in either of these primary areas, the Dump was specifically identified in this BA as a "source of adverse effects to marbled murrelets (*Brachyrampus marmoratus marmoratus*) (McCoy, 2001).

- **Draft Makah Strategic Project Implementation Plan (SPIP) for Department of Defense (DoD) Environmental Mitigation:** In January, 2001, a draft SPIP to address DoD environmental mitigation on the Makah Reservation was developed. The plan discussed historical uses of the Reservation by the DoD, identified environmental impacts from these uses, and outlined a strategic approach to their cleanup. Initial project priorities identified in this plan are: closing the Warmhouse Beach Dump, and cleanup at the Navy Station and former housing area. The plan addressed closing the Warmhouse Beach Dump using consolidation and closure-in-place. (Ridolfi, 2001a).

- **Warmhouse Beach Open Dump – Hydrogeological Investigation:** A hydrogeologic investigation of the Dump was conducted to support plans for dump closure. Using IHS funding, four monitor wells were drilled around the periphery of the Dump. This study identified a layer of waste mixed with soil of variable thickness that overlies a hard grey siltstone. Although water was encountered in one well, the formation did not give up "0.1 gallons per minute of potable groundwater," and thus does not meet the regulatory definition of an aquifer per 40 CFR 258.5 (b) as cited in Brown & Caldwell (1999) (Ridolfi, 2001b).

- **Draft Solid Waste Management Plan:** This plan addresses existing solid waste challenges for the Makah, including closing the Warmhouse Beach Dump, providing alternative solid waste options, and increasing the reuse and recycling of a portion of the waste stream (Ridolfi, 2002a).

- **Preliminary Engineering Report:** This report included an engineering evaluation of five alternatives to using the Warmhouse Beach Dump for solid waste disposal, and an evaluation of three siting options for a solid waste handling facility (transfer station). A discussion on the importance of closing the Dump was also included (Ridolfi, 2002c).

- **Environmental Report:** This report included an environmental evaluation of the five alternatives to using the Warmhouse Beach Dump for solid waste disposal, and an brief evaluation of potential environmental impacts associated with the three siting options for a solid waste handling facility. A discussion on the existing adverse environmental effects associated with the Dump was also included (Ridolfi, 2002d).

2.0 DESIGN CONSIDERATIONS

This section outlines specific site conditions that have been considered during the development of the Warmhouse Beach Dump Closure Plan and identifies additional information that should be gathered prior to final design and project implementation.

2.1 Site Description

The Warmhouse Beach Dump is located about 2 to 3 miles northwest of Neah Bay, off an unpaved road from the road to Koitlah Point, at Latitude 48° 23'20" North and Longitude 124° 39'24" West in the northwest quadrant of Section 4, Township 33 North, Range 15 West of the Willamette Meridian. The Dump is located on a "saddle" between the drainage for Classet Creek and another unnamed creek. The site is bordered by forests, with drainage to the east and west; the west drainage (Classet Creek) outfalls to Warmhouse Beach. Seeps from the Dump area to these creeks have been observed (Ridolfi, 2001b).

The active portion of the Dump consists of about 7 acres at the top of a ridge, with a majority of the waste presently located within a deep ravine. Figure 2 provides a layout of the existing Dump and shows its proximity to local surface drainageways.

At an approximate elevation of 260 feet msl, the northernmost extent of the Dump is approximately 800 feet inland from the shoreline of Warmhouse Beach. The Dump is generally aligned in a near east-west line along an existing rock slope and is generally oval-shaped. The average dimensions of the surface portion of the dump are about 500 feet in width by 250 feet in length by up to at least 40 feet in height. In the ravine at the toe of the waste, the waste extends below the surface to a depth of at least 22 feet (White Shield, 1995). The current surface of the dump occupies about 3 acres. There is scattered debris along the access road to the dump, and drums, tires, and other debris in the ravine west of the access road. Because the Dump is open and active, the volume and exact location of the waste will vary from the conditions shown on Figure 2 until the Dump is closed. Using local waste projection rates and population estimates, the waste volume is likely to be between 55,000 and 65,000 cubic yards by early 2003 (Ridolfi, 2002b).

2.2 Hazardous Waste or Substance Contamination

Criteria established by the USEPA's Tribal Solid Waste Interagency Workgroup were used to quantify the potential hazard to human health and the environment posed by the Dump. In this system, sites with a score of more than 30 points are designated as having high hazard potential. Sites with a high hazard score present an immediate threat to human health and the

environment. Table 2 details the criteria used to evaluate the Warmhouse Beach Dump and the resulting hazard points assigned for each criterion. The Warmhouse Beach Dump received an overall score of 60, which qualifies it as a high-hazard site (Ridolfi, 2001a). In addition, the Dump is a potential threat to cultural resources in the Warmhouse Beach area, and attracts large numbers of crows and seagulls.

Table 2. Summary of Hazard Scoring

Hazard Point Factors	High Factors	Moderate Factors	Low Factors	Points Assigned
Site Contents Category*		Site Waste Content: All categories except MSW Hazardous waste < 2% by volume (15 points)	Site Waste Content: MSW only	30
Rainfall		Medium rainfall (10 - 25 in./yr.) (2 points)	Low rainfall < 10 in./yr.	4
Distance to Aquatic Resources	Less than 50 ft (30 points)	51 – 100 ft 10 points 101 – 200 ft 8 points 201 – 600 ft 4 points		0
Site Drainage		Moderate drainage-limited ponding; drainage effects largely neutral (2 points)	Site drainage contributes to protection of ground water or surface water	8
Potential to Create Leachate at Site		Moderate probability (2 points)	Low probability	4
Distance to Domestic Water Source	Less than 1,000 ft (4 points)	1,000 – 5,000 ft (2 points)		0
Site Accessibility	Unrestricted access – residences nearby, less than 1 mile (4 points)		Restricted and controlled access	2
Frequency of Burning		Infrequent burning (monthly) (2 points)	Burning never occurs	4
Site Materials Exposure to Public & Vectors		Materials in open trenches, limited scavenging (2 points)	Materials are covered, no scavenging	4
Degree of Public Concern Over Site-Aesthetics		Little public concern – only government awareness (2 points)	No concern expressed by any entity	4
			Total Points	60 High Priority

Source: Ridolfi, 2001a

During the 2001 hydrogeological investigation, a limited number of samples of the ground water, surface water, subsurface soils, and stream sediments were obtained and analyzed for polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), total petroleum hydrocarbon (TPH), volatile range (NWTPH-Gx), TPH semivolatile range (NWTPH-Dx) and 15 metals from the USEPA Target Analyte List (TAL) (Ridolfi, 2001b).

Analysis of these initial samples from the monitoring wells indicated the presence of lead at concentrations in excess of USEPA drinking water standards, as well as barium, chromium, selenium, vanadium, and zinc. Analysis of downstream surface water and sediment samples indicated the presence of cadmium, chromium, copper, lead, and zinc at concentrations considerably higher than the Criteria for Maximum Concentrations (Ridolfi, 2001b). Arsenic and silver were also detected. Other substances detected, but at concentrations below threshold criteria, are acetone, 2-butanone, methylene chloride, barium, beryllium, cobalt, silver, thallium, total petroleum diesel (TPD-DX), and vanadium (Ridolfi, 2001b).

2.3 Geotechnical Evaluation

The Warmhouse Beach Dump site is located on top of siltstones of the Hoko River Formation, a geologic rock formation composed primarily of siltstone and pebble-cobble conglomerates, with thin, fine to medium grained sandstone beds. This formation dips to the northwest at approximately 30 degrees. It is estimated that this formation potentially extends to at least 2,000 feet below the site (USGS, as cited in Brown & Caldwell, 1999).

On-site soils are primarily sandy silts with a high percentage of organics from the adjacent forest area. These soils overlay a hard grey siltstone. Silty soils developed on the Hoko Formation are often found as slope-wash over cliff and cut faces, and are generally less than four to five feet thick. This is true for this site; there are small areas along the upper portion of the Dump where the conglomerate has weathered to a sandy gravel, but in most areas where the conglomerate is present, the surface is cemented, and there is no soil layer. The siltstone is also exposed in areas along the access road (USGS, as cited in Brown & Caldwell, 1999).

While the underlying rock makes an ideal foundation for an in-place closure, it may be necessary to locate additional soils to use for capping materials. As a part of the geotechnical evaluation performed in support of the closure design, soil gradations and Atterberg limits should be analyzed for the on-site soils and any other anticipated borrow sources.

Survey information indicates that the existing angle of repose for the waste ranges from nearly vertical on the western slope to about 45 degrees (1H:1V) on the remaining slopes. Generally, these slopes do not appear to be unstable; however, guidance for slope stability on landfill closures recommends slopes no steeper than 2H:1V, with a 3H:1V slope being the typical slope used for stability and ease of maintenance (Richardson, 1997; USEPA, 1995). A qualified geotechnical engineer should review the final slope configuration as part of the final design.

A settlement analysis was not performed, but this is another task that is typically addressed during final design. Because the lower 20 feet of the waste have previously been consolidated within the ravine, it is expected that most of the settlement should occur in the more recent upper waste. Because this waste is about 20 feet in height, the resulting settlement is not expected to be more than a foot at most with proper placement and compaction prior to closure.

Koerner and Daniel (1997) indicate that most cover systems can adjust to settlement in the range of 0.5 foot to 1.5 feet without undue deformation of the liner materials.

2.4 Ground Water

Ground water on the reservation originates as precipitation falling on both the uplands and lowlands. It is estimated that nearly 80 percent of this precipitation runs off to streams because of the low permeability of the impervious bedrock, and soils that occur over much of the Reservation (USWB, 1965, as cited in Brown & Caldwell, 1999). With their location within a temperate rainforest, the remaining 20 percent of the runoff is removed through evapotranspiration (PGG, 1996 in Brown & Caldwell, 1999). As a result, although Neah Bay is technically one of the wettest places in the United States, the ground water resources are limited (Brown & Caldwell, 1999).

This is true to some extent for the Dump. During the 1995 Dump characterization effort, water was encountered in two of the test pits in the waste located in the ravine (White Shield, 1995). For the 2001 hydrogeologic investigation, four monitor wells were drilled along the toe of the Dump. During this investigation, water was encountered in only one well, and the formation did not give up enough potable ground water to meet the regulatory definition of an aquifer. This study identified a layer of waste mixed with soil of variable thickness that overlies a hard grey siltstone (Ridolfi, 2001b).

Additional monitoring of water levels in these wells during inclement weather has indicated water in all four wells (Ridolfi, 2003). As these observations are correlated with increased precipitation, it is believed that these observations are related to precipitation flowing along the interface between the waste and the underlying rock formation (Ridolfi, 2003).

2.5 Surface Water

The Dump is located on a ridge between the drainage for Classet Creek and another unnamed creek that outfalls to the Strait of Juan de Fuca near Kydikabbit Point (see Figure 1). The site is bordered by forests, with drainage to the east and west; the west drainage (Classet Creek) outfalls to Warmhouse Beach. Both creeks are steep, with relatively narrow streambeds. The Dump is located outside the 100-year floodplain as delimited by the Federal Emergency Management Agency, as well as outside of wetlands or other critical areas as indicated on the Clallam County Critical Areas Map (Clallam County, 2000).

Seeps from the Dump area to these creeks have been observed (Ridolfi, 2001b). Analysis of surface water samples taken from below the Dump in the western drainage indicates the presence of hazardous substances and a potential contaminant pathway from the Dump (Ridolfi, 2001b). Additional surface water sampling should be conducted to help assess the downstream risk, and to provide baseline data for project monitoring.

2.5.1 Hydrologic Analysis

In order to quantify the surface water flowing from the site, a hydrologic analysis of the Warmhouse Beach Dump site was performed using the U.S. Army Corps of Engineers' (USACE) Hydrologic Engineering Center's HEC-1 hydrologic computer model and the Soil Conservation Service's (SCS) unit hydrograph methodology. An SCS Type Ia storm distribution was utilized for this analysis, with an Antecedent Moisture Condition of III to

reflect the fully saturated soil conditions that would be expected in an area with frequent precipitation (SCS, 1972). The peak flow rates were developed for 2-year-, 10-year, 25-year-, and 100-year-frequency storm events with durations of 24 hours.

Because the site is located near sea level, is relatively small, and within is a rock-based hydrologic unit, the rainfall was not adjusted for rain-on-snow events, as they are not a significant factor for this type of application. Point rainfall amounts from the Neah Bay were obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 2 "Precipitation – Frequency Atlas of the Western United States, Volume, IX, Washington" as excerpted in the Washington State Department of Ecology (WADOE) Surface Water Management Manual, (WADOE, 2001b). The point rainfall amounts (precipitation) and resulting estimated peak flows for the seven acre site are shown in Table 3.

Table 3. Summary of Precipitation Hydrologic Parameters and Peak Flow Rates

Drainage Parameter	2-Year 24-Hour Storm	10-Year 24-Hour Storm	25-Year 24-Hour Storm	100-Year 24-Hour Storm
Precipitation (inches)[1]	4.5	5.8	7.8	8.8
Peak flow rates (cfs)[2]	5.0	7.0	9.0	11.2
Data Source: [1]WADOE, 2001b; [2]Ridolfi, 2003.				

2.5.2 Hydraulic Analysis

Hydraulic design for the channels was performed utilizing Manning's formula (Chow, 1959) with an iterative spreadsheet that allows design from a range of channel cross-sections. Flows ranging from baseflows of 2 to 3 cubic feet per second (cfs) to the 100-year-frequency storm event of 11 cfs were used for these analyses. This analysis indicates that the existing drainage swales are sufficient to convey the runoff from the 100-year event.

2.6 Percolation

The USEPA's Hydraulic Evaluation of Landfill Performance (HELP) computer model, version 3.07, was used to assess the potential for the runoff to percolate through the Warmhouse Beach Dump (USEPA, 1997). Weather data from the National Weather Service stations at Neah Bay and at Tatoosh Island were input into the HELP model along with the existing dump cover configuration and assumed waste density. The average annual precipitation at Neah Bay is over 102.4 inches, three-quarters of which occurs during the six-month period from October through March (WRCC, 2002).

The estimated average percolation under existing conditions at the Warmhouse Beach Dump is 74.0 inches per year. This means that about 72 percent of the precipitation falling on the Warmhouse Beach Dump flows completely through the waste and into the underlying soils and ground water. Converting for the whole Dump area, this equates to 806 thousand cubic feet per year, or around 6.0 million gallons per year. This equates to an average flow rate of a little more than 11 gallons per minute (GPM).

2.7 Landfill Gas Generation

There are no measurements of gas generation or of waste density for the existing waste in the Warmhouse Beach Dump. Although landfill gas has not been identified during characterization of the Warmhouse Beach Dump, all of the primary constituents necessary for its formation are present: (1) wood waste, putrescible (rotting) food waste, and organics have been identified in the dump; (2) yearly annual rainfall is over 100 inches; and (3) the waste is normally at a moderate temperature (Richardson, 1997; McBean et al., 1995).

Guidance on the design of landfill covers developed by the American Society of Civil Engineers (ASCE) recommends the use of a fairly conservative estimate of gas generation, about 0.1 standard cubic foot per pound of waste per year (Richardson, 1997, based on USDOE, 1981). Applying this rate to the estimated waste volume yields a theoretical gas generation rate for the dump of about 3.8 cubic feet per minute (cfm).

Typically, landfill gas is an approximate 50-50 mix of methane and carbon dioxide, with a small percentage of other trace gases and liquids. In addition, there are aqueous vapors derived from precipitation, liquids, and solutions that have been buried in the dump, such as chlorinated or petroleum hydrocarbons, pesticides, or products of waste decomposition. The most frequently encountered trace gas within landfill gas is benzene (McBean et al., 1995). Toluene, xylene, and vinyl chloride are also frequently encountered and can be generated for a long period of time (McBean et al., 1995). Ground water and soil samples from the Warmhouse Beach Dump have been found to contain benzene compounds, toluene, xylene, and other similar substances (Ridolfi, 2001b), indicating the presence of those compounds in the Dump; thus, there is some potential for these constituents to occur in landfill gas at the Warmhouse Beach Dump as well.

2.8 Sensitive Environments

The Reservation encompasses about 42 square miles of an area considered to be temperate rain forest. The Flattery Rocks National Wildlife Refuge is located along the western shore of the Makah Indian Reservation, as is the Olympic Coast National Marine Sanctuary. The Olympic National Park is located about 40 to 50 miles south and east of the Reservation. As a whole, the Olympic Peninsula includes numerous types of habitat and supports diverse plant and wildlife species. Fish found along the coast of Neah Bay include Pacific halibut, rockfish, coho salmon, and chinook salmon. Several trout and salmon species use the Sooes and Waatch Rivers, as well as other tributary creeks and streams. Gray whales and orca (killer whales) travel the Strait of Juan de Fuca from Tatoosh Island. Other marine mammals commonly found in the vicinity include porpoises, dolphins, sea lions, and harbor seals. Deer, elk, mountain lion, bear, and lynx are common in the upland. Bald eagles, hawks, boreal owls, grouse, and various other birds have also been sighted throughout the Reservation, mainly along the coast and the river floodplains.

Warmhouse Beach, located adjacent to the current open Dump, could be considered prime habitat for marbled murrelets. However, murrelet nesting is presently inhibited by crows and seagulls using the Dump (McCoy, 2001). Presently, the kelp bed and shellfish habitats of Warmhouse Beach are deteriorated to the point where there may be impacts to traditional Tribal uses of these resources. Table 4 includes a summary of listed, proposed, or candidate species that may warrant special consideration with respect to dump closure:

Table 4. Special Status Species on the Makah Reservation

Common Name	Scientific Name	Status with Respect to the Dump
Bald eagle	*Haliaeetus leucocephalus*	Potential adverse effects associated with solid waste haul off-Reservation; Mitigation may be required.
Marbled murrelet	*Brachyramphus marmoratus marmoratus*	Adversely affected by existing conditions at the dump.
Northern spotted owl	*Strix occidentalis caurina*	No effect.
Bull trout	*Salvinus confluentus*	No effect.
Source: McCoy, 2001		

2.9 Adjacent Land Use, Traffic, and Access

Primary access to the site is from Cape Flattery Road, to the road to Koitlah Point. A 12 to 16 feet wide graded but unpaved road winds up the hill to the Dump from the turn-off to Koitlah Point. These World War II-era roads were constructed by the U.S. military to serve the airbase located approximately 3 miles south of the Dump. Adjacent land use is primarily forest lands. While the site is relatively remote, access to the site is presently unlimited.

2.10 Site Utilities

No permanent utility installations are proposed for this project. There are no existing water or power lines located on site. Temporary water, power and sanitary facilities will have to be provided during the construction period.

3.0 CIVIL ENGINEERING DESIGN

On the basis of previous evaluations, and ongoing consultation with the USEPA, Makah Tribal Council, and technical staff, the Warmhouse Beach Dump Closure Plan presented here is for partial removal and closure in place (containment). This section describes the specific engineering criteria used to develop the initial concepts for this closure action.

3.1 Description of Dump Closure Action

The Warmhouse Beach Dump Closure Project consists of containment, stabilization, and reclamation activities for closure of the Warmhouse Beach Dump. Approximately 50,000 to 60,000 cy of contaminated waste, soil, and sediment are present within the portion of the site covered by this closure plan. In addition to dump closure, the project also includes construction of a gravel access road, diversion channels and cleanup of associated miscellaneous debris along the access road and in the channels immediately downstream of the Dump.

3.2 Design Elements

Each of the primary design elements included in the Warmhouse Beach Dump Closure is discussed below.

3.2.1 Limited Clearing

Most of the site work for the dump closure will occur in areas previously impacted by dumping; therefore, very little established vegetation will require clearing. The proposed surface water control measures will require grass and small scrub removal along a 10–foot wide strip. In all, a length of around 500 feet will be affected. The total clearing requirement for this project affects an area of a little less than 1/2 acre.

3.2.2 Surface Debris Removal and Waste Consolidation

Surface debris removal will be required for several small accumulations of waste along the entrance road. In addition, the drums, barrels, tires and other debris in the channels below the Dump should be retrieved and disposed of properly. An estimated 25,000 to 35,000 cubic yards of waste will be consolidated on site in order to minimize the waste footprint, and to provide a more stable landfill slope. The waste should be placed in separate layers and compacted until there is no observed vertical deflection, and surface voids are filled as completely as practicable with debris, soil, or gravel. The existing waste slope ranges from 2:1 to steeper than 1:1. The wastes will be graded to a 3:1 sideslope along the exterior of the containment to minimize erosion potential, allow for future maintenance, provide more natural aesthetics, and enhance slope structural stability. Section 4.0 presents two options for the final configuration of the waste on site.

3.2.3 Seismic Risks and Tsunamis

Seismic risks (earthquakes) and tsunamis are both potentially catastrophic events that have a high hazard risk associated with them; however, there is a low frequency of occurrence (WADOE, 2001c). According to a recent assessment of coastal hazards conducted by the Washington Department of Ecology:

> *"The risks of seismic events and tsunamis are equally great on Washington's ocean coast and in Puget Sound[...] Recent studies indicate that the Puget Sound region is vulnerable to severe earthquakes and that these earthquakes have left a record of severe coastal impacts including tsunami, sudden land level changes, ground shaking and liquefaction, and major landsliding[...] now is the time to recognize and begin mitigating this hazard along our Pacific Coast and inside the Strait of Juan de Fuca"* (WADOE, 2001c).

USEPA design guidance concerning seismic hazards for abandoned dumps and landfills includes evaluation of the potential for fault displacement-induced damage and assessment of the impacts of earthquake-induced ground motions. According to the 1999 Brown & Caldwell assessment, there is a small, unnamed fault located between the Dump and the ocean; however, field personnel have been unable to locate this fault to date (Brown & Caldwell, 1999). There are no other known active faults located within a mile of the dump, and no history of earthquake epicenters occurring within 100 miles of the site.

The impacts of earthquake-induced ground motions are evaluated on the basis of a statistically derived horizontal peak ground acceleration. Draft USEPA design guidance concerning the evaluation of seismic hazards for landfills includes USGS probabilistic seismic mapping prepared in support of RCRA Subtitle D (40 CFR Part 258) regulations governing landfill siting and closure. Information contained within this guidance indicates that the Warmhouse Beach Dump may be located within a Seismic Impact Zone (an area with a 10 percent or greater

probability that the maximum horizontal acceleration will exceed 0.10g in 250 years) (Richardson et al., in print).

The horizontal peak ground acceleration is used to evaluate slope stability and the potential for liquefaction of a dump or landfill (Richardson, 1997). However, the waste deposits at the Warmhouse Beach Dump are less than 30 meters in depth and the soils are relatively well-consolidated and located on top of bedrock; therefore, the relative risk to this particular site may be minimal. Prior to final construction, the seismic zones for this project should be verified with current USGS seismic mapping. If the revised maps indicate that the project lies within a zone of maximum horizontal acceleration greater than 0.1g in 250 years, then a full seismic evaluation per the RCRA Subtitle D (258) Seismic Guidance for Municipal Solid Waste Landfill Facilities should be performed, and the results incorporated into the final project design.

Tsunamis are a series of very large ocean waves that are normally associated with seismic events, but may be triggered by other catastrophic events such as landslides, mudslides, volcano eruptions or even meteors (University of Washington (UW), 2003). Geologic studies, archaeological evidence, and Makah Tribal legends all indicate that tsunamis have occurred along Cape Flattery in the past (USGS, 2003, Paulsen, 2002, Ludwin, 1999). The National Weather Service has installed NOAA Weather radio receivers at Neah Bay (to cover the Strait of Juan de Fuca) and on Mount Olympus (Olympic National Park) that are specifically intended to provide alert capabilities for tsunamis for three counties (Grays Harbor, Jefferson, and Clallam) and five coastal Indian Nations (Quinault, Makah, Quileute, Hoh, and Ozette) (Frinnell-Hanrahan, 1999). While there is evidence of prior tsunamis occurring along Cape Flattery, the Dump site is located at a mean elevation of about 240 feet above mean sea level, and thus should be elevated above the area likely to be impacted by tsunamis.

3.2.4 Surface Water Control

Because of the proximity of the dump to existing surface water and the overall drainage pattern through the site, effective surface water control will be required before, during, and following project construction.

The on-site drainage will be handled by runoff control channels along the periphery of the Dump. A small channel will be constructed along the perimeter of the containment with a easterly outfall into the adjacent surface water body. The slope along this channel periphery varies from 0.5 to 3 percent. The chosen typical geometry is a riprap lined V-bottom channel with a minimum 2-foot depth.

3.2.5 Landfill Cover Design

The landfill cover design was developed using the USEPA's HELP computer model (Schroeder at al., 1994). Using weather and soil parameters from the National Weather Service station at Neah Bay and Tatoosh Island, a range of landfill cover alternatives was evaluated using the HELP model to reflect a 100-year repository life. Six different cover configurations were investigated to determine the relative effectiveness in preventing rainfall from percolating into the landfill. All of the covers assumed a one acre area, 3-percent top slope, moderate grass coverage, and a "fair" designation for cover construction quality. The modeled cover alternatives ranged from existing conditions, to a RCRA Subtitle D-type cover with a double barrier system. Table 5 summarizes the alternatives evaluated, and their relative performance expressed as percent reduction of precipitation into the waste layer.

Table 5. Summary of HELP Modeling Results for Cover Alternatives

Alternative Number	Cover Alternative Description	Percolation		Reduction in Precipitation[1]	Improvement of Existing Conditions[2]
		(inches)	(cubic feet/ one acre)	(percent)	(percent)
X	Existing conditions: no cap	74.0	268,500	27.6%	0%
1	12-inches of growth media	68.8	249,900	32.6%	5%
2	18-inches of growth media	66.8	242,400	34.6%	7%
3	Capillary break-type cover: 18-inches of growth media over 6-inches gravel (note: HELP model does not effectively model lateral drainage from this type of cover (Schroeder et al., 1994)	64.3	243,900	37.0%	9.4%
4	**New composite cover: 18-inches growth media, 6-inch gravel layer, GCL liner on 6-inch coarse sand layer, over waste**	**0.43**	**1,600**	**99.9%**	**75.3%**
5	New composite cover: 18-inches growth media over 6-inch gravel layer, 12-inch clay liner over waste	54.9	206,800	46.2%	19.6%
6	New composite RCRA Subtitle D cover: 18-inches growth media over 6-inch gravel layer, GCL liner, then 6-inches barrier soil over waste	0.07	300	99.9%	75.4%

Notes:

bold = Recommended alternative for cover configuration

GCL: geosynthetic clay liner

[1] Represents reduction of total initial precipitation hitting the waste; in other words, this alternative is preventing X per cent of the initial precipitation from percolating through the waste.

[2] Represents cover alternative improvement in reducing percolation from existing conditions; this alternative is preventing an additional X percent of the initial precipitation from percolating through the waste.

Source: Ridolfi, 2002e

From the results of this modeling, it can be concluded that:

- Covers formed of soil materials alone would not be as effective as the composite covers in reducing percolation.
- It is possible to develop a fairly conservative cover that can prevent the majority of precipitation from passing vertically through the waste.

- By regrading the waste and placing a composite cover containing a geosynthetic liner material over the existing cap, it is possible to significantly reduce the percolation of rainfall through the waste.

- There is very little difference in landfill performance between a cover containing a full RCRA Subtitle D double-lined cover section, and a cap with only geosynthetic clay liner (GCL).

Given the modeling results and the fact that GCLs have a higher surface friction and provide a more forgiving material with respect to constructibility, a cover system with a gravel layer over GCL is recommended for this project. It should be noted that the HELP model does not effectively model lateral drainage out of the cover or lateral drainage from ground water in and out of the containment. The selected design configuration is fairly conservative, as this type of cover relies on lateral drainage in the form of a capillary break to effectively divert runoff from passing through the waste; thus the actual leachate percolation should be even less than the model predicts.

Using the results of the HELP modeling, a multi-layered cover was designed to isolate the waste at the Warmhouse Beach Dump, and to significantly reduce rainfall percolation through the waste containment. Each layer in the cover has a specific purpose, and several of these layers actually perform more than one function as a part of the overall cover design. Typical cross-sections through the containment are included in Figure 3. A description of the layers forming the resulting cover configuration from the waste outward to the surface is as follows:

- **Lower Gravel Collection Layer** – The leachate and gas collection layer is a 6-inch thick layer of gravel or coarse sand placed immediately on top of the waste. This layer ties into the siltstone at the toe of the waste containment. The lower gravel collection layer provides a defined pathway for landfill gases to flow upward by diffusion from the waste towards the passive gas vents, and for any liquids within the waste to flow downward towards the percolation collection system.

- **Barrier Layer** – The barrier layer physically prevents rainfall from percolating downward into the waste. This layer consists of a geosynthetic clay liner (GCL) underlain by a sand or soil cushion. The barrier layer passes over the gravel collection layer and is also anchored into the siltstone beneath the site, thus forming a system that hydraulically isolates the waste within the dump.

- **Drainage Layer** – Immediately above the barrier layer, there is a 6-inch thick gravel drainage layer. The primary purpose of this layer is to intercept and laterally divert any runoff percolating through the soil layer. This layer conveys percolation to the run off channel that surrounds the dump.

- **Soil Layer** – An 18-inch thick soil layer is placed over the drainage layer to provide adequate substrate material to support germination and sustained growth for vegetative cover, help prevent erosion of the soil materials and allow for reduction in percolation by evaporation and transpiration. The difference in hydraulic conductivity between the soil and gravel materials forms a capillary break. While not apparent in the models, this type of capillary break can also help prevent downward percolation of the rainfall into the waste (Dwyer, 1998). An erosion mat has been included along the slopes only to help prevent soil erosion prior to vegetation establishment.

- **Geotextile Filter Fabric** – Geotextile filter fabric has been included along the bottom of the lower gravel layer, and between the soil layer and the gravel drainage layer.

3.2.6 Percolation System

The previous evaluations of consolidation and closure in place indicate that a formal leachate collection system should not be necessary (SAIC, 1993; Brown & Caldwell, 1999). However, because of observations of existing water within the waste, and high annual rainfall, it may be necessary to include ways of managing the residual percolation from the waste after the cap is placed (i.e., while the waste "dries out").

As this drainage follows the interface between the siltstone and the waste, and the siltstone has a dip of about 30 degrees, this de-watering should occur fairly rapidly. This dewatering period can be handled either by capping a majority of the dump, and allowing a portion along the toe to remain open for a period of time (two to three years or so) until bottom drainage is no longer noted; or by installing a v-shaped section of perforated pipe along the toe of the containment, with a boot through the cover system. In either case, this drainage should be monitored and periodically sampled. If contaminants are detected in the percolation, then the drainage may need to be diverted for treatment. Note that the boot section may allow better control and future capture of this drainage as necessary.

3.2.7 Landfill Gas Control Measures

Guidance for closing abandoned landfills and dumps recommends as a general rule that gas collection be incorporated to address the likelihood of gas generation (Koerner and Daniel, 1997; USEPA, 1995b). Under this design scenario, ASCE guidance recommends installation of a passive vent system at a rate of one vent per acre, with vents spaced about 90 to 100 feet apart and located at the "high points" of the cover. The purpose of these vents is to help prevent the buildup of methane and other harmful gases within the landfill (Richardson, 1997; Koerner and Daniel, 1997).

Since the Dump has a final footprint of a little less than an acre, the design includes a single vent placed along the containment centerline at the top of the waste. A collection system of 4-inch-diameter perforated high-density polyethylene (HDPE) pipes will be placed at about 100-foot spacing along the top of the waste. Arranged like veins on a leaf, this network is configured to encourage gas collection and flow upgradient toward the vents. The gas collection pipes will be bedded in the 6-inch gravel gas collection layer placed above the waste. The vent will consist of a 4-inch-diameter HDPE "goose neck"-shaped pipe section that projects above the top of the covered Dump surface. This allows passive flow of the gases from below the cap and defined locations for future monitoring of gas from the containment. If monitoring of these vents indicates that exhaust exceeds 25 percent of the lower explosive limit (LEL), additional venting or perhaps an active gas extraction system would be required. If no gas is detected, the vents can be decommissioned (Richardson, 1997). The gas collection system is shown in Figure 4.

3.2.8 Site Grading and Erosion Control

Site grading and erosion control measures are designed to minimize the potential for surficial erosion from disturbed areas. These measures are critical to the overall stabilization of the site.

Grading: Grading will be limited to backfilling voids resulting from the removal of contaminated material and gentle shaping of the ground surface to match existing valley slopes. Slopes along the site vary from 0.5 to 3 percent, consistent with the existing cross slopes. Design slopes for site grading have been limited to match existing grades where possible and to provide a positive gradient toward the surface water area to the west of the containment.

Erosion control: Erosion control measures should be designed using the Universal Soil Loss Equation and guidelines set forth in *Erosion & Sediment Control Handbook* (Goldman et al., 1986). Anticipated erosion control measures for this site include: Excelsior matting or equivalent, with grass and forb seeding and perimeter vegetation for the containment itself; seed, mulch, vegetation blocks, and willow cuttings for the channel bank areas, and hand seeding with a grass-forb mixture supplemented by plant blocks for the other disturbed areas of the site.

3.2.9 Site Revegetation and Site Rehabilitation

Revegetation and rehabilitation plan for this site is intended to maximize the use of existing vegetation as a source of colonization. While there are excellent sources for colonizing the site with native species from the adjacent undisturbed areas, the immediate concern is erosion control until these plants are established. A limited planting scheme is proposed to stabilize the site, and provide initial screening and access control. The plant species selected are native plants suitable for use at this elevation and for the ecotypes encountered. Most are also hardy species suitable for use in a disturbed regime. Conifers are not included because of the degree of site disturbance and the proximity of healthy conifer populations. It is expected that succession will occur naturally when the site becomes able to support conifer species.

The primary goal of revegetation is site stabilization, which will be accomplished by installing willow cuttings along the channel banks and planting the majority of the site with a grass-forb seed mixture. A mix of native grass and forb plant species will be developed through consultation with Makah Natural Resources personnel and several other references pertinent to the Olympic Peninsula (USFS, 1996; USDA, 2001; FHWA, 1999; and Pojar and MacKinnon, 1994). Plant species will be selected based on appropriateness for the site, ability to provide adequate erosion control through sod formation or root structure, and ability to provide effective soil stabilization during both the initial year and second year following planting. Inoculated legumes (lupine, or a short-lived native clover) may be included as necessary to enhance nitrogen fixation, thus augmenting the soil fertility. An application rate will be determined during final design that will encourage rapid development of a vegetative cover adequate to stabilize the slopes and prevent invasion by noxious weeds. It should incorporate several species as a safety factor in plant selection, so that if one species does not thrive in a particular part of the site, there are several others that might.

Soil preparation will consist of disking natural organic materials such as peat, fertilizer, and lime into the soils used for on-site fill. Agricultural testing will be required for any borrow or topsoil material being used as growth media, and the final quantities of additives will be based on the quality of the soil being used.

Because the site is located within a narrow valley with healthy adjacent plant communities, limited revegetation is proposed beyond site stabilization. The revegetation for this site is based on a "trigger approach" in which initial block plantings are provided on a limited scale and colonization from these groups and the adjacent plant communities is relied on for full revegetation (Winterhalder, 1990).

Planting in blocks will provide shade for the cuttings, a more natural appearance, and limited protection from browsing (Hoag, 1993). Each 15-foot by 15-foot planting block will contain 10 container-based plants from three different tree and shrub species established using the typical "line-planting" methods used for reforestation. It is anticipated that this method will result in lower costs per block and a more random, more natural looking plant configuration within each block. A total of 20 of these blocks is recommended, which will provide plantings at about one block per 25 feet along the toe of the containment.

3.2.10 Site Access and Access Control

Both site access and subsequent access control are important elements of this project. Current site access is from an existing unpaved road onto the road to Koitlah Point. To provide access during construction and allow ongoing monitoring and maintenance of the percolation system, a new 300-foot-long gravel access road is included along the southern edge of the containment. The 6-inch-thick gravel surface course is to be placed and compacted in two lifts.

Access control methods include a double-swing, steel pipe, padlocked gate at the entry of the access road to prevent unauthorized entry along the toe of the containment. To prevent damage to the containment from unauthorized pedestrian and vehicular use, a combination of 24-inch diameter boulders and "hostile vegetation" is planned for the lower perimeter of the containment. "Hostile vegetation" consists of native plants that have a pungent or unappealing odor, have thorns or brambles, or simply grow thickly enough to discourage human access. Nootka rose (*Rosa nutkana*) and Douglas spirea (*Spirea douglassii*) are plants that could be considered for this purpose on the basis of both "hostile" properties and plant aesthetics.

4.0 ALTERNATIVE COVER CONFIGURATIONS

During several discussions during the development of the Warmhouse Beach Dump Closure Plan, two alternative cover configurations evolved for the actual final shape of the containment:

1. **The Slope Option** – where the waste is simply regraded to a more stable slope; and
2. **The Ravine Option** – where the waste is consolidated within the existing ravine.

Both options meet the project objectives, and meet EPA Guidance for landfill closure. Both effectively isolate the waste to reduce the risks to human health and the environment. And both options would support future uses of the Dump site by the Makah Tribe for interpretive or other purposes.

4.1 Alternative Cover Concept 1 – The Slope Option

4.1.1 Description

The Slope Option assumes that the waste from along the road, the channels and the existing hillside would be consolidated along the existing south slope of the Dump. The waste from the east and west edges of the Dump would also be consolidated into this area. Approximately 22,000 cubic yards of waste material and contaminated soils located outside of the containment footprint would be excavated, placed on the existing waste dump along the hillside, and graded

and compacted to a final surface. Post-removal verification sampling would be conducted to confirm complete removals of all hazardous substances within the removal limits.

The waste would be graded and compacted to form a 3:1 slope from the top edge of the hillside across the ravine to existing elevation at the south side of the ravine. The waste would form a wedge against the hillside. A 12-feet wide access road and drainage channels would placed along about 500 feet of the southern toe of the slope. Additional survey data along the eastern edge of the site may be required to establish final grades for the slope so that there is a smooth transition to the existing slope. Figure 4 shows the cover grading plan under this cover option. The configuration would be one large oval shaped hilltop with an adjacent valley – most likely a very natural looking feature. The containment under this option would have a final surface area of a little under an acre.

A multimedia engineered cover would be installed over the consolidated and compacted waste materials. This cap includes an internal drainage layer, a passive gas venting system, a geosynthetic barrier layer and a layer with growth media to support vegetative growth. Figure 5 provides a typical cross-section through this cover alternative.

Following the removals, the site would be regraded for positive drainage, and soil amendments would be added as necessary to support uplands and riparian revegetation. Disturbed areas of the site would be revegetated with native plant species appropriate to Cape Flattery and to the various habitat types (e.g., elevation and aspect) encountered.

At least one monitoring well will need to be relocated under this option, as it is located within the projected footprint of the containment. In addition, additional off-site characterization and possible remediation of the impacts of the Dump may be required.

In order to prevent re-contamination of the site from illegal dumping, site access would be restricted by a steel pipe gate; this can be augmented with public information and enforcement. In addition, to protect the integrity of the cover, a perimeter barrier formed of hostile vegetation (thorny plants) and boulders would be placed around the containment.

4.1.2 Residual Effects

The residual effects of this removal action should be: the top of the Dump would be clean, and the waste would be a wedge-shaped deposit in the adjacent ravine. There should be improvements to downstream water quality and a reduction in the number of crows, seagulls, and ravens at the site. With the establishment of vegetation, site should be stabilized and the top of the hill could be made available by the Tribe for limited public use.

There may be a spike, or short-term increase, in measured concentrations of metals or volatile organic compounds (VOCs) in the ground or surface water immediately following removal. Such a spike can reflect the inadvertent release of some of those materials during the removal action and would be expected to diminish with time. With increased time following closure, there should be a reduction of moisture percolating from the waste. However, if long-term monitoring does not reflect such a decline, it could be an indication that not all of the contaminated materials have been successfully removed, and other measures may be required.

4.1.3 Considerations for Habitat Rehabilitation

While the affected area is currently largely devoid of vegetation, there are healthy vegetative communities close to the project. With an effective waste removal effort to eliminate phytotoxic substances from the site and an effective revegetation effort, it is anticipated that habitat rehabilitation should be relatively easy to accomplish.

4.1.4 Evaluation of Effectiveness and Implementability

Table 6 provides a brief summary of the evaluation of the Alternative Cover Concept 1 – the Slope Option with respect to effectiveness and implementability criteria.

Table 6. Summary Evaluation of Alternative Cover Concept 1 – The Slope Option

Evaluation Criterion	Evaluation
Long-Term Effectiveness and Permanence	Removes only a portion of the source from the immediate project site. Includes actions to reduce the mobility of contaminants of concern in the environment and thus reduces the potential for ecological receptors to be exposed to those contaminants.
Reduction in Potential Exposure	Reduces the potential for direct ecological exposure to the most highly contaminated media and reduces contaminant transport via erosion and leachate production.
Site Stabilization	Site stabilized through engineered controls.
Monitoring & Institutional Controls	Requires long-term management monitoring and institutional controls; this could be effectively administered by the Makah.
Residual Risks	Associated with any contaminated media left in place, sources that are only partially contained, and continued loadings of contaminants to aquatic environments.
Time Required to Implement	1-2 years to implement completely with 5-10 year ecological recovery period.
Compliance with Cleanup Criteria	Attainment of chemical-specific action criteria designed to protect the environment, including the Clean Water Act and both federal and Makah water quality criteria.
Reduction of Toxicity, Mobility, or Volume Through Treatment	No reduction of toxicity, mobility or volume through treatment.
Short-Term Effectiveness	
Risks to Community	• Low risk to the community during remediation from hazards from imported construction materials.
Risks to On-Site Workers	Low to moderate risk to workers. In general, these risks increase with the volume of materials (currently estimated at 22,000 cy) subject to handling.
Risks to Environment	• Construction within floodplains and riparian areas; • Some unavoidable temporary disruption of habitat would occur; • Contaminated and uncontaminated sediment loads from runoff and erosion are expected to increase during construction; and • Existing vegetation may be disturbed or destroyed.
Implementability	Cover Concept 1 is considered technically feasible.
Uncertainties	Uncertainties include: the lateral extent of the waste, the depth and composition of the wastes along the perimeter of the site.
Challenges	Challenges include slope stability of existing waste.
Administrative Requirements	• A cultural resources consultation (National Historic Preservation Act). • Coordination with natural resource agencies (Fish and Wildlife Coordination Act).
Off-Site Treatment, Storage, and Disposal of Waste	Off-site treatment, storage and disposal of waste not required.

In summary, Cover Alternative 1, the Slope Option, would meet the threshold criterion of overall protection of the environment.

4.1.5 Estimate of Probable Costs

Cost estimates for Alternative Cover Concept 1 were developed using 2003 dollars, 30 years of operation and maintenance (O&M) and a discount factor of 5 percent. Initial capital costs include 20 percent for contingencies and 5 percent for engineering prior to construction, construction management, inspection, and verification sampling. A current estimate of probable costs for implementing the Slope Option is presented in Table 7.

Table 7. Estimate of Probable Cost of Alternative Cover Concept 1 – The Slope Option

Cost Element	Estimate of Probable Cost
General Requirements (11.25%)	$62,800
Site Work	$38,100
Waste Material Handling	$282,000
Dump Closure	$202,200
Site Rehabilitation	$20,700
Total Construction	**$605,900**
Contingencies (20%)	$121,200
Engineering, Project Inspection Clean-up Verification (15%)	$109,100
TOTAL PROJECT COSTS	**$836,100**
Estimated Annual O&M	$20,300
30 years O&M	$312,600
TOTAL LIFE CYCLE COSTS	**$1,148,700**

It should be noted that there is a great deal of uncertainty associated with this estimate, due to factors such as possible dewatering, undefined subsurface conditions, and unknown hazardous substances.

4.2 Alternative Cover Concept 2 – The Ravine Option

4.2.1 Description

The Ravine Option assumes that the waste from along the road, the channels and the existing hillside would be consolidated on top of the other waste within the existing ravine due south of the active Dump face. The waste from the east and west edges of the Dump would also be consolidated into this area. More waste would be relocated under this option – approximately 28,000 cubic yards of waste material and contaminated soils located outside of the containment footprint would be excavated, placed in the Ravine, and graded and compacted to a final surface. Post-removal verification sampling would be conducted to confirm complete removals of all hazardous substances within the limits.

The waste would be graded and compacted to form a 3 percent top slope from a crown along the center of the ravine. The resulting excavation top elevation of the containment is estimated to about 20 feet higher than the existing elevation in this area. The containment would slope to meet existing ground at the eastern and western edges at about a 3:1 slope. The waste would form a pentagon-shaped shaped wedge inside the ravine. A 12-feet wide access road and

drainage channels would placed along about 700 feet of the upper edge of the Dump. Additional survey data along the eastern edge of the site may be required to establish final grades for the slope so that there is a smooth transition to the existing slope. Figure 6 shows the cover grading plan under this cover option. The configuration would be one large oval shaped hilltop with an adjacent triangular shaped valley – also thought to be a very natural looking configuration. The containment under this option would have a final surface area of a little under a half an acre.

A multimedia engineered cover would be installed over the consolidated and compacted waste materials. This cap includes an internal drainage layer, a passive gas venting system, a geosynthetic barrier layer and a layer with growth media to support vegetative growth. Figure 7 provides a typical cross-section through this cover alternative.

Following the removals, the site would be regraded for positive drainage, and soil amendments would be added as necessary to support upland and riparian revegetation. Disturbed areas of the site would be revegetated with native plant species appropriate to Cape Flattery and to the various habitat types (e.g., elevation and aspect) encountered.

At least one monitoring well will need to be relocated under this option, as it is located within the projected footprint of the containment. In addition, additional off-site characterization and possible remediation of the impacts of the Dump may be required.

In order to prevent re-contamination of the site from illegal dumping, site access would be restricted by a steel pipe gate; this can be augmented with public information and enforcement. In addition, to protect the integrity of the cover, a perimeter barrier formed of hostile vegetation (thorny plants) and boulders would be placed around the containment.

4.2.2 Residual Effects

The residual effects of this removal action should be: the top of the dump would be clean, and the waste would be a smaller, deeper plug-deposit in the adjacent ravine. There should be improvements to downstream water quality and a reduction in the number of crows, seagulls, and ravens at the site. With the establishment of vegetation, site should be stabilized and the top of the hill could be made available by the Tribe for limited public use.

As for the first option, there may be a spike, or short-term increase, in measured concentrations of metals or VOCs in the ground or surface water immediately following removal. With increased time following closure, there should be a reduction of moisture percolating from the waste. However, if long-term monitoring does not reflect such a decline, it could be an indication that not all of the contaminated materials have been successfully removed, and other measures may be required.

4.2.3 Considerations for Habitat Rehabilitation

While the affected area is currently largely devoid of vegetation, there are healthy vegetative communities close to the project. With an effective waste removal effort to eliminate phytotoxic substances from the site and an effective revegetation effort, it is anticipated that habitat rehabilitation should be relatively easy to accomplish.

4.2.4 Evaluation of Effectiveness and Implementability

Table 8 provides a brief summary of the evaluation of the Alternative Cover Concept 2 – the Ravine Option with respect to effectiveness and implementability criteria.

Table 8. Summary Evaluation of Alternative Cover Concept 2 – The Ravine Option

Evaluation Criterion	Evaluation
Long-Term Effectiveness and Permanence	Removes only a portion of the source from the immediate project site. Reduces the potential for ecological receptors to be exposed to those contaminants.
Reduction in Potential Exposure	Reduces the potential for ecological exposure to the most highly contaminated media and reduces contaminant transport via erosion and leachate production.
Site Stabilization	Site stabilized through engineered controls.
Monitoring & Institutional Controls	Requires long-term management, monitoring and institutional controls, to ensure the integrity; this could be effectively administered by the Makah.
Residual Risks	Associated with any contaminated media left in place, sources that are only partially contained, and continued loadings of contaminants to aquatic environments.
Time Required to Implement	1-2 years to implement completely with 5-10 year ecological recovery period.
Compliance with Cleanup Criteria	Attainment of chemical-specific action criteria designed to protect the environment, including the Clean Water Act and both federal and Draft Makah water quality criteria.
Reduction of Toxicity, Mobility, or Volume Through Treatment	No reduction of toxicity, mobility or volume through treatment.
Short-Term Effectiveness	
Risks to Community	• Low risk to the community during remediation from hazards from imported construction materials.
Risks to On-Site Workers	Low to moderate risk to workers and traffic-related hazards. These risks increase with the volume of materials (currently estimated at 28,000 cy) subject to handling.
Risks to Environment	• Construction within floodplains and riparian areas; • Some unavoidable temporary disruption of habitat would occur; • Contaminated and uncontaminated sediment loads from runoff and erosion are expected to increase during construction; and • Existing vegetation may be disturbed or destroyed.
Implementability	Cover Concept 2 is considered technically feasible.
Uncertainties	Uncertainties include: the depth and extent of the waste in the removal areas of the waste, the depth and composition of the wastes along the perimeter of the site.
Challenges	Challenges include slope stability of existing waste.
Administrative Requirements	• A cultural resources consultation (National Historic Preservation Act). • Coordination with natural resource agencies (Fish and Wildlife Coordination Act).
Off-Site Treatment, Storage, and Disposal of Waste	Off-site treatment, storage and disposal of waste not required.

In summary, Alternative Concept 2, the Ravine Option, would also meet the threshold criterion of overall protection of the environment.

4.2.5 Estimate of Probable Costs

Cost estimates for Alternative Cover Concept 2 were developed using 2003 dollars, 30 years of O&M and a discount factor of 5 percent. Initial capital costs include 20 percent for contingencies and 5 percent for engineering prior to construction, construction management, inspection, and verification sampling. A current estimate of probable costs for implementing the Ravine Option is presented in Table 9.

Table 9. Estimate of Probable Cost of Alternative Cover Concept 2 – The Ravine Option

Cost Element	Estimate of Probable Cost
General Requirements (11.25%)	$71,000
Site Work	$38,200
Waste Material Handling	$362,200
Dump Closure	$190,200
Site Rehabilitation	$21,500
Total Construction	$684,600
Contingencies (20%)	$136,900
Engineering, Project Inspection Clean-up Verification (15%)	$123,200
TOTAL PROJECT COSTS	$944,700
Estimated Annual O&M	$20,300
30 years O&M	$312,600
TOTAL LIFE CYCLE COSTS	$1,257,300

There is a great deal of uncertainty associated with this estimate, due to factors such as possible dewatering, undefined subsurface conditions, and unknown hazardous substances.

4.3 Summary of Option Evaluation

In summary, both options should effectively meet the objective of this project. Cover Concept 1, the Slope Option may require less material handling; but Cover Concept 2, the Ravine Option has a smaller resulting surface area for the cap. In addition, while the Slope Option has a slightly lower project cost, the costs for both options are within ten percent of each other. Table 10 compares the relative advantages and disadvantages of the two alternatives.

Table 10. Summary Comparison of Cover Alternatives

Alternative Cover Concept 1 – the Slope Option	
Advantages	***Disadvantages***
• Natural final configuration that fits well with surrounding topography • Less waste handling required (22,000 CY) • Less road construction • May be easier to construct (simply grading and compaction) • One drainage point for monitoring and control • Sideslope allows more lateral drainage (potentially less percolation) • Lower overall project costs	• Waste deposit less well-defined • With a larger area covered, the costs for the cover itself are higher • Less area available to Tribe for post-remedial use
Alternative Cover Concept 2 – the Ravine Option	
Advantages	***Disadvantages***
• Larger area remediated • Symmetrical, well-defined cap area • Two areas available to Tribe for post-remedial use • Smaller area capped; lower capping costs	• Requires more manipulation and reworking of waste (i.e., placing, grading, and compacting excavated waste inside closure instead of grading down the hill) • Anticipated higher total capital costs due to higher material handling costs • More road construction required, more drainage required • Flatter area available for percolation; may be offset my smaller cover area

5.0 SITE MONITORING AND MAINTENANCE REQUIREMENTS

Post-closure monitoring and maintenance requirements are anticipated for a minimum of 5 years following construction. Table 11 includes a summary of anticipated post-closure monitoring and maintenance components:

Table 11. Summary of Post-Closure Monitoring and Maintenance Requirements

Project Component	Frequency	Monitor Requirement	O&M Requirements
Stream Rehabilitation	Annual Inspection	• In-stream habitat assessment • Channel banks for erosion/repair • Culvert inspection • Channel migration	• NA • Erosion repair, channel clearing • Clearing of debris, sediment
Waste Containment	Annual Inspection	Erosion/cover condition	Erosion repair, minor fill, reseeding as necessary
	Semi-Annual Inspection	• Run-on control system – debris, erosion & function • Survey markers to assess settlement	• Clear debris, repair riprap • NA
Surface & Ground Water	Quarterly	Sample & analyses to assess effectiveness of closure	NA unless successive samples over a year show substantive residual contaminants
Landfill Gas	Monthly	Sample air at passive gas vents & analyze for methane	• If landfill gas exceeds LEL, additional measures may be required • If no methane is detected over a year, vents can be decommissioned
Percolation System	Monthly for first 2 years, then quarterly	• Assess percolation flow rates from containment • Sample outlet to assess requirements for treatment	NA
Site Rehabilitation	Semi-annual Inspection	Reclaimed slopes and graded areas for erosion and for degree of vegetative cover provided	Erosion repair, minor fill, reseeding as necessary
	Quarterly	Photo-monitoring from selected locations to assess recovery over time	NA
	Monthly	Verify integrity of site access control and that no further unauthorized disposal occurs at the site	If evidence of illegal dumping, step up education and enforcement efforts; improve access control
NA = not applicable			

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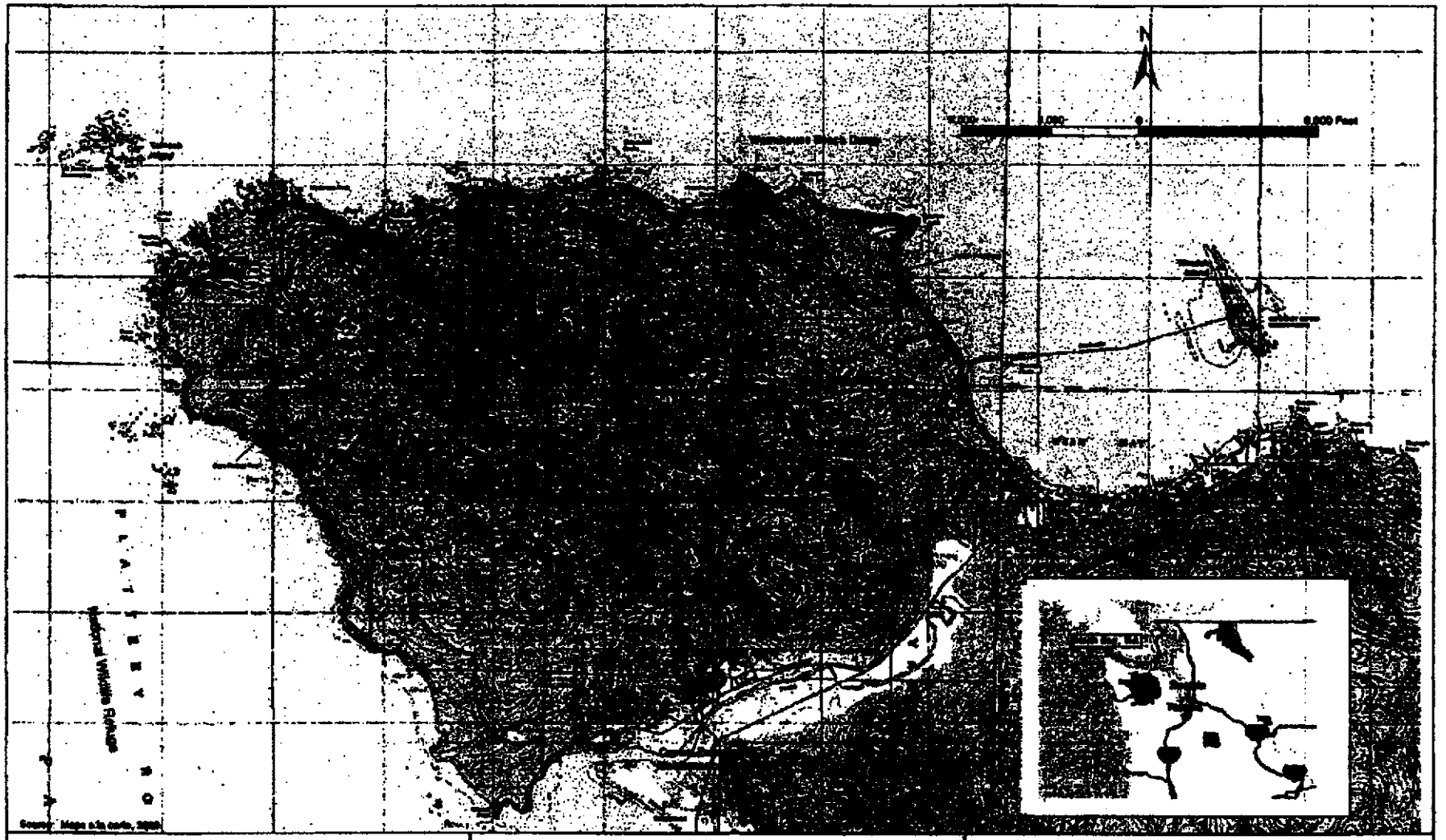
FIGURES

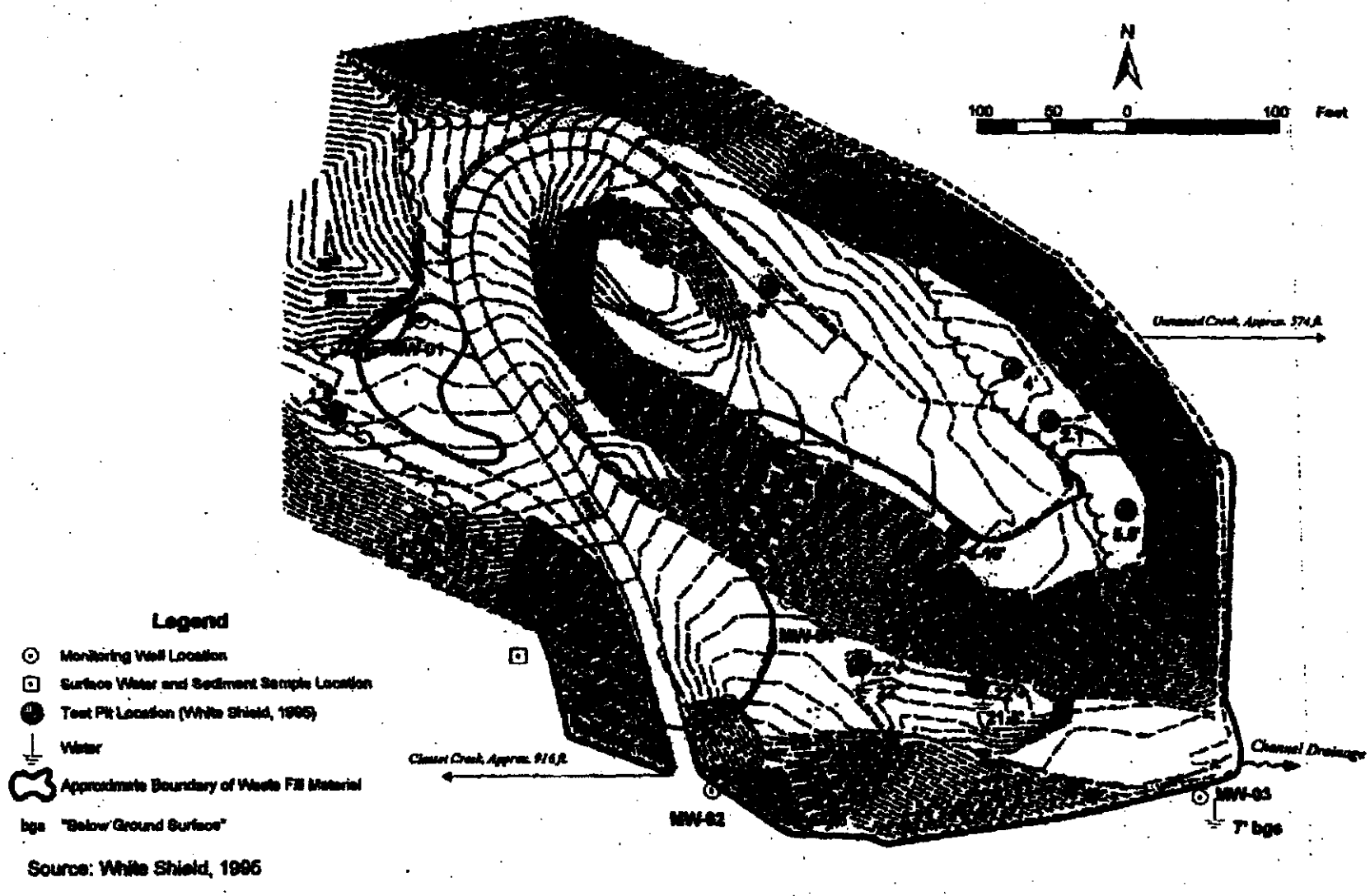


RIDOLFI Inc.

Makah Tribal Council
Warmhouse Beach Dump Closure Plan

Figure 1

Location Map

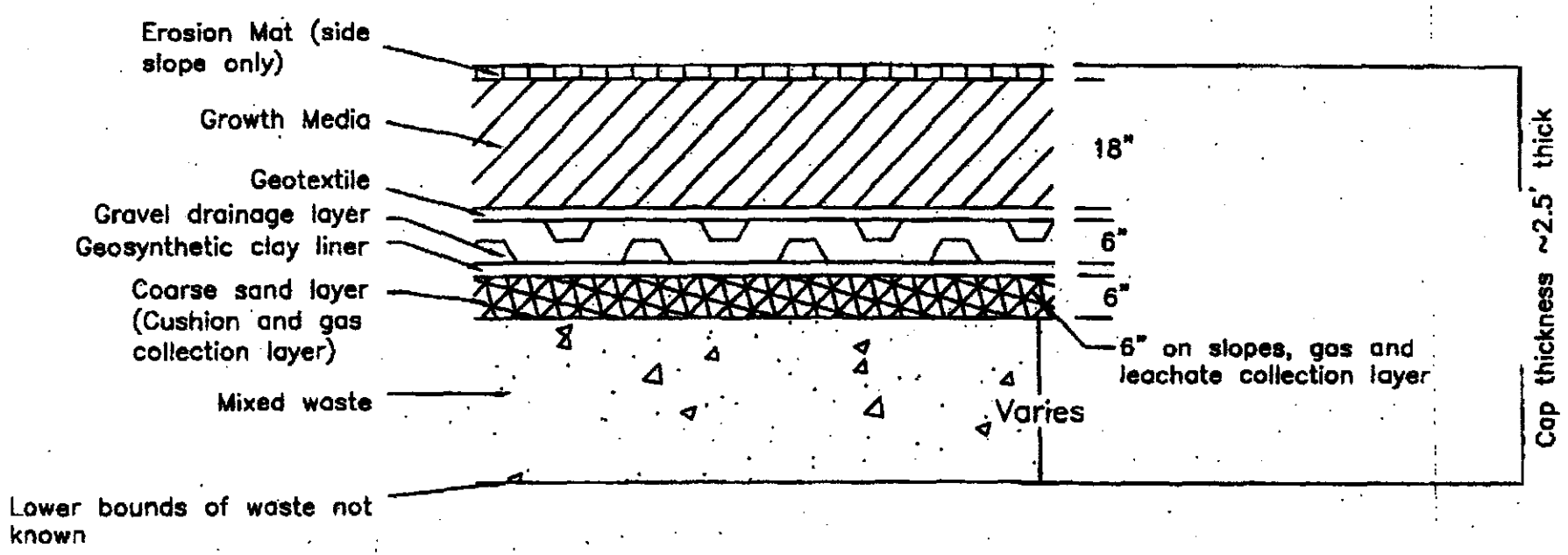


RIDOLFI Inc.

Makah Tribal Council
Warmhouse Beach Dump Closure Plan

Figure 2

Existing Site Conditions



Cover Sequence
Scale 1" = 2'

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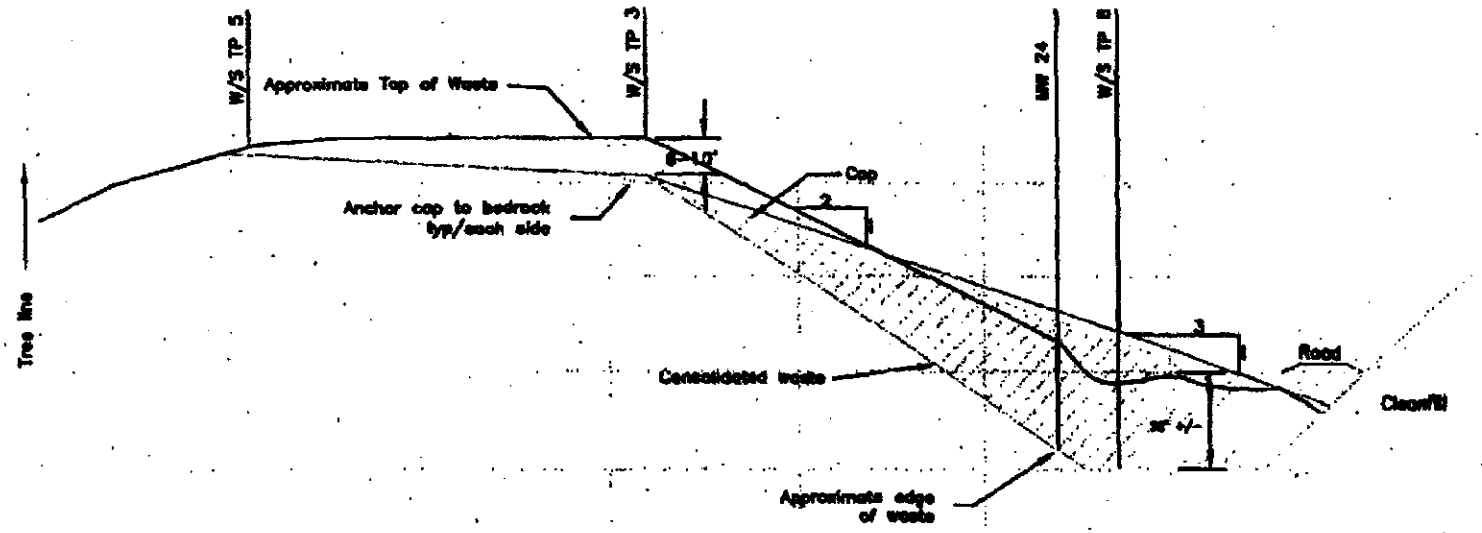
Makah Tribal Council
Warmhouse Beach Dump Closure Plan

Figure 3
Typical Cover Cross-Section

RIDOLFI Inc.	Makah Tribal Council Warehouse Beach Dump Closure Plan	Figure 4 Final Grading Plan Alternative Cover Concept & The Slope Option



Horizontal and Vertical Scale
1"=50'

RIDOLFI Inc.	Makah Tribal Council Warmhouse Beach Dump Closure Plan	Figure 5 Typical Cross-Section for Alt Cover Concept 1 The Slope Option

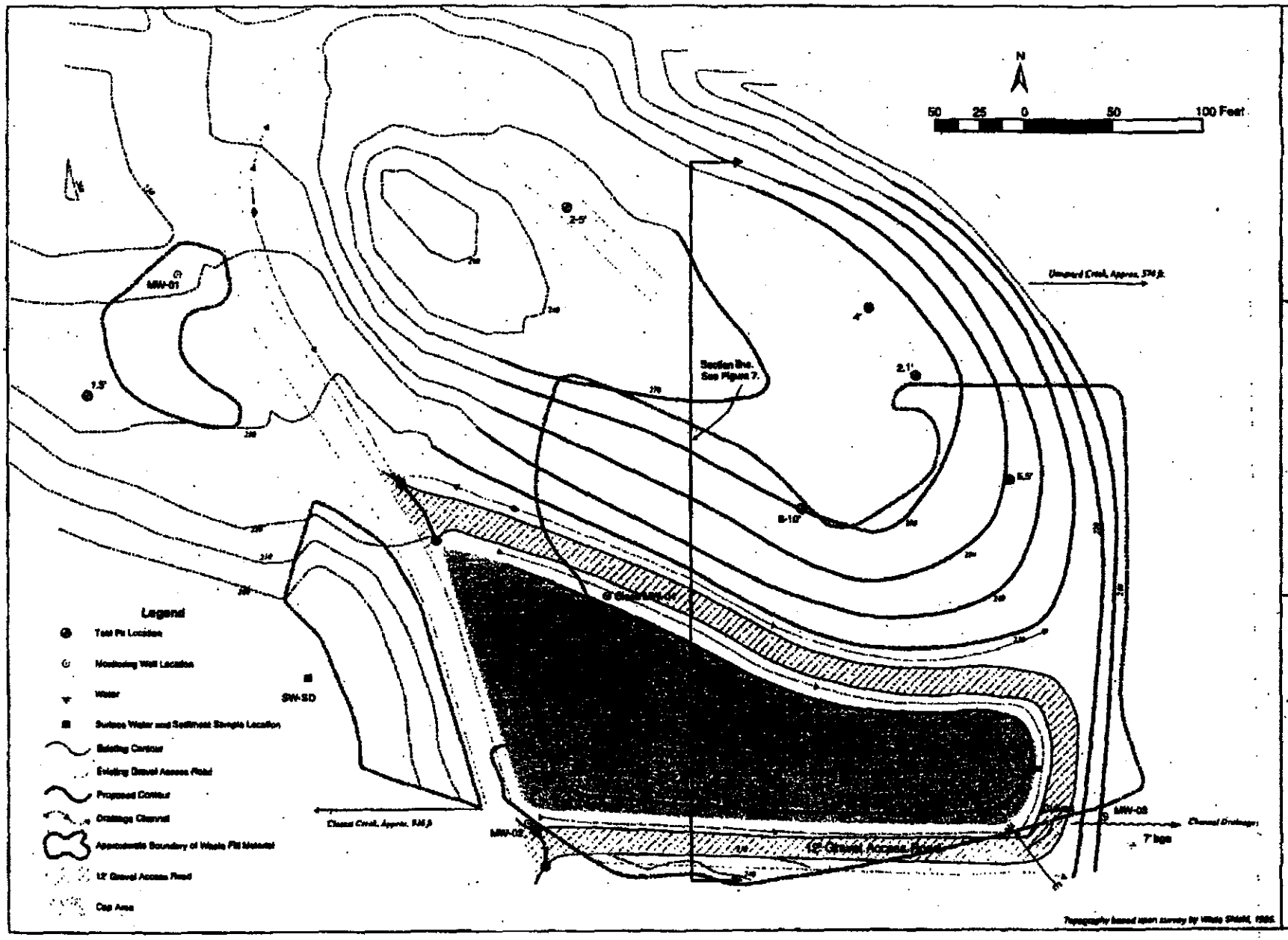
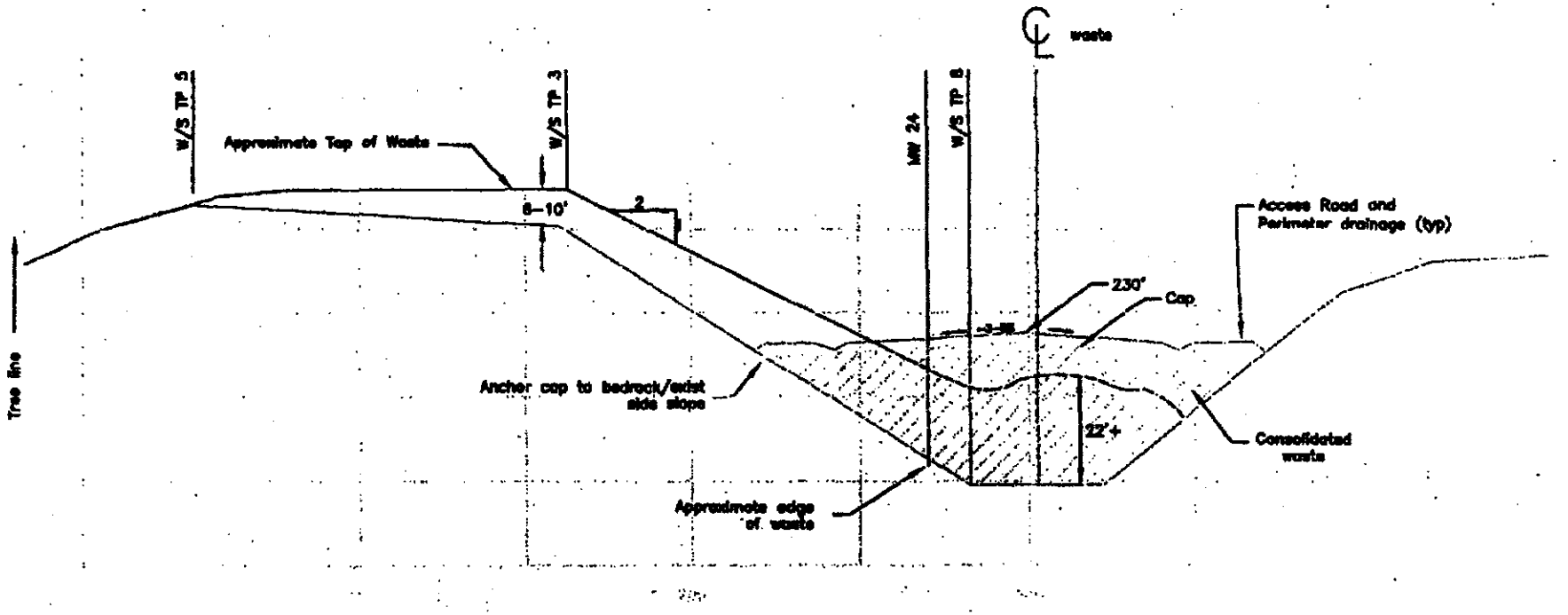


Figure 6

Final Grading Plan
Alternative Cover Concept 2
The Ravine Option

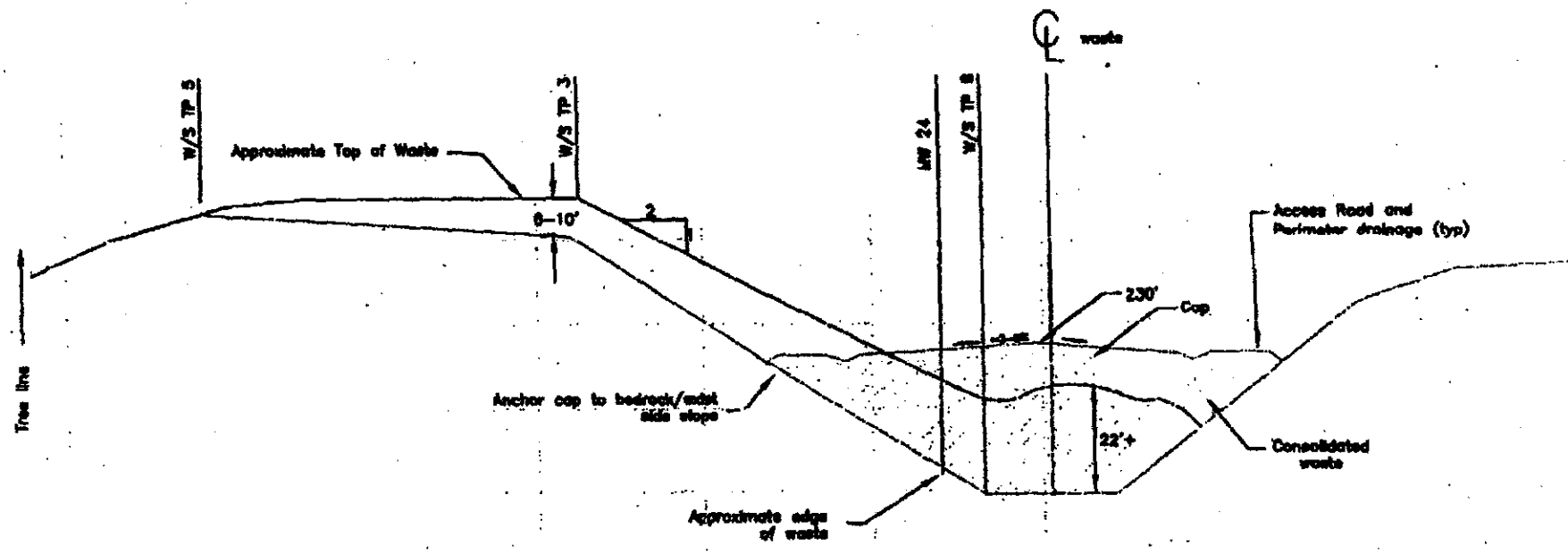
Makah Tribal Council
Warehouse Beach Dump Closure Plan

RIDOLFI Inc.



Horizontal and Vertical Scale
1"=50'

RIDOLFI Inc.	Makah Tribal Council Warmhouse Beach Dump Closure Plan	Figure 7 Typical Cross-Section for Alt Cover Concept 2 The Ravine Option



Horizontal and Vertical Scale
1"=50'

RIDOLFI Inc.	Makah Tribal Council Warmhouse Beach Dump Closure Plan	Figure 7 Typical Cross–Section for Alt Cover Concept 2 The Ravine Option