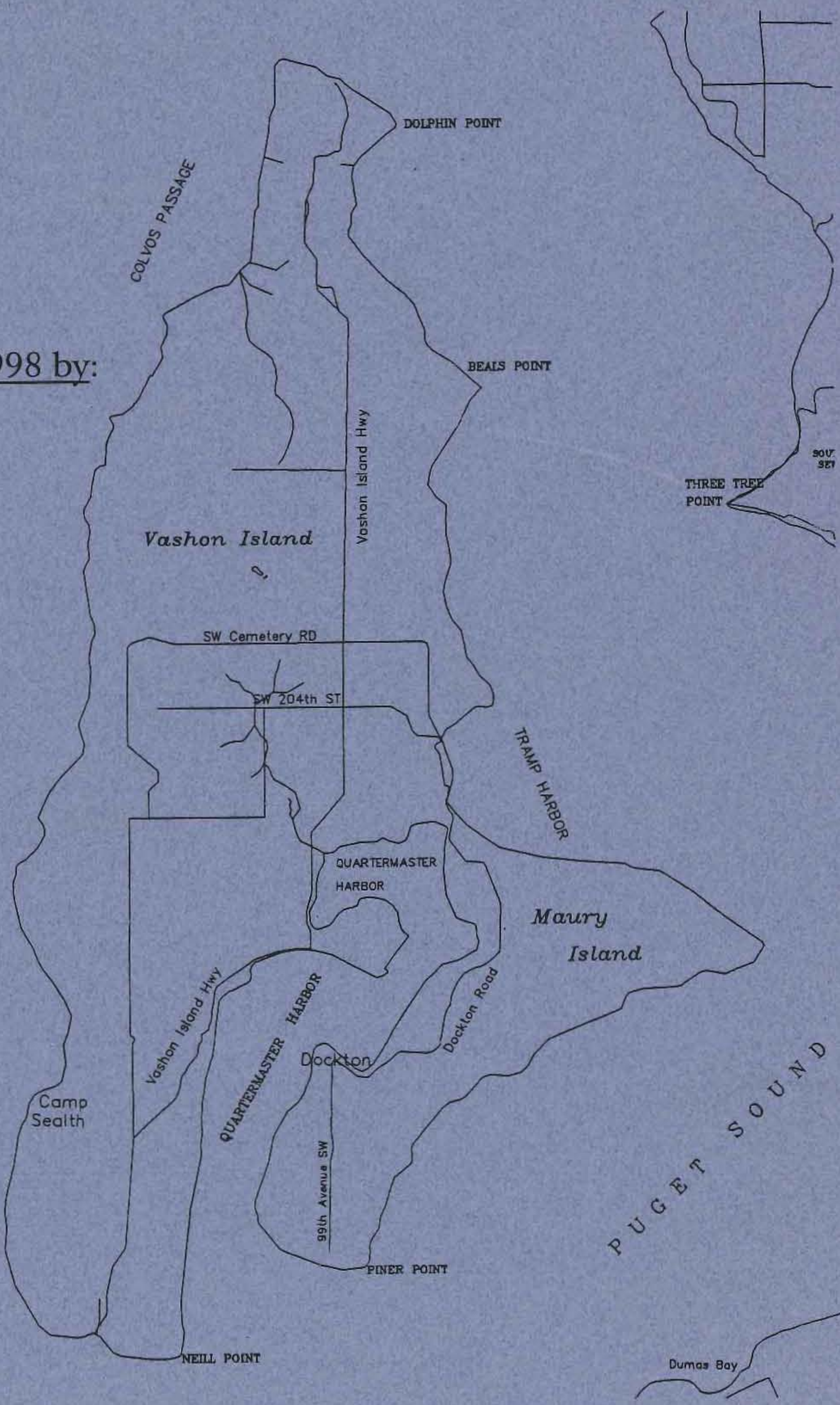
Vashon-Maury Island
Ground Water Management Plan

Final

Submitted December, 1998 by:
Vashon - Maury Island
Ground Water
Advisory Committee

Vashon-Maury Island
Ground Water
Advisory Committee



Vashon-Maury Island
Ground Water Management Plan:

Management Strategies

December 1998
Final

Data and information contained in this document are current as of the period of project performance: 1989 - 1995.

Submitted by:

Vashon-Maury Island Ground Water Management Committee

King County Department of Natural Resources
Water and Land Resources Division
Suite 2200
700 Fifth Avenue
Seattle, WA 98104
(206) 296-6519

Seattle-King County Department of Public Health
Environmental Health Division
Suite 700
999 Third Avenue
Seattle, WA 98104
(206) 296-4722

Funded in part by the Washington Department of Ecology Centennial Clean Water Fund.

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Table of Contents

Vashon-Maury Island
Ground Water Management Plan

December 1998

Table of Contents

Table of Contents
(continued)

Tables

Appendices

Supplement: Area Characterization

(Published Separately)

Executive Summary

Vashon-Maury Island Ground Water Management Plan

December 1998

Executive Summary

Overview

The Vashon-Maury Island Ground Water Management Area is a thirty seven square mile area located in the southern end of Puget Sound. The Island is bordered on the west by Colvos Passage from the Kitsap Peninsula, on the south by Dalco Passage from Tacoma, on the east by Puget Sound and King County, and on the north by Puget Sound. Low density residential development covers much of the Island with zoning of one home per five and ten acres. Higher density residential areas are concentrated in the Vashon Town Center, Vashon Heights, Burton, Dockton, and along parts of the shoreline. Multifamily, commercial and industrial uses are presently concentrated in the unincorporated town of Vashon and adjacent areas where sewer and other urban services are available.

The Vashon-Maury Island Ground Water Management Area was designated a Sole Source Aquifer by the United States Environmental Protection Agency in June, 1994 because Island ground and surface water provides all of the water needed for residential, commercial and agricultural needs. All water used on Vashon-Maury Island comes from precipitation that falls on the Island.

Seven Group A public water systems, ninety eight Group B public water systems, and an estimated 3,000 individual water systems rely on the Island's ground water. Approximately sixty nine percent of the Group A water systems and an estimated fifty to seventy five percent of Group B and individual wells draw water that is 25 feet or less below the surface of the ground.

The Vashon-Maury Island Ground Water Advisory Committee developed this Plan. They were appointed by the Department of Ecology and will be submitting the Plan to the State for certification. The Ground Water Advisory Committee met over a ten year period and consisted of representatives from many different groups that manage, develop, or rely on ground water in the area.

The Vashon-Maury Island Ground Water Management Plan contains a statement of purpose, introduction, recommended ground water management strategies, and a recommended implementation process. The supplement to the plan contains the area characterization, background for each issue addressed by the proposed management strategies, references, and appendices.

Ground Water Quality and Quantity Issues

Ground water provides the Island's primary water supply. Drinking water in the Vashon-Maury Island Ground Water Management Area is provided by ground water sources and creeks that augment supply for some purveyors and individual systems. A two-part aquifer system (shallow and deep) was identified in 1983. Most of the Island wells withdraw water from the shallow aquifer. The deep aquifer is about 400 feet deep or more. Water District Number 19's well draws from this deep aquifer. This simplified two aquifer system has now been defined in more detail to include four water bearing zones distributed throughout the Island. Although they are portrayed as separate units, the aquifer configuration is actually more complex and several of the water bearing zones are likely interconnected. Passage of water down through these zones allows potential contamination to travel from the susceptible near surface zones to successively deeper zones.

Wells that draw water from shallow aquifer zones are most vulnerable to contamination from land use activities. The vulnerability and susceptibility of shallow ground water is evident from the increased nitrate concentrations from 0.5 milligrams per liter (mg/l) in mid-1980's to 3.2 mg/l in 1994 occurring in the Burton Water Company well and from leachate derived contamination of both shallow and deep aquifers in the vicinity of the Vashon landfill. Because of the vulnerability of the shallow aquifer to contamination and the dependence of Island residents on shallow ground water for potable supply, the Vashon Ground Water Advisory Committee adopted the following two fundamental principles:

- On Vashon the quantity and quality of ground water is inextricably tied to the quantity and quality of surface water. Adequate protection of ground water requires protecting surface water supplies as well.
- Current Island residents have invested in drilling wells and obtaining water supplies. They should not be forced to drill deep wells, at a substantial cost, in order to continue using the same amount of water. It is not acceptable to allow the Island's population to increase to the point where current residents lose their existing water supplies due to contamination or overuse.

Water quality on Vashon-Maury Island is also threatened by seawater intrusion occurring along the coast. When ground water is pumped from aquifers that are in hydraulic continuity with Puget Sound, seawater may flow toward the well resulting in elevated levels of chloride. Wells with elevated chloride levels were identified in 1983 on the northern end of Vashon Island and the southeastern section of Maury Island. Wells monitored along the coastline in 1989 and 1990 as part of this Plan showed no evidence of seawater intrusion. However, a well with seawater intrusion in the northeast area (near Glen Acres) of Vashon was closed in 1993.

Extensive mapping of physically susceptible and recharge areas has been performed as part of this ground water planning process. The areas ranked as highly susceptible to ground water contamination indicate areas where the potential for contamination resulting from specific land management practices is high due to the permeability of the overlying soil, surficial geologic materials, and a shallow depth to ground water. Some management strategies identified in this Plan, as well as resource protection and land use policies in the King County Comprehensive Plan and Vashon-Maury Island Community

Plan, are applicable in these highly susceptible areas. Therefore, the Ground Water Advisory Committee adopted the following two fundamental principles:

- Enforcement of existing laws is essential to protect water resources. Adequate funding must be provided for enforcement.
- The 1986 Vashon Community Plan included many policies to protect water resources. The need for those policies has not changed. They should be fully implemented.

Land use activities affect both recharge and demand for water. Decrease in ground water recharge can be caused by development (by paving and building over high recharge areas and by loss of forested lands in areas with steep topography). In addition, continued suburbanization of Vashon-Maury Island will require greater volumes of ground water to be withdrawn from the aquifer system. Because the Island aquifer and surface water systems provide the only sources of water, and the maintenance of stable ground water levels could be affected by new development, management and land use strategies are proposed in this Plan to assist in preserving ground water quantity.

Vashon Island's population, development, and its related groundwater impacts have been increasing. The population has grown from 7,400 in 1970 to an estimated 10,200 in 1994. King County's population target for the Vashon rural area is an increase of only 720 to 1,200 persons (300 - 500 households) by 2012 for a total population between 10,930 and 11,400 persons. However, existing zoning would allow approximately 20,000 total residents. An analysis prepared when developing the Vashon Community Plan determined that the ground water available for consumption is approximately 930 acre-feet per year. It was estimated that this ground water supply could support an island population of between 10,900 to 13,200 people without significant impacts to surface or ground water resources. The technical analysis prepared for this Ground Water Management Plan estimates total ground water for the Island at 12,895 acre-feet per year, but made no attempt to estimate a maximum population that the Island's ground water resources could support. However, the authors of this higher estimate have stated that only a fraction of the water is available for consumption, this estimate of water does not necessarily support a higher population figure than that estimated in 1983, and that if too much water is withdrawn, the effects will be seen at the surface in the form of lower stream flows, lower water table, and increased potential for seawater intrusion. Therefore, they recommended that both the 1983 and the 1990 estimates of water availability should be taken together to form a set of boundaries for water resource management policy development. Interconnected water-bearing zones and other parameters such as rainfall and infiltration estimates account for the difference in estimated ground water resources.

Ground Water Management Plan Goals

The underlying goal for the development of this Plan is to manage the ground water resources of King County to optimize current and long-term benefits for present and future residents. To achieve this goal, a broad range of strategies are proposed in the plan. Eighteen specific goals intended to provide direction for programs that protect ground water quality and quantity are divided into three categories.

Goals Related to Both Ground Water Quantity and Quality: Four goals are proposed that would protect ground water resources by using special area designations, developing a data collection and management program, infiltrating storm water, increasing educational efforts for the citizens and local officials of the management area, and implementing land use measures.

Goals Related to Ground Water Quality: Water quality in the Vashon-Maury Island Ground Water Management Area is generally excellent. The emphasis of this proposed plan is on strategies and programs to protect existing water quality. Thirteen goals are proposed that address hazardous materials management, infrastructure (e.g., sewage treatment, underground storage tanks, and landfills), pesticides, and sand and gravel mining to prevent ground water contamination.

Goal Related to Ground Water Quantity: The overriding goal of the plan is to manage the quantity of ground water resources of Vashon-Maury Island for present and future residents. This goal is addressed through a combination of conservation, education, long term monitoring and data collection program and land use measures.

Recommendations

The Vashon-Maury Island Ground Water Management Plan provides a description of the ground water resources, identifies potential threats to long term water quality and quantity, recommends management strategies for protection, and suggests funding methods for implementation. After careful study and deliberation about the possible and effective ground water protection measures, the Vashon-Maury Island Ground Water Advisory Committee adopted approximately 53 management strategies.

Management strategies that have been prioritized as "high" address the vulnerability of the Vashon-Maury Island aquifer system and it's importance as primary supply of potable water. These strategies include:

- Applying land use controls to prevent overuse or contamination, including applying one residential unit per ten acre zoning in areas highly susceptible to contamination (consistent with the King County Comprehensive Plan R-205A);
- Incorporating an assessment of water quality impacts from specific land uses in a "Guidance for Environmental Reviewers," especially in areas that are determined to be highly susceptible to ground water contamination, or in high recharge areas;
- Developing basic strategies that King County could implement to assist purveyors in their well head protection efforts;
- Implementing a seawater intrusion program;

- Monitoring trigger levels of certain parameters to help in assessing land use impacts on ground water;
- Assessing development's potential impact to recharge areas or infiltration potential during environmental review. Also, an analysis of aquifer capacity and associated surface water and ground water interaction should be performed, if water rights application is part of the development proposal;
- Requesting King County to enforce and implement adopted resource and land use policies applicable to Vashon-Maury Island; and,
- Adding to existing educational efforts for citizens and local governments.

Implementation

The Vashon-Maury Island Ground Water Management Plan is intended to provide a framework to assist cooperation between regulatory agencies through implementation of the adopted management strategies. The management plan recommends forming a management committee for ground water protection activities in the planning area. The Representation on the Vashon-Maury Island Management Committee would consist of the King County Department of Natural Resources, a private citizen, water purveyor, and four members of the current Ground Water Advisory Committee.

The key task for implementing agencies is to develop programs, projects, budgets, and regulations consistent with this plan. Implementing agencies with the most responsibility include: King County Department of Natural Resources, Seattle-King County Department of Public Health, Water District Number 19, and the State Department of Ecology.

Funding

A major source of long term funding must be developed to implement the ground water management plan. The Ground Water Advisory Committee recommends that the Metropolitan King County Council authorize a ballot measure to create an Aquifer Protection Area to provide funding for the implementation of the plan (Chapter 36.36 RCW). The ballot measure must specifically state the programs that would be implemented and time frame in which they would be completed. If voters approve the Aquifer Protection Area, the County can collect monthly ground water and septic system user fees. These funds must be used only for Vashon-Maury Island Ground Water Management Area activities. The Ground Water Advisory Committee has adopted the following two principles to guide the eventual implementation of the Aquifer Protection Area.

- When the local community chooses to tax itself to protect its water resources, the local community should set the priorities and manage the expenditure of those tax dollars, rather than turning the money over to a regional government that is not as accessible or as knowledgeable about local circumstances.

- When the local community chooses to tax itself to pay for additional protection of its water resources, the money raised should not be used to pay for governmental functions that are typically supported by general funds, such as the enactment of legislation, or that are already the responsibility of governmental bodies, such as the enforcement of existing laws.

In its review of the Management Plan, the Metropolitan King County Council has deferred creation of an Aquifer Protection Area until other funding options have been adequately considered.

The programs identified in this plan will have substantial public costs. The Ground Water Advisory Committee prioritized the programs into high, medium and low categories in part because of anticipated funding limitations. Based on preliminary estimates, implementing the high priority projects would cost approximately $460,000; the medium priority $27,000; and the low priority $789,000.

Acknowledgments

Vashon-Maury Island
Ground Water Management Plan

December 1998

Acknowledgments

The Vashon-Maury Island Ground Water Advisory Committee was formed in 1988 and met regularly throughout the planning process. The Committee's role was to develop the plan according to the state regulations, and to provide their represented agency's perspective during the development. The input provided by the Committee was the foundation for the Plan.

This Plan has been produced by the Vashon-Maury Island Ground Water Advisory Committee, in conjunction with: the Seattle-King County Health Department; the King County Department of Natural Resources, Water and Land Resources Division; and the Department of Ecology. The King County Department of Development and Environmental Services, King County Council Staff, and the King Conservation District also contributed information or staff.

The Seattle-King County Health Department's Environmental Health Division initiated the ground water planning process. Under direction and support from Charles Kleeburg, then Chief of the Division, William J. Lasby committed to undertaking this complex and lengthy task. Mr. Lasby directed the development of the Plan from 1987 through 1995, and is recognized for his dedication and leadership. Also, the professional and volunteer staff of the Seattle-King County Health Department ground water program are recognized for their perseverance through the many unanticipated setbacks and demands of ground water program development.

The Plan was prepared with the assistance of the consulting team of Geraghty and Miller, Inc. with Ecochem Inc., URS, and Okanogan/Tacoma Pump and Drilling. The Ground Water Advisory Committee and King County staff would like to thank the numerous other organizations and citizens who contributed during the course of the development of this plan.

Ground Water Advisory Committee

Membership	Representing
Rick Ames	Vashon Sewer District
Dan Chasan, Chair	Citizen Advisory Committee for Vashon
Ken Fulton	Water District #19
Jim Garrison	Burton Water Company
Laurie Geissinger, Vice Chair	Environmental Planner
Mark Isaacson	King County Department of Natural Resources
Frank Jackson	Citizen
Bob James	Washington State Department of Health
Laura Lowe	Washington State Department of Ecology
W.M. "Luke" Lukoskie	Island Spring Inc.
Lawrence Niece	L.H. Niece & Co.
Stephanie Warden	King County Council Staff (former)

Contributing Agencies

King County

Executive
Ron Sims

Metropolitan King County Council

Maggi Fimia	District 1
Cynthia Sullivan	District 2
Louise Miller	District 3
Larry Phillips	District 4
Dwight Petz	District 5
Rob McKenna	District 6
Pete von Reichbauer	District 7
Greg Nickels	District 8
Kent Pullen	District 9
Larry Gossett	District 10
Jane Hague	District 11
Brian Derdowski	District 12
Christopher Vance	District 13

Seattle-King County Health Department
Dr. Alonzo Plough, Health Officer
Carl Osaki, Chief, Environmental Health Section
Trudy Rolla, Supervisor, Drinking Water Program

King County Department of Natural Resources
Pam Bissonnette, Director
Nancy Hansen, Manager, Water and Land Resources Division
Debbie Arima, Assistant Manager, Water and Land Resources Division
Bill Eckel, Manager, Regional Water Resources Services Unit

Ground Water Program Interdepartmental Team
Mark Isaacson, Project Manager
Lisa Dally Wilson, Hydrogeologist
Sean Groom, Research Assistant
Kathryn Morrill, Program Analyst
Trudy C. Rolla, Senior Environmental Health Specialist
Paul Shallow, Senior Environmental Health Specialist
Ken Johnson, Ground Water Program Lead
Ella Raczkowski, Program Analyst

Contributing Staff & Former Ground Water Advisory Committee Members

Charlotte Anderson	The Beachcomber Newspaper
Jay Becker	The Beachcomber Newspaper
Peggy Bailey	Citizen
Dick Bain*	Citizen Advisory Committee for Vashon
Kathie Balcom	Citizen
Jerry Balcom*	Maury Mutual Water Association
Brent Barnett	Washington State Department of Ecology
Moe Batra	Washington State Department of Health
Carol Baxter	Citizen
Ben Binuya	King County Water District #19
Robert Blomgren	Citizen
Derek Booth	King County Surface Water Management
Becky Braicks	Citizen
Fran Brooks	Citizen
John Browne	Citizen
Bob Bruce	King County Council Staff
Lisa Burden	Administrative Specialist
Kendall Campbell	Citizen
Gordon Clemans	Citizen
Nancy Darling	Washington State Department of Ecology
Steve Deem	Washington State Department of Health
Dan Dittrich	Farmer
Enid Dolstad	League of Women Voters
Jack Dolstad	Westside Water Association (Deceased)
Ken Duncan	Heights Water District
Dave Feltman	King County Parks, Planning and Resources
Steve Fischnaller	Environmental Health Specialist
Reed Fitzpatrick	Heights Water District
Rollie Freiberg	Well Driller
Jeanette Gifford	Citizen
C.W. Gloger	Washington State Department of Natural Resources
Larry Goldstein*	Washington State Department of Ecology
Tony Gomez	Seattle-King County Health Department
Rick Hoasch	Citizen
Shirley Jurgensen	King County Solid Waste Division
Susie Kalhorn	Citizen
Holly Kean	King County Council Staff
Kevin Kiernan	King County Solid Waste Division
Donna Klemka	Private Well User
John Komorita	King County Solid Waste Division
Jim Kramer	Manager, Surface Water Management Division (former)
Bob Krimmel	Citizen

William J. Lasby	Supervisor, Drinking Water Program (former)
Caroline Leachtenauer*	King County Council Staff
Matt Mask	Citizen
David Masters	King County Parks, Planning and Resources
Sandy Mathis	Citizen
John May	Citizen
Bruce McLean	Environmental Health Specialist
Bill Miller	Washington State Department of Ecology
Bruce Monell*	Department of Natural Resources
Don Nyberg	K-2 Corporation
Keith Oratz	King County Council Staff
Jon Pace	Washington State Department of Ecology
Dave Peeler	Washington State Department of Ecology
Karen Perla	Citizen
Ray Phaneuf	Heights Water District
Elizabeth Phinney	Department of Ecology
Dave Pierce	Washington State Department of Natural Resources
Walter Pine	Vashon Sewer District
Marcie Plancich	Dockton Water Association
Richard Rodrigues	King County Building and Land Development
Monica Roppo	Seattle-King County Health Department
Michael Rundlett	Washington State Department of Ecology
Charles Saul	Maury Mutual Water Association
Robert Seibold	Colvos Design
Katherine Shedd	Citizen
Rick Siffert	Washington State Department of Health
Cha Smith	Washington Toxics Coalition
Dom Spano	Gold Beach Water Co.
Ginny Stern	Washington State Department of Health
Dayle Ann Stratton	Washington State Department of Health
Bonnie Shride	League of Women Voters
Mary Swanson	Citizen
Bill Tobin	Citizen
Igor Vern	Washington State Department of Ecology
Myrtle Walls	Grange
Don Wejceichowski	K-2 Corporation (deceased)
Roy Wilkerson	King County Water District #19 (retired)
Floyd Williams	K-2 Corporation

* Denotes alternate

Statement of Purpose

Vashon-Maury Island
Ground Water Management Plan

December 1998

Statement of Purpose

The people who live on Vashon Island have good reason to protect their ground water because:

- Vashon is a sole-source aquifer.
- The Vashon Community Plan states unequivocally that "all land use policies and regulations for Vashon shall reflect the overriding importance of the fact that the whole island is the recharge area for a sole-source aquifer. All of Vashon Island shall therefore be considered a ground water recharge area."
- Vashon's aquifer, the primary source of drinking water on the island, is a valuable resource that the current generation has a trust responsibility to preserve for posterity.
- Pollution of ground water is difficult and costly to arrest and almost impossible to reverse once it has begun.

For all those reasons, the Vashon Ground Water Advisory Committee decided at the outset that its goal is: *to manage the ground water resources of King County to optimize current and long-term benefits for present and future residents.* To achieve that goal we ask King County to: **adopt a non-degradation policy for Vashon**. The Ground Water Advisory Committee also set forth guiding principles for implementation of this Plan, which include:

1. On Vashon the quantity and quality of ground water is inextricably tied to the quantity and quality of surface water. Adequate protection of ground water requires protecting surface water supplies as well.

2. Current Island residents have invested in drilling wells and obtaining water supplies. They should not be forced to drill deep wells, at a substantial cost, in order to continue using the same amount of water. It is not acceptable to allow the Island's population to increase to the point where current residents lose their existing water supplies.

3. Use of ground water resources should not result in the loss of Island habitat. Withdrawal of water from the Island's aquifer should maintain sufficient base flows to support the streams and wetland ecology.

4. Enforcement of existing laws is essential to protect water resources. Adequate funding must be provided for enforcement.

5. The 1986 Vashon Community Plan included many policies to protect water resources. The need for those policies has not changed. They should be fully implemented.

6. When the local community chooses to tax itself to protect its water resources, the local community should set the priorities and manage the expenditure of those tax

dollars, rather than turning the money over to a regional government that is not as accessible, as responsive, or as knowledgeable about local circumstances.

7. When a local community chooses to tax itself to pay for additional protection of its water resources, the money raised should not be used to pay for governmental functions that are typically supported by general funds, such as the enactment of legislation, or that are already the responsibility of governmental bodies, such as the enforcement of existing laws.

Once a ground water source is contaminated, it may be lost forever and the cost of protecting ground water from contamination is considerably less than the cost of remedial action. Therefore, a major focus of the Ground Water Management Plan is on prevention with strategies that include:

- Educational programs in the schools;
- Educational placards displayed wherever herbicides, pesticides, motor oil, or any chemicals which may enter the surface or ground water (e.g., drain cleaners and laundry detergent) is sold;
- Educational material displayed in libraries and other public places; and,
- Land use measures to prevent overuse and contamination.

However, prevention will not totally protect the ground water resource. Therefore, an early warning system to alert the community and political institutions to any significant increase in pollution is needed. This early warning system must consist of both monitoring and a mechanism for quick response. The monitoring shall continue and build on the data accumulated under the original Vashon Ground Water Management grant. If it reveals that any significant pollution has reached a threshold level, the Management Committee will have six months to recommend action to the Metropolitan King County Council. Threshold levels for significant pollutants may include:

1. For any substance that is carcinogenic, mutagenic or teratogenic, and has not previously been detected in Vashon ground water: any detectable level that is confirmed by repeated (at least two samples at least two weeks apart) monitoring.

2. For any substance that is carcinogenic, mutagenic or teratogenic and has previously been detected at background levels: 10 percent of Washington state's ground water limit.

3. For any primary pollutant (a potential risk to public health, except fecal coliform) that has not previously been detected in Vashon ground water: any detectable level that is confirmed by repeated (at least two samples at least two weeks apart) monitoring.

4. For fecal coliform, the trigger is any detection that is not corrected by disinfection procedures.

5. For any primary pollutant that has previously been detected at background levels: 20 percent of Washington State's ground water limit.

6. For any secondary pollutant (primarily of aesthetic concern, but not the probable result of seawater intrusion): 50 percent of Washington state's ground water limit except where naturally occurring levels are higher.

7. For any secondary pollutant that is the probable result of seawater intrusion: 10 percent of Washington state's ground water limit.

Priority Assessment of Issues

Evaluation and assessment of the Island's water resources led to a series of policy statements and recommendations for long-term planning and resource protection. The general priorities defined by the Ground Water Advisory Committee are discussed in Chapter 2, Management Strategies. The specific issues and recommendations are further prioritized based on criteria such as potential for ground water protection, community preferences, and funding mechanisms. The top priorities identified by the Ground Water Advisory Committee are:

- Establish the Ground Water Management Area as an aquifer protection area;
- Establish a data collection and management program for quality and quantity;
- Define trigger levels for indicator chemicals or contaminants;
- Establish a response mechanism for monitoring results that reach trigger levels defined in the Area Characterization;
- Provide public education to ensure the stewardship of the resource; and,
- Implement land use measures to prevent overuse and contamination.

At the request of the Metropolitan King County Council, the creation of an Aquifer Protection Area will be deferred until other options have been considered for appropriate funding sources.

Chapter One

Introduction

Vashon-Maury Island
Ground Water Management Plan

December 1998

Introduction

A Ground Water Management Plan for the Vashon-Maury Island Ground Water Management Area has been developed because (1) the ground water of the Island is a limited resource, vital to the future of the Island, the well being of its residents, and the vitality of our living natural resources; (2) ground water is not a separate body of water nor is it a separate environmental resource; (3) ground water needs to be protected and managed as a part of the entire hydrologic system, ecosystem, and economic system; and (4) the citizens and officials of King County are the stewards of the ground water resource, both for present and future generations. Therefore, it is essential that the ground water resource be protected from sources of contamination. Once a ground water source is contaminated, it may be lost forever and the cost of protecting ground water from contamination is considerably less than the cost of remedial action.

Today's generally good state of Island groundwater can be largely attributed to the 1986 *Vashon-Maury Island Community Plan*, which foresaw the importance of protecting our sole source aquifer a decade ago, brought public attention to the issue, and established appropriate land uses and policies. This Ground Water Management Plan requires continuation of the Vashon Plan policies, particularly in regard to land use, in order to withstand ever greater pressure on the resource in the upcoming decade and beyond.

Water quantity problems on the Island loom large. In the fall of 1994 four of seven major Island water purveyors were experiencing water shortages (Water District 19, Heights, Burton and Westside) as they have frequently in recent years. While there may be other options in the form of deeper wells or further stream flow reductions, they are not considered solutions because they could lead to unsustainable water use and ultimately be detrimental to the Island's ecology. While this Plan deals strictly with human use issues, there remains the major issue of leaving an adequate water supply to maintain the overall ecology of the Island. The Ground Water Advisory Committee does not regard water that is not consumed by humans to be wasted, but rather regard it as the lifeblood of the soils, vegetation, streams and wetlands that support an abundance of natural life which Islanders deem important.

1.1 Ground Water Management Program Purpose and Scope

The purpose of the Washington State Department of Ecology's Ground Water Management Program is to foster the development and implementation of local ground water management plans. These plans represent a consensus on the most practical ground water protection measures to safeguard quality and ensure continued availability of this vital resource. The Vashon Ground Water Management Plan directs local and state agencies in developing regulations and programs to protect ground water.

The purpose of the Vashon-Maury Island Ground Water Management Plan is to provide a framework for cooperation between various agencies through implementation of the adopted ground water protection measures. It is also intended to serve as a guide to further focused research on the aquifers in addressing data and regulatory protection gaps.

1.2 Ground Water Management

In response to growing concern in Washington State about ground water resources, the state legislature passed Substitute House Bill 232 in 1985 (Chapter 90.44.400 RCW *Regulation of Public Ground Waters*). This legislation directed the Department of Ecology to:

- Identify specific locations in need of ground water management programs,
- Establish a program to provide financial assistance to these locations, and
- Develop guidelines for the implementation of local ground water management strategies.

Ecology responded by adopting regulations defining a ground water management area as an area that encloses one or more aquifers, and which exhibits a justifiable concern for the quality and/or quantity of the ground water (*Ground Water Management Areas and Programs* Chapter 173-100 WAC).

Ecology's ground water program establishes protocols and guidelines for developing a local ground water management plan. A ground water management plan is designed to protect ground water quality and assure ground water quantity for current and future uses. The guidelines establish a process that allows for ground water issues, concerns, and opportunities from all interested groups and agencies to be incorporated into the planning process. The process is designed so that a ground water management plan can be initiated and developed on the local level while being supported by state legislation and regulations. The ground water management program process also provides local government with a method to achieve comprehensive ground water protection goals.

On June 9, 1986, King County petitioned Ecology to designate the Vashon-Maury Island Ground Water Management Area as a ground water management area. The petition document outlined a number of ground water protection problems facing the area, including:

- Potential contamination sources threaten ground water quality, or ground water is susceptible to contamination,
- Major aquifers have the potential for over use based on projected future demands, and
- Aquifers where an approved coordinated water system plan has identified a need for a Ground Water Management Plan.

Ecology designated the Vashon-Maury Island Ground Water Management Area on October 7, 1986 and approved the membership of the Ground Water Advisory Committee, consisting of a broad cross section of interests with representatives from many groups. Ecology selected the Seattle-King County Health Department to be the lead agency because it has jurisdiction throughout the Vashon Ground Water Management Area and has a regulatory role in water systems, on-site sewage systems, and other environmental health concerns. On January 1, 1996, the Metropolitan King County Council assigned responsibility for the ground water program to the Department of Natural Resources, Surface Water Management Division.

1.3 Management Plan Process Goals and Objectives

The first step in developing a ground water management plan is to establish goals and objectives. The Ground Water Advisory Committee and the Seattle-King County Department of Public Health developed the following goal and objectives to help guide the process for development of the plans.

Goal To manage the ground water resources of King County to optimize current and long-term benefits for present and future residents.

Objectives

- Designate the Vashon-Maury Island Ground Water Management Area as a Ground Water Management Area, making it eligible for state grants designated for development of ground water management programs and plans.

- Develop a Ground Water Management Plan. This plan must:
  1. Be consistent with federal regulations, state ground water management laws and local ordinances.
  2. Include the public and local agencies participation in drafting, reviewing and modifying the plan.
  3. Include elements as described in WAC 173-100 *Ground Water Management Areas and Programs*. These include:

     a) A public involvement plan to educate and inform the public about ground water and the Ground Water Management Plan process. The public will be informed of the need to protect the ground water resource from contamination and overuse and will provide support to the public and private actions required to protect the resource.
     b) An area characterization section that includes mapping jurisdictional boundaries showing land and water use management authorities boundaries and goals; a description of the locale; the hydrogeology; the ground water quality; and the current ground water use and future needs.

c) Identification and description of threats to ground water; stating goals and objectives related to these threats; and recommending strategies that solve or reduce these threats. Technical understanding of the ground water resource will be developed to assist decision-makers in formulating public policy.
d) An implementation process for the plan, which includes:
   i. a work plan for each affected agency and jurisdiction,
   ii. an effectiveness monitoring system, and
   iii. a process for periodic review and revision.

- Obtain local approval and state certification of the plan, which will ensure implementation of the recommended ground water protection measures. Public agencies will work cooperatively to fulfill their responsibilities to protect the ground water resource. Local, state and regional land-use and water-use plans, policies and regulations will be enacted to protect the ground water resource.

1.4 Plan Contents

The proposed Vashon-Maury Island Ground Water Management Plan contains management strategies and a proposed implementation process. The supplement contains the area characterization. Each of these sections is briefly described below.

The "Recommended Ground Water Management Strategies" address the potential threats to ground water quality and quantity. The recommended management strategies are prefaced by adopted goals and a summary statement of the issues explored by the Ground Water Advisory Committee and followed by recommended management strategies. This section also contains a work plan for each management strategy, including identifying the responsible agencies and priority.

The "Recommended Implementation Process for the Ground Water Management Program" describes the preferred methods for funding and implementing the plan. It also contains tables showing the management strategies. The management strategies are listed in order, based on the Ground Water Advisory Committee priorities for funding and implementation. Another table lists the management strategy by responsible agency, in implementation order, with priority.

The Supplement to this Plan contains the area characterization and other background materials. The area characterization section describes the ground water management area's hydrogeology and ground water quality, lists the governments and agencies that manage land and water use and describes their responsibilities, and characterizes historical land use activities that impact ground water quality and quantity.

The Supplement also contains the background material and discussion for each recommended ground water management strategy. The complete issue papers the Ground Water Advisory Committee used to make the recommendations, with unabridged background information, are available upon request from the Ground Water Program in the Water and Land Resources Division.

1.5 Management Plan Team and Responsibilities

Development of this plan was a coordinated effort between local and state government and citizen representatives on the Ground Water Advisory Committee. The following provides a brief explanation of the responsibilities of each group in developing the ground water management plan.

Ground Water Advisory Committee

The Vashon Ground Water Advisory Committee plays a critical role in developing a sound ground water management plan. The Ground Water Advisory Committee consists of a broad cross section of ground water interest groups, including local, state and federal government agencies, large and small businesses, environmental organizations and citizens. The Ground Water Advisory Committee is responsible for assuring that the Ground Water Management Plan is both technically and functionally sound. The committee will give final approval to the plan before it is submitted to Ecology for certification. The committee's specific duties include:

- Oversee the development of the Ground Water Management Plan;
- Review the work plan, schedule and budget developed by the lead agency;
- Assure that the plan is functional, and will not cause environmental or economic adversity;
- Verify that the plan is consistent with the state's regulations on ground water protection; and
- Formulate and implement a public involvement plan.

Ecology appointed the Ground Water Advisory Committee in cooperation with local governments and participated on the advisory committee. Ecology staff reviewed and approved interim plan products (e.g., Public Involvement Plan, Data Collection and Analysis Plan, Quality Assurance/Quality Control Plan, and the Data Management Plan), participated on the Ground Water Advisory Committee, and held a public hearing on the draft plan. In addition, Ecology will certify the final Ground Water Management Plan after all affected agencies have had an opportunity to concur with those provisions they are being asked to implement.

Seattle-King County Health Department

The Seattle-King County Health Department was responsible for coordinating the activities necessary to develop this proposed Ground Water Management Plan. As lead agency, this included preparing a work plan, coordinating data collection, scheduling advisory committee meetings, developing the issue papers, drafting the plan based on committee direction, and obtaining concurrence from the affected agencies.

King County Department of Natural Resources

The Metropolitan King County Council transferred the ground water management program from the Seattle-King County Health Department to the Surface Water Management Division as part of the County's reorganization plan. Transfer of the program occurred on January 1, 1996, which coincided with the Surface Water Management Division being placed in the new Department of Natural Resources. Subsequently, the Surface Water Management Division was renamed the Water and Land Resources Division and is the lead agency for the ground water management program.

Consultants

This Ground Water Management Plan was developed jointly with Geraghty & Miller, Inc,. Ecochem, Inc. and URS Consultants. The consulting team prepared portions of this document including the Data Collection and Analysis Plan; the Quality Assurance/Quality Control Plan; the Data Management Plan; collected stream flow measurements; trained the County staff and volunteers in data collection; oversaw drilling of the test well; conducted quality control of samples collected; and drafted the Area Characterization (published as a Supplement to this Plan).

1.6 Public Review, Adoption, and Implementation

Public Review

Upon completion of a draft plan Ecology held a public hearing for comment and review of the plan. This public hearing was held at the Vashon High School on December 14, 1995. Public comments from that hearing are included as an appendix to this document. The Ground Water Advisory Committee also held a public workshop at the Vashon Public Library on January 27, 1996. The lead agency collected public and agency comments during the three month period between December and March, 1996. Comments received during this period were analyzed by the Ground Water Advisory Committee and, where appropriate, included in the text of this document.

The Draft Vashon-Maury Island Ground Water Management Plan has been reviewed under the requirements of the State Environmental Policy Act. The Seattle-King County Health Department prepared an environmental checklist and published a Determination of Nonsignificance in November of 1995. No comments were received pertaining to the adequacy of the environmental review and the determination was sent to the Department of Ecology after the public comment period had closed.

Adoption

Various drafts of this plan have been prepared, leading up to the present finalization. A Draft was published in March 1995 for concurrence review and comment by various affected agencies. Comments collected during the comment period (to March 1996) were incorporated into a final draft published in July 1996. This draft was submitted to the Metropolitan King County Council, and was assigned to the Law, Justice, and Human Services Committee, and hearings were held in July - October 1996 and August - September 1997. However, the plan was not passed, either for concurrence or non-concurrence, in either 1996 or 1997.

In 1998 there was a new effort to move the plan along. This time the plan was referred to two committees, the Utilities and Natural Resources Committee and the Growth Management Committee. Hearings were held in May and June of 1998, and the plan was approved, with conditions, for passage by the Council. On July 6, 1998, the County Council passed Motion 10493 that basically concurred with the plan, although with conditions. The motion, and a sample letter that was attached by Council to the motion, are included in Appendix B.

The Department of Natural Resources sent these concurrence materials to the Ground Water Advisory Committee (GWAC) on September 3rd with a cover letter. The GWAC met on October 20th to discuss the changes required by Council, and subsequently drafted a letter (dated November 18) to Louise Miller, Council Chair, with a cover letter to Laura Lowe at the Department of Ecology. All of these items are also included in Appendix B. The GWAC letter requested that the plan be forwarded to Ecology, and so it was revised according to Council's motion and submitted in December 1998.

Implementation

Affected agencies and jurisdictions are responsible for implementing the plan following adoption by Ecology. The plan may be modified under the supervision of the Vashon-Maury Island Ground Water Management Committee. This committee will advise implementing agencies, oversee ground water management activities, review new issues, and consider new programs that emerged after the plan was adopted. It is the responsibility of the Management Committee to develop a process for how to incorporate new issues and programs.

Chapter Two

Management Strategies

Vashon-Maury Island
Ground Water Management Plan

December 1998

Recommended Management Strategies

2.1 Introduction

The Vashon-Maury Island Ground Water Management Plan contains management strategies to address the potential threats to ground water quality and quantity in the planning area. The Vashon-Maury Island Ground Water Advisory Committee identified topics or potential problems of concern and adopted management strategies for the following topics: special area designations to enhance ground water protection, storm water management, land use, seawater intrusion, education, hazardous materials management, underground storage tank management, on-site sewage disposal system use, pesticides and fertilizers, well construction and decommissioning and well owners' responsibilities, sewer pipes, solid waste landfills, burial of human remains, sand and gravel mining, and biosolids and effluent.

In developing the management strategies, the Vashon-Maury Island Ground Water Advisory Committee attempted to make maximum use of existing governmental programs and regulatory structures and was determined to build on existing efforts rather than developing new and potentially duplicative programs. The Committee preferred strategies that could be understood and supported by the citizens of Vashon-Maury Island. The Committee prioritized the management strategies because they recognized that the strategies would need to be implemented over several years.

The Vashon-Maury Island Ground Water Management Plan is intended to provide a framework to assist cooperation between various regulatory agencies and utilities through implementation of the adopted ground water protection measures. It is also intended to serve as a guide to further focused research on the aquifers to address data and regulatory protection gaps.

This chapter covers those issues that affect both ground water quality and quantity (Section 2.2); those that affect ground water quality only (Section 2.3); and those that affect ground water quantity only (Section 2.4). The sections first describe the goals for each issue, then specific issues with each topic are stated, and the adopted management strategy(ies).

2.2 Program Elements Related To Ground Water Quality And Quantity

During the planning process, two significant legislative acts influenced the Ground Water Advisory Committee's recommendations. The first is the Growth Management Act, which was passed by the Washington legislature in 1990. This act requires local government to identify and protect areas that are critical for aquifer recharge. The Ground Water Advisory Committee responded by recommending some actions that are countywide in applicability rather than limited to the Ground Water Management Area.

This is in keeping with the directive of the Growth Management Act to local governments to cooperatively protect aquifer resources on a county or regional basis.

The second is wellhead protection requirements in the State Department of Health Wellhead Protection Program. The program requires public water system purveyors to delineate wellhead protection areas for each public water system and develop programs to protect ground water in those areas. The Ground Water Advisory Committee recognized the need for King County to be able to respond to recommendations in Wellhead Protection Plans for land use and other ground water protection strategies.

The Ground Water Advisory Committee identified six topics that affect ground water quantity and quality: special area designation, land use, seawater intrusion, data collection and management, storm water management, and education. This section includes a goal statement, issue summary and recommended management strategies for each of these topic areas.

2.2.1 Special Area Designations to Enhance Ground Water Protection

Goal Statement: *To use available special area designations in conjunction with local regulations and policies to enhance ground water protection efforts in the Vashon-Maury Island Ground Water Management Area.*

A number of special federal, state, and local area designations may be used to enhance a ground water management program. Incorporating them may offer such benefits as a source of funds to implement ground water protection measures, enhanced eligibility for grant funds, or expanded review of development proposals. Increased public recognition of the value of an aquifer may be an important result of a special area designation. The special area designations discussed in this chapter are:

- Areas with a critical recharging effect on aquifers used for potable water per Chapter 36.70A RCW Growth Management;
- Wellhead Protection Areas per the 1986 amendments to the federal Safe Drinking Water Act;
- Environmentally Sensitive Areas per Chapter 197-11 WAC State Environmental Policy Act Rules;
- Special Protection Areas per Chapter 173-200 WAC Water Quality Standards for Ground Waters of the State of Washington;
- Sole-Source Aquifers per the federal Safe Drinking Water Act of 1974; and
- Aquifer Protection Areas per Chapter 36.36 RCW.

Areas with a Critical Recharging Effect on Aquifers Used for Potable Water per the Growth Management Act (RCW 36.70A)

The Growth Management Act of 1990 requires all counties and cities in Washington to plan in order to manage growth. This act, much of which is codified in Chapter 36.70A RCW, requires that the largest and fastest growing counties conduct land use planning to achieve protection of critical areas.

The Growth Management Act also requires that the comprehensive plans contain land use controls to protect quality and quantity of ground water used for public water supplies (Chapter 36.70A.070(1) RCW). King County adopted the King County Comprehensive Plan, which contains several policies related to ground water protection to meet Growth Management Act requirements. These policies provide the basis and lay a foundation for incorporating ground water into overall natural resource management by King County. These policies include:

NE - 332 In unincorporated King County, areas identified as sole source aquifers or as areas with high susceptibility for ground water contamination where aquifers are used for potable water are designated as Critical Aquifer Recharge Areas as shown on the map, entitled Areas Highly Susceptible to Ground Water Contamination. Since this map focuses primarily on water quality issues, the County shall work in conjunction with cities and ground water purveyors as new information from ground water and wellhead protection studies adopted by the County or state agencies becomes available.

NE-333 King County should protect the quality and quantity of ground water countywide by:

a. Placing a priority on implementation of adopted Ground Water Management Plans;
b. Developing a process by which King County will review, and implement, as appropriate, adopted Wellhead Protection Programs in conjunction with cities and ground water purveyors; and
c. Developing, with affected jurisdictions, Best Management Practices for new development and for forestry, agriculture, and mining operations recommended in adopted Ground Water Management Plans and Wellhead Protection Programs as appropriate. The goals of these practices should be to promote aquifer recharge quality and to strive for no net reduction of recharge to ground water quantity.
d. Refining regulations as appropriate to protect critical aquifer recharge areas when information is evaluated and adopted by King County.

NE-335 In making future zoning and land use decisions that are subject to environmental review, King County shall evaluate and monitor ground water policies, their implementation costs and the impacts upon the quantity and quality of ground water. The depletion or degradation of aquifers needed for potable water supplies should be avoided or mitigated, and the need to plan and develop feasible and equivalent replacement sources to compensate for the potential loss of water supplies should be considered.

NE-336 King County should protect groundwater in the Rural Area by:

a. preferring land uses that retain a high ratio of permeable to impermeable surface area and that maintain or augment the infiltration capacity of the natural soils, and
b. Requiring standards for maximum vegetation clearing limits, impervious surface limits, and where appropriate, infiltration of surface water. These standards should be designed to provide appropriate exceptions consistent with Policy R-216.

The Wellhead Protection Program

The 1986 amendments to the Safe Drinking Water Act established a Well Head Protection Program intended to safeguard ground waters used by public water supply wells. A Well Head Protection Area is defined in the Safe Drinking Water Act as "the surface and subsurface area around a well or wellfield supplying a public water system through which contaminants are reasonably likely to move toward and reach such water well or wellfield" (42 U.S.C.A. 300h-7(e)). Due to the nature of wellhead protection, much of the actual implementation efforts will be done by public water systems, local governments and by those agencies with source-specific jurisdictional responsibilities. Public water system purveyors are responsible for delineating the Well Head Protection Area and inventorying sources of contamination within the Well Head Protection Area. The effectiveness of these programs was largely predicated on the ability of the municipal well owner to directly regulate land use in all or a large portion of the zone of contribution. On Vashon, where public water system(s) do not control surrounding land use, the success of the Wellhead Protection Program will depend on the willingness of King County to impose necessary land use or other restrictions.

Considering the large number of public water systems in King County, responding to requests for and implementing individualized land use controls for each would be unworkable for King County. However, it should be possible to develop strategies under which King County could help implement Wellhead Protection Programs. Development of these strategies would benefit water systems required to prepare Wellhead Protection Programs. Such an approach is consistent with the state Wellhead Protection Program, which recommends a countywide approach to wellhead protection and the adopted policy in the King County Comprehensive Plan (NE-333).

Environmentally Sensitive Area Designation Under the State Environmental Protection Act

The State Environmental Policy Act (SEPA) rules are implemented in unincorporated King County through the King County Code, "County Environmental Procedures" (Title

20.44). The Department of Development and Environmental Services is responsible for environmental review in relation to code requirements and for implementing SEPA compliance for private development proposals in King County. Municipalities within King County have either adopted the SEPA rules by reference or have developed their own regulations incorporating them. Municipalities conduct environmental review for projects occurring within incorporated boundaries.

In developing the SEPA rules, Ecology determined that some classes or types of activities, because of their size or nature, are not likely to represent a significant environmental impact and should, under ordinary circumstances, be exempt from SEPA requirements. This list of exempted types of activities is termed categorical exemptions. The categorical exemptions include some activities that could potentially represent a significant adverse environmental impact in areas of unusual ground water sensitivity.

Local governments have the authority to lower thresholds for requiring environmental review by designating certain portions of their land use jurisdiction as an Environmentally Sensitive Area. These areas are generally more vulnerable to the adverse effects of land and water-use activities. Designation would permit the Metropolitan King County Council to eliminate from environmental review specific categorical exemptions that may have an impact on ground water.

Special Protection Areas Established Under Washington Water Quality Standards for Ground Waters

Ecology may designate Special Protection Areas to identify portions of the state with ground waters that require extraordinary consideration or increased protection because of one or more unique characteristics (Chapter 173-200-090 WAC). Ecology will consider the unique characteristics of a Special Protection Area when developing regulations, guidelines, and policies; when regulating activities; and when prioritizing department resources for ground water quality protection programs. Within Special Protection Areas, Ecology can choose to establish more stringent ground water quality criteria and contaminant enforcement limits. In addition, Ecology can impose special requirements for permits issued under authority of Ecology administered programs. Examples would be the State Waste Discharge Permit Program (Chapter 173-216 WAC) and permits for the withdrawal of ground water (water rights) issued pursuant to Chapter 90.44 RCW (Regulation of Public Ground Waters).

Sole Source Aquifer Designation under the Federal Safe Drinking Water Act

The primary intent of the program is to prevent projects that receive federal financial assistance from contaminating aquifers representing the sole or principal source

of drinking water for an area. Projects that receive a portion, but not 100 percent, of their funding from the federal government are affected. The two Sole Source Aquifers in King County are Vashon Island and the lower Cedar River Valley. A Sole Source Aquifer designation conveys a number of positive benefits, the most important of which is its public awareness value.

Aquifer Protection Areas Per Chapter 36.36 RCW

The purpose of an Aquifer Protection Area is to establish a funding base for ground water protection, preservation, and rehabilitation programs. Aquifer Protection Areas are established through an election ballot issue requiring approval from a simple majority of voters within the proposed Aquifer Protection Area. If voters approve the Aquifer Protection Area, the county can collect modest water and septic system user fees. Fees may only be collected from users of water withdrawn from an aquifer as opposed to a surface water source.

Issue 1 - General Protection of Aquifers: Effective aquifer protection requires cooperation between land use jurisdictions because aquifers do not coincide with jurisdictional boundaries. General policies that provide guidance for land use decisions could be adopted by King County to provide a basic level of protection for aquifers. Environmental review should be standardized to include thorough consideration of a proposed development's impact on ground water. Ground water concern areas need to be defined and mapped.

SA-1A Elimination of categorical exemptions to the State Environmental Policy Act: King County, in conjunction with the Management Committee, will determine whether any categorical exemptions to the State Environmental Policy Act which are: installation of underground chemical storage tanks with a capacity of less than 10,000 gallons; construction of commercial buildings of less than 4,000 square feet and associated parking for up to 20 automobiles; construction of parking lots for up to 20 vehicles; construction of agricultural structures of under 10,000 square feet; and periodic use of Washington Department of Agriculture approved chemicals to maintain a utility or transportation right-of-way in its design condition (Chapter 197-11-800 WAC) should be eliminated in the most physically susceptible and recharge areas as mapped in the Vashon Ground Water Management Plan.

Who:	King County King County Department of Natural Resources and the Management Committee
Priority:	High
Time:	0.25 FTE
Fund Source:	Agency general funds

SA-1B Designation of Environmentally Sensitive Areas: King County will determine if any categorical exemptions should be eliminated and, if necessary, designate the Vashon-Maury Island Ground Water Management Area as an Environmentally Sensitive Area as authorized by the State Environmental Policy Act, so that categorical exemptions, as determined under SA-1A, may be eliminated.

Who: King County Department of Natural Resources
Priority: Low
Time: 0.25 FTE
Fund Source: Agency general funds

SA-1C Adoption of General Aquifer Protection Policies: King County Department of Natural Resources and Office of Strategic Planning will prepare amendments to the King County Comprehensive Plan to include a policy that recognizes wellhead protection programs will provide direction for focusing intense aquifer protection efforts in those areas where the existing built environment presents very significant risks to public drinking water systems.

Who: King County Department of Natural Resources and Office of Budget and Strategic Planning
Priority: Low
Time: 0.125 FTE
Fund Source: Agency general funds

SA-1D Enhanced environmental review to protect aquifers: King County Department of Natural Resources will develop guidance to assist environmental reviewers to: identify proposed development that may significantly impact ground water in aquifer recharge areas mapped by the Vashon Ground Water Management Plan; recognize and require adequate information to assess impacts upon ground water; and recognize and propose effective mitigation.

Who: King County Department of Natural Resources
Priority: Low
Time: 0.5 FTE
Fund Source: Agency general funds

SA - 1E Ground Water Concern Areas. King County Department of Natural Resources, through an on-going process, will map areas where ground water is physically susceptible to contamination. These areas have been mapped according to the following criteria:

- Soil permeability - Soil units are defined by the Natural Resources Conservation Service in the *Soil Survey of the King County Area* (Soil Conservation Service 1973). The units are rated high, moderate, or low permeability according to the description in the Survey. (1/4 weight given to this criteria.)

- Geologic materials - United States Geological Survey maps provide information on surficial geology. High, moderate, or low permeability has been determined by professional judgment. (Full weight.)

- Depth to water - Drillers logs and previous investigations are used to determine depth to the uppermost water table. Existing water table elevation maps are used, if available. High (0-25 feet from surface), moderate (25-75 feet from surface), and low (greater than 75 feet from surface) contamination potentials are assigned. (Full weight.)

Areas receive overall ratings by use of an overlay map that incorporates ratings from the three physical parameters. A combined rating score is assigned to each portion of the mapped area. Determination of whether an area has a high, moderate, or low potential for recharge is based on the combined rating.

The ground water susceptibility maps produced for the Ground Water Management Plan and for the King County Comprehensive Plan were based on available information. Both the Ground Water Management Plan and the Comprehensive Plan specify that the maps will be refined as new information becomes available. Identification and protection of areas important to the quantity and quality of ground water is required by the Growth Management Act. King County expects to meet this requirement by starting with the maps currently produced, and adding new information as it becomes available. However, decisions that result in severe changes in the use of property should be deferred until detailed studies of the affected areas can be accomplished. New information may include precipitation data, land coverage and land use, for recharge and vulnerability estimation.

Who:	King County Department of Natural Resources
Priority:	Low
Cost:	0.25 FTE
Fund Source:	Agency general funds would be used to disseminate mapped information. The Aquifer Protection Area Fund would support further revisions of the maps for Vashon-Maury Island.

Issue 2 - Wellhead Protection: Public water system purveyors are required to meet federal and state requirements to delineate and adopt measures to protect wellhead protection areas. Implementation of the Vashon Ground Water Management Plan will fulfill some wellhead protection needs. However, specific strategies to provide an increased level of protection to public water systems are required by the Washington State Department of Health. In order to accommodate the needs of the large system purveyors, King County needs to develop a way to assist wellhead protection in the unincorporated area.

SA-2 Wellhead Protection: King County Department of Natural Resources, in conjunction with the Management Committee, will develop strategies that King County could adopt to help purveyors implement Wellhead Protection Programs. King County would support water purveyors within the Vashon Ground Water Management Area who are applying for grants or other funding for the purpose of delineating Wellhead Protection Areas and developing and implementing protective strategies.

Who: King County Department of Natural Resources
Priority: High
Time: 0.5 FTE
Fund Source: Agency general funds

Issue 3 - Special Protection Areas: Special Protection Areas designation enhances local ground water protection efforts by increasing the level of public concern about the aquifer and by providing additional protection when Ecology is regulating activities, developing regulations and prioritizing resources for ground water protection programs.

SA-3 Designation of Special Protection Area: King County Department of Natural Resources will prepare an application for Special Protection Area status for the Vashon Ground Water Management Area under *Water Quality Standards for Ground Waters of the State of Washington* (Chapter 173-200 WAC).

Who: King County Department of Natural Resources
Priority: High
Time: 0.125 FTE
Fund Source: Aquifer Protection Area Fund

2.2.2 Land Use and Vashon-Maury Island Ground Water

Land management practices should be avoided that can cause potential ground water contamination or overuse of the water supply thereby requiring Island residents to deepen existing wells, develop a new water system or connect to other existing water systems. Therefore, the Ground Water Advisory Committee adopted the following goal to guide development of land use management strategies:

> *To preserve and protect the quality and quantity of ground water for present and future use by reducing or eliminating impacts from land use and associated population density and contamination sources.*

Seven Group A public water systems, ninety-eight Group B public water systems, and an estimated 3,000 individual water systems currently rely on the Island's groundwater to provide water to all Island residents and businesses. Since an estimated that fifty to seventy percent of the water systems draw from shallow ground water and surface water sources, it is imperative that land use policies be implemented to ensure that drinking water supplies will not be adversely affected. The King County Comprehensive Plan and Vashon Community Plan have policies, which, if implemented, would help protect the existing shallow aquifer and drinking water systems. Additional land use measures are proposed in this plan.

Replacing the Island's natural forest cover with impervious surface coverage reduces ground water recharge and base flow to streams. In general, population growth from new development places new demands upon the ground water resources. Commercial development, such as in the Vashon Town Center, with its related roofs, parking lots and roads, significantly reduce rainfall infiltration. Where infiltration does occur, roadway runoff often introduces contaminants into the ground water. Rural development, with a lower percentage of impervious surface coverage, generally causes less site-specific rainfall infiltration reduction, but the cumulative impact of rural development can harm an island's aquifer. Residential low-density development can reduce recharge by 30 percent from previous forest cover. Rural pastures also reduce recharge, but their amount has not been estimated because hydrologic parameters have not been developed. (Hartley, David M., King County Surface Water Management, unpublished memo, August 29, 1995.) In addition, any reduction in the water supply to the till layer will reduce the recharge to regional ground water by as much as 17 percent in areas with 30 percent impervious surface and 70 percent lawn area (Wigmosta, *et. al.*, 1994). This is because the topsoil above the till layer that provides the sponge-like effect to keep the till constantly supplied with water would be removed.

Vashon Island's population, development, and its related groundwater impacts have been increasing. The population has grown from 7,400 in 1970 to an estimated 10,200 in 1994. King County's population target for the Vashon rural area is an increase of only 720 to 1,200 persons (300 - 500 households) by 2012 for a total population between 10,930 and 11,400 persons. However, existing zoning would allow approximately 20,000 total residents. An analysis prepared when developing the Vashon Community Plan determined that the ground water available for consumption is approximately 930 acre-feet per year. It was estimated that this ground water supply could support an island population of between 10,900 to 13,200 people without significant impacts to surface or ground water resources. The technical analysis prepared for this Ground Water Management Plan estimates total ground water for the Island at 12,895 acre-feet per year, but made no attempt to estimate a maximum population that the Island's ground water resources could support. However, the authors of this higher estimate have stated that only a fraction of the water is available for consumption, this estimate of water does not necessarily support a higher population figure than that estimated in 1983, and that if too much water is withdrawn, the effects will be seen at the surface in the form of lower stream flows, lower water table, and increased potential for seawater intrusion. Therefore, they recommended that both the 1983 and the 1990 estimates of water availability should be taken together to form a set of boundaries for water resource management policy development. Interconnected water-bearing zones and other parameters such as rainfall and infiltration estimates account for the difference in estimated ground water resources.

Land Use Management Strategies

The Ground Water Management Committee recommends that, until a more definitive water budget is developed, the land use and ground water programs should rely on the 1983 water availability estimates. This would require resource and land use planners to be more conservative in their approach to growth on the Island. It would also require the

County to adopt a non-degradation policy for the Island's water resources, which is the intent of the management strategies contained in this plan. Since existing development will not likely be changed, the approach to protect ground water from existing and future impacts of development is to:

- Monitor the quality and quantity of ground water, and implement mitigation measures when unacceptable levels are reached,
- Predicate any future development upon knowledge about the quality and quantity of ground water and that development's potential impact on groundwater; and
- Prevent or limit development that would impact ground water, through the policies in the King County Comprehensive Plan, Vashon Community Plan, the King County Zoning Code and the measures recommended in this Plan.

Groundwater Monitoring

Monitoring groundwater quality and quantity data will allow the Management Committee to advise the Metropolitan King County Council of any trends or exceedance of trigger points and to modify (advance or delay) implementation of other recommendations. The Management Committee will also determine mitigation procedures and recommend these to King County. The mitigation procedures might include:

- Establishing more restrictive standards for grading, topsoil placement, and/or enhancement, landscaping, native vegetation retention, impervious surface coverage and storm drain facilities. Land coverage on the developable areas of sites would not exceed set standards, unless geotechnical and subsurface aquifer studies show that there will be no additional impacts. Possible standards could include setting impervious surface limitation at 20%; and setting lawn areas coverage at 40%.
- Locating storm water infiltration facilities to replicate the natural system so that the top mantle of soil can accept the water from infiltration facilities;
- Using soil enhancement and other landscaping methods that are conducive to water infiltration;
- Preventing alteration of natural hydrologic features that would reduce their functional ability to preserve ground water quality and quantity;
- Conducting detailed technical analysis and subsurface exploration with appropriate geotechnical methods, water quality sampling and aquatic habitat analysis to ensure that the proposed storm drain systems will replace the existing undeveloped condition for the specific site geology;
- Specifying maintenance and operation provisions for existing natural drainage systems and on-site drainage facilities; and

- Developing a property owner's manual for every property owner in a well head protection area, or other definable area, that is experiencing adverse ground water quality and/or quantity impacts.

LU-1 Land Use Impacts to Ground Water -- Ground Water Monitoring. The King County Department of Natural Resources will monitor data, and report at least once a year to the Management Committee. The report will notify the Management Committee if the trigger levels are neared or exceeded, or if trends are noted. The Management Committee will also be notified if any monitored parameter shows a significant, sudden change. The trigger levels are:

- Trigger Level for Quality: 10% increase over baseline for any ground water standard, over two years;
- Trigger Level for Quantity: 10% decrease in water levels, over five - ten years, adjusted for precipitation; and,
- Trigger Level for Trend: half the Washington State limit or the result moves from zero to a quarter of the Washington State limit.

Who: King County Department of Natural Resources
Priority: High
Time: Part of the data collection and management program; an estimated 0.1 FTE to work with the Management Committee on analyzing trends.
Fund Source: Aquifer Protection Area

LU-2 Land Use Impacts to Ground Water -- Ground Water Monitoring. The Management Committee will review the data and determine if action is needed. If needed, the Management Committee will:

- Advise the Metropolitan King County Council that development is impacting the ground water resources (based on the observed trends);
- Request King County to apply a moratorium on new dwelling unit construction as per King County Comprehensive Plan Policy R-107 of the King County Comprehensive Plan; and,
- Develop, with the King County Department of Natural Resources, mitigation measures to address the observed trends.

Who: Management Committee
Priority: High
Time: Estimated 0.1 FTE for committee staffing
Fund Source: Aquifer Protection Area

King County Comprehensive Plan

The Vashon Ground Water Advisory Committee discussed many types of land use controls that could be implemented by the County to help preserve the quality and quantity of drinking water for present and future residents. Several members strongly believe that there is a sound basis for including in this Ground Water Management Plan recommendations for amendments to the County's comprehensive plan that would restrict subdivisions of land in areas highly susceptible to contamination and provide for a moratorium on building permits after Island population had reached 13,000 persons. Although such recommendations were not adopted by the Committee, they are representative of concerns expressed by Island residents in public hearings and workshops that future growth should be based on conservative estimates of available drinking water to prevent depleting and contaminating the resource.

The King County Comprehensive Plan contains the policies for land use development on the Island. The King County Comprehensive Plan designates Vashon as rural and supports low density residential development for most of the Island, and recognizes the significant influence land use development can have on the quality and quantity of ground water resources. The comprehensive plan states: "The Vashon community planning area, unlike the Rural Area as a whole, requires additional attention to plan for growth because its water supply is derived from a sole-source aquifer." The Plan reflects the objectives of the Vashon Community Plan, as noted on the following page, and contains three land use policies related specifically to Vashon-Maury Island, which include:

R-107 King County should monitor the quantity and quality of the water supply for the Vashon Community Planning area, along with building permit and subdivision data, and reassess the Vashon Community Plan's allowable growth capacity, if warranted. If new information indicates an immediate and severe water shortage, the County should apply a complete moratorium on construction of new dwelling units while it updates the Vashon Community Plan and Area Zoning.

R-205A For Vashon-Maury Island, a residential density of one home per 10 acres:
a. shall be maintained on existing areas as applied through area zoning to help protect community character and reduce adverse impacts on the island's infrastructure; and
b. may be applied to areas identified as highly susceptible to ground water contamination or reduced recharge in a ground water management plan with which King County has concurred.

NE-302 Development should occur in a manner that supports continued ecological and hydrological functioning of water resources. Development should not have a significant adverse impact on water quality or water quantity. On Vashon Island, development should maintain base flows, natural water levels fluctuations, ground water recharge in Critical Aquifer Recharge Areas and fish and wildlife habitat.

The Vashon Ground Water Advisory Committee recommends that these policies in the comprehensive plan need to be supplemented because: 1) the aquifer most residents draw water from is relatively shallow and is therefore very sensitive to impacts from land use development, 2) potable water resources are limited to those available on the Island,

3) the County's comprehensive plan recognizes that Island population growth is increasing at a rate faster than forecasted in the Vashon Community Plan, and 4) some of the County's regulations could effectively result in a doubling of allowable dwelling units. To avoid having to address an "immediate and severe water shortage" referred to in Policy R-107 the following management strategy is recommended:

LU - 3 Land Use Impacts to Ground Water - King County Comprehensive Plan Policies. King County Department of Natural Resources and the Office of Strategic Planning will propose amendments to the King County Comprehensive Plan to include the following policies related to growth and development on Vashon, for the Metropolitan King County Council's consideration:

- General -- Ground water based public water supplies should be protected by minimizing land-use impacts on ground water quality or quantity to preserve the supply of high quality drinking water for present and future populations.
- "Rounding Up" Policy -- On Vashon-Maury Island, King County shall not apply its policy of "rounding up," which allows the creation of new building lots that are three-quarters of the size allowed in a zone.
- Non-conforming Building Sites -- On Vashon-Maury Island, King County shall not allow the creation of multiple non-conforming building sites, such as allowing two non-conforming sites to be created when a road bisects one lot.
- Enforcement of Land Use Code -- King County shall allocate sufficient funds for effective enforcement of land use code provisions on Vashon-Maury Island, including the P-suffix requirements and the policies in the Vashon Community Plan.

Who:	King County Office of Budget & Strategic Planning
Priority:	High
Time:	0.125 FTE
Fund Source:	Agency general funds

Vashon Community Plan and Area Zoning

The 1986 Vashon Community Plan and Area Zoning updated the 1981 Plan. During this update, the concern about limited ground water supplies was expressed. The *Vashon/Maury Island Water Resources Study* (Carr, 1983) served as the basis for the updated 1986 Vashon Plan. The 1986 Plan contained new and revised policies, development conditions, special recommendations, and zoning for the Island to reflect the 1983 information on the Island's groundwater.

The 1986 Vashon Community Plan's major objective for land use and zoning recommendation's was to accommodate the forecast population while still retaining the rural character of the Island and protecting the water resource. The recommendations for land use and public improvement decisions in the 1986 Vashon Community Plan are for a period of six to ten years. The Vashon Community Plan contains several policies that would help prevent ground water depletion or degradation. However, emphasis should be placed on their implementation.

LU - 4 Land Use Impacts to Ground Water - Vashon Community Plan Policies. Implementation of the following policies of the Vashon Community Plan shall be fully funded, and the King County Zoning Code revised as necessary:

V-3 All land-use polices and regulations for Vashon shall reflect the overriding importance of the fact that the whole Island is the recharge area for a sole-source aquifer. All of Vashon Island shall, therefore, be considered a ground water recharge area. Within the Island, based largely on soil types, there are areas of relatively high, medium, and low recharge potential. Areas of higher recharge potential should receive extra protection.

SR 1 All development and maintenance of public lands and projects funded by community development block grants should be model examples of protection of the ground water resource, including, but not limited to, infiltration techniques, water-use conservation, and pollution abatement.

SR 1 King County should review all short plat applications on Vashon Island for conformance with policies in this plan. Short Plats should be denied if they are inconsistent with this plan or conditions should be required to insure that short plats are consistent with policies in the community plan.

V-57 To protect domestic water resources, high ground water recharge areas and watersheds should be maintained in residential or similarly non-intensive uses at low densities.

V-61 Special consideration should be given to the impacts of new development on the Island's ground water resources. This should apply to major developments, development in high ground water recharge areas, or development near public water supplies.

6 High recharge area P-suffix conditions include the following:

a. New commercial or industrial development that occurs in a high recharge area is limited to 60 percent impervious surface and must include natural or planted landscapes covering 40 percent of the land area.
b. Runoff discharge may not exceed pre-development levels as per King County Code 20.50.
c. Listed uses specified in the zoning code for General Commercial and Light manufacturing zones are excluded from high recharge areas. Examples are car washes, paint shops, boat builders, and kennels.
d. Listed unclassified uses specified in the zoning code are excluded from High Recharge Areas. Examples are landfills, incinerators, transfer stations, fairgrounds and airports.

Who:	King County Department of Development and Environmental Services, Office of Strategic Planning, and Department of Natural Resources
Priority:	High
Time:	Estimated 0.1 FTE for evaluating current codes for compliance with the Vashon Community Plan policies
Fund Source:	Agency general funds

LU - 5 Land Use Impacts to Ground Water - Area Zoning. King County shall maintain zoning of one home per ten acres where it exists currently. King County shall expand the zoning of one home per ten acres to include those areas identified in this Plan as being highly physically susceptible to contamination or reduced recharge.

King County shall maintain zoning of a maximum density of one home per five acres where it exists currently. King County shall expand the zoning of one home per five acres where a higher density zone currently exists and the area has been identified in this Plan as being moderately physically susceptible to contamination or reduced recharge.

Who:	King County Department of Development and Environmental Services, Code Development Section
Priority:	High
Time:	Estimated 0.1 FTE to initiate any zoning changes for the areas of high susceptibility
Fund Source:	Agency general funds

2.2.3 Seawater Intrusion

The threat to ground water from seawater intrusion is a concern along Vashon's coast. When ground water is pumped from aquifers that are in hydraulic continuity with Puget Sound, seawater may flow toward the well resulting in elevated levels of chloride. Seawater intrusion can vary between regions, depending on geology, aquifer characteristics, topography, and the size of the recharge area. Occurrence of seawater intrusion may also vary seasonally due to fluctuations in rainfall and water use such as in the summer where low rainfall and higher groundwater use coincides. Also, elevated levels of chloride, between 10 mg/l and 100 mg/l, can result from on-site sewage systems, landfills, road salts, and sea spray. Ecology determined that chloride levels of 100 mg/l or more indicate seawater intrusion (Dion and Sumioka, 1984).

In response to concerns about seawater intrusion along Washington's coastlines, Ecology adopted the Seawater Intrusion Policy. The goal of the policy is to prevent seawater intrusion in areas where it has not occurred and to control seawater intrusion where the problem already exists. The Policy guides Ecology's administration and regulation of water rights in areas where risk of seawater intrusion exists. Ecology works with the Washington State Department of Health, local health and planning departments to implement the Policy. Risk of seawater intrusion is identified by reviewing lab analysis for chloride for a new well, a test well, or a well within a one-half mile of a proposed well. Chloride concentrations from 25 to 100 mg/l indicate a low risk area. Chloride concentrations from 100 to 200 mg/l, or less than 100 mg/l with an increasing trend, indicate a medium risk area. Chloride concentrations of 200 mg/l or more, or levels between 100 and 200 mg/l with a rising trend, indicate a high risk area. Ecology may also use the indicated risk to condition or deny water right applications.

Island County and the Department of Ecology established the first Seawater Intrusion Program. The Island County Health Department evaluates existing and new wells and determines the relative risk of seawater intrusion. Based on the risk, the Island County Health Department may require monitoring, pump testing, limitations on number of connections, or may deny new system formation. The Draft Island County Ground Water Management Plan builds on the Island County Health Department's program by establishing classification criteria to further identify the risk of seawater intrusion from developing new wells or permitting additional withdrawals in the coastal zone. They developed a classification criteria matrix to generate a comparable value indicating the total of relative effects.

The *Vashon/Maury Island Water Resources Study* (Carr and Associates, 1983) identified wells on the northern end of Vashon Island and the south-eastern section of Maury Island with elevated chloride levels. Wells monitored along the coastline during 1989 and 1990 for this Plan showed no evidence of seawater intrusion. However, a Group B well with seawater intrusion in the northeast area (near Glen Acres) of Vashon was closed in 1993.

Seawater Intrusion Management Strategies

Other parts of the Draft Vashon-Maury Island Ground Water Management Plan have three general management strategies related to seawater intrusion. Recommended management strategies LU-1 and LU-2 require the monitoring of wells for certain contaminants, and, if trigger levels are reached, the Management Committee would develop mitigation measures with King County Department of Natural Resources to address observed trends. The Data Collection and Management Program contains specific sampling and analysis activities related to seawater intrusion. The Ground Water Advisory Committee, during development of the Plan, stated its support of Ecology's Seawater Intrusion Policy.

However, the Ground Water Advisory Committee finds that seawater intrusion is of great importance on Vashon-Maury Island and requires more specific management strategies. The majority of the wells that are or could be drilled into the coastal zones would be for drinking water systems. These provide water for individual homes, or groups of homes as public water systems. The wells that would serve more than six homes would require a water right from Ecology. Review and approval of these drinking water systems, by Seattle-King County Health Department, the Washington State Department of Health, or review and approval of water right applications by Ecology, need to consider the potential for causing or increasing seawater intrusion. Therefore, the following management strategies are recommended for adoption.

SI - 1 Seawater Intrusion Criteria Development: The King County Department of Natural Resources should develop a consistent and objective set of criteria to classify ground water impacts from developing new wells or permitting additional withdrawals in the coastal zone of Vashon-Maury Island to avoid increasing or causing seawater intrusion problems. The classification criteria developed for the Island County Ground Water Management Plan will provide a model. This criteria would assign a value to developing new wells or permitting additional withdrawals for: distance to seawater; static water level; pumping water level; geographic location; pumping rate; completion elevation; chloride concentration in area; infiltration potential at site and the number of existing wells in the area. These values would be multiplied by weighting factors and summed to generate an overall value, the total of relative effects. The classification criteria would be used by Ecology to evaluate water right applications and by the Seattle-King County Health Department and the Washington State Department of Health in reviewing drinking water systems.

Who:	King County Department of Natural Resources
Priority:	High
Time:	0.125 FTE
Fund Source:	Aquifer Protection Area funds

SI - 2 Seawater Intrusion Program: The Seattle-King County Health Department and the Washington State Department of Health should adopt a Seawater Intrusion Policy regarding drinking water wells in the coastal areas on Vashon-Maury Island. The Island County Health Department's policy may provide a model. The Policy should assign risk categories to existing non-expanding, existing expanding, and new water systems (individual and public). The Policy should require a variety of methods to assure that the relative risk of seawater intrusion for developing or maintaining an individual or public water system is addressed. These methods could include monitoring and reporting chloride and conductivity; reporting source meter readings; prohibiting new connections; requiring conservation methods; requiring individual meters; monitoring during phased development; or denial of development of a new water system. The Seattle-King County Health Department and the Washington State Department of Health would use the criteria developed under SI-1 as part of the seawater intrusion policy/program. The Seattle-King County Health Department and the Washington State Department of Health should adopt specific water well design and construction standards needed to implement the Seawater Intrusion Policy.

Who:	Seattle-King County Health Department and the Washington State Department of Health
Priority:	High
Time:	0.25 FTE
Fund Source:	Aquifer Protection Area funds

SI - 3 Seawater Intrusion Special Protection Area: The Ground Water Advisory Committee requests Ecology to designate the coastal zone or portions of the coastal zone as a Special Protection Area under Washington Ground Water Quality Standards (Chapter 173-200 WAC) and require that the ground water impact associated with developing new wells or permitting additional withdrawals in the coastal zone be classified and used as a criteria in determining new water right certification, to avoid increasing or causing seawater intrusion problems. Ecology would use the classification criteria developed under SI-1 as part of the review of any new water right application.

Who:	Ecology
Priority:	High
Time:	To be determined
Fund Source:	Agency general funds

2.2.4 Data Collection and Management Program

Goal Statement: *To provide the necessary information to facilitate preservation of the quality and quantity of the Island's ground water. Effective long-term monitoring is the key to protecting and achieving optimum use of the Island's water resources.*

Long-term data collection of ground water quality and quantity, precipitation and stream flow on Vashon Island is necessary to monitor and protect the ground water resource from depletion and contamination. The focus of monitoring shall be on the earliest possible detection of ground water degradation and depletion in the most vulnerable recharge areas. The data collected needs to be entered into a database and analyzed to provide useful information for making resource management decisions. The recommended data collection program has estimated laboratory analysis costs of $44,000 per year, plus a one-time estimated cost of $50,000 to drill a new monitoring well. Data is collected and analyzed so that state and local agencies can:

- Determine water resource trends in ground water quality and quantity;
- Make informed decisions on such issues as land use and water rights;
- Plan for peak water use and population growth impacts;
- Conduct water programs such as well construction and decommissioning, operation and maintenance;
- Develop and refine a water resource model;
- Respond to data requests from water agencies and other interested parties; and,
- Respond to incidents such as water level declines.

Issue 1 - Data Collection, Analysis and Management: Ground water resource data on a long-term basis enables land and water use agencies to make informed decisions. Data collection and analysis to date has been used to develop a general characterization of ground water hydrology on Vashon. Additional data collection and analysis is needed to refine characterization of the aquifer and to manage the resource.

DCM - 1 Data Collection, Analysis and Management: The King County Department of Natural Resources will develop and implement a data collection and management program that monitors water quality, water level, precipitation and stream discharge parameters. Where water level declines or ground water contamination is observed, convene the Ground Water Advisory Committee to determine a solution (per LU-1). The program would:

- Collect data needed according to the Vashon Data Collection List (see Appendix E: Recommended Data Collection Program);
- Continue data entry into the database, manages the data for quality control and applicability to analysis techniques, shares the data with other agencies and ensures data compatibility with other data collection efforts; and
- Analyze the data to better our understanding of ground water hydrology to estimate the available resource; assess the impacts of land use on the resource; and determine if a sophisticated numerical or computerized model is needed or would be useful.

Who:	King County Department of Natural Resources, Ecology, utilities, well drillers, Management Committee, and volunteers
Priority:	High
Time:	0.75 FTE for Department of Natural Resources staff
Fund Source:	Aquifer Protection Area

2.2.5 Ground Water Quality and Quantity Issues Associated with Storm Water Management

Goal Statement: *To promote storm water management practices that provide the greatest amount of recharge while protecting ground water quality.*

Past and present storm water management practices account for some ground water quantity and quality problems. Ground water quality may be affected if storm water containing contaminants is recharged intentionally or inadvertently. Also, precipitation is diverted to surface water when, under natural conditions, it would be recharged to ground water. As a result, the quantity of water recharged to ground water may be decreased. The Vashon Ground Water Management Committee adopted the following management strategies to address stormwater management issues. Education strategies related to stormwater management are found in the Education Program.

Issue 1 - Assessment of Existing Storm Water Facilities: Existing storm water management facilities (or the lack of facilities) in the most physically susceptible, high recharge, and wellhead protection areas may pose a risk to ground water quality and the population served by public water systems. Some facilities were constructed with little concern for ground water quality. Of particular concern are dry wells used in commercial and industrial areas. Also, some areas have only ditches as storm water facilities. This situation may be found in areas with highly permeable soils that were developed prior to current regulations. Storm water enters ditches in these areas and rapidly infiltrates without benefit of treatment.

ST-1 Assessment of Existing Storm Water Facilities: King County should assess the adequacy of storm water facilities in the most physically susceptible, high recharge and wellhead protection areas to protect ground water quality and to give these areas high priority for water quality facility retrofit as warranted. Vashon-Maury Island is presently outside of the service area for the Water and Land Resources Division. The Division could accomplish this task only if the Island becomes a part of the service area. The Ground Water Advisory Committee supports expanding the service area for the Division onto the Island.

Who:	King County Department of Natural Resources, Water and Land Resources Division
Priority:	Medium
Time:	To be determined, based on service area constraints of the Water and Land Resources Division
Fund Source:	Agency general funds

Issue 2 - Roadside Soil: Roadside soil can accumulate wastes which may be toxic to ground water from vehicles using these routes. This soil and debris are routinely accumulated and stockpiled in a pasture where the wastes may be leaching into the ground water.

ST-2 Roadside Soil: King County Department of Transportation, Roads Services Division will evaluate the ground water in areas where roadside accumulations are stockpiled on Vashon.

Who:	King County Department of Transportation, Road Services Division.
Priority:	Medium
Time:	Expected to be done with existing resources
Fund Source:	Agency general funds

Issue 3 Coordination between Surface and Ground Water Planning Efforts. Surface and ground water planning efforts should be effectively coordinated to make the best use of limited resources.

ST-3 Coordination Between Surface and Ground Water Planning Efforts - Ecology Programs: Ecology will assess surface and ground water quality planning programs to determine how they could be combined or coordinated in a way that is both scientifically justified and provides for greater efficiency.

Who:	Ecology
Priority:	Low
Time:	0.32 FTE
Fund Source:	Agency general funds

2.2.6 Ground Water Education Program

Goal Statement: *To increase individual participation in protecting the ground water resource by educating citizens in the Vashon Ground Water Management Area about ground water, the threats to quantity and quality, and ways they can reduce those threats.*

Providing citizens on Vashon with information on the ground water resource and protection may be a particularly effective protection method. Understanding, caring, and commitment are needed to protect a finite basic resource which is impacted by a wide variety of activities. Although regulations may help, groups of informed citizens actively caring for their ground water under their own communities might be more effective. Providing technical assistance will not address all the concerns but will entice some community members to take individual action. Currently, a number of education programs focused on individual sources of contamination. However, no comprehensive ground water education program focuses on the following tasks:

- Help engender understanding and concern in order to protect the resource;
- Aid in developing resource protection messages that are consistent regardless of the specific education program;
- Coordinate with other resource protection programs that focus on a specific issue, such as solid waste, hazardous waste, surface water and storm water management;
- Develop specific education activities and materials for point and non-point sources of contamination that do not have their own individual programs;
- Support research on ground water resource; and
- Encourage and promote conservation.

A comprehensive program would coordinate existing environmental education programs to develop consistent messages about the ground water resource and ground water protection. This component would be done by briefing environmental educators about the Island's ground water system, and supporting joint programs. The program would respond to local ground water quality and quantity concerns that are not already covered by other programs. This program would provide assistance for local planning efforts and other ground water protection projects.

Issue 1 - Existing Education: Considerable effort is underway to educate the public regarding the prevention of non-point pollution, conservation, well construction and improper disposal of hazardous materials. Agencies or jurisdictions involved include King County (the Seattle-King County Health Department, Cooperative Extension, Department of Development and Environmental Services, Department of Natural

Resources, Water and Land Resources Division and Water Pollution Control Division (formerly Metro), Puget Sound Water Quality Authority, Ecology, King Conservation District, Natural Resources Conservation Service, schools and others. It is unknown if these existing educational materials contain ground water resource protection information.

ED-1 Existing Education: King County and other jurisdictions will jointly carry out a ground water education program which will review existing education activities and make use of these programs when applicable. The King County Department of Natural Resources will review applicable educational efforts underway to determine whether the protection of ground water is emphasized. The King County Department of Natural Resources will seek the cooperation of the parties involved to include ground water information and concerns in the educational programs. The specific elements of the program are:

- Existing educational program content will be reviewed for agreement with the Vashon Ground Water Management Plan policies and goals. The King County Department of Natural Resources will review the current educational programs of the Natural Resources Conservation Service, Cooperative Extension and others to ensure that the Vashon Ground Water Management Plan goals and policies are reflected;
- The Local Hazardous Waste Management Program in King County will coordinate with the Household Hazardous Waste Education Committee to include information about the risks to ground water associated with the disposal of household hazardous wastes to on-site sewage systems as part of their household hazardous waste educational activities;
- King County and water utilities will work with local nurseries, the Washington State University Cooperative Extension Service and the Conservation Districts to promote the availability of appropriate seed stocks, plants and materials to achieve xeriscaping (use of low-water use plants);
- The ground water education program will support conservation education efforts in the schools, and for the general public as described in the *Conservation Planning Requirements* (Washington Water Utilities Council, Department of Health, Department of Ecology, March 1994;
- Cooperative Extension and the King County Department of Natural Resources will prepare a brochure to educate residents about landscaping practices that promote aquifer recharge;
- The education program should include information on pesticides and fertilizer use, including the strategies in *Protecting Ground Water: A Strategy for Managing Agricultural Pesticides and Nutrients, April, 1992* and the 1991 *Puget Sound Water Quality Authority Plan* (Household Hazardous Waste Program: Information and Education on Less-Toxic Alternatives for Household Products and Non-Point Source Pollution Program: Puget Sound Pest Management Information Program) to help insure that small farmers and homeowners receive more information about pesticide and fertilizer use;

- The Seattle-King County Health Department will coordinate measures to increase public awareness concerning the potential impacts of discharging household chemical products to an on-site sewage system. Such measures would be an extension of activities scheduled as part of the Local Hazardous Waste Management program;
- Educational programs concerning the effect of landscaping practices on aquifer recharge could be coupled with education on the impacts of pesticide and herbicide use on ground water quality. A discussion of proper disposal of household hazardous waste could be included. Landscaping tips should include a discussion of native vegetation and its role in facilitating infiltration of moisture. Educational efforts would complement and combine with the current efforts of the Seattle-King County Health Department, Cooperative Extension, and the Conservation District. This information could be disseminated through the Master Gardener and other programs of Cooperative Extension; and
- General public knowledge about the public health significance of the requirements for well construction, operation, maintenance, and decommissioning is lacking. The Vashon Ground Water Management Plan Education Program will coordinate with and support the Department of Ecology's well identification, well construction, proper well maintenance, contamination sources and well decommissioning projects. Informed well owners and other community members are probably more likely to comply with the well construction and decommissioning regulations. Methods of informing well owners might include distributing a questionnaire about wells to homes in the community, developing and distributing an educational brochure for homeowners, and supplementing the brochure with community educational programs. The questionnaire should be designed to ascertain the number of wells on each property, the construction methods used, and the number of wells that require decommissioning. The brochure should include recommended practices and legal requirements for well construction and decommissioning. It should also include the reasons why practices such as sealing the well are both advisable and required by law so that homeowners are knowledgeable before they make plans to construct or decommission a well.

Issue 2 - New Educational Elements: Several issues do not have any existing education program upon which to build. These have been identified through the Ground Water Advisory Committee consideration of ground water protection issues. These specific elements need to be adopted as part of the education program.

ED-2 New Educational Elements: King County will carry out a ground water education program which will develop specific education activities and materials for sources of contamination. The King County Department of Natural Resources will report to the Management Committee on the adequacy of existing educational programs to address ground water concerns. This report will include proposed changes as a result of review and discussions carried out in ED-1. The King County Department of Natural Resources will then develop a supplemental educational program to address deficiencies identified above, and present it to the Management Committee for review and adoption.

New educational programs will be developed and implemented according to the adopted Vashon Ground Water Advisory Committee actions below (this is a partial list, more elements are expected to be developed as the program progresses):

- Increase awareness concerning proper on-site sewage system operation and maintenance, including the risks associated with disposal of hazardous wastes in such systems. Amend the existing public information pamphlet concerning on-site sewage system maintenance and operation to provide instructions concerning proper household hazardous waste disposal practices;
- Educate homeowners and other owners of exempt underground storage tanks regarding tank abandonment requirements of the Uniform Fire Code;
- Include information about the relationship between solid waste disposal and the threat to ground water quality;
- Develop information brochures directed at builders/developers and homeowners with ideas on how to minimize surface water runoff increase due to property development.
- Presentations to appropriate banking and insurance company associations to inform them of the current regulating environment in regards to well owner responsibilities and the potential for contamination to the aquifers and the resulting expenses associated with clean-up.
- Sponsoring informational booths at local fairs; booth displays at local libraries or bank lobbies.
- The existing public information pamphlet concerning on-site sewage system maintenance and operation will be amended to provide instructions concerning proper household hazardous waste disposal practices prior to any scheduled reprinting.
- A committed and trained group of volunteers will expand the knowledge of protecting the ground water resource. These volunteers will function in a role similar to that established by the Cooperative Extension Service, Master Gardener and Land-Water Steward Volunteer Programs;
- Providing information about recycling and educating residents about reducing the waste stream may reduce the amount of solid and hazardous waste going into the landfills and the amount of hazardous products that people buy;
- Support schools or individual teachers with an interest in ground water protection. Such support could include providing education materials, or developing school skits;
- Working with neighborhood groups on neighborhood ground water protection efforts;
- Developing and installing interpretive signs, such as signs explaining Wellhead Protection Areas.
- Development of a video on water resources for cable television and distribution to local video outlets.

Who:	King County Department of Natural Resources
Priority:	Medium
Cost:	0.25 FTE
Fund Source:	Aquifer Protection Area

2.3 Programs To Protect Ground Water Quality

The Ground Water Advisory Committee researched ten subject areas that potentially could affect ground water quality: hazardous materials management, underground storage tank management, on-site sewage treatment and disposal system use, use of pesticide and fertilizer, well construction and decommissioning, sewer pipes, solid waste landfills, burial of human remains, sand and gravel mining, and biosolids and sewage effluent. This section includes a goal statement, summary of the issues, and proposed management strategies for each subject area.

2.3.1 Hazardous Materials Management

Goal Statement: *To ensure that ground water is not contaminated due to improper management, including disposal, of hazardous wastes.*

Industrial and commercial processes produce and use hazardous substances. Hazardous materials use is not, however, limited to industries and businesses. They are widely available and used by almost everyone. The impact of these substances on the environment, particularly ground water, is often determined by the management practices of the businesses and individuals that use them. The recommendations for Hazardous Materials Management are in the Unfinished Agenda section.

2.3.2 Underground Storage Tank Management

Goal Statement: *To ensure that underground chemical and fuel storage tanks and piping systems are managed adequately to prevent contamination of ground water.*

Commercial underground petroleum and chemical storage tanks represent a significant potential threat to ground water quality in King County. Leakage from underground storage tanks and associated piping often occurs without detection and even relatively small amounts of certain compounds can have serious adverse impacts on ground water quality. Once released from an underground storage tank, some volatile organic compounds and petroleum products can rapidly migrate to ground water.

Ecology currently lists 28 commercial tanks in use on Vashon Island and it is estimated that an excess of 700 residential underground storage tanks are in use. Ecology is aware of seven sites in the Vashon-Maury Island Ground Water Management Area that have contaminated ground water. Six of these have completed remediation. Underground storage tanks are regulated by federal, state, and local governments. Private sector pressures from insurance and lending institutions also bring increasing pressure to bear upon owners and operators of underground storage tanks to install and maintain systems in a manner which reduces liability risks by avoiding spills.

Leaking underground home heating oil tanks may present a threat to ground water quality. Both federal and state regulations adopt a less aggressive approach to regulation of heating oil tanks, however, because of differences in the constituency and migration of fuel oils in the soil. Potential problems associated with home heating oil tanks include leakage from operating tanks and releases from improperly abandoned tanks containing residual product. Many of the existing home heating oil tanks within King County are likely to be bare steel tanks without protection from rusting and, as such, a large percentage may be leaking or will leak in the future.

Issue 1 - Augment State Underground Storage Tanks Program: The underground storage tank management program administered by Ecology does not have the resources to field check and monitor for compliance with regulations. As part of their Wellhead Protection Plans, purveyors are to identify potential threats to their wells, including underground storage tanks. The King County Comprehensive Plan policy NE-333 states that the County should review and implement, as appropriate, adopted Wellhead Protection Programs in conjunction ground water purveyors. Recommended Management Strategy SA-2 states that the Management Committee will develop strategies that King County could adopt to help implement Wellhead Protection Programs. These strategies should include ways to address underground storage tanks.

UST-1 Wellhead Protection Strategies for Underground Storage Tanks. The King County Department of Natural Resources, in conjunction with the Management Committee, will include the following in the strategies for wellhead protection. They would be implemented only if specifically requested by a water purveyor as part of their Wellhead Protection Plan.

- **1A Augment State Underground Storage Tanks Program - Designation as an ESA under Chapter 90.76 RCW:** King County Department of Natural Resources will prepare a petition to Ecology to designate the Vashon Ground Water Management Area as an Environmentally Sensitive Area under Chapter 90.76 RCW Underground Storage Tanks for the Metropolitan King County Council's consideration. An Environmentally Sensitive Area designation under the authority of Chapter 90.76 RCW is not the same as an Environmentally Sensitive Area designation under the State Environmental Policy Act (Chapter 197-11-908 WAC); although, a single area could be designated as an Environmentally Sensitive Area under both provisions of state law. Designation under RCW 90.76 affects only the construction and operation of underground storage tanks while designation under SEPA can affect a much broader range of land use activities.

- **1B Augment State Underground Storage Tanks Program:** King County Department of Natural Resources will prepare a program and related ordinances to enhance the current inspection of underground storage tank installation and removal in the Environmentally Sensitive Area to include the relevant requirements of Chapter

173-360 WAC - Underground Storage Tank Regulations for the Metropolitan King County Council's consideration.

- **1C Augment State Underground Storage Tanks Program:** Ecology and King County will ensure that underground storage tanks on Vashon Island are inspected to determine if they are leaking.

- **1D Disclosure and Secondary Containment:** The King County Department of Natural Resources will prepare an ordinance for the Metropolitan King County Council's consideration regarding underground tanks containing the following provisions: disclosure at the time of sale of any property in King County of the number, location, and legal status of existing underground fuel and chemical storage tanks; and require secondary containment for new tanks or have above ground installation.

- **1E Exempt Tanks:** The Department of Natural Resources will prepare an ordinance for the Metropolitan King County Council's consideration requiring secondary containment for underground chemical storage tanks as defined by Chapter 173-360-120 WAC and for heating oil tanks of all sizes and motor fuel tanks of 1,100 gallons or less.

- **1F Heating Oil Tanks - Abandonment and Maintenance:** The King County Department of Natural Resources will prepare an ordinance for the Metropolitan King County Council's consideration regarding underground home heating oil tanks containing the following provisions: proof from the Fire Marshal that the underground heating oil tank is abandoned in accordance with regulations prior to release of any permits associated with energy conversion (gas piping, electrical, etc.); and require underground heating oil tanks which are abandoned in place are filled with a material that precludes further storage of any chemical in the tank.

Who:	King County Department of Natural Resources
Priority:	Low
Cost:	0.25 FTE
Fund Source:	Aquifer Protection Area

Issue 2 - New Tanks: Underground storage tanks if not properly constructed, installed and maintained can cause degradation of Vashon's ground water resource.

UST-2 New Tank Prohibition: If approved by Ecology, King County will amend the King County Code to prohibit the installation of new underground fuel tanks in residential zones on Vashon Island.

Who: Department of Development and Environmental Services.

Priority: Low
Cost: 0.125 FTE
Fund Source: Agency general funds

2.3.3 On-Site Sewage Treatment and Disposal System Use

Goal Statement: *To promote on-site sewage treatment and disposal practices that are effective in protecting ground water resources from possible adverse impacts.*

Ground water contamination associated with domestic on-site sewage system effluent can involve a number of contaminants including nitrate, bacteria, viruses, and trace organic chemical compounds. Nitrate is often considered the most significant contaminant associated with domestic wastewater since it is highly resistant to removal from treatment mechanisms present in the soil profile. Bacteria and viruses can be attenuated during migration through a few feet of fine to medium textured soils provided unsaturated flow conditions can be maintained. However, coarse textured, excessively permeable soils are ineffective in removing bacteria and viruses. Also, domestic effluent often contains volatile and semi-volatile organic compounds at very low levels. These organic chemicals are generally residues from household cleaning and paint products, and are known as household hazardous wastes. If on-site sewage systems are improperly designed or constructed, installed in inadequate soils, used at too high of a development density, or used to dispose of non-domestic wastewater, they can adversely impact surface and ground water quality as well as public health.

Vashon Island is a sole-source aquifer where all ground water on the island is either potential drinking water or base flow for streams. Also, Vashon Island is a rural area where on-site sewage disposal is the main method of sewage disposal, with the exception of the community sewerage system within the town of Vashon. The King County Comprehensive Plan and Vashon Community Plan state that Vashon is a rural area. The 1986 Vashon Community Plan policies relating to on-site wastewater and alternative sewage systems (V-44, V-46, V-47, V-48 and V-49) state that on-site waste disposal systems are considered as permanent solutions to wastewater disposal outside sewer local service areas.

In 1989 and 1990 the Seattle King County Health Department conducted a sanitary survey of seven coastal communities: Beulah Park, Cove, Bunker Trail, Spring Beach, Paradise Cove, Patten Palisades and Quartermaster Harbor to assess the status and operation of on-site sewage systems. As a result, the first four communities listed were declared "severe public health hazard areas" by the Washington State Department of Health pursuant to the Department of Ecology's Centennial Clean Water Fund grant criteria. In these four communities, no more than 25 percent of on-site sewage systems were functioning properly. More information concerning this study is available in the *Sewage Facilities Plan for the Severe Public Health Hazard Areas, Vashon Island,* Barrett Consulting Group, November 1993.

An extensive regulatory system is currently in place at the state and local level to prevent adverse public health and environmental impacts from the use of on-site sewage treatment and disposal systems. During the development of the Vashon Ground Water Management Plan, the Ground Water Advisory Committee identified the need to revise the state on-site regulations to meet the intent of the Water Quality Standards for Ground Water (Chapter 173-200 WAC). The state regulations were recently modified and implemented on January 1, 1995, strengthening the ground water protection provisions of applicable on-site sewage system regulations and standards. In addition to the regulatory programs, the King County Comprehensive Plan contains several policies about on-site systems:

F-315 On-site wastewater treatment systems in the Rural Area and Natural Resource Lands should be designed, built, and operated as permanent methods of sewage disposal.

F-316 King County should monitor on-site systems that have shown evidence of failure or potential for failure. The data should be used to correct existing problems and prevent future problems. King County should analyze public funding options for correcting on-site wastewater system failures that may include, where feasible and otherwise consistent with this Plan, conversion to community sewage system, or the installation of public sewers.

Improved design criteria in the revised regulations appear to have further reduced the threat to ground water quality posed by new individual residential on-site systems. Within the Vashon Ground Water Management Area, the 1989-90 Sanitary Survey concluded that existing high-density developments are served by conventional on-site sewage systems. To date, ground water quality problems associated with such developments have not been fully documented. Also, extensive ground water monitoring efforts to identify problems associated with on-site sewage systems have not been undertaken. The Vashon Ground Water Management Committee adopted the following management strategies to address on-site sewage treatment issues. Education strategies related to on-site sewage treatment are found in the Education Program.

Issue 1 - Nitrate Concerns: The designs of most on-site sewage treatment and disposal systems installed in Type 1 soils (coarse sands or coarser) prior to April 1987, the implementation date of King County Board of Health Title 13, did not incorporate enhanced treatment technology. These systems often support development densities that exceed one residential unit, or equivalent, per acre. The poor treatment efficiency of conventional on-site sewage systems installed in coarse textured soils suggests a potential for nitrate contamination of underlying ground water, especially in areas where the density of on-site sewage systems is relatively high. Nitrate concentrations may build up in the zone of contribution to public water systems to unacceptable levels resulting in irreversible loss of drinking water supplies.

OS-1A Nitrate Concerns: The King County Department of Natural Resources will include the following in the wellhead protection strategies: the Seattle-King County Health Department will work with land use authorities to require alternative methods of development and/or revised land use for those tracts less than an acre in size which are undeveloped in areas where nitrogen levels are found to be unacceptable (more than 5 mg/l); and the Seattle-King County Health Department will work with the Board of Health to require alternate methods of sewage disposal for those tracts less than an acre in size in areas where nitrogen levels are found to be unacceptable (more than 5 mg/l) or showing increased trends.

OS-1B Nitrate Concerns: King County Department of Natural Resources will consult with the Vashon Management Committee on action taken to resolve problems where on-site sewage disposal systems are determined to have a measurable effect on the aquifer from nitrogen levels.

Who:	King County Department of Natural Resources, Management Committee.
Priority:	High
Cost:	0.125 FTE
Fund Source:	Aquifer Protection Area

Issue 2 - Household Hazardous Wastes: Household hazardous wastes can enter ground water through the wastewater stream when residues from cleaning and paint products or quantities of unwanted chemical substances are disposed of in a sink or toilet connected to an on-site sewage system. When discharged to an on-site sewage system, household hazardous wastes may pass through the system and migrate to underlying ground water. While wastes from any single residence are not likely to have detectable impacts on underlying ground water, the cumulative effects of many residences may be significant. Many people are unaware that common household products often contain chemical compounds that can represent an environmental or even public health hazard if disposed in an on-site sewage system.

OS-2 Household Hazardous Wastes: The Local Hazardous Waste Program in King County will coordinate with the Household Hazardous Waste Education Committee to include information about the risks to ground water associated with the disposal of household hazardous wastes to on-site sewage systems when conducting household hazardous waste educational activities.

Who:	Local Hazardous Waste Program in King County
Priority:	High
Cost:	To be determined
Fund Source:	Agency general funds

Issue 3 - Operation and Maintenance: Home and business owners may not be aware of the location and proper operation and maintenance of on-site sewage treatment and disposal systems.

OS-3A Operation and Maintenance: The Seattle-King County Health Department will prepare amendments to *Title 13 of the Code of the King County Board of Health* for King County Board of Health's consideration to require that the on-site sewage treatment and disposal system as-built plan be recorded with the property deed in order that it be transferred with the title at the time of property purchase. In addition, information concerning the relationship between on-site system maintenance and operation practices and ground water protection should be added to the standard as-built plan form.

Who:	Seattle-King County Health Department, King County Board of Health
Priority:	High
Time:	0.08 FTE
Fund Source:	Agency general funds

OS-3B Operation and Maintenance: The Seattle-King County Health Department will examine the feasibility of a county-wide on-site sewage system management program to determine its effectiveness in the protection of ground water.

Who:	Seattle-King County Health Department.
Priority:	High
Time:	0.5 FTE
Fund Source:	Agency general funds

2.3.4 Pesticide and Fertilizer Use

Goal Statement: *To prevent ground water contamination from the use of pesticide and fertilizer.*

Pesticides and fertilizers are used for the control of plant and animal pests and promotion of plant growth. Pesticides are a large and varied group of substances that are specifically designed to kill biological organisms including weeds, insects, and rodents. Fertilizer is used to promote plant growth. Pesticides and fertilizers are used for agriculture, home, forestry, and rights-of-way maintenance. Pesticides and fertilizer have the potential to contaminate ground water even when they are used according to the label instructions. The King County Comprehensive Plan policy NE-502 states that King County should actively encourage the use of environmentally safe methods of vegetation control and that herbicide use should be minimized. The Vashon Ground Water Management Committee adopted the following management strategies to address pesticide and fertilizer issues. Education strategies related to pesticide and fertilizer uses are found in the Education Program.

Issue 1 - Pesticide and Fertilizer - Past Use: Past use of pesticide and fertilizer may pose a threat to ground water quality.

PF-1A Pesticide and Fertilizer - Past Use: Include land uses that have the potential for pesticide and fertilizer use in the determination of vulnerable aquifer areas. See the strategy described in the "Special Protection Areas" paper.

PF-1B Pesticide and Fertilizer - Past Use: The King County Department of Natural Resources will monitor for specific pesticides and fertilizers in the physically susceptible areas, where they are expected to occur based upon past land use, in the Data Collection and Management Program.

Who:	King County Department of Natural Resources
Priority:	Low
Time:	No additional costs, they are included as part of the Data Collection and Management Program
Fund Source:	Aquifer Protection Area

Issue 2 - Pesticide and Fertilizer Use: Use of pesticide and fertilizer may pose a threat to ground water quality.

PF-2A Pesticide and Fertilizer Use: King County will encourage and support the King Conservation District in development of Farm Plans using best management practices for any agricultural user of pesticide and fertilizer in the physically susceptible and recharge areas.

Who:	King Conservation District
Priority:	Low
Cost:	$94,900
Fund Source:	Agency general funds

PF-2B Pesticide and Fertilizer Use: King County Department of Natural Resources, in conjunction with the Management Committee, will evaluate the Cooperative Extension Pesticide Reduction Program for effectiveness in protecting ground water and applicability to the Vashon Ground Water Management Area.

Who:	King County Department of Natural Resources
Priority:	Low
Time:	0.125 FTE
Fund Source:	Agency general funds

PF-2C Pesticide and Fertilizer Use: King County Roads Services Division uses an Integrated Pest Management Program for roadside right-of-way maintenance. King County Department of Natural Resources, in conjunction with the Management Committee, will determine if maintenance practices by others for roads and utility rights-of-way in the Vashon Ground Water Management Area needs to be restricted to non-chemical methods.

Who:	King County Department of Natural Resources
Priority:	Low
Time:	0.125 FTE
Fund Source:	Agency general funds

2.3.5 Well Construction, Decommissioning and Well Owners' Responsibilities

<u>Goal Statement</u>: *To protect the quality of ground water in the county by ensuring that proper well construction and decommissioning procedures are followed.*

Wells provide a link between an aquifer and the earth's surface. Modern wells consist of a well casing that extends downward from the ground surface to the aquifer within a cylindrical bore hole. The Minimum Standards for Construction and Maintenance of Wells (Chapter 173-160 WAC) requires that the space between the casing and the wall of the borehole be sealed to prevent vertical movement of water along the outside of the casing. If this space is not adequately sealed, it may serve as a conduit by which contaminated surface or subsurface water may travel into an aquifer. Regulations also require that any well that is unusable, has been permanently discontinued, is in such disrepair that its continued use is impractical, or is an environmental, safety, or public health hazard, must be decommissioned.

The seven large public water systems (Group A) on Vashon are regulated by the Washington State Department of Health. Also, the numerous small water systems (Group B) and individual water systems are regulated by the Seattle-King County Health Department. The Vashon Ground Water Management Committee adopted the following management strategies to address well construction and decommissioning issues. Education strategies related to well construction and decommissioning are found in the Education Program.

Issue 1 - State Program: Existing regulations for well construction and decommissioning are not adequately enforced. Ecology does not receive enough funding to inspect more than a small percentage of wells during construction or decommissioning.

WC-1A State Program: Ecology, King County, and special purpose districts will pursue funding for the well construction and decommissioning program and pursue legislation, with input from affected parties. King County and special purpose districts should support the proposed legislation.

Who:	Ecology, King County
Priority:	Low
Cost:	Ecology estimates $70,000; 0.08 FTE for King County
Fund Source:	Agency general funds

WC-1B State Program: Seattle-King County Health Department and Ecology will develop a local health department program for implementation of the delegated portion of the well construction and decommissioning program in King County.

Who:	Ecology and Seattle-King County Health Department
Priority:	Low
Time:	Seattle-King County Health Department: 0.5 FTE, Ecology: $70,000/year
Fund Source:	Agency general funds

Issue 2 - Well Identification: Wells need to be identified so that Ecology may implement programs to protect the ground water resource. No method to systematically identify wells exists; wells that were drilled before 1973 were not required to submit well logs to Ecology; and there no agency is identifying wells that should be abandoned.

WC-2A Well Identification: King County Department of Natural Resources will prepare an ordinance for the Metropolitan King County Council's consideration which would require property sellers to disclose to buyers the existence of used or unused wells on the property. Ecology will prepare draft legislation to require sellers to disclose to buyers the existence of used or unused wells on the property.

Who:	King County and Ecology
Priority:	Low
Cost:	0.08 FTE for King County; Ecology estimates $17,500 for Year 1 and $35,000 for Year 2
Fund Source:	Agency general funds

WC-2B Well Identification: King County Department of Natural Resources will prepare an ordinance for the Metropolitan King County Council's consideration which would require that applicants establish the location and status of wells present on the property in question during environmental review, rezone and land use permit applications. King County will provide this information to Ecology.

Who:	King County
Priority:	Low
Cost:	0.08 FTE
Fund Source:	Agency general funds

2.3.6 Sewer Pipes

<u>Goal Statement</u>: *To prevent the degradation of ground water which may be caused by wastewater leaking from gravity sewer pipes and side sewers, and to prevent the loss of water through infiltration to gravity sewer pipes and side sewers.*

The Vashon Sewer District has provided sewage collection and treatment for the town of Vashon since 1947. Presently about 330 customers comprise the Vashon Sewer District.

In 1955, the Vashon Sewer District installed its first gravity sewers. Currently, the Vashon sewage collection system consists of approximately 21,500 feet of gravity pipe and 10,000 feet of force main. Approximately 12,200 feet of gravity pipe is 8-inch diameter concrete pipe, 8,200 feet is 8-inch PVC pipe, and the remaining 1,100 feet is 8 inch asbestos cement. Concrete piping has cement mortar joints that usually leak soon after installation. In the mid 1960's, rubber gasket concrete pipe joints were developed and installed which allow some movement of the joint after installation without appreciable infiltration (*Vashon Sewer District Comprehensive Sewer Plan, June, 1992*).

Infiltration is defined as ground water entering sewer pipes through leaking joints or defects, both as runoff during storm events or as base flow from other sources. Inflow refers to direct flows of storm water into sewer pipes through hookups such as roof and footing drains. Because sources of infiltration and inflow (I and I) are not easily distinguished by sewer authorities, they are commonly considered under the single heading. Infiltration into sewer systems also represents potential export losses of ground water. Export loss means that ground water is transported out of the basin by the sanitary sewer reducing the total amount of available ground water.

In November 1989, Gary and Osborne completed a study of infiltration and inflow at the Vashon Sewage treatment plant. The study concluded that the sewer system experiences seasonal increases in flow due to infiltration and inflow related to the height of the ground water table and precipitation intensity. Gary and Osborne recommended rehabilitation work which would reduce 0.20 million gallons per day of inflow (*Vashon Sewer District Comprehensive Sewer Plan, June 1992*). The rate of infiltration was estimated to reach approximately 0.074 million gallons per day (51 gallons per minute). A physical survey, smoke testing and television inspection of much of the sewer system indicated that catch basins, open cleanouts, leaking joints, root intrusion, and leaking manholes were sources of infiltration and inflow.

If ground water infiltrates into sewer pipes during periods when the water table is high, then it is conceivable that wastewater is discharged into the ground when the water table is lowered. In 1991, the Vashon Sewer District while conducting investigations concluded that exfiltration may also be occurring. Excavations at a few selected locations support the exfiltration possibility by showing damp soil around the pipe in otherwise dry backfill. Although a limited number of tests along the pipe trench have not detected fecal coliform, further investigation may be warranted. Pipe repair is an important priority to protect the local ground water quality (*Vashon Sewer District Comprehensive Sewer Plan, June 1992*).

Numerous utility officials consider side sewers on private property more of a threat to ground water quality than the sewer mains themselves. For example, in a Kent study, in an older neighborhood, side sewers were determined to contribute 75 percent of the infiltration to Kent sewers. This was detected by the King County Water Pollution Control Division (formerly Metro) using a smoke test; Kent and Metro bore the cost of replacing these leaking side sewers.

Issue 1 - Infiltration and Exfiltration: Infiltration of ground water into gravity sewer pipes may be causing significant export losses of ground water from the Vashon Ground Water Management Area. Exfiltration of sewage from leaking sewer pipes may be causing contamination of ground water.

SP-1A Infiltration and Exfiltration: King County Department of Natural Resources will review and analyze existing studies and on going programs developed by the Vashon Sewer District to determine if infiltration and exfiltration are impacting ground water quality and quantity in the Vashon Ground Water Management Area and, analyze conclusions and determine appropriate follow up action, if any.

Who:	King County Department of Natural Resources
Priority:	Low
Time:	0.5 FTE
Fund Source:	Aquifer Protection Area

SP-1B Infiltration: The Management Committee will review the Vashon Sewer District Comprehensive Plan prior to any significant expansion of the sewer district area to determine the impacts on aquifer depletion.

Who:	Management Committee
Priority:	Low
Time:	To be determined
Fund Source:	Aquifer Protection Area

SP-1C Sewer Maintenance Programs: The Vashon Management Committee encourages the Vashon Sewer District to continue or adopt a regularly scheduled leak detection and repair program, and a public education program related to side sewer maintenance.

Who:	Vashon Sewer District
Priority:	Low
Time:	To be determined
Fund Source:	Agency general funds

SP-1D Leakproof Piping: The Vashon Ground Water Advisory Committee encourages King County to amend the King County Code 13.24 to require the following: new sewer piping installed in the most physically susceptible and recharge areas be leakproof; and existing leaking sewer pipes including side sewers will be replaced with leakproof piping in the most physically susceptible and recharge areas according to a schedule contained in the Sewer Utility Comprehensive Plans.

Who:	King County, Office of Budget and Strategic Planning
Priority:	Low

Cost: 0.125 FTE
Fund Source: Agency general funds

2.3.7 Solid Waste Landfills

Goal Statement: *To eliminate or reduce the occurrence of ground water contamination by the operation of solid waste disposal facilities and if the Vashon landfill continues to be a source of contamination, then it should be closed and a transfer station provided.*

The ground water impact from landfills is from leachate production. Leachate is water or other liquid that has been contaminated by dissolved or suspended materials due to contact with solid waste or gases from the solid waste. Ground water that has been contaminated by leachate may affect public health. Ground water that is not currently being used for drinking water also needs to be protected from leachate contamination, as it may become a drinking water source in the future.

The Vashon landfill is located in west central Vashon Island. This site has been used since the early 1900's. The 9.3-acre refuse area is located on a 145-acre site. The old refuse area adjacent to the current refuse site has been capped. All wastes are accepted at the landfill except liquids, flammable materials, dangerous or hazardous wastes. King County Solid Waste Division expects to close the landfill in the year 2000. The Vashon Ground Water Management Committee recommended management strategies to address landfill issues are found in the Unfinished and Finished Agenda's of this Plan. Education strategies related to solid waste disposal are found in the Education Program.

2.3.8 Burial of Human Remains

Goal Statement: *To prevent the degradation of ground water from embalming fluids, disintegrating metal caskets, decaying human remains and other materials associated with processing bodies for burial or cremation.*

Under certain hydrogeologic conditions, burial practices could have an affected on local ground water quality. One active cemetery is located on Vashon Island and one inactive cemetery on Maury Island. The Vashon Episcopal Church of the Holy Spirit also has a memorial garden columbarium used for earth burial of cremated remains. Nothing is known about the existing or potential effect of decomposing corpses and caskets on ground water on Vashon.

The Vashon Ground Water Advisory Committee concluded that ground water impacts from cemeteries was not a concern in the Vashon-Maury Island Ground Water Management Area. No further action is necessary at this time. However, the data collection and management plan may include monitoring near the cemetery.

2.3.9 Sand and Gravel Mining

Goal Statement: *To ensure that regulatory programs are adequate to prevent adverse effects upon ground water quality attributable to sand and gravel mining operations.*

Productive sand and gravel mines are often located over vulnerable aquifers. Mining activities in these areas can increase ground water vulnerability to contamination from both the extraction process and site reclamation. Four major commercial and a number of smaller sand and gravel extraction operations are located on the Island. The four major facilities, located on the south shore of Maury Island, operate throughout the year. The other sites, which operate intermittently, are located across the Island. The King County Comprehensive Plan contains these policies related to mining:

RL-410 The periodic review process for Mining zoned sites and those sites operating in the Forest Production District and as legal nonconforming uses shall include sufficient public notice and comment opportunities. The purpose of the periodic review process is to provide opportunities for public review and comment on the internal resource facility's fulfillment of state and county regulations and implementation of industry-standard Best Management Practices, and for King County to modify, add or remove conditions to address new circumstances and/or unanticipated project-related impacts. The periodic review process is not intended to reexamine the appropriateness of the mineral resource use, or to consider expansion of operations beyond the scope of existing permitted operations since that review would be accomplished through the County's permitting process. The periodic review is intended to be part of King County's ongoing enforcement and inspections of mineral resource sites, and not to be part of the County's permitting process.

RL-411 Conditions and mitigations for significant adverse environmental impacts associated with mining operations should be required especially in the following areas: Environmentally sensitive and critical areas, such as surface and ground water quality and quantity, wetlands, fisheries and wildlife habitats.

R-412 King County should work with the state and federal governments to ensure that the proposals for underground mining, oil and gas extraction, and surface coal mining are reviewed with consideration of local land use and environmental requirements.

R-413 King County should work with the State Department of Natural Resources to ensure that mining areas are reclaimed in a timely and appropriate manner. Where mining is completed in phases, reclamation also should be completed in phases as the resource is depleted.

Issue 1 - Aquifer Impacts and Regulation: Sand, gravel and rock quarry mining can cause changes in the site or include activities which increase the potential for contamination of important aquifers. Major changes have occurred at the state level regarding general permitting of sand, gravel, and rock quarry mining operations. Ecology require performance standards as part of the General Permit for all mines in King County. All discharges from sand, gravel, and rock quarry mines must meet the Ground Water Quality Standards (Chapter 173-200 WAC) and the Surface Water Standards (Chapter 173-201A WAC). There may be changes as a result of oversight or problems of coordination between the General Permit process and local zoning or policies found in the King County Comprehensive Plan.

SG-1 Aquifer Impacts and Regulation: The environmental guidance document should include the following Best Management Practices for sand, gravel and rock quarries:

1. For sites with a planned excavation depth lower than the ground water table, a detailed hydrologic report should be filed. This may be a part of a complete Environmental Impact Statement or be an appendix to an environmental checklist.
2. When mining activities are to be located in designated wellhead protection areas, special protection areas, sensitive aquifer areas, or principal recharge zones an Environmental Impact Statement should be required.
3. Where possible, mining sites should utilize internal drainage, in order to support continued ground water recharge and minimize off-site discharges.
4. When ground water is exposed during the mining operation and the resulting impoundment is larger than 3 acres, ground water should be monitored for both water level (monthly) and water quality (quarterly to semi-annually) over the life of the operation. Water level and water quality monitoring should also be considered when depth to seasonal high water is reduced to 5 feet or less.
5. Associated activities such as concrete, asphalt or other batch processing plants shall not contaminate ground waters.
6. Truck and equipment wash runoff should be routed to an approved retention and treatment facility, equipped with an oil-water separator prior to its release to retention ponds.
7. Fuel (oils) storage and handling facilities should be located some distance from the main sediment and wash water retention facility. All such facilities should be equipped with approved containment, monitoring, and collection systems. Fuel storage should be aboveground. These sites should be lined and bermed with sufficient capacity to accommodate spills and leaks. Runoff from these surfaces should be routed to a retention pond that can be monitored and cleaned in the event of a spill.
8. All sites should maintain a fuels/hazardous waste management plan. This would be maintained by the operator and be available on the site at all times.
9. At closure of the site, after accidental spills, or at the request of the Washington State Department of Natural Resources/Ecology, all contaminated material will be removed and disposed of with approved methods and at approved disposal sites. This material will not be used as fill at the site.

10. In general, impoundments of greater than 3 acres should not be filled. These sites should be stabilized as lakes and ponds and the surrounding area revegetated to insure stability of the site. Future land-use decisions should reflect increased ground water vulnerability at the site. Individual sites may be filled if it can be demonstrated that sufficient inert material can be obtained to serve as fill. Impoundments of less than three acres should not be filled if there is doubt as to quality or supply of inert fill.
11. Excavation pits should not be used as landfill disposal sites for unclassified or non-inert wastes. In general municipal landfills are not an appropriate use of gravel sites located over semi-confined and unconfined ground waters.
12. Pits with standing water that are slated to be filled may use only approved inert earth materials (native fill/overburden) to fill the area up to the high water table. The remaining fill should meet the conditions described in 10 and 11.
13. Future land use should reflect the increased vulnerability of ground water at the site and the change in the water balance of the area.

Who:	King County Department of Natural Resources
Priority:	Low
Cost:	0.5 FTE
Fund Source:	General Agency funds

Issue 2 - Environmental Review: The environmental review process may not provide adequate technical review of siting issues during review of applications for rezones and unclassified use permits.

SG-2 Environmental Review: King County will fund adequate staff for the King County Department of Natural Resources to perform technical/hydrological reviews of projects undergoing environmental review regarding the protection of ground water.

Who:	King County Department of Natural Resources
Priority:	Low
Cost:	0.125 FTE
fund Source:	General Agency funds

Issue 3 - Land Use of Inactive or Reclaimed Mines: Subsequent land use of reclaimed sand and gravel mining sites should reflect the increased susceptibility of aquifers to contamination. Currently no formal requirement that this be given special consideration exists.

SG-3 Land Use of Inactive or Reclaimed Mines. King County Department of Natural Resources and the Office of Strategic Planning will propose an amendment to the King County Comprehensive Plan for the Metropolitan King County Council's consideration to include a policy which provides that land use of inactive or reclaimed sand, gravel and rock quarry mines be carefully evaluated in light of the increased susceptibility of aquifers to contamination due to mining activities.

Who:	King County Office of Strategic Planning, in conjunction with the King County Department of Natural Resources
Priority:	Low
Time:	0.25 FTE
Fund Source	General agency funds

2.3.10 Biosolids and Sewage Effluent

Goal Statement: *To provide assurance that groundwater will not be contaminated by biosolids or the reuse of wastewater effluent.*

Biosolids are the treated and primarily organic sewage solids generated from wastewater treatment plants. Biosolids may be utilized for various beneficial uses including compost and fertilizer production, agricultural and silvicultural land application, land reclamation, and the manufacture of various construction materials. In 1993, the Department of Ecology issued the draft *Biosolids Management Guidelines for Washington State*. The Seattle-King County Health Department currently enforces existing state regulations through Title 10 of the King County Board of Health. Also, the Seattle-King County Health Department requires permits for biosolids treatment facilities and land application sites. The permitting process includes review of biosolids quality, site specific project design and operations, inspections, and environmental monitoring.

The only biosolids currently generated on the island are from the sewage treatment process at the Vashon Sewer District Treatment plant. These wastes are currently transported off island for disposal. In the past, disposal was on the Island. The Ground Water Advisory Committee resolved that biosolids generated on the Island (although currently disposed of off the Island) should be disposed on the Island. When application for biosolids is made for site approval, the Seattle-King County Health Department will forward a copy of the permit application to the Management Committee.

Sewage effluent is liquid left after sewage has settled. This liquid may be untreated, or it may be further settled, filtered, and disinfected, depending on final use. Reuse of effluent is regulated by the State Water Pollution Control Act (Chapter 90.48 RCW) administered by Ecology and by the "Wastewater Reclamation and Reuse Interim Standards."

The Ground Water Advisory Committee determined that no action was needed on these issues, as the existing regulatory approach was sufficient for ground water protection.

2.4 Ground Water Quantity Program

Goal Statement: *To manage the ground water resources of King County to optimize current and long-term benefits for present and future residents.*

Ground water quantity is important because ground water is used for drinking water, irrigation, industrial processes, and provides flow to streams that support fish and other wildlife. Aquifers, and related surface water levels, are maintained by preserving recharge. The two main causes of ground water depletion are reducing recharge by increasing permeable surfaces and by overuse. Recharge occurs only through relatively undisturbed, permeable soils. Population growth, with it's related construction of buildings and roads, causes an increase in impermeable surfaces and the demand for ground water.

The state of Washington has attempted to balance the needs of its citizens with maintaining the water resource. Ecology administers laws dealing with water appropriations and allocations. Allocations to new users must not conflict with existing use; however, the information needed to know when such a conflict may occur is lacking. Some areas of the state have experienced the effects of unwise use of aquifers, such as water level decline and seawater intrusion. Parties involved in water use are developing and using innovative techniques, such as conservation and artificial recharge, to decrease water use and increase water availability. Recent interest in maintaining surface water resources has spotlighted the interaction of ground water and surface water. Future ground water resource management must consider this interaction.

The *Ground Water Areas Management and Programs* (Chapter 173-100 WAC) contains guidelines on program content which were to be adapted to the particular needs of a ground water management plan. Included in the program content is a section on alternatives, which outlines various land and water use management strategies that address each of the ground water problems discussed in a problem definition section. It states that the alternative management strategies would address water conservation, conflicts with existing water rights and minimum instream flow requirements, programs to resolve such conflicts, and long-term policies and construction practices necessary to protect existing water rights and subsequent facilities installed in accordance with the Ground Water Management Plan program and/or other water right procedures. This Plan does not address these topics, except for conservation. Several new state programs, initiated since the WAC was written, provide programs to resolve conflicts with existing water rights and minimum instream flow requirements, and long-term policies and construction practices necessary to protect existing water rights and subsequent facilities (generally, under the Water Resources Forum from the Chelan Agreement). The Ground Water Advisory Committee found that an important step in addressing ground water quantity issues is to develop and implement a long-term monitoring and data collection program to provide decision makers with the necessary ground water information. Other important steps are conservation, education, and land use controls.

Issue 1 - Aquifer Recharge Preservation. One way to ensure continued recharge is through environmental review on individual developments. However, the current checklist for environmental review does not require a description of impacts to ground water recharge.

WQ-1 Aquifer Recharge Preservation: The Ground Water Advisory Committee requests that Ecology amend the environmental checklist to include impacts on the quantity of aquifer recharge. Until the change by Ecology can be made, King County will consider impacts on the quantity of aquifer recharge during environmental checklist review.

Who: Ecology and King County Department of Development and Environmental Services
Priority: Low
Time: Ecology; $7,000; DDES; to be determined
Fund Source: General agency funds

Issue 2 - Data Needs: The many needs for a complete characterization of the aquifer resource including: by Ecology for water rights application analysis, surface water/ground water interaction determination, possible ground water reservation and other resource management concerns. To date, this has not been completed.

WQ-2 Data Needs: Design and implement a ground water data collection management program which would enable Ecology and others (such as purveyors, land use planners and public officials) who make land and water use decisions to make water resource decisions based on more complete information.

Who: King County Department of Natural Resources, in the Data Collection and Management Program
Priority: High
Time: See Data Collection and Management Program
Fund Source: Aquifer Protection Area

Issue 3 - Water Rights: Water rights records do not necessarily accurately reflect actual pumpage rates and current use of the ground water resource.

WQ-3 Water Rights: Utilities will update their water right records and report to Ecology, as per the recommended program in the "Five Year Water Resource Data Management Plan."

Who: Water purveyors
Priority: Low
Time: To be determined
Fund Source: General agency funds

Issue 4 - Conservation: Conservation has been shown to have a positive impact on ground water resources. Some conservation methods could be implemented to enhance current programs including landscaping methods. King County Board of Health regulations for small and individual water systems do not include conservation elements.

The intent of the Vashon-Maury Island Ground Water Management Program is to devise a conservation program that will reduce the need for further ground and surface water appropriations. The Vashon Ground Water Management Committee adopted the following management strategies to address conservation issues. Education strategies related to conservation are found in the Education Program.

WQ-4A Conservation: The Seattle-King County Health Department will propose a revision to regulations for existing, new or expanded Group B Small Public Water Systems to cover water conservation goals and measures for consideration by the King County Board of Health and develop educational materials for new and existing individual well owners encouraging conservation measures.

Who:	Seattle-King County Health Department, King County Board of Health.
Priority:	High
Time:	0.10 FTE
Fund Source:	General agency funds

WQ-4B Conservation: All Group A water systems, and any water system with a King County right-of-way use permit, must include conservation measures and goals as set forth in the Vashon Coordinated Water Supply Plan, in their comprehensive water system plans.

Who:	All water system purveyors, as required by the Washington State department of Health and King County
Priority:	High
Time:	Purveyors determine and fund
Fund Source:	General agency funds

Issue 5 - Artificial Recharge: Artificial recharge is a new technique that is being tried in this area. However, not enough is known about the feasibility for long-term artificial recharge.

WQ-5 Artificial Recharge: Water purveyors should investigate artificial recharge.

Who:	Public water systems
Priority:	Low
Time:	To be determined
Fund Source:	General agency funds

Issue 7 - Reservation: Ground water reservation may be used to limit the amount of ground water withdrawn from a system.

WQ-7 Reservation: The Vashon-Maury Island Ground Water Advisory Committee encourages utilities to petition Ecology for water supply reservation of the ground water resource consistent with the King County Coordinated Water Supply plans, and the Growth Management projections for Vashon.

2.5 Unfinished Agenda

The Guidelines for Ground Water Management Area and Programs calls for concurrence on the recommended management strategies, and resolution of any non-concurrence issues by the Ground Water Advisory Committee. During review of the Draft Vashon-Maury Island Ground Water Management Plan, some management strategies were identified that the implementing agency could not commit resources or otherwise agree with at this time. The Department of Ecology's guidance for concurrence allows that unresolved issues may be placed onto an Unfinished Agenda section. These issues may not be critical to successful overall Plan implementation. However, Ecology retains the final determination on whether Unfinished Agenda items are critical.

2.5.1 Stormwater

Roadway Runoff: The State Highway Runoff Program provides for improved water quality and quantity controls for storm water runoff from new and existing state highways. The King County Surface Water Design Manual requires water quality and quantity controls for new roadways in King County. However, state and local programs may not address quality and quantity problems associated with existing roadways. Existing contamination problems may be identified via Basin Plans developed by King County Water and Land Resources Division via other processes to identify needed capital improvements. King County will then address the problems identified as funding allows.

ST-1 Roadway Runoff: The King County Department of Transportation, Roads Division will give highest priority to the most physically susceptible and recharge areas and Wellhead Protection Areas when identifying and correcting water quality problems associated with existing roadways and, develop a program to retrofit existing structures, which will require storm water quality and quantity controls comparable to new regulations when doing major renovation or widening of roads.

This management strategy is included in the Unfinished Agenda because the King County Department of Transportation, Roads Services Division, cannot concur due to the potential cost associated with action ST-6. Roads Services produces the six-year project list of which the yearly budget for road maintenance is based. The present prioritization process for the budget does not include the proposed factors. Staff, during the concurrence discussion, stated that consideration of location of a road (such as if it is in a sensitive area) could be considered for inclusion as a factor in future budget development.

ST-2 Ground Water Quality Concerns - Long Term Impacts: King County will sponsor research on the long term impacts of the infiltration of pretreated stormwater on ground water quality. This research will be supported by monitoring variables in areas where the facility is installed and operating.

This management strategy is included in the Unfinished Agenda because the King County Water and Land Resources Division cannot concur due to the cost associated with the project. The 1996 budget for facility monitoring program was significantly cut and current monitoring efforts are focused on facility maintenance. The Center for Urban Water Resources may be able to coordinate a study with funding from different jurisdictions, of which the Division may be able to contribute to such a study. Typical costs of storm water facility evaluations are approximately $20,000 - $30,000 per facility.

2.5.2 Hazardous Materials

Hazardous Materials Management: Businesses on Vashon-Maury Island may use hazardous materials, or generate hazardous waste. Due to the sole-source nature of the aquifer, hazardous waste should not be disposed on the Island.

HM-1 Hazardous Waste Management: The Ground Water Advisory Committee recommends that, as part of the Aquifer Protection Area activities, hazardous materials brought onto the Island by manufacturing facilities should be tracked to see that none of these materials are disposed of on the island.

This management strategy is included in the Unfinished Agenda because the establishing a program of this scope would be a huge task. Part of the complexity comes from the wording, where "hazardous materials by manufacturing facilities" would include gasoline. The Management Committee may reconsider this recommendation when establishing the Aquifer Protection Area.

HM-2 Hazardous Waste Management: King County will provide a hazardous materials collection facility at the landfill, and provide educational materials to island residents about the threat to the aquifer from misuse and improper disposal of hazardous materials. At a minimum, a cost-effective and non-fee based pickup site for waste oil and antifreeze will be established at the landfill.

This management strategy is included in the Unfinished Agenda because the Seattle-King County Health Department does not concur. The cost to operate such a facility could exceed $1 million per year. Vashon currently contributes approximately $8,500 per year to the County's hazardous waste program. The hazardous waste mobile once a year visit costs approximately $70,000. The Wastemobile is funded from local hazardous waste management fees, not solid waste tonnage fees. The focus of the Local Hazardous Waste Management Program is education and reducing the hazardous waste stream, not increasing the number of collection facilities. In addition, the County collects hazardous waste only from households, not businesses due to legal and budgetary restrictions.

2.5.3 Solid Waste

Composting: Vashon residents have no public facility available for disposal of yard wastes such as grass clippings other than disposal at the landfill. These wastes should be composted which would reduce the volume of solid waste for disposal.

SW-1 Composting: King County Solid Waste Division will provide a compost facility with liner at the landfill for use by Vashon residents.

This proposed management strategy is in the Unfinished Agenda because the Solid Waste Division has stated that a compost facility would not be cost effective and advised that yard waste, including grass clippings, would be collected from the year 2000 when the Vashon facility is closed and hauled off-island to existing compost facilities. Also, the Seattle King County Health Department advised that a compost facility has a high capital cost. For example, the Cedar Grove compost facility has spent $6 million on their aeration system alone. These facilities need a lot of expensive equipment including aerators, grinders, movers, scrubs, in addition to a concrete pad, piping, etc. Compost cannot be just placed in a pile because of the fire hazard (may combust) and it would not meet the odor standards of the Puget Sound Air Pollution Control Authority.

2.5.4 Water Quantity

Decline Limits: Water level decline limits are set by Ecology and can be an effective tool for managing the resource. Ecology needs long-term information in order to set decline limits.

WQ-1 Decline Limits: Ecology shall review the information collected through the Data Collection and Management Program and recommendations shall be made to prevent further declines or restore pre-decline levels and to maintain safe sustainable yields. All jurisdictions shall then follow the appropriate mitigation actions as recommended by Ecology. Also, Ecology will consult with the Management Committee in setting water level decline limit "triggers."

Ecology cannot concur with WQ-8A prior to knowing the workload, costs, and probable outcomes, and is therefore placed in the Unfinished Agenda (Ecology, April 26, 1995).

2.5.5 Aquifer Protection Area

Funding: Metropolitan King County Council is investigating various funding alternatives for the Groundwater Management Program. The Ground Water Advisory Committee recommended the use of an Aquifer Protection Area.

The Ground Water Advisory Committee recommends that the Metropolitan King County Council designate the Vashon-Maury Island Ground Water Management Area as an Aquifer Protection Area to provide funding for the implementation of the Vashon Ground Water Management Plan (RCW Chapter 36.36). The purpose of an Aquifer Protection Area is to establish a funding base for ground water protection, preservation, and rehabilitation programs. Aquifer Protection Areas are established through an election ballot issue requiring approval from a simple majority of voters within the proposed Aquifer Protection Area. If voters approve the Aquifer Protection Area, the county can collect modest water and septic system user fees. Fees may only be collected from users of water withdrawn from an aquifer, as opposed to a surface water source, and is not related to the amount of water used. The ballot measure must describe the specific use, and any changes in specific uses or the fee would require voter approval.

The Ground Water Advisory Committee has stated that the appropriation of Aquifer Protection Area funds should be guided by the following two principles:

1. When the local community chooses to tax itself to protect its water resources, the local community should set the priorities and manage the expenditure of those tax dollars, rather than turning the money over to a regional government that is not as accessible, as responsive, or as knowledgeable about local circumstances.

2. When a local community chooses to tax itself to pay for additional protection of its water resources, the money raised should not be used to pay for governmental functions that are typically supported by general funds, such as the enactment of legislation, or that are already the responsibility of governmental bodies, such as the enforcement of existing laws.

Creation and adoption of the Vashon-Maury Island Ground Water Management Area as an Aquifer Protection Area could ensure adequate long-term funding for implementing the Vashon Ground Water Management Plan. Community support would be demonstrated because the Aquifer Protection Area has to be approved by a majority of the people in the area. Also, an Aquifer Protection Area is consistent with Ecology's Ground Water Management Plan implementation ideas and what other counties have used.

The Ground Water Advisory Committee recognizes that the ballot measure must describe specific use of the funds, and any changes in specific uses or the fee would require voter approval. Fee collection is limited, in that the Aquifer Protection Area fees may only be collected from users of water withdrawn from an aquifer as opposed to a surface water source; the fee is not related to the amount of water used; and fees may be assessed on on-site sewage disposal only, not other sources of ground water contamination.

Since Council preferred to leave this issue unresolved until the alternatives are fully considered, this issue is included in the Unfinished Agenda.

2.6 Finished Agenda

The Ground Water Advisory Committee started reviewing ground water issues in 1988 and adopted several recommended management strategies that have been accomplished, either partially or completely. The following recommended management strategies have been removed from the body of the plan for clarity and placed in this section. The Ground Water Advisory Committee wanted to retain those management strategies in the Plan that, during their review and adoption process, were considered important so that the review of critical issues is documented.

2.6.1 On-Site Sewage Systems

OS-1 Nitrate Concerns. The Seattle-King County Health Department should investigate apparent high-risk areas to determine the existence of impacts on ground water from on-site sewage systems.

This management strategy is included in the Finished Agenda because the Seattle-King County Health Department has completed an on-site sewage system survey of Vashon. Information from this study could be used to refine the wording of this action. Also, need to define what are "high risk areas." This could be considered by the Management Committee in the future.

OS-2 Operation and Maintenance: The Seattle-King County Health Department will develop performance standards for on-site systems that minimize the risk of ground water contamination.

This management strategy is included in the Finished Agenda because performance standards are already in Title 13 (Jim Henriksen, Seattle-King County Health Department), that is based on the state regulations. The state regulations were revised to meet the state Ground Water Standards.

2.6.2 Solid Waste

Issue 1 - Standards: Standards can be improved to provide better ground water protection. The areas where changes may be made include: aquifer protection areas; and cell expansion in existing facilities. The Seattle-King County Health Department will prepare amendments to Title 10 to prohibit siting or expansion of landfills in the most physically susceptible and recharge areas for King County Board of Health's approval.

SW-1 Standards: Ecology's Minimum Functional Standards and the Seattle-King County Health Department (Title 10) will amend regulations to clearly state that cell expansion is subject to current standards, including location, for King County Board of Health's consideration.

This management strategy is included in the Finished Agenda because Ecology has adopted Chapter 173-351, and Seattle-King County Health Department is in the process of formally adopting WAC 173-351, which includes these provisions.

Issue 2 - Site Analysis: The present landfill site is perhaps not the best site for a landfill. Monitoring of the landfill by King County indicates that ground water quality has been impacted by leachate from the landfill. Although King County is taking steps to protect the ground water quality in the vicinity of the landfill, a better site on Vashon may be available for solid waste disposal.

SW-2 Site Analysis: King County Solid Waste Division will evaluate sites on Vashon before any expansion of the existing site is undertaken, to determine the best available site for a landfill.

This management strategy is included in the Finished Agenda because the landfill is to be closed in the Year 2000 and this action no longer applicable (King County Solid Waste). The Seattle-King County Health Department advised that the only identified abandoned landfill on Vashon is at the present site and monitoring will continue at least until the year 2030.

2.6.3 Sand and Gravel

Regulatory Modifications: Sand, gravel, and rock quarry mining can cause changes in the site or include activities which increase the potential for contamination of important aquifers. Major changes have occurred at the state level regarding general permitting of sand, gravel, and rock quarry mining operations.

SG-1 Regulatory Modifications: King County should comply with the National Pollutant Discharge Elimination System permit program and Ecology's "General Permit" requirements.

This management strategy is included in the Finished Agenda because the General Permit has replaced the Best Management Practices. King County complies with NPDES and its General Permit requirements.

2.6.4 Water Quantity

Issue 1 - Policies and Ordinances: Several policies and ordinances are proposed which may provide broad protection for aquifer recharge areas. There is an opportunity to influence which policies are adopted for ground water protection.

WQ-1 Policies and Ordinances:

1. King County will amend the King County Comprehensive Plan Policy E-337 to include aquifer recharge.
2. King County will consider adopting a clearing ordinance with guidelines for clearing on lands outside of sensitive areas and specific performance standards including phasing and seasonal clearing activities, retention requirements, and coverage. The ordinance should include the clarification of a clearing permit process.
3. King County will implement interim development standards whereby clearing is limited on subdivision, short subdivision, and new residential and commercial building projects to protect water quality, limit surface water runoff and erosion, and maintain wildlife habitat and visual buffers, until such time that a clearing ordinance is adopted.

This management strategy is included in the Finished Agenda because the King County Comprehensive Plan adopted in 1994 addresses ground water recharge in many policies, including: U-206, NE-302, NE-309, NE-333, NE-334, NE-335, NE-336 and R-216.

WQ-2 Conservation: King County will adopt the proposed landscaping ordinances to encourage conservation in new developments. Landscaping plans should incorporate native growth areas, use of plant species that are drought tolerant, water efficient irrigation technologies, soil amendments, and limitations on the amount of turf.

This management strategy is included in the Finished Agenda because King County adopted a landscaping ordinance in January 1994 that includes most of these elements.

SA-1C Adoption of General Aquifer Protection Policies: King County will adopt the following policies to protect ground water on Vashon Island by: a) preferring land uses that retain a high ratio of permeable to impermeable surface area and maintain or augment the infiltration capacity of the natural soils; and b) requiring standards for maximum vegetation clearing limits, impervious surface limits, maximizing topsoil retention and, where appropriate, infiltration of surface water.

The language in this proposed policy is the same as in the adopted Policy NE 336 of the King County Comprehensive Plan. Therefore, this action is placed in the Finished Agenda.

2.6.5 Stormwater

Issue 1 Runoff Versus Recharge. The King County Surface Water Design Manual does not limit runoff volumes. Rather, the Manual requires that there be no increase in peak runoff rates. Potential ground water recharge is lost to runoff causing depletion of aquifers.

ST - 1 Runoff Versus Recharge. King County will amend/adopt surface water design manuals to require that runoff be infiltrated when site conditions permit except where potential ground water contamination cannot be prevented by pollution source controls and stormwater pretreatment. Extreme caution on recharge and infiltration is needed based on a site by site evaluation. We will strive to achieve a policy of no net reduction of recharge in any new development or redevelopment in the most physically susceptible areas.

Strategy ST-1 is in the Finished Agenda because King County Water and Land Resources Division has proposed a revised Design Manual that provides for infiltration, where appropriate and meets the State's design manual guidelines for encouraging infiltration.

Issue 2 - Ground Water Quality Concerns: Numerous studies have demonstrated that non-point source pollution is a major contributor to ground water degradation. Water quality controls and infiltration of storm water will increasingly be used to reduce non-point source pollution effects upon both surface and ground water resources. Technology associated with these practices is in early stages and long-term effects on ground water quality are unknown. While water quality controls will improve the quality of the water discharged to the ground, the increasing emphasis on infiltration poses risks. Infiltration will be employed most often in areas with glacial and alluvial soils associated in the most physically susceptible and recharge areas. Regardless of how comprehensive new requirements may be, treatment systems will sometimes fail for a variety of reasons and they cannot be expected to function optimally at all times. Additionally, non-point source pollution that is not borne by storm water will infiltrate and reach ground water regardless of storm water management techniques.

ST-2 Facility Requirements: King County within the Vashon Ground Water Management Area will require that all types of stormwater facilities be designed to protect ground water.

This issue and management strategy is placed in the Finished Agenda because the King County Surface Water Design Manual requires that runoff be pretreated to a level of water quality equivalent to that of surface water.

Issue 3 - Coordination between Surface and Ground Water Planning Efforts: Surface and ground water planning efforts should be effectively coordinated to make the best use of limited resources.

ST-3 Coordination Between Surface and Ground Water Planning Efforts - Puget Sound Water Quality Authority: The Puget Sound Water Quality Authority recognizes that surface and ground water form a continuous and dynamic system which must be comprehensively protected. The Puget Sound Water Quality Management Plan should be revised to address all water quality issues in the Puget Sound drainage basin, including ground water.

This is in the Finished Agenda because the Puget Sound Water Quality Authority adopted the *Managing Nonpoint Pollution - An Action Plan Handbook for Puget Sound Watersheds*, in June 1993 and stated in their letter of February 27, 1996 that ground water is adequately protected by utilizing existing components of the Plan and through the Non-Point Source Pollution Program. The Puget Sound Plan also contains an education component which includes ground water and is being utilized by the Vashon School District.

2.6.6 On-Site Sewage Systems

OS-2A Commercial Hazardous Materials: The Seattle-King County Health Department should: inventory commercial, industrial, and institutional facilities served by on-site sewage treatment and disposal systems which potentially use, store, or dispose of hazardous materials; educate operators regarding hazardous materials management, and; selectively monitor those facilities that appear to represent a significant risk to ground water quality.

OS-2B Hazardous Materials: The Seattle-King County Health Department will prepare amendments to *Title 13 of the Code of the King County Board of Health* to expressly prohibit the use of on-site sewage systems for disposal of any materials or substances other than domestic sewage as defined Chapter 246-272-010 WAC, for King County Board of Health consideration.

These strategies are in the Finished Agenda because the Seattle-King County Health Department implements the recommendations in OS-2A through the Local Hazardous Waste Management Program in King County. Title 13 is in the process of being amended this year to meet the State regulations and will include the requirements of OS-2B.

Chapter Three

Recommended Implementation Process

Vashon-Maury Island
Ground Water Management Plan

December 1998

Recommended Implementation Process for the Ground Water Management Program

3.1 Introduction

The ground water management planning process has been funded by Department of Ecology Centennial Clean Water Fund grants and contributions from King County. However, implementation of the Vashon Ground Water Management Plan depends upon long-term funding and appropriate assignment of responsibility. Executive and legislative branches of government and other public and private interests have important roles in the implementation of the Ground Water Management Plan to protect ground water quality and quantity. The recommended implementation process described in this chapter assigns roles and tasks and proposes a source of funding. Topics addressed include:

- Legislative Authority
- Funding
- Washington State Department of Ecology
- Ground Water Management Committee
- Ground Water Advisory Committee
- Lead Agency
- Implementation of the Plan
- Process for Evaluation and Revision of the Plan

Summary tables list actions to be taken during plan implementation. These tables also list priorities, who is responsible for implementation, cost, source of funds, and an approximate schedule for commencing and completing the work.

3.2 Legislative Authority

Legislative authority of the Metropolitan King County Council and the Seattle-King County Board of Health are needed to ensure the Ground Water Management Plan and the necessary ordinances are implemented. The Ground Water Advisory Committee recommends that legislative authority for implementation of the Vashon Ground Water Management Plan be shared between the Metropolitan King County Council and the Seattle-King County Board of Health. Roles of each legislative authority are recommended below.

Metropolitan King County Council

The Metropolitan King County Council is legislative authority of the county. The Metropolitan King County Council exercises its legislative power by adoption and enactment of ordinances; by levying taxes, appropriating revenue and adopting budgets; and other powers as described in the King County Charter (King County Charter, Sections 220 - 270). The Council ensures that the policies in the King County Comprehensive Plan are carried out through ordinances implementing the Plan. The role of the Council in implementing this plan would be:

- Adopt the Vashon Ground Water Management Plan after it has been certified by Ecology;
- Appoint members of the Ground Water Management Committee from nominees provided by entities represented;
- Adopt updates to the Vashon Ground Water Management Plan, upon recommendations from the Management Committee and concurrence by affected agencies;
- Allocate aquifer protection funds after approval by the Management Committee and concurrence from affected agencies; and
- Adopt ordinances necessary for the implementation of the Vashon Ground Water Management Plan (generally addressing such matters as land use, zoning, and regulations governing the activities of county agencies).

King County Board of Health

The Seattle-King County Board of Health has powers concerning health and sanitary measures for the protection of the public health within the county, including: enacting rules and enforcement of regulations to preserve, promote, and improve public health, and establishing fee schedules for issuing or renewing permits. The role of the Board in implementing this plan would be to adopt ordinances necessary for the implementation of the Vashon Ground Water Management Plan generally addressing activities regulated by the Seattle-King County Health Department (e.g., on-site sewage disposal, small public and private drinking water systems, wellhead protection, solid waste disposal,).

Special Purpose Districts & Associations

Other administrative bodies include the Board of Commissioners for Water District Number 19, various water associations, and the Vashon Sewer District. These boards set policies and rates for the provision of water within their service area and would be responsible for adopting measures as needed to implement the Vashon Ground Water Management Plan within their jurisdiction.

3.3 Funding

King County is currently exploring approximately 6-8 long-term funding alternatives for the purpose of implementing a ground water management program. If a regional funding source cannot be identified, the Vashon-Maury Island Ground Water Management Committee should assess the feasibility of establishing an Aquifer Protection Area to provide funding for implementation of the Plan.

3.4 Washington Department of Ecology

A certified Ground Water Management Plan is codified in the Washington Administrative Code and administered by Ecology. Ecology will rely on local government cooperation to implement the Plan, but it may assist the lead agency, if needed, to gain compliance with provisions of the adopted Plan.

3.5 Ground Water Management Committee

The Ground Water Advisory Committee recommends the formation of a Ground Water Management Committee (Management Committee) that will coordinate ground water protection activities. The Management Committee will be advised by the Advisory Committee, at its discretion, for a period of three years after certification of the Vashon Ground Water Management Plan by Ecology. The Management Committee will carry out the following tasks:

- Allocation of Aquifer Protection Funds: review, amend as necessary, adopt, and recommend to the Metropolitan King County Council an annual allocation of aquifer protection funds based upon the Ground Water Management Plan.

- Monitor the implementation of the Ground Water Management Plans: review annual reports on implementation prepared by the lead agency; and determine whether implementation is adequate and whether changes are needed in priorities, monitoring, reporting etc., during the implementation period.

- Update the Vashon Ground Water Management Plan:
  1. Act as a forum to consider new or ongoing ground water protection issues of significance to all Ground Water Management Areas;
  2. Determine whether revisions are needed to the Vashon Ground Water Management Plan;
  3. Review, amend as necessary, adopt, and recommend for adoption by the Metropolitan King County Council, and the King County Board of Health, an updated Vashon Ground Water Management Plan three years after certification of the original Vashon Ground Water Management Plan by Ecology; and
  4. Determine appropriate response actions when trigger levels have been reached.

- Perform tasks as assigned in the Vashon Ground Water Management Plan, such as facilitating wellhead protection; determining categorical exemptions to environmental regulations that should be eliminated in sensitive aquifer areas; and developing guidance documents to assist environmental reviewers in King County.

The Management Committee should consist of a core committee of nine members constituted as follows: one representative of the Ground Water Advisory Committee, one representative of the County's Department of Natural Resources, one representative of the Island's water purveyors, a representative of residential well users, one representative of the Vashon Chamber of Commerce, one representative of the Vashon-Maury Island Community Council, a representative of business owners, a representative of commercial agriculturists and a representative of a Vashon environmental organization. Members of the Management Committee would be appointed by motion by the Metropolitan King County Council with members serving staggered terms of three years.

This core committee should meet regularly to provide oversight to the implementation, to ensure that the budget process is performed in a fair and equitable manner, and to address the topics as assigned in the Vashon Ground Water Management Plan. Other members should be representative of those agencies required to implement the Plan. Individual members of the Management Committee will have the responsibility to coordinate internally with the entity represented.

Public Involvement: Interested public groups and individuals should be kept informed of the core committee work and implementation progress by inclusion on a notification list. Those on the list should receive core committee meeting agenda and minutes and routine updates on the Vashon Ground Water Management Plan progress. The core committee meetings should be open to the public, if they wish to attend. Also, if the core committee is aware of an agency or individual that has an interest in a topic under discussion, they should be invited to attend. Elected officials should also be included on the notification list. Elected officials may also have the opportunity to have presentations on the Vashon Ground Water Management Plan progress.

Dispute Resolution: There should be a process for dispute resolution. The first step in dispute resolution should be with the core committee. If the aggrieved party wishes, then the Dispute Resolution Group should meet with the party. The Dispute Resolution Group should consist of the chair of each of the core committees.

Bylaws: Decisions of the Management Committee will be by consensus whenever possible. Procedures for resolving lack of consensus should be adopted by the committee for inclusion in its bylaws. Management Committee bylaws should include a provision stating that Ground Water Advisory Committee recommendations will be carefully and promptly considered and followed by a written response.

The Management Committee may make use of subcommittees to accomplish some of its tasks due to its size. For example, a subcommittee might address the topic of hazardous materials transport through aquifer protection areas. Federal and State agencies will be asked to serve in a technical capacity, as appropriate, on the subcommittees.

Water purveyors relying on a ground water source may be asked to contribute to technical subcommittees formed to advise the Management Committee because the Vashon Ground Water Management Plan may fulfill many wellhead protection needs. Minimum wellhead protection strategies developed by the Management Committee will add to what is already contained in the Vashon Ground Water Management Plan. It is also expected that individual purveyors will have system specific needs that they will want to include in their own wellhead protection programs.

3.6 Ground Water Advisory Committee

The Ground Water Advisory Committee was established to develop the Vashon Ground Water Management Plan. After the Plan is certified by Ecology, the Committee's duties are completed (Chapter 173-100 WAC). However, successful implementation of the Vashon Ground Water Management Plan depends upon support by the affected agencies and the community.

The Ground Water Advisory Committee recommends that they continue to meet as needed. The role of the Committee would be to monitor implementation of the Vashon Ground Water Management Plan and to make recommendations to the Management Committee via its representatives. The Ground Water Advisory Committee would also review and comment upon the first Vashon Ground Water Management Plan update.

3.7 Lead Agency

Implementation of the Vashon Ground Water Management Plan will require staff to perform day-to-day tasks. This staff needs to be familiar with the Vashon Ground Water Management Plan, data base management, area concerns, budget process, and be technically capable. This staff needs to provide administrative functions to the satisfaction of the Management Committee and the legislative authorities.

The Ground Water Advisory Committee recommends that the King County Department of Natural Resources serve as lead agency for the implementation of the Vashon Ground Water Management Plan. In fulfilling its role as lead agency, Department of Natural Resources will:

- Refine cost estimates of the Vashon Ground Water Management Plan in consultation with implementing governments and agencies and determine the amount of the aquifer protection fee;
- Prepare an annual proposed allocation of the aquifer protection fund based upon the adopted Vashon Ground Water Management Plan implementation plans for review and adoption by the Management Committee, affected agencies, and the Metropolitan King County Council;
- Ensure that funds are disbursed per the adopted allocation plan to implementing agencies;
- Provide staff support to the Management Committee and the Ground Water Advisory Committee;
- Monitor the implementation of the Vashon Ground Water Management Plan and bring issues to the attention of the Management Committee;

- Prepare annual implementation reports for the review of the Management Committee and Ground Water Advisory Committee;
- Implement elements of the Vashon Ground Water Management Plan as assigned to the lead agency by adopted implementation plans;
- Coordinate implementation of multi-jurisdictional program efforts such as data collection and sensitive aquifer area mapping;
- Coordinate with other King County planning processes and with federal, state, and local agencies regarding ground water protection;
- Coordinate the process for revision of the Vashon Ground Water Management Plan:
  1. Prepare draft update of the Vashon Ground Water Management Plan for review, amendment as necessary, and approval of the Management Committee;
  2. Hold public hearings;
  3. Submit draft updates of the Vashon Ground Water Management Plan to the Metropolitan King County Council and carry out the process of obtaining concurrence from affected governments and agencies.

3.8 Implementation of the Plan

Ground Water Advisory Committee implementation priorities are listed in Tables One and Two. Prioritization enables the Committee to ensure that ground water protection is maximized in the near term. The schedule contained in the Implementation Plan provides a framework within which all governments and agencies can plan their Vashon Ground Water Management Plan implementation activities.

Each table lists, in relation to a specific action, its priority, who will be responsible for carrying it out, how much it will cost, what the source of funding will be, and approximately when it will be accomplished. Table One is organized by Committee-determined priority. Table Two is organized by the agency or government entity that will be responsible for implementing the action.

King County implementation efforts will be phased in over time and are dependent upon the availability of funding.

3.9 Process For Evaluation & Revision of the Plan

A process for periodic evaluation and revision of the Vashon Ground Water Management Plan is established in order to ensure that the goals of the Vashon Ground Water Management Plan are achieved efficiently under changing conditions. The Management Committee, the Ground Water Advisory Committee, the Lead Agency, and agencies affected by the Vashon Ground Water Management Plan will be involved in the evaluation and revision of the Vashon Ground Water Management Plan. The first revision will be considered three years from the date of the Vashon Ground Water Management Plan certification by Ecology. Subsequent revisions will be considered on five-year intervals unless the Management Committee determines that more frequent updates are needed.

The concurrence process will be initiated by the Lead Agency following adoption of revisions by the Management Committee. Public hearings will be held as required by law. The draft update will be submitted to the Metropolitan King County Council for review, amendment, and adoption when all affected governments and agencies have concurred.

Ground Water Management Plan updates at time intervals smaller than three years should be avoided due to the lengthy process of review, public hearings, concurrence, and adoption. Other mechanisms may be used to implement short-term changes either in substance or priority. For example, a grant could be sought to carry out a specific new task that the Management Committee feels is urgent but which is not included in the current Vashon Ground Water Management Plan. Alternatively, Vashon Ground Water Management Plan priorities could be changed in order to step up activity related to an issue that the Management Committee determines is more urgent than others.

The Lead Agency will assist the Management Committee in its evaluation of the Vashon Ground Water Management Plan by preparing annual implementation reports. These reports will cover such topics as:

- Progress in implementing plan elements in comparison with established priorities and schedule;
- Problems encountered in implementation of specific program elements;
- Proposed revisions or priority adjustments to address problems encountered in implementation; and
- Changes in federal, state, or local laws impacting the Vashon Ground Water Management Plan.

The Management Committee will use the reports as well as its own deliberations and the recommendations of the Ground Water Advisory Committee to determine whether and how Ground Water Management Plan should be modified when it is updated.

Table 1

Management Strategies in Priority Order

Vashon-Maury Island
Ground Water Management Plan

December 1998

TABLE 1
Management Strategies by Priority

GWAC Priority	Management Strategy	Agent	Priority 1 FTE	Priority 2 FTE	Priority 3 FTE	Aquifer Protection Area	Other Source
1	DCM - 1 Data Collection, Analysis and Management	King County Department of Natural Resources	0.75	0.00	0.00	APA	
1	DCM - 1 Data Collection, Analysis and Management - Tagging	Ecology	TBD			APA	
1	DCM - 1 Data Collection, Analysis and Management - Tagging	Purveyors	TBD			APA	
1	DCM - 1 Data Collection, Analysis and Management - Tagging	Well Drillers	TBD			APA	
1	LU - 1 Ground Water Monitoring	King County Department of Natural Resources	0.10			APA	
1	LU - 2 Ground Water Monitoring	King County Department of Natural Resources	0.10				Agency funds
1	LU - 2 Ground Water Monitoring	Management Committee	TBD			APA	
1	LU - 3 KCCP Policies	King County Office of Budget & Strategic Planning	0.13				Agency funds
1	LU - 4 Vashon Community Plan Policies	King County DDES	0.10				Agency funds
1	LU - 5 Area Zoning	King County DDES	0.10				Agency funds

TABLE 1
Management Strategies by Priority

GWAC Priority	Management Strategy	Agent	Priority 1 FTE	Priority 2 FTE	Priority 3 FTE	Aquifer Protection Area	Other Source
1	OS - 1A, 1B Nitrate Concerns	King County Department of Natural Resources	0.13			APA	
1	OS - 1B Nitrate Concerns	Management Committee	TBD			APA	
1	OS - 2A Hazardous Materials Education - LHWMP	SKCHD	0.04			APA	
1	OS - 3A Operation and Maintenance	SKCHD	0.08				Agency
1	OS - 3B Operation and Maintenance	SKCHD	0.50				Agency
1	SA - 1A Elimination of categorical exemptions to SEPA	King County Department of Natural Resources	0.25				Agency
1	SA - 1A Elimination of categorical exemptions to SEPA	Management Committee	TBD			APA	
1	SA - 2 Wellhead Protection Strategies	King County Department of Natural Resources	0.50				General Agency Funds
1	SA - 3 Special Protection Area	King County Department of Natural Resources	0.13			APA	
1	SI - 1 Criteria Development	King County Department of Natural Resources	0.13				Agency funds
1	SI - 2 Seawater Intrusion Program	SKCHD	0.25				Agency funds

TABLE 1
Management Strategies by Priority

GWAC Priority	Management Strategy	Agent	Priority 1 FTE	Priority 2 FTE	Priority 3 FTE	Aquifer Protection Area	Other Source
1	SI - 2 Seawater Intrusion Program	WA Department of Health	TBD				Agency funds
1	SI - 3 Special Protection Area	Ecology	TBD				Agency funds
1	WQ - 2 Data Needs	King County Department of Natural Resources	0.00			APA	
1	WQ - 4A Conservation	SKCHD	0.10				General Agency Funds
1	WQ - 4B Conservation	Purveyors - Group A	TBD				Agency
2	ED - 1, 2 Education Program	King County Department of Natural Resources		0.25		APA	
2	ST - 1 Assessment of Existing Stormwater Facilities	King County Department of Natural Resources, WLR Division		TBD			Agency
2	ST - 2 Roadside Soil	King County King County Department of Transportation Road Services		No additional	No additional		General Agency Funds

TABLE 1
Management Strategies by Priority

GWAC Priority	Management Strategy	Agent	Priority 1 FTE	Priority 2 FTE	Priority 3 FTE	Aquifer Protection Area	Other Source
3	PF - 1A, 1B Pesticide and Fertilizer - Past Use	King County Department of Natural Resources			No additional cost, included in Data Collection Management Program		
3	PF - 2A Pesticide and Fertilizer Use	Conservation District			0.87		Agency
3	PF - 2B Pesticide and Fertilizer Use: Pesticide Reduction Program	King County Department of Natural Resources			0.13		Agency
3	PF - 2B Pesticide and Fertilizer Use: Pesticide Reduction Program	Management Committee			TBD	APA	
3	PF - 2C Pesticide and Fertilizer Use	King County Department of Natural Resources			0.13		Agency
3	SA - 1B Designation of Environmentally Sensitive Areas	King County Department of Natural Resources			0.25		Agency
3	SA - 1C Adoption of general aquifer protection policies	King County Department of Natural Resources			0.13		Agency

TABLE 1
Management Strategies by Priority

GWAC Priority	Management Strategy	Agent	Priority 1 FTE	Priority 2 FTE	Priority 3 FTE	Aquifer Protection Area	Other Source
3	SA - 1C Adoption of general aquifer protection policies	King County Office of Budget & Strategic Planning			0.13		Agency
3	SA - 1D Enhanced environmental review to protect aquifers	King County Department of Natural Resources			0.50		Agency
3	SA - 1E Define ground water recharge areas	King County Department of Natural Resources			0.25	APA	
3	SG - 1 Aquifer Impacts and Regulations	King County Department of Natural Resources			0.50		General Agency Funds
3	SG - 2 Environmental Review	King County Department of Natural Resources			0.13		General Agency funds
3	SG - 3 Land Use of Inactive or Reclaimed Mines: King County Comprehensive Plan	King County Department of Natural Resources			0.13		General Agency funds
3	SG - 3 Land Use of Inactive or Reclaimed Mines: King County Comprehensive Plan	King County Office of Budget & Strategic Planning			0.13		General Agency Funds
3	SP - 1A Sewer - Infiltration and Exfiltration	King County Department of Natural Resources			0.50	APA	
3	SP - 1B Infiltration	Management Committee			TBD	APA	

TABLE 1
Management Strategies by Priority

GWAC Priority	Management Strategy	Agent	Priority 1 FTE	Priority 2 FTE	Priority 3 FTE	Aquifer Protection Area	Other Source
3	SP - 1C Sewer Maintenance Programs	Vashon Sewer District			TBD		Agency
3	SP - 1D Leakproof Piping	King County Office of Budget & Strategic Planning			0.13		Agency
3	ST - 3 Coordination Between Surface and Ground Water Planning Efforts - Ecology	Ecology			0.32		General Agency Funds
3	UST - 1(A) Augment State UST Program Petition for ESAs UST - 1(B) Augment State UST Program - enhance current inspection UST - 1(C) Augment State UST Program - leak inspection UST - 1(D) Disclosure and Secondary Containment	King County Department of Natural Resources			0.25	APA	
3	UST - 1(E) Exempt Tanks UST - 1(F) Heating Oil Tanks	King County Department of Natural Resources			0.00	APA	
3	UST - 2 Prohibit new USTs on Vashon	King County DDES			0.13		General Agency Funds
3	WC - 1A State Program	Ecology			0.64		General Agency Funds

TABLE 1
Management Strategies by Priority

GWAC Priority	Management Strategy	Agent	Priority 1 FTE	Priority 2 FTE	Priority 3 FTE	Aquifer Protection Area	Other Source
3	WC - 1A State Program	King County			0.08		General Agency Funds
3	WC - 1B State Program	Ecology			0.64		General Agency Funds
3	WC - 1B State Program	SKCHD			0.50		Agency
3	WC - 2A Well Identification	Ecology			0.48		General Agency Funds
3	WC - 2A Well Identification	King County Department of Natural Resources			0.08		Agency
3	WC - 2B Well Identification	King County Department of Natural Resources			0.08		Agency
3	WQ - 1A Aquifer Recharge Preservation	Ecology			0.06		Agency
3	WQ - 1A Aquifer Recharge Preservation	King County DDES			0.13		Agency
3	WQ - 3 Water rights	Purveyors			TBD		General Agency Funds

TABLE 1
Management Strategies by Priority

GWAC Priority	Management Strategy	Agent	Priority 1 FTE	Priority 2 FTE	Priority 3 FTE	Aquifer Protection Area	Other Source
3	WQ - 5 Artificial recharge	Purveyors			TBD		General Agency Funds
3	WQ - 7 Reservation	GWAC encourages			TBD		Agency

Table 2

Management Strategies in Implementing Agency Order

Vashon-Maury Island
Ground Water Management Plan

December 1998

Table 2
Management Strategies by Implementing Agency

GWAC Priority	Management Strategy	Agent	Priority 1 FTE	Priority 2 FTE	Priority 3 FTE	Aquifer Protection Area	Other Source
3	PF - 2A Pesticide and Fertilizer Use	Conservation District			0.87		Agency
		Conservation District Total	0.00	0.00	0.87		
1	DCM - 1 Data Collection, Analysis and Management - Tagging	Ecology	TBD			APA	
1	SI - 3 Special Protection Area	Ecology	TBD				Agency funds
3	ST - 3 Coordination Between Surface and Ground Water Planning Efforts - Ecology	Ecology			0.32		General Agency Funds
3	WC - 1A State Program	Ecology			0.64		General Agency Funds
3	WC - 1B State Program	Ecology			0.64		General Agency Funds
3	WC - 2A Well Identification	Ecology			0.48		General Agency Funds
3	WQ - 1A Aquifer Recharge Preservation	Ecology			0.06		Agency
		Ecology Total	0.00	0.00	2.16		
3	WQ - 7 Reservation	GWAC encourages			TBD		Agency
		GWAC encourages Total	0.00	0.00	0.00		

Table 2
Management Strategies by Implementing Agency

GWAC Priority	Management Strategy	Agent	Priority 1 FTE	Priority 2 FTE	Priority 3 FTE	Aquifer Protection Area	Other Source
3	WC - 1A State Program	King County			0.08		General Agency Funds
		King County Total	0.00	0.00	0.08		
1	LU - 4 Vashon Community Plan Policies	King County DDES	0.10				Agency funds
1	LU - 5 Area Zoning	King County DDES	0.10				Agency funds
3	UST - 2 Prohibit new USTs on Vashon	King County DDES			0.13		General Agency Funds
3	WQ - 1A Aquifer Recharge Preservation	King County DDES			0.13		Agency
		King County DDES Total	0.20	0.00	0.25		
1	DCM - 1 Data Collection, Analysis and Management	King County Department of Natural Resources	0.75			APA	
	DCM - 1 Data Collection, Analysis and Management - Lab and Equipment	King County Department of Natural Resources					
2	ED - 1, 2 Education Program	King County Department of Natural Resources		0.25		APA	

Table 2
Management Strategies by Implementing Agency

GWAC Priority	Management Strategy	Agent	Priority 1 FTE	Priority 2 FTE	Priority 3 FTE	Aquifer Protection Area	Other Source
1	LU - 1 Ground Water Monitoring	King County Department of Natural Resources	0.10			APA	
1	LU - 2 Ground Water Monitoring	King County Department of Natural Resources	0.10				Agency funds
3	PF - 1A, 1B Pesticide and Fertilizer - Past Use	King County Department of Natural Resources			No additional cost, included in Data Collection Management Program		
3	PF - 2B Pesticide and Fertilizer Use: Pesticide Reduction Program	King County Department of Natural Resources			0.13		Agency
3	PF - 2C Pesticide and Fertilizer Use	King County Department of Natural Resources			0.13		Agency
1	SA - 1A Elimination of categorical exemptions to SEPA	King County Department of Natural Resources	0.25				Agency

Table 2
Management Strategies by Implementing Agency

GWAC Priority	Management Strategy	Agent	Priority 1 FTE	Priority 2 FTE	Priority 3 FTE	Aquifer Protection Area	Other Source
3	SA - 1B Designation of Environmentally Sensitive Areas	King County Department of Natural Resources			0.25		Agency
3	SA - 1C Adoption of general aquifer protection policies	King County Department of Natural Resources			0.13		Agency
3	SA - 1D Enhanced environmental review to protect aquifers	King County Department of Natural Resources			0.50		Agency
3	SA - 1E Define ground water recharge areas	King County Department of Natural Resources			0.25	APA	
1	SA - 2 Wellhead Protection Strategies	King County Department of Natural Resources	0.50				General Agency Funds
1	SA - 3 Special Protection Area	King County Department of Natural Resources	0.13			APA	
3	SG - 1 Aquifer Impacts and Regulations	King County Department of Natural Resources			0.50		General Agency Funds
3	SG - 2 Environmental Review	King County Department of Natural Resources			0.13		General Agency funds

Table 2
Management Strategies by Implementing Agency

GWAC Priority	Management Strategy	Agent	Priority 1 FTE	Priority 2 FTE	Priority 3 FTE	Aquifer Protection Area	Other Source
3	SG - 3 Land Use of Inactive or Reclaimed Mines: King County Comprehensive Plan	King County Department of Natural Resources			0.13		General Agency funds
1	SI - 1 Criteria Development	King County Department of Natural Resources	0.13				Agency funds
3	SP - 1A Sewer - Infiltration and Exfiltration	King County Department of Natural Resources			0.50	APA	
3	UST - 1(A) Augment State UST Program - Petition for ESAs UST - 1(B) Augment State UST Program - enhance current inspection UST - 1(C) Augment State UST Program - leak inspection UST - 1(D) Disclosure and Secondary Containment	King County Department of Natural Resources			0.25	APA	
3	UST - 1(E) Exempt Tanks UST - 1(F) Heating Oil Tanks	King County Department of Natural Resources			0.00	APA	
3	WC - 2A Well Identification	King County Department of Natural Resources			0.08		Agency

Table 2
Management Strategies by Implementing Agency

GWAC Priority	Management Strategy	Agent	Priority 1 FTE	Priority 2 FTE	Priority 3 FTE	Aquifer Protection Area	Other Source
3	WC - 2B Well Identification	King County Department of Natural Resources			0.08		Agency
1	WQ - 2 Data Needs	King County Department of Natural Resources	See Data Collection Management Program			APA	
1	OS - 1A, 1B Nitrate Concerns	King County Department of Natural Resources	0.13			APA	
		King County Department of Natural Resources Total	2.08	0.25	3.03		
2	ST - 1 Assessment of Existing Stormwater Facilities	King County Department of Natural Resources, WLR Division		TBD			Agency
		King County Department of Natural Resources, WLR Division Total	0.00	0	0.00		
2	ST - 2 Roadside Soil	King County Department of Transportation Road Services		No additional			General Agency Funds

Table 2
Management Strategies by Implementing Agency

GWAC Priority	Management Strategy	Agent	Priority 1 FTE	Priority 2 FTE	Priority 3 FTE	Aquifer Protection Area	Other Source
		King County Department of Transportation Road Services Total	0.00	0.00	0.00		
1	LU - 3 KCCP Policies	King County Office of Budget & Strategic Planning	0.13				Agency funds
3	SG - 3 Land Use of Inactive or Reclaimed Mines: King County Comprehensive Plan	King County Office of Budget & Strategic Planning			0.13		General Agency Funds
3	SA - 1C Adoption of general aquifer protection policies	King County Office of Budget & Strategic Planning			0.13		Agency
3	SP - 1D Leakproof Piping	King County Office of Budget & Strategic Planning			0.13		Agency
		King County Office of Budget & Strategic Planning Total	0.13	0.00	0.38		
1	LU - 2 Ground Water Monitoring	Management Committee	TBD			APA	
1	OS - 1B Nitrate Concerns	Management Committee	TBD			APA	
3	PF - 2B Pesticide and Fertilizer Use: Pesticide Reduction Program	Management Committee			TBD	APA	
1	SA - 1A Elimination of categorical exemptions to SEPA	Management Committee	TBD			APA	

Table 2
Management Strategies by Implementing Agency

GWAC Priority	Management Strategy	Agent	Priority 1 FTE	Priority 2 FTE	Priority 3 FTE	Aquifer Protection Area	Other Source
3	SP - 1B Infiltration	Management Committee			TBD	APA	
		Management Committee Total	0.00	0.00	0.00		
1	DCM - 1 Data Collection, Analysis and Management - Tagging	Purveyors	TBD			APA	
3	WQ - 3 Water rights	Purveyors			TBD		General Agency Funds
3	WQ - 5 Artificial recharge	Purveyors			TBD		General Agency Funds
		Purveyors Total	0.00	0.00	0.00		
1	WQ - 4B Conservation	Purveyors - Group A	TBD				Agency
		Purveyors - Group A Total	0.00	0.00	0.00		
1	OS - 2A Hazardous Materials Education LHWMP	SKCHD	0.04			APA	
1	OS - 3A Operation and Maintenance	SKCHD	0.08				Agency
1	OS - 3B Operation and Maintenance	SKCHD	0.50				Agency
1	SI - 2 Seawater Intrusion Program	SKCHD	0.25				Agency funds
3	WC - 1B State Program	SKCHD			0.50		Agency
1	WQ - 4A Conservation	SKCHD	0.10				General Agency Funds

Table 2
Management Strategies by Implementing Agency

GWAC Priority	Management Strategy	Agent	Priority 1 FTE	Priority 2 FTE	Priority 3 FTE	Aquifer Protection Area	Other Source
		SKCHD Total	0.97	0.00	0.50		
3	SP - 1C Sewer Maintenance Programs	Vashon Sewer District			TBD		Agency
		Vashon Sewer District Total	0.00	0.00	0.00		
1	SI - 2 Seawater Intrusion Program	WA Department of Health	TBD				Agency funds
		WA Department of Health Total	0.00	0.00	0.00		
1	DCM - 1 Data Collection, Analysis and Management - Tagging	Well Drillers	TBD			APA	
		Well Drillers Total	0.00	0	0.00		
		Grand Total	3.37	0.25	7.27		

Appendices

Appendix A: Public Comment

Appendix B: Letters of Concurrence or Comment

Appendix C: Guidelines for Development of Ground Water Management Areas and Programs

Appendix D: Management Strategy References

Appendix E: Recommended Data Collection and Analysis Program

Vashon-Maury Island
Ground Water Management Plan

December 1998

Appendix A

Public Comment

Vashon-Maury Island
Ground Water Management Plan

December 1998

Appendix A

Public Comment

VASHON-MAURY ISLAND GROUND WATER MANAGEMENT PLAN
PUBLIC HEARING COMMENTS - DECEMBER 14, 1995 - 8:45 P.M.

The following comment was taped and transcribed by the Washington State Department of Ecology:

David S. Vogel, 10608 SW Cedarhurst Road, Vashon Island, WA, 98070:

I think it's imperative that the nitrate concerns be addressed more carefully and more fully. There is no allocation for funding with regard to nitrate concerns. It's all to be determined, and it seems like a very costly proposition that should be done soon.

Appendix B

Letters of Concurrence or Comment

Vashon-Maury Island
Ground Water Management Plan

December 1998

APPENDIX B

Letters of Concurrence or Comment

This Appendix contains letters of concurrence or comment letters on the draft of March 1995 and subsequent revisions through December 1998. The current draft includes changes based on these comments. Letters are included from:

- Washington State Department of Ecology
- Puget Sound Water Quality Authority
- King Conservation District
- Seattle-King County Health Department
- King County Department of Development and Environmental Services
- King County Department of Natural Resources, Water Pollution Control Division
- King County Department of Natural Resources, Surface Water Management Division (memo)
- King County Department of Natural Resources, Solid Waste Division
- King County Department of Transportation, Road Services Division
- Dockton Water Association, Mr. H. M Todd.
- Vashon-Maury Island Water Purveyors Association
- Mr. Robert Colombo
- Mr. And Mrs. R. A. Danielson
- Laurie Geissinger, GWAC member
- Donna Lee Klemka (former GWAC member) and Martin W. Baker
- P.J. Ritzhaupt

- Metropolitan King County Council, with response from Vashon-Maury Island Ground Water Advisory Committee

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

P.O. Box 47600 • Olympia, Washington 98504-7600
(360) 407-6000 • TDD Only (Hearing Impaired) (360) 407-6006

May 3, 1996

Mark Isaacson
Ground Water Management Plan Program
Surface Water Management Division
700 Fifth Avenue, Suite 2200
Seattle, Washington 98104

Dear Mr. Isaacson:

Re: Concurrence on the Draft Vashon-Maury Island Ground Water Management Plan

I have reviewed the draft Vashon-Maury Island Ground Water Management Plan. The Department of Ecology concurs with the draft plan that was published in December, 1995.

I look forward to working with you to certify and complete the Vashon-Maury Island Ground Water Management Plan. I can be reached at 360/407-7255 if you have any questions.

Sincerely,

Laura H. Lowe

Laura H. Lowe
Environmental Planner
Shorelands and Water Resources Program

LL:ll

cc: Grant File

STATE OF WASHINGTON
PUGET SOUND WATER QUALITY AUTHORITY
PO Box 40900 • Olympia, Washington 98504-0900
(360) 407-7300 • FAX (360) 407-7333

February 27, 1996

Mark Isaacson
Groundwater Project Manager
King County Dept. of Natural Resources
Surface Water Management Division
700 Fifth Ave., 22nd Floor
Seattle, WA 98104-9830

Reference: Draft Vashon-Maury Island Groundwater Management Plan

Dear Mr. Isaacson,

We have completed our review of the Draft Vashon-Maury Island Ground Water Management Plan (GWMP). While we enthusiastically agree with the overall intent and direction of the plan to protect groundwater quality, and find that the GWMP adequately addresses issues of concern to water quality in Puget Sound, we do not concur with the need to revise the Puget Sound Water Quality Management Plan (Puget Sound Plan) to specifically include groundwater in order for the GWMP to be effective.

As the GWMP notes, existing ground and surface water planning regulations encourage coordinated efforts within and between local and state agencies and jurisdictions. The Departments of Ecology and Health, as well as King County have programs that address groundwater quality and quantity, and the watershed planning concept seeks to address all issues within watersheds as well. The Dept. of Ecology has the statutory mandate for groundwater, and the Authority's role is limited to directing public concerns to Ecology and supporting research and programs of other agencies, such as USGS, Ecology, and Health.

Utilizing existing components of the Puget Sound Plan can address the potential land use impacts mentioned in the GWMP that affect ground water supplies. The Stormwater and CSO program covers runoff, erosion control for new construction and redevelopment projects, water quality monitoring, and the use of Best Management Practices for source control. On-site sewage systems, pesticide and fertilizer use, timber harvesting and road construction, and agricultural practices are covered within the Non-Point Source Pollution program, and the Non-Point rule (WAC 400-12). *Managing Non-Point Pollution: an action plan handbook for Puget Sound watersheds* specifically addresses groundwater as a pathway for migration of pollutants. Educational efforts are certainly an important component of protecting ground and surface water supplies. The existing Education and Public Involvement Program within the Puget Sound Plan has already been utilized by the Vashon Island School District through a Public Involvement and Education (PIE) grant to inform, educate and further public awareness of the relationship between ground water, surface water and the marine environment through school curriculum development, public forums, and public participation. Water quality monitoring and data collection are covered in several elements of the Puget Sound Plan as well.

The Authority believes that the planning process initiated by development of the Vashon-Maury Island Ground Water Management Plan should not be held up by a requirement to amend the Puget Sound Plan. We believe that implementation of the existing elements of the Plan will adequately address the concerns over land use and groundwater supplies noted in the GWMP.

We strongly support the efforts of the Vashon-Maury Island Groundwater Advisory Committee in their efforts to implement this Management Plan. Please contact me if you have any further questions or concerns.

Sincerely,

Nancy McKay

Nancy Mckay
Executive Director

King Conservation District
935 Powell Ave. SW - Renton, WA 98055 - (206) 226-4867 - FAX (206) 764-6677

March 6, 1996

Mark Isaacson
Groundwater Project Manager
King County Dept. of Natural Resources
Surface Water Management Division
700-Fifth Ave., 22nd Floor
Seattle, WA 98104-9830

Dear Mr. Isaacson:

In reviewing the draft Vashon-Maury Island Groundwater Management Area Plan, we found a few instances where it is clear the authors do not fully understand the relationship of King County Conservation District and the Federal agency of the US Dept. of Agriculture - Natural Resources Conservation Service (NRCS) does all of its work through the Conservation District. King Conservation District has employees that are locally funded in addition to a few Federal employees. King Conservation District uses technical standards developed by NRCS whenever they are applicable. The Conservation District also has agreements with many other federal, state and local agencies for sharing of information and services.

As far as the plan itself is concerned King Conservation District does concur with the goals and objectives of the plan.

Specific actions listed for King Conservation District and by association, SCS or Soil Conservation Service are ED-1, PF-2A, PF-3B:

ED-1, elements 1 and 3. King Conservation District welcomes people and agencies for assistance.

PF-2A, Task 1,2. King Conservation District concurs with these tasks, but currently does not have sufficient funds from all sources to target areas specifically in this plan. It is estimated (roughly) that identification of farms in the susceptible areas and development of plans in those areas would cost from $5,000-$10,000 depending on actual numbers of farms in the area. Another note here is that we do have a relatively new program available to us from NRCS that will evaluate the susceptibility of ground water contamination from pesticides and herbicides in various soil mapping units. The Cooperative Extension programs may be based on the same information. Current funding is primarily from a county special assessment authorized by the King County Council through 1997.

PF3B, We welcome cooperative efforts listed for Soil Conservation Service.

In summary, King Conservation District concurs with the plan goals and objectives and also agrees to do the specific items mentioned subject to the availability of funding. We are willing to discuss and explore new funding sources to be able to carry out specific tasks.

Sincerely,

Jack Davis

Jack Davis
District Manager

City of Seattle
Norman B. Rice, *Mayor*

King County
Gary Locke, *Executive*

Seattle-King County Department of Public Health

Alonzo L. Plough, Ph.D., MPH, *Director*

March 26, 1996

Mark Isaakson, Manager Ground Water Project
King County Surface Water Management Division
Department of Natural Resources
700 5th Avenue, Suite 2200
Seattle, WA 98104

Re: **Vashon Ground Water Management Plan**

Dear Mark:

Thank you for the opportunity to review the draft Vashon-Maury Island Ground Water Management Plan. We have communicated to your staff proposed changes to the draft plan to reflect our position on the issues and policies in the plan. Paul Shallow has furnished us copies of the rewritten sections of the draft plan.

The Seattle-King County Health Department concurs with the plan as written except where specifically noted below in our comments. After the Metropolitan King County Council has reviewed and concurred with the plan, and the funding has been secured, we look forward to implementation of the tasks identified to our agency.

Onsite Sewage Treatment and Disposal System Use

Concurrence to actions in this section is based on removing reference to food waste in OS-2B, and deletion of OS-4C as provided in rewrite draft by Paul Shallow.

Biosolids and Effluent
Concurrence to actions in this section based on March 1995 rewrites as requested.

Solid Waste
Concurrence to actions in this section is based on March 1995 rewrites as requested with SW-1A amended to reflect adoption in Title 10 of Chapter 173-351 WAC by reference, and SW-1B and Issue 4 deleted as a plan actions. Additionally, we recommend the use of the ground water standards as an early warning threshold for reactivation of the GWAC for the reasons stated in earlier correspondence to you and request the following text changes.

Page 3-120~~77~~ Paragraph 2, adding clarifying words to the text about the program.

Environmental Health Division Room 201 Smith Tower Seattle, Washington 98104 (206) 296-4722

The Code of the King County Board of Health, Title 10, "King County Solid Waste Regulations." ~~The Seattle-King County Board of Health has~~ adopteds standards more stringent than the Minimum Functional Standards (WAC 173-304) as the local regulation for governing design, construction, operation, and closure of solid waste facilities other than municipal waste landfills in King County. The Seattle-King County Health Department presently enforces WAC 173-351 - " criteria for municipal solid waste landfills", which governs the design, construction, operation and closure of municipal waste landfills within King County. ~~The Seattle-King County Health Department, Environmental Health Division enforces Title 10. The Seattle- King County Health Department revised Title 10 during 1992. Among other changes, demolition disposal sites now must meet criteria for mixed waste landfills.~~ The Seattle King County Health Department revised Title 10 in 1992 to require woodwaste landfills to have leachate control systems(liners), methane gas control systems, and ground water monitoring systems. Title 10 is considered more stringent than the minimum functional standards (WAC 173-304).

page 3-125~~77~~ Paragraph 5 Minor word edit in line 4 to drop the "of".
~~This alternative is feasible because the Solid Waste Division is proceeding with this program. Funding for the Solid Waste division, program has been identified. Implementation would not require additional resources.~~ However, ~~a timely investigation of these sites~~ this evaluation is requested to show the Solid Waste Division that this issue is ~~of~~ important to the Ground Water Advisory Committee and to ground water quality.

Hazardous Waste
Concurrence to actions in this section is based on March 1995 rewrites of the policies OS-2A and OS-3A as requested and the deletion of proposed policies HM-1 and HM-2.

Additionally, we would like to see the following minor edits:
Hm-1 Hazardous Waste Management: (Page 3-65)
Note to GWAC: The Seattle ....Hazardous materials used by manufacturing...

HM-2 Hazardous Waste Management: (Page 3-65)
Note: to GWAC: The Seattle......The cost to operate such a facility could be as much as ~~exceed~~ $1 million per year.

If you have any questions, please call Bill Lasby at 296-4795.

Sincerely,

Larry Kirchner

Larry Kirchner, Acting Chief
Environmental Health Division

BL:dm

cc: Greg Bishop, Acting Principal Environmental Health Specialist
Dave Hickok, Acting Supervisor Solid Waste Program
Jim Henriksen, Wastewater Program
Bill Lasby, Drinking Water Program
Wally Swofford, Chem/Physical Hazard Program
Todd Yerkes, Local Hazardous Waste Management Program

King County
Department of Development
and Environmental Services
3600 - 136th Place Southeast
Bellevue, Washington 98006-1400

August 9, 1996

TO: Mark Issacson, Project Manager, Surface Water Management Division

FM: Robert S. Derrick, Director

RE: Vashon Maury Island Groundwater Management Plan

Thank you for including the majority of the revisions we requested to the November draft of the Vashon-Maury Island Groundwater Management Plan (GWMP). With resolution acceptable to the Department of the following outstanding issues, the Department of Development and Environmental Services (DDES) will be able to concur with the plan:

1. Funding. The tasks assigned to DDES are identified to be funded by "General Agency Funds". As discussed in our previous comments, DDES is a fee-supported agency and needs specific funding to conduct any work that does not generate fees. An acceptable funding source will have to be identified for the agency to complete the assigned tasks or they are unlikely to be completed. We again request that the tasks be funded through the Aquifer Protection Fund or some other specific source.
2. SEPA Categorical Exemptions. The plan's recommendation that SEPA categorical exemptions are considered for repeal is in direct conflict with the County's recent efforts to meet the requirements of the state's Regulatory Reform Act. DDES has completed an analytical review of the current categorical thresholds and application of SEPA mitigation to projects. Most of the projects above the thresholds had no additional mitigations identified - usually because the existing environmental protection measures were already codified. The conclusion was that thresholds be expanded; not exempted as the plan recommends. In light of the mandated 120 day permit time limits, the expectation that even smaller projects be subjected to SEPA review is unrealistic. The plan's focus should be on each jurisdiction's development of adequate regulation that precludes the need for individual SEPA review for many project types. This recommendation should be removed.
3. Coordination with other GWMPs. Most of the tasks that are identified for DDES are consistent across all of the GWMPs. DDES concurs with the level of effort and proposed schedule identified in the Redmond Bear Creek GWMP; not with this plan. Since the completion of tasks identified under this one plan will complete the majority of the tasks

identified for DDES in the other plans, the funding of these tasks should be shared across all plans.

It is our understanding that some of these issues will not be resolved until after the King County Council has reviewed and concurred with the plan. We look forward to working with the Management Committee to resolve any outstanding issues and move forward with a successful implementation of the plan. After the Council has reviewed and concurred with the plan, the outstanding issues have been resolved, and the funding has been secured, we look forward to implementation of the tasks identified for our agency.

RSD:js

cc: Dan Chason, Chair, Ground Water Advisory Committee
Doug Rushton, Washington State Department of Ecology
Greg Kipp, Deputy Director, Department of Development and Environmental Services
ATTN: Jerry Balcom, Supervisor, Code Development Section
Mark Carey, Manager, Land Use Services Division
Tom McDonald, Manager, Building Services Division

King County
Water Pollution Control Division
Department of Natural Resources
821 Second Avenue
Seattle, WA 98104-1598

March 14, 1996

Bill Lasby
Drinking Water and Ground Water Programs
Seattle-King County Department of Public Health
Environmental Health Division
Room 201 Smith Tower
Seattle, WA 98104

Dear Mr. Lasby:

Thank you for the opportunity to comment on the Draft Ground Water Management Plan for the Vashon-Maury Island Ground Water Management Area. Overall the documents were easy to comprehend and conveyed information well. There were only a few comments on the plan as follows:

- Page 3 - 23 - Has the Vashon Town Plan been adopted? The text states that it will be adopted in December of 1995.

- Page 3 - 36 - "Metro" no longer exists. Reference to Metro should now be the King County Department of Natural Resources, Water Pollution Control Division.

- Page 3 - 133 - Paragraph 3 - There is a discussion of proposed regulations requiring a conservation element for ground water management plans. Has this proposed regulation been adopted? Is it possible to include what the requirements are for a conservation element? Also, could you include when the proposed regulations would be adopted?

If you have any questions or comments regarding these remarks, please feel free to contact me at (206) 684-1253 or Darlene Gaziano, Water Quality Planner at (206) 684-1147.

Sincerely,

Elsie Hulsizer

Elsie Hulsizer
Acting Environmental Programs Manager
King County Department of Natural Resources

cc: Jackie Reid, King County Department of Natural Resources
Darlene Gaziano, King County Department of Natural Resources

April 1, 1996

TO: Paul Shallow
FM: Lorin Reinelt
RE: Vashon GWMP - Proposed language for ST-1

The following is the proposed language and title for a revised recommendation ST-1 in the Vashon GWMP. The recommendation is consistent with the current proposal in the 1996 draft Surface Water Design Manual. For subdivisions and commercial developments, infiltration is not required, but would likely be necessary on coarse soils in order to meet pre-development flow control requirements.

ST-1: King County Surface Water Design Manual Infiltration Requirements

The infiltration and water quality treatment design standards of the King County Surface Water Design Manual should encourage infiltration of stormwater after treatment in order to maintain aquifer recharge and protect groundwater quality. When infiltrating runoff from new development of pollution-generating impervious surfaces in the Vashon Groundwater Management Area, a sole-source aquifer area, stormwater treatment shall be required using one of the following options:

1. If soil infiltration rates are greater than 2.4 inches per hour, stormwater shall be treated prior to infiltration using a facility from the basic water quality menu in the Surface Water Design Manual, designed to remove 80 percent of total suspended solids and associated pollutants. Any one of the following facility options can be used to satisfy the basic water quality protection requirement: biofiltration swale, filter strip, wetpond, wetvault, constructed wetland, sand filter, or a new technology capable of 80 percent TSS removal.

2. If soil infiltration rates are between 2.4 and 9 inches per hour, soil treatment can be used to satisfy the treatment requirements if certain soil depths and characteristics are met in terms of cation exchange capacity, organic content, or grain size distribution.

Roof downspout dispersion or infiltration systems, consistent with lot size and soil type, should be required for new residential development.

cc: Louise Kulzer

King County
Solid Waste Division
Department of Natural Resources
Yesler Building
400 Yesler Way, Room 600
Seattle, WA 98104-2637
(206) 296-6542

March 22, 1996

TO: Mark Isaacson, Project Manager, Surface Water Management Division

FM: Kevin Kiernan, Engineering Services Manager KK

RE: Vashon - Maury Island Ground Water Management Plan

Thank you for providing us the opportunity to review the Draft Groundwater Management and the Supplement Draft Area Characterization Plans for Vashon - Maury Island. This memorandum is organized to first comment on management strategies and then comment on the Supplement Draft Area Characterization.

We have reviewed section 3.3.7, Solid Waste Landfills, of the Draft Ground Water management Plan, and have the following comments:

GOAL:

Revise the second sentence to recognize King County's recent decision to close the Vashon Landfill in the year 2000 to replaced it with a transfer station that will become operational in the same year.

ISSUES:

- Amendments to Title 10 for landfills cell expansion (SW-1A and 1B)

You should consider revising the focus of SW - 1A and 1B amendments to Title 10 as a consequence of the impending closure of the Vashon Island Landfill and its replacement with a Transfer Station.

- Establishment of a Hazardous Waste Transfer Station(SW-2)

We do not agree with the rationale for recommending that King County establish a hazardous waste transfer station on the Island. It is true that King County does not accept hazardous and other dangerous wastes at any of our facilities, and our existing Waste Clearance and Screening Program is designed to minimize any accidental receipt of such wastes. King County does have an existing county-wide Hazardous Waste Collection and Disposal Program designed to collect and dispose hazardous wastes off-island.

Hazardous wastes are managed outside the solid waste disposal system. A mobile hazardous waste collection facility (Wastemobile) makes regularly scheduled stops on Vashon Island to collect paints, pesticides, cleaners, solvents, adhesives, and other hazardous materials. All wastes are removed from the site at the end of each collection day. Some materials are recycled, others are neutralized, and most harmful wastes are hauled to hazardous waste landfills or incinerators. The County continues to devote significant resources on public education through several publications and advertisements about this program. Was this program considered prior to the preparation of this draft report?

Hazardous waste management is coordinated through the local Hazardous Waste Management Plan. This plan is coordinated through the Seattle-King County Department of Public Health, the Water Pollution Control Division, the Solid Waste Division, the Suburban Cities Association, and the City of Seattle. The public process for this plan was recently completed, although if you act quickly, input may still be possible.

- Evaluation of sites for locating a new landfill (SW-3)

This recommendation has become unnecessary based on information discussed earlier.

- Provision of a Compost Facility (SW-4)

We do not believe that a separate Composting Facility will be viable or cost-effective at Vashon Island. This conclusion is based on pilot studies conducted in the past by the Division. Moreover, the proposed municipal solid waste transfer station, after it becomes operational in the year 2000, is scheduled to provide yard waste collection services. The collected yard waste, including grass clippings, will be hauled to existing off-island composting facilities.

- Investigation and Remediation of Abandoned Sites (SW-5)

We would appreciate the opportunity to provide input and comment on future determinations regarding this issue.

- Education Program (SW-6)

This section should acknowledge the significant progress the Division has made in educating its citizens about the Wastemobile Hazardous Waste Collection and Disposal service. King County already has a nationally recognized public information program on waste reduction and recycling. New educational elements should be modified to recognize the existence of this program.

We would like to be provided the opportunity to provide input and comment on future determinations with regard to the issues discussed above, and on the following:

- Designation of Environmentally Sensitive Areas (SA-1A)
- Elimination of Categorical Exemptions to SEPA (SA-1B)
- Adoption of General Aquifer Protection Policies (SA-1C)
- Enhanced environmental review to protect aquifers (SA-1D)
- Ground water recharge areas (SA-1E)
- Wellhead Protection (SA-2A)
- Designation of Special Protection Area (SA- 3)

We have also reviewed the Draft Vashon-Maury Island Ground Water Management Plan Supplement Area Characterization for landfills and have the following comments and suggestions:

Section 5.3.1 Description

Revise the fourth paragraph to read as follows: "...To comply ..a leachate collection and Pretreatment System ".

Background

Revise this section to indicate that eight new groundwater monitoring wells were completed in 1995 around the Vashon Landfill (four shallow and four deep). Details on this project are provided in the "Draft Monitoring Well Construction and Hydrogeologic Report for Vashon Island Landfill, 1995" prepared for King County Solid Waste Division by CH2M Hill. King County began collecting samples from these wells in November 1995. This latest report provides supplemental hydrogeological information on the existing monitored groundwater zone (Units IIA and IIB), establishes an initial hydrogeologic Unit IIC monitoring network, and defines the deep hydrostratigraphic conditions beneath the landfill to approximately 350 feet below ground surface. A draft copy of this report will be provided to you upon written request.

Deep Ground Water

Revise the third paragraph to indicate that King County has scheduled the construction of the second stage of an active landfill gas collection and treatment system to be completed by September 1996. The initial stage, completed in 1995, consisted of the installation of eight new landfill gas perimeter probes to monitor the performance of the stage II system. The latter system consists of an interior landfill gas collection, extraction, and treatment system.

Future Plans

Revise the first paragraph to include the eight new groundwater wells and all related information.

Revise the second paragraph to indicate that the Consultant completed the Vashon Landfill Gas migration control study in 1993. Their recommended strategy for the control of landfill migration, which is being implemented as discussed above, is a three-stage plan. Stage I was completed in 1995. Stage II will be completed in 1996. Stage III if necessary will include the design and construction of a perimeter landfill gas control system at the site in 1998.

Revise the third paragraph to indicate that an evaluation of three site Conceptual Development Alternatives was completed in 1995. Details of this evaluation are in the "Vashon Island Landfill Conceptual Development Alternatives Report, 1995" prepared for King County Solid Waste Division by CH2M Hill. This study projects that the capacity in the existing developed landfill area will be exhausted in the first quarter of the year 2000, and recommended the closure of the landfill and its replacement with a transfer station. King County accepted this recommendation, and plans for the development of a transfer station in the year 2000 are proceeding on schedule.

Thank you for the opportunity to comment. If you have any questions, please contact me on extension 6-4419.

KK:VOO:mfn
VOO18/ekcgwmp.doc

cc: Rodney G. Hansen, Manager, Solid Waste Division
Jeff Gaisford, Acting Waste Reduction/Recycling Manager
Shirley Jurgensen, Supervising Engineer
Victor O. Okereke, Senior Engineer

King County
Road Services Division

Department of
Transportation

Yesler Building
400 Yesler Way MS 4Y
Seattle, WA 98104-2637

March 19, 1996

TO: Paul Shallow, King County Department of Natural Resources
Ground Water Program

FM: Jesse Krail, King County Road Engineer, Department of Transportation,
Road Services Division

RE: Review of Redmond - Bear Creek Valley, Issaquah Creek Valley,
East King County, and Vashon Island Ground Water Management Plans

Thank you for the opportunity to review the referenced groundwater management plans. Department of Transportation, Road Services Division, Environmental Unit and Maintenance Operations Section staff have completed a review of the documents. The referenced groundwater management plans provide excellent guidance for protecting groundwater resources. However, we have the following comments about some of the plan policies:

Issaquah Creek Policy SA1A, Redmond Policy SA1A, and East King County SA1A
Road Services Division will want to be closely involved with any decisions made about revisions to existing SEPA exemptions. We perform a large quantity of SEPA exempt maintenance and upgrade work on King County bridges and roads, and this work is done on a tight timeline. Changes to exemptions for routine maintenance projects could significantly reduce our ability to service roads and bridges with a quick turn-around. This could result in unsafe conditions on our roadways. We request some acknowledgment and commitment within the management plans of the need for our Division's input to that decision-making process.

Issaquah Creek Policies ST-1 and ST-2A, Redmond Policies ST1A and ST2A,
East King Policies ST-1A and ST-2A, and Vashon Policies ST-1 and ST-2B
Road Services Division will want to be closely involved in any effort to revise the Surface Water Design Manual. We request some acknowledgment and commitment within the management plans of the need for our division's input to that decision-making process.

Issaquah Policy ST-6, Redmond Policy ST 5A, East King Policy ST-6A, Vashon Policy ST-6
As noted in previous comments from Jon Cassidy, Road Services Maintenance Division, a six-year budget process is already in place to guide our capital expenditures. Changes or additions in project prioritization must take the existing planning process into consideration. From the groundwater protection aspect, we certainly agree in concept to giving high priority to physically susceptible areas when identifying retrofit opportunities.

However, there are other planning factors in road construction/retrofit that must be taken into account that may be of higher or equally high priority.

Vashon Policy WQ-1A
The Division wishes to assist in the development of the ordinance that establishes clearing guidelines and performance standards with retention requirements.

Vashon Policy WQ-9, Item 5
This policy calls for maintaining high ground water recharge areas in residential or non-intensive uses at low densities. Has there been consideration of how this policy will impact existing or proposed roads crossing through these areas? The plan should take this issue into account.

East King County Plan Environmental Checklist (Item 14 -Transportation)
This checklist item states that there will be no impacts to transportation. The checklist should be based on some analysis of the impacts to the Division's ability to provide transportation facilities based on the cost of proposed/anticipated retrofits. SEPA review is obviously not an appropriate vehicle for cost/benefit analysis, but impact of cost on ability to provide and maintain transportation facilities and resulting transportation system impacts is a legitimate avenue to pursue.

East King County plan Table 3.8.1, Implementation Priority
This table should include Division staff time and cost estimates based on our need to participate in further policy review and development.

Thank you again for the opportunity to comment on these plans. Please call Supervising Environmental Engineer Vicki Shapley at 296-6520 or Environmental Engineer Kathy Fendt at 296-8779 if you have any questions concerning our comments.

JK:kf

cc: Jon Cassidy, Supervising Engineer
Lydia Reynolds, Manager, Project Support Services
Vicki Shapley, Supervising Environmental Engineer
Kathy Fendt, Environmental Engineer

Dockton Water Association
9710 S.W. Windmill Street
Vashon, Washington 98070

March 12, 1996

Mark Issacson
Groundwater Project Manager
King County Dept. of Natural Resources
Surface Water Management Division
700 Fifth Ave., 22nd Floor
Seattle, WA 98104-9830

Dear Mr. Issacson:

While my comments on the overall Vashon-Maury Island Ground Water Management Plan are included in the submittal by the Vashon-Maury Water Purveyors Association, the comments below cover errors specific to the Dockton Water Association. All comments address the supplement.

In table 2.6-3a, the total water rights for DWA is listed as 0.16 cfs. In reality this is the water right for only one of three sources, namely our Dockton Springs facility (Cert. # S1-23804C). We have an additional water right (Cert. # S1-20464C) for .03 cfs (16 acre ft./yr) for our Hake Springs facility and one for our Sandy Shores well facility (Cert. # unknown) for 100-128 gal/min. The latter right was originally registered to a Mr. Cleve Bard for the Sandy Shores Water Co.

On page 44, DWA is identified as one of three purveyors who have exceeded the maximum allowable withdrawal quantities. The annual allowable withdrawal quantity divided by what would be pumped at the maximum instantaneous rate for a year provides a factor of 30%. Applied to the well at 100 gpm, produces an allowable annual withdrawal of 15,768,000 gallons. When combined with the total allowable for the two spring sources (13,368,000 gallons), the total would be 29,136,000 gallons. We have never exceeded that amount of annual pumpage.

In table 2.6-4. Should you wish to update number of connections, the DWA total is now 317.

Sincerely,

H.M. Todd
President

VASHON-MAURY ISLAND WATER PURVEYORS ASSN.

March 12, 1996

RECEIVED
MAR 14 1996
SURFACE WATER MANAGEMENT DIVISION
OFFICE SUPPORT SERVICES

Mark Issacson
Groundwater Poject Manager
King County Dept. of Natural Resources
Surface Water Management Divison
700 Fifth Avenue, 22nd Floor
Seattle, WA 98104-9830

Dear Mr. Issacson:

Enclosed are comments on the Vashon-Maury Island Ground Water Management Plan. The comments were cooperatively compiled by the members of the Association who have signed below.

The concensus of the participants was that the plan was overly ambitious and too costly. We do not believe that residents will vote positively on the formation of the proposed Aquifer Protection Area as defined in the plan. We recommend that you simplify the plan to the basic needs for aquifer protection with emphasis on costs.

As noted in the comments, we found that many of the tasks proposed to be charged to the APA were legislative mandates to the agencies involved and should be funded under the existing tax structure. Also, many others were common to other APAs or had County wide application but were proposed to be fully funded by the Vashon-Maury Island APA.

Sincerely,

Larry Higley
Heights Water Assn.

Terry Jansen
Westside Water Assn.

Mike Todd
Dockton Water Assn.

Doug Dolstad
Island Water Management

Jim Garrison
Burton Water Co.

Mark Salkind (CS)

Mark Salkind
Beulah Park Water Assn.

Ben Binuya
K.C. Water Dist. # 19

Tom Baxter
Maury Mutual Water Co.

COMMENTS ON
VASHON-MAURY ISLAND
GROUND WATER MANAGEMENT PLAN
Vashon/Maury Island Water Purveyors Association

GENERAL

1. The plan describes many tasks (ordinance & regulation preparation; studies, education, etc.). which have County-wide application, but whose total cost is charged to the Vashon APA funds.

2. Some tasks are already the responsibility of State or County agencies in their basic mandated charter and should be funded by existing taxes; however, the costs of executing many of these tasks is charged to Vashon APA funds.

   Example: Ecology, due to a stated lack of funds, is delegating the oversight of well construction and abandonment to SKCHD. The cost of development of the SKCHD program and training of inspectors is proposed to be charged to Vashon APA funds.

3. The plan proposes to resolve a number of problems through enactment of ordinances, regulations and zoning; however, there is a lack of commitment to the enforcement of these new mandates or existing ones that affect ground water quality and quantity. New regulations, without provisions for enforcement, are not worth doing.

4. The funding estimate for the plan addresses the costs over a three year period with costs tagged to the initial implementation timeframe of each level of priority. It does not address the continuing annual costs for maintaining the initiatives set in place in the initial three years. Monitoring and sampling, for example, will be an ongoing and long term effort.

5. The GWAC is described as the policy making body for the GWMP, yet their policy statement as described in paragraph 3.5.2 is part of the unfinished agenda and has only reached the draft stage. It would appear that the plan was drafted without benefit of a firm policy from the responsible agency. The policy should be adopted in final form before adoption of GWMP. Further, in a meeting with the GWAC, members of that committee expressed concern that their inputs were not considered and that they had very little, if any, consultation on the content of the plan as drafted. There is reason to doubt that the County intends to allow any real policy power to the GWAC and only intends to use them as a buffer and to instill a false sense of local control of the GWMP.

6. The GWAC is given the responsibility to resolve any problems uncovered by the monitoring of water quality or quantity and are given six months to resolve each such issue. The GWAC has neither the resources or expertise to formulate solutions (most of which will be technical) to these problems. There appears to be no consideration of funding for GWAC activities. Solutions to problems will undoubtedly require the paid services of technical consultants as well as administrative expenses.

7. While a funding estimate has been provided, it apparently doesn't include all the costs "To be determined during concurrence" that occur in many of the paragraphs of the plan. Also costs are identified for the first three years only. It is obvious that some tasks are ongoing over many years, e.g. , Data Collection

and Analysis. The continuing costs should be identified.

8. Control of the proliferation of individual or small group wells has not been addressed. Outside of the considerations of conservation, each of these wells will be uncontrolled or poorly controlled point sources of contamination.

9. The use of incentives as opposed to new regulations should be explored as a more effective approach to contamination control. A surcharge or use tax could be applied to the purchase of such contaminants as pesticides to discourage their use. Tax incentives could be offered for low water usage landscaping, for example.

SPECIFIC TO NO. 1 & 2 PRIORITIES (Table 4.8.1)

Although reviewed, specific comments on Priority 3 issues are not addressed here since the issues are too numerous and the general comments can be applied to nearly all the proposed activities.

HM - 1 Hazardous Waste Management - Tracking.

Would appear to be a prudent plan. Responsibility of State Ecology and King County under the Hazardous Waste Management Act. Page 3-59 seems to acknowledge this cost responsibility, but Table 4.8.1 charges it all to Vashon APA funds. The table needs revision to match the text.

3.5.2 Non - Degradation Policy.

See General Comment 5.

OS - 1A&B Nitrate Concerns

Acceptable as is. Will probably require sampling of water at each source prior to treatment. Currently one sample is taken after treatment from point in distribution system. Also, see general comment 6.

OS - 1C Nitrate Concerns

The investigation of high risk areas to ground water from on-site disposal would seem to be a current responsibility of SKCHD if high risk areas are defined as areas susceptible to failed septic systems. General comment 2 applies.

OS-2B Hazardous Materials

An appropriate safeguard; however, per general comment 2, it should not be charged to APA funds.

OS-3A Household Hazardous Waste

Acceptable as is.

OS-2A Commercial Hazardous Waste

An appropriate action; however, per general comment 2, need for APA funds are not identified.

OS-4B Operation and Maintenance

While not clear in text, it would appear that the results of this study would address only regulations pertaining to construction of new on-site systems. Existing systems in Type 1 soils would continue to contribute to aquifer contamination is such a case. Retrofit of existing systems would be very expensive. The study is probably worthwhile; however, t he results should be presented to the GWAC before implementation of regulations. A cost/benefit analysis should be included as a part of the study.

OS-4A Operation and Maintenance

Recording of as-builts for septic systems is a good idea. As written in the plan it would only apply to new systems. Some method should be considered to require recording at any transfer of title, if not previously done. Since SKCHD has copies of as-builts, owners, at time of transfer could obtain copies for recording. Attachments to such copies could contain the additional information proposed. General Comments 1 and 2 apply to this task.

OS-4C Operation and Maintenance

The SKCHD already includes home owner on-site sewage system operation and maintenance information on the as-built form, and if the suggestion to apply recording to existing systems is implemented, this task could be deleted. Performance standards should already be well known by SKCHD, so no development should be required, only an update to the form.

SA-2B Wellhead Protection

This paragraph should include, not only the implementation of land-use measures, but a strong commitment to enforcement. Abatement of contaminating practices by landowners in the wellhead protection area cannot be enforced by purveyors. Their only available tool is persuasion, which often is not effective.

SA-1A Designation of Environmentally Sensitive Areas

Designation of Vashon-Maury Islands total land mass as an Environmentally Sensitive Area, while having some advantage to ground water protection, also opens the door to more restrictive use of private property for noncontaminating uses. Currently the appropriate areas per the SEPA regulations (steep slopes, wetlands, etc.) have been delineated where appropriate on the islands. Perhaps the Environmentally Sensitive Area designation could incorporate limitations of application to only those practices or construction that could have an adverse effect on the aquifer.

SA-2C Wellhead Protection

Currently, grants for wellhead protection are limited to political entities. Water District 19 is the only purveyor in this category. Private purveyors have entered into an interlocal agreement with District 19 to cooperate in a Wellhead Protection program for which District 19 will apply for a grant.

SA-2A Wellhead Protection

The tasks defined here are a part of the Wellhead Protection Program mandated by the State DOH on all Class A water systems. It is not specific to Vashon-Maury Islands and it is assumed that it is included in plan for reference.

WQ-4A Conservation

Landscaping ordinances would be difficult to enforce and would probably be resented as excessive government control. A better approach would be the use of incentives for use of landscaping that reduced water usage. The incentive could be reduced taxes in a similar vein as the Public Benefit Rating System.

WQ-4D Conservation

Acceptable as written. Assume this is for information only since it is already a requirement.

WQ-4C Conservation

Acceptable, except General Comment 1 applies.

WQ-4B Conservation

This may be impractical to enforce considering the number of Group B systems, some of which only serve two or three houses. Comments 1 & 2 apply.

UST- 1C Augment State Underground Storage Tank Program

It is not clear that this issue includes a test of buried tanks for leakage except during installation and removal. The larger issue would seem to be leakage from tanks that remain buried.

If the only issue is inspection during installation and removal, it would appear that having the Fire Marshal's office handle the total inspection process and provide a copy to SKCHD would be the most cost effective course. It wouldn't take much additional training to observe if a leak had occurred during tank removal.

DCM-1 Data Collection Analysis and Management

While this is the heart of the GWMP, it seems too elaborate and expensive. Much of the monitoring is already required of purveyors under state regulations and this data should be used for the DCMP. The plan should be simplified to gather

and analyze only the basic data required for quality and quantity monitoring.
This is a task which will continue for many years. At $261,000/yr., a less expensive approach is needed.

Many Paragraphs — Education Program Elements

Education is a desirable component of the GWMP; however, $230 per household over a three year period is overkill. Much of the education material is common to other APAs (See general comment 1.)

HM-1
HM-2 — Hazardous Waste Management

See General Comment 2.

C-1 — Burial of Human Remains

The first question is whether any action would be taken if so indicated by study. The public acceptance of digging up bodies and moving them someplace else could hardly be expected. Unless you have a plan and the political courage to carry it out, the study would be a waste of money. General comment 1 applies.

Mark Issaicson
King County Surface Water Management Division
700 fifth Avenue, Suite 2200
Seattle, WA 98104

January 30, 1996

RECEIVED
FEB 01 1996
SURFACE WATER MANAGEMENT DIVISION
OFFICE SUPPORT SERVICES

Subject: Vashon Groundwater Management Plan

In response to the invitation for public comment on the Vashon Groundwater Management Plan, I have the following contribution as a practicing environmental professional and land owner on Vashon.

1. From the meeting conducted Saturday, January 27, 1996 at the Vashon library, the committee and its members have evidently completed their task at hand and be congratulated for their work. They should also be quickly disbanded - ten years is to long for a citizen group to be together.

2. After ten years of study and hard work, putting the plan to the voters would be prudent, there is no plan "made in heaven." Regulations required to protect groundwater resources are "on the books" but they lack real time enforcement - the major hurdle that needs to be addressed by SWM and the Attorney General's office.

3. Proactive, full time enforcement could be achieved with privatization of a program with Vashon resident funds or as a position fully funded by the city government. From my working experience with the regulatory community, the County government and its departments clearly do not have the necessary resources for day-to-day enforcement issues other than those that are through citizen compliant and/or conflict.

4. The groundwater management program requires an individual to fulfill two areas of need - a lobbyist and a pragmatic environmental professional. The lobbyist is responsible for acting as a facilitator among the potential government agencies affected by this program and as an expeditor for island issues.

5. The environmental professional must have the necessary technical skills for the program's scientific objectives and have practical credentials for enforcement of the various regulations that pertain to protection (i.e., underground storage tanks, well head protection, septic and building regulations, etc.). This would include routine compliance and enforcement actions and the ability to collect and analyze the data required to meet the long term objectives of the program. This last effort is especially important as it is required to make rational and effective engineering-based decisions concerning the quality of our resource.

Thank you for your time. Please feel free to call me at (206) 633-6899 to discuss this letter.

Respectfully,

R. Colombo

Robert Colombo
P.O. Box 1734
Vashon, WA 98070

RECEIVED
MAR 14 1996
SURFACE WATER MANAGEMENT DIVISION
OFFICE SUPPORT SERVICES

Mr. Marc Isaacson
Ground Water Program
Dept. of Natural Resources
700 5th. Ave.
Suite 2200
Seattle, WA. 98104

3/13/96

Dear Mr. Isaacson,

We are writing to you regarding the Vashon-Maury Island Ground Water Management Plan. As private well users, we may be affected by future determination of status of ground water. In respect to the carrying capacity, we would urge that any management plans take into consideration the renovation factor and be as conservative as possible.

We are concerned with the amount of growth that is taking place with seemingly no regard to water supply and effluent from increase in population.

Thank you for your consideration of this issue and we look forward to any response you have to this matter.

Sincerely,

Mr. and Mrs. R.A. Danielson
PO Box 2007
Vashon, WA. 98070

March 15, 1996

Mr. Mark Issacson
King County Department of Natural Resources
Groundwater Management Division
700 5th Avenue, Suite 2200
Seattle, WA 98104-9830

Dear Mr. Issacson:

I want to reiterate some concerns that have been expressed at recent meetings on the draft Vashon-Maury Island Ground Water Management Plan. I am hopeful we can find ways to strengthen the plan and build public confidence in it. I am committed to working with you toward that end.

1. Water Budget - The plan is lacking a water budget. Without this, it seems to me our community has no "benchmark" against which to evaluate the impact of changes in land use activity or zoning. As we are beginning to find out, we cannot be assured that it will be possible to take action to sufficiently protect high recharge areas without very clear parameters concerning water supply. We must make use of the best available information, and continue to do enough monitoring to improve upon our the existing knowledge. Without anything better, it seems as though the most practical alternative is to continue to rely the water budget developed by Carr and Associates in 1983.

2. Deep Aquifer - Our fundamental understanding of the deep aquifer is so lacking, and the costs and risks so great of relying on it, that for all practical purposes we need to focus more closely on the continued ability of the shallow aquifer to serve our needs. At least half of the residents of Vashon and Maury rely on (shallow aquifer) individual private wells, and are not part of larger systems. There have been some very expensive, non-productive attempts by public systems to obtain water from the deep aquifer. For private well users, future reliance on the deep aquifer is simply not an option. For others, it is bound to be far more speculative than perhaps we have conveyed in the draft plan. Our willingness to "relax" about more restrictive and substantive strategies to protect

groundwater rests largely on perceptions about the the deep aquifer. There is a false security and false economy in expecting future water needs to be met by drilling more deep aquifer wells, that is, not without wholesale changes in land use, that Vashon in all past planning efforts has consciously avoided. The bottom line is that our management strategies should be rigorous to offer us a sustainable future without relying so much on the deep aquifer.

3. Ground and Surface Water Interface - The relationship between ground and surface water is under-developed in the plan and its management strategies. In recent meetings, the reliance of both public supply systems and individual domestic system water users on surface waters has been highlighted, and I think our policies and management strategies must be more inclusive to gain public acceptance.

4. Saltwater Intrusion - The 1983 Carr report states: "Chemical analyses for this and prior studies show a definite indication of salt water intrusion on the Islands. This is evidenced by high concentrations of chloride and high specific conductance in a number of wells." Carr also reported on analyses of water from springs and stream sources showing higher chloride than the well sources. After including Carr's finding in a letter of July 9, 1993, I and several other committee members expressed continuing concern that perhaps this issue had not received enough attention in our plan. My understanding is that this resulted from some more favorable findings in different test results, from different wells. I continue to have concerns about this problem, as it seems to me the "early warning" light is already flashing - at least at some well sites. We need to address saltwater intrusion with higher priority.

5. Vegetative Cover - Insofar as vegetation removal can increase runoff and - all things considered - cause a net decrease in the volume of water reaching the aquifer, it seems our management strategies must be revised to deal more effectively with this issue. The rapid conversion (loss) of forest lands on Vashon-Maury Islands has a direct impact on the sustainability of our water supply, yet this is taking place with virtually no consideration of groundwater, not to mention other impacts.

6. Residential Density - Another issue that surfaced at recent meetings relates to overall density in residential zones which affect assumptions we make regarding future water quality and demand. There are apparently allowances resulting from changes to the Comprehensive Plan that allow for "accessory dwellings", or what amounts to an additional dwelling unit on each residential lot, and "rounding up", or an allowance to build on a lot that is less than the minimum size for that zone in some cases. There has also been concern expressed about an allowance for building on a lot created by a County roadway, even if the lot is undersized, based upon the existing zoning. We have an obligation to address these concerns, including but not limited to any significant changes brought about by revisions to the Comprehensive Plan. Integration of these planning efforts is vital to the protection of water resources.

Thank you for your help so far. I look forward to working with you to complete an effective Groundwater Management Plan.

Sincerely,

Laurie G. Geissinger
13209 SW Reddings Beach Road
Vashon, WA 98070
(206) 463-5870 or 386-4585

11 March 1996

Marc Isaacson
Groundwater Program
King County Department of Natural Resources
700 5th Avenue, Suite 2200
Seattle, WA 98104

Dear Mr. Isaacson:

We have lived in the Reddings Beach Loop area of Vashon Island for nearly twenty years. Two wells on our 15 acres have been used for data collection for both the 1983 and the current ground water resource studies. We are familiar with both of these studies, and are committed to doing our part to preserve our ground water resource. We are committed from both an economic and a natural resource perspective. We know that the economic value of our home and surrounding land rests to a large extent on the potability of the water we draw from our well and on our continuing ability to draw our supply from it. We are also committed to preserving the natural resource base which has created and sustained the biodiversity which we all appreciate on our island.

The draft Vashon-Maury Island Ground Water Management Plan recognizes the two critical issues of quality and quantity of our groundwater resource, but falls short of addressing them adequately. In its draft form, the plan reads like a generic, county-wide document that does not address issues specific to our island, the nature of our existing utility service and the management constraints inherent in it, and the nature of the aquifers from which we get our water.

There are several relationships which we believe must be the focus of a ground water plan: 1) the relationship between the quality of ground water and the amount and character of effluent discharged from homes and businesses, 2) the relationship between types and density of development and water quality and availability, and 3) the relationship between surface and ground water. Each relationship must be developed fully, with management strategies designed to address specific threats to ground water quality and quantity.

Following are our recommendations for changes to the draft plan. First, we want to articulate some principles we believe must underly the plan if our island's ground water resource is to be protected. First, the management plan should be conservative in its assumptions and in the time frame allowed before a "trigger" occurs. This is especially important because of the years of lag time before the effect of an action actually shows up in the data being collected. The plan talks about an "early warning system" when, in fact, all we really have, de facto, is a late warning system.

Secondly, under some of the interactions described above, we are dealing solely with the language of utilities. Under others, however, discussion of land use sneaks in, whether we like it or not. This is simply a reflection of the unique nature of our island, the characteristics of its water resources, and the way utilities are provided here -- on an island served by a sole source aquifer and a mixture of purveyors, private wells, septic systems and sewers, even land use becomes a utility issue.

Thirdly, the deep aquifer appears to be regarded as the "back-up" we have to the shallow aquifer from which many private well users currently draw their water. We believe this perspective is not only unrealistic, but downright wrong. As development which exceeds the water budget (the only one we have to go on, since the new study does not provide one) occurs, levels in existing wells may drop, and these may be "stranded" as they lose contact with the ever-dropping ground water level. This eliminates the economic value of the affected properties, forcing those private well users to dig costly wells into the deep aquifer. It is absolutely wrong that existing private well users of the shallow aquifer be forced to seek new water supplies and pay these costs.

Based on these underlying principles, we would like to have the following recommendations incorporated in the final plan:

1. Rewrite the Statement of Purpose and other appropriate portions of the plan to describe the dependence of 75% of island water systems on surface and shallow water and to describe the interdependence of surface and ground water on the island. This creates the awareness of the interaction of the two, and the need for addressing surface water quality in providing for the protection of ground and drinking water.

2. A trigger level for quantity must be defined in both purveyor areas and those in which private wells are used.

3. The renovation factor developed for this island should be used as the basis for developing management strategies.

4. Existing policies in the Vashon Community Plan should be enforced, including the P-suffix conditions. Additional conditions should be implemented, including disallowing accessory dwellings, the creation of a second parcel by a bisecting road, the application of the "rounding up" principle, and any other provisions of county regulations which provide for essentially a doubling of the density in a designated zone.

5. The time frame for the trigger mechanisms should be shortened, but still allow for the observation of a trend. A 5-year period, with a 5% drop may be reasonable.

6. Salt water intrusion (currently occurring along the shoreline of part of the island) needs to be addressed. Data collection has occurred at specific sites in previous studies, and this should be acknowledged, analyzed for use in developing management strategies, and should be continued.

We urge you to help us protect our property value by protecting the water supply we currently have. Please create management strategies in the ground water plan which will assure the protection of both the quantity and quality of our water resource which is used not only by purveyors, but also by private well users currently drawing water from the shallow aquifer. Our ground water management plan should be based on the objective of protecting existing sources and existing quality. Otherwise, the county places a tremendous and costly burden on each property owner on this island. If our resource quality and quantity is not protected today, you force us to pay in the future for unwise and short-sighted resource planning. For those in government and the public who argue for private property rights, this plea must ring a bell -- a plea to help us maintain the value of our property by maintaining the existing resource base on which it (and our family) is dependent.

Thank you for considering our comments.

Sincerely,

Donnalee Klemka Martin W. Baker

Donna Lee Klemka
Martin W. Baker
23707 Landers Road SW
Vashon Island, WA 98070

December 29, 1995
9639 SW Elisha Lane
Vashon Island
Washington, 98070
1-206-463-2433

Mark Isaacson
Groundwater Project Manager
King Co. Dep. of Nat. Resources
400 Yesler Way Room 700
Seattle, Washington 98104

I live on a small island which has been identified as a sole-source aquifer by the government. Groundwater is crucial to the future of Vashon Island... it's all we have. Over-population here will result in pumping water out faster than rainfall percolates down and our aquifers will be depleted. If we dump pollutants down the drain, spread herbicides/pesticides, or build too many houses in one spot our aquifers will be polluted. We started to protect our water back in 1986 with community involvement by writing a groundwater protection and management plan. We want to preserve drinking water and natural streams systems - and do it in a way that permits key decisions to be made locally. Drying up streams so someone can build more spec houses isn't part of our plan. We value preserving the islands natural systems and do not consider streams that support wildlife to be a waste of water.

Because of State and County negligence and indifference, our Vashon ground water management plan has moved glacially thro county and state agencies. Finally we are at the public hearing and comment stage. I have lived on Vashon for 19 years and plan to stay. I favor a strong protection plan for our aquifers and natural stream watersheds. We already have minimum 5-10 acre zoning to protect aquifers from over-building; because of our plan, King Co. cuts our island roadsides vegetation rather than spraying chemicals which would pollute our aquifers. We oppose the paving over of natural island roadsides to prevent water runoff and encourage water soaking in down to the aquifer. We will continue to protect the quantity and quality of Vashon's only water source, our island aquifer. Once it becomes depleted or polluted, it cannot be fixed. There is no room for mismanagement and no time for more delay in implimenting a critical island -

[redacted]

water quality protection plan.

Sincerely —

P.J. Fitzhaupt

Science Teacher

Puget Sound Water Quality Author[illegible]

[redacted]

Editorials

Population: Off the agenda

The United Nations Conference on the Environment and Development in Brazil next month is billed as the largest and most important event of its kind ever to be held on the planet.

Unfortunately, [illegible] conference will not address [illegible] single most crucial aspect [illegible] environment and development [illegible] human population explosion [illegible] that threatens to strip the [illegible] biosphere of its ability to [illegible] human life.

That's a morally [illegible] omission. It mocks the very [illegible] the conferees claim to [illegible] rational development of [illegible] Earth's resources.

Today there are 5.5 billion [illegible] us on the planet. By the [illegible] end, there will be 11.5 billion, not the 10 billion only recently expected by demographers. That's largely because 500 million women in developing countries do not have access to safe and effective means of contraception.

But the United States government seems to have stopped caring. The Bush Administration has added to the population explosion by withdrawing support from the United Nations Population Fund and by curtailing U.S. contributions to the International Planned Parenthood Federation.

Those actions are hard to square with a sensible statement [illegible] made by the erstwhile Rep. George Bush of Texas when he headed the Republican Congressional Task Force on Population and the Environment [illegible]. "We need to make population and family planning household words. We need to take [illegible]

[illegible]

support [illegible] family planning, but the Vatican pressed to have it removed from [illegible] will pass up a crucial opportunity to lay urgently needed groundwork for rational population growth. And their successors in the 21st century surely soon will come to lament it.

King County
Water and Land Resources Division
Department of Natural Resources
700 Fifth Avenue, Suite 2200
Seattle, WA 98104-5022
(206) 296-6519
(206) 296-0192 FAX

September 3, 1998

Dan Chasan
Chair, Vashon - Maury Island Ground Water Advisory Committee
17228 Westside Highway Southwest
Vashon, WA 98070

Dear Mr. Chasan:

Enclosed please find a copy of Motion 10493, passed by the Metropolitan King County Council on July 6, 1998, regarding their concurrence with the Vashon - Maury Island Ground Water Management Plan.

As you know, County Council voted to require several changes in the Management Strategies document. Their recommendations, and the rationale for each, are listed in the enclosed concurrence letter that Council wrote (dated June 12 with the motion number "10493" stamped on each page). The concurrence letter states agreement with the goals and objectives of the groundwater program and specifies the revisions that are necessary for Council's concurrence with the plans. We will include both the motion and concurrence letter in Appendix B ("Letters of Concurrence or Comment") of the Management Plan.

We believe that the best course of action, for the sake of groundwater protection, is to make the changes required by Council, finalize the plans and submit them to Ecology for certification, and proceed to implementation. This cover letter, transmitting to you the motion and concurrence letter from Council, describes in detail the changes we will make to the document to accomplish these requirements. Please let us know at your earliest convenience if you agree with the approach and the proposed changes. I do not know whether it will be necessary (or even possible after such a long time) to call a meeting of the Ground Water Advisory Committee to ratify these changes. If you think that this is necessary, please call me (at 206-296-8323) and I will be glad to assist you in assembling the committee members.

These recommendations include:

<u>Management Strategy LU-3</u> (Land Use Impacts to Ground Water, p. 2-14): the second and sixth bullets, relating to accessory dwelling units and vegetative removal, will be deleted from Management Strategy LU-3.

Management Strategy UST-2 (New Tank Prohibition, p. 2-28) the text of this strategy will be changed to the following (shown here with changes highlighted): "If approved by Ecology, King County will amend the King County ~~Zoning~~ Code to prohibit the installation of new underground fuel tanks in residential zones on Vashon Island."

Section 3.3 (Funding, p. 3-2) will be changed to the following: "King County is currently exploring approximately 6-8 long term funding alternatives for the purpose of implementing a ground water management program. If a regional funding source cannot be identified, the Vashon-Maury Island Ground Water Management Committee should assess the feasibility of establishing an Aquifer Protection Area to provide funding for implementation of the Plan." The original text, to authorize a ballot measure to establish an Aquifer Protection Area, will be moved into a new section in the Unfinished Agenda (Section 2.5) to become a new Section 2.5.5 "Aquifer Protection Area" (at the bottom of p. 2-48). The section will begin: "Metropolitan King County Council is investigating various funding alternatives for the Groundwater Management Program. The Ground Water Advisory Committee recommended the use of an Aquifer Protection Area." The section will conclude: "Since Council preferred to leave this issue unresolved until the alternatives are fully considered, this issue is included in the Unfinished Agenda."

Section 3.5 (Ground Water Management Committee, p. 3-4) will be changed to authorize a larger Management Committee. The first three sentences of the first paragraph (following "The Management Committee should consist of a core committee ") will be changed to "of nine members constituted as follows: one representative of the Ground Water Advisory Committee, one representative of the County's Department of Natural Resources, one representative of the Island's water purveyors, a representative of residential well users, one representative of the Vashon Chamber of Commerce, one representative of the Vashon-Maury Island Community Council, a representative of business owners, a representative of commercial agriculturists and a representative of a Vashon environmental organization. Members of the Management Committee would be appointed by motion by the Metropolitan King County Council with members serving staggered terms of three years."

Section 3.8 (Implementation of the Plan, p. 3-7) will be changed to include the following paragraph at the end of the section: "King County implementation efforts will be phased in over time and is dependent upon the availability of funding."

As the enclosed concurrence letter by County Council says, King County is pressing ahead to begin implementation of the groundwater program. We, at Department of Natural Resources, are developing approaches for the various management strategies included in the Management Plans. We are working on a long-term funding option which will allow us to expand our efforts in new directions and establish contacts with agencies and municipalities which may help this effort. We will, of course, be able to accomplish more when long-term funding is secured.

Thank you for the dedication and diligence of the Vashon - Maury Island Ground Water Advisory Committee on this lengthy project. Please contact me at 206-296-8323 to discuss any questions you have about the above changes to the plans, and about what we can do to start the implementation phase of the groundwater program.

Sincerely,

Ken Johnson

Ken Johnson
Groundwater Program Lead

KJ:pra26

Enclosures

cc: Distribution List

DISTRIBUTION LIST

Bill Tobin, Citizen at Large
Bob James, DOH NW Drinking Water
Bonnie Shride, League of Women Voters
Bruce Monell, WA Department of Natural Resources
Kathy Minsch, Puget Sound Water Action Team
Donna Klemka, Citizen at Large
Floyd Williams, K-2 Corporation
Frank Jackson, Citizen at Large
Jerry Balcom, Citizen at Large
Jim Garrison, Burton Water Company
Keith Oratz, KC Council Staff
Ken Fulton, Water District #19
Larry Higley, Citizen at Large
Laura H. Lowe, WA Department of Ecology
Laura Wishik, Citizen at Large
Laurie Geissinger, Citizen at Large
Lawrence Niece, L.H. Niece & Co.
Luke Lukoskie, Island Spring Incorporated
Rick Ames, Vashon Sewer District
Susie Kalhorn, Citizen at Large

09/23/97

sub 6/12/98 kn

Introduced By: PETE VON REICHBAUER, JANE HAGUE, LARRY PHILLIPS, Greg Nickels

Proposed No.: 97-594

MOTION NO. 10493

A MOTION regarding concurrence with the recommendations contained in the Vashon-Maury Island Ground Water Management Plan.

WHEREAS, the Washington State Growth Management Act requires jurisdictions to designate critical areas, including areas with a critical recharging effect on aquifers used for potable water, RCW.36.70A.050, and

WHEREAS, Policy C-5 of the Countywide Planning Policies states that all jurisdictions that are included in ground water management plans shall support the development, adoption and implementation of the plans, Ordinance 11446, and

WHEREAS, Policy NE-333 of the King County Comprehensive Plan states that King County should protect the quality and quantity of the ground water countywide by placing a priority on implementation of ground water management plans, and

WHEREAS, the Washington State Department of Ecology has designated King County as the lead agency responsible for coordinating and undertaking the activities necessary for development of ground water management programs in the county, WAC 173-100-080, and

WHEREAS, a ground water advisory committee has been established for the Vashon-Maury Island ground water management area, and

WHEREAS, the ground water advisory committee contained representatives of local governments, special purpose districts, water associations, agricultural interests, well drilling firms, industry and environmental organizations, and

WHEREAS, the Vashon-Maury Island ground water advisory committee has overseen the development of the Vashon-Maury Island Ground Water Management Plan, and

WHEREAS, the oversight provided by the ground water advisory committee has included reviewing the work plan, schedule and budget for development of the plan, assuring that the proposed plan is technically and functionally sound and verifying that the proposed plan is consistent with Washington state laws and authorities of affected agencies, WAC 173-100-090, and

WHEREAS the Washington State Department of Ecology and the King Conservation District are required to implement some of the recommendations in the Vashon-Maury Island Ground Water Management Plan and have issued letters of concurrence, and

WHEREAS, following the King County council's review and comment on the plan's recommendations, the Vashon-Maury Island Ground Water Management Plan will be submitted to the Washington State Department of Ecology for certification in accordance with WAC 173-100-120, and

WHEREAS, following the Department of Ecology's certification of the Vashon-Maury Island Ground Water Management Plan, the metropolitan King County council will be responsible for implementing those portions of the Plan which are within their jurisdictional authority to implement;

NOW, THEREFORE BE IT MOVED by the Council of King County:

The King County executive is hereby requested to transmit to the Vashon-Maury Island Ground Water Advisory Committee a letter, substantially in the form attached, identifying the county's findings and indicating areas of county concurrence and non-concurrence with recommendations contained in the Vashon-Maury Island Ground Water Management Plan. This letter should contain the following:

1. a clear statement of concurrence or nonconcurrence;
2. a statement of agreement with the goals and objectives of the ground water program; and
3. specific revisions necessary for county concurrence.

PASSED by a vote of 12 to 0 this 6th day of July, 1998.

KING COUNTY COUNCIL
KING COUNTY, WASHINGTON

Louise Miller
Chair

ATTEST:

[signature]
Clerk of the Council

Attachments:
Concurrence Letter

10493

June 12, 1998

Dan Chasan
Chair, Vashon Ground Water Advisory Committee
17228 Westside Highway SW
Vashon, WA 98070

Dear Mr. Chasan:

King County generally agrees with the goals and objectives of the Vashon-Maury Island Ground Water Management Plan, yet makes a statement of nonconcurrence based on its finding of inconsistency between the recommendations contained in the Plan and the intent of chapter 90.44 RCW and other federal, state and local laws. The County recognizes the importance of the Plan's recommendations to preserve and protect ground water, a highly valued natural resource. The County's role in implementing the recommendations of this Plan reflects the County's responsibility as a resource manager, a land development regulator, and the permitting authority for the unincorporated areas of King County.

King County's statement of nonconcurrence is based on its finding of inconsistency between several recommendations included in the Plan and adopted county comprehensive planning policies and county laws. These recommendations must be modified as set forth below to achieve consistency and to allow county concurrence with the Draft Ground Water Management Plan. These recommendations include Management Strategy LU-3, Management Strategy UST-2, Section 3.3, Funding, Section 3.5, Ground Water Management Committee and Section 3.8, Plan Implementation. A summary of the basis for inconsistency and the changes necessary for King County concurrence follows.

King County does not concur with the recommendations of Management Strategy LU-3 (Land Use Impacts to Ground Water) relating to accessory dwelling units and vegetative removal. This finding of inconsistency is based upon the fact that:

1. prohibition of accessory dwelling units in single family zones is inconsistent with KCCP policies H-104, H-302 and H-603 - H-605;
2. pursuant to changes adopted by the State Legislature in 1997 to the Forest Practices Act, a Memorandum of Agreement (MOA) between King County and the State DNR is no longer necessary and is no longer being pursued by either party; and
3. the recommendation to adopt a MOA with DNR is inconsistent with KCCP policies RL-209 and RL-210.

King County can make a finding of consistency only if the recommendations relating to accessory dwelling units and vegetative removal are deleted from Management Strategy LU-3.

King County does not concur with the recommendation of Management Strategy UST-2 (New Tank Prohibition) as it is currently written. This finding of inconsistency is based upon the fact that:

1. King County has limited regulatory authority for underground storage tanks. King County can implement UST-2 if the State DOE approves designation of the Vashon-Maury Island Ground Water Management Area as an Environmentally Sensitive Area and approves the proposed prohibition of new underground tanks in residential zones;
2. it is inconsistent with Countywide Planning Policy ED-10; and
3. it is inconsistent with KCCP Policy ED-101

King County can make a finding of consistency only if Management Strategy UST-2 is modified to read as follows: "If approved by the State DOE, King County will amend the King County Code to prohibit the installation of new underground fuel tanks in residential zones, on Vashon Island."

King County does not concur with the recommendation in Section 3.3, for the Metropolitan King County Council to authorize a ballot measure to establish an Aquifer Protection Area. This finding of inconsistency is based upon the Council's adoption of Ordinance 12926 which required the King County Executive to provide a proposal for long term funding of King County's ground water program. King County's funding efforts will focus on identification of a long term funding source, and establishment of an Aquifer Protection Area will not be authorized until after these efforts have been exhausted.

King County can make a finding of consistency only if the text of Section 3.3 is amended as follows: "King County is currently exploring approximately 6-8 long term funding alternatives for the purpose of implementing a ground water management program. If a regional funding source cannot be identified, the Vashon-Maury Island Ground Water Management Committee should assess the feasibility of establishing an Aquifer Protection Area to provide funding for implementation of the Plan.".

The Draft Plan currently proposes that the Management Committee should consist of a core committee of five to seven members including representatives from the Ground Water Advisory Committee, King County Department of Natural Resources, a water purveyor, and a private citizen. This core group would apparently be supplemented to ensure that there are at least four members from the Ground Water Advisory Committee.

While the aforementioned membership categories are essential to future success, the County would like to ensure that the Management Committee (and the implementation process) benefits from a broader range of views and expertise. Thus, the County does not concur with the recommendations contained in Section 3.5 of the Draft Plan. King County concurs with a larger Management Committee of nine members constituted as follows: one representative of the Ground Water Advisory Committee, one representative of the County's Department of Natural Resources, one representative of the Island's water purveyors, a representative of residential well users, one representative of the Vashon Chamber of Commerce, one representative of the Vashon-Maury Island Community Council, a representative of business owners, a representative of commercial agriculturists and a representative of a Vashon environmental organization. Members of the Management Committee would be appointed by motion by the Metropolitan King County Council with members serving staggered terms of three years.

King County does not concur with the recommendations contained in Section 3.8 regarding implementation of the Plan. A finding of inconsistency is based upon existing obligations imposed by federal, state and local laws related to county revenues and expenditures. These limitations restrict the county from being able to fully commit to Plan implementation following certification.

King County can make a finding of consistency only if the text of Section 3.8 is amended to include the following statement: "King County implementation efforts will be phased in over time and is dependent upon the availability of funding.

King County places a high priority on implementing the specific management strategies relating to wellhead protection, development of best management practices, education, and mapping of critical aquifer recharge areas. During the initial phases of implementation, the County would start to undertake other activities such as coordinating and staffing the anticipated interjurisdictional ground water management committees; developing a data collection and management program to monitor ground water quality and quantity; and enhancing education programs to promote ground water protection.

Thank you for the dedication and diligence of the Vashon-Maury Island Ground Water Advisory Committee on this lengthy project. Please contact Mark Isaacson, Department of Natural Resources, Water and Land Resources Division, at 206-296-8369 to discuss starting the next steps in this effort.

Sincerely,

Ron Sims
King County Executive

17228 Westside Highway SW
Vashon WA 98070
November 18, 1998

Laura Lowe
Washington Department of Ecology
P.O. Box 47600
Olympia WA 98504-7600

Dear Ms. Lowe:

This is the Vashon-Maury Island Ground Water Advisory Committee's response to Metropolitan King County Council motion 10493 and the Council's attached non-concurrence letter seeking to modify the proposed Vashon-Maury Island Ground Water Management Plan. I have enclosed the Council's motion and letter.

As you know, WAC 173-100-120(2) says that "Statements of non-concurrence shall be resolved by the [Ground Water Advisory] committee."

By accepting most of King County's proposed changes and suggesting plan modifications in response to the remaining three, the GWAC has resolved the non-concurrence issues to its own satisfaction.

Now, under the terms of WAC 173-100-120(3), I am transmitting the plan along with the suggested modifications to the Department of Ecology. I hope the Department will certify the plan with the revisions proposed by King County and the GWAC. If Ecology is not willing to do that, I hope it will mediate the remaining disagreements so that we can move forward to protect Vashon's sole-source aquifer.

Very truly yours,

Dan Chasan

Dan Chasan
chairman
Vashon Groundwater Advisory Committee

November 18, 1998

From: Dan Chasan
chairman
Vashon Ground Water Advisory Committee
17228 Westside Highway SW
Vashon WA 98070

RECEIVED
NOV 23 1998
KING COUNTY
WATER & LAND RESOURCES DIVISION

To: Louise Miller
chair
Metropolitan King County Council
King County Courthouse
Seattle WA 98104

Re: Vashon-Maury Island Ground Water Management Plan

Dear Ms. Miller:

The Vashon -Maury Island Ground Water Advisory Committee cannot accept all the changes proposed in the non-concurrence letter attached to Council motion 10493. We expect King County to let Vashon residents choose their own representatives and protect their own resources. We expect King County to treat groundwater protection with the urgency it deserves. The letter states that because of "obligations imposed by federal, state and local laws related to county revenues and expenditures . . . King County can make a finding of consistency only if the text . . . is amended to include the following statement: 'King County implementation efforts will be phased in over time and is dependent upon the availability of funding.'" This is disingenuous at best. "Inconsistency" is not the issue. Obviously, funding groundwater protection must not interfere with programs required by federal, state or local law. But the county does not spend money only on programs that are legally required. The issue is simply one of choice. We assume the county will choose to protect groundwater. Therefore, instead of the deliberately vague "phased in over time" and "dependent upon the availability of funding," the plan should state: "No later than April 15, 2000, King County will commit itself to funding all high-priority items in the Vashon-Maury Island Ground Water Management Plan by January 1, 2003."

The letter also states "King County does not concur with the recommendation . . . to authorize a ballot measure to establish an Aquifer Protection Area. . . . King County can make a finding of consistency only if the text . . . is amended as follows: 'King County is currently exploring approximately 6-8 long term funding alternatives for the purpose of implementing a ground water management program. If a regional funding source cannot be identified, the Vashon-Maury Island Ground Water Management Committee should assess the feasibility of establishing an Aquifer Protection Area to provide funding for implementation of the Plan.'" Again, the issue is not consistency but choice. We have not proposed an Aquifer Protection Area as a way to help King County escape its countywide funding obligations. We have said that an Aquifer Protection Area should not pay for things County government is already obligated to do. But we do not have any confidence in King County's willingness to fund groundwater protection in an adequate or timely manner, and we believe Vashon may want to go beyond whatever program the County chooses to fund. Once an Aquifer Protection Area is established, its functions can, of course, expand or contract as the people of Vashon decide at the polls. We concede it may make sense to wait and see whether or not King County decides to fund groundwater protection in a timely manner. We do not think it is wise--and we think it shows an appalling contempt for the democratic process--to take an Aquifer Protection Area off the table indefinitely. An Aquifer Protection Area has been proposed as a way to let Vashon residents reach into their own pockets--if they choose--to do for themselves things the County will not otherwise do for them. Why not let Vashon residents do that? Is the County bureaucracy so fixated on uniformity that it can't stand the idea of Vashon doing something more? We ask the County to commit itself to an Aquifer Protection Area vote--if Vashon residents want one--by a date certain. The plan should state that "The citizens of Vashon may vote to form an Aquifer Protection Area for the purpose of financing any high priority item(s) to which King County has not committed funds and/or any supplemental public education or monitoring. After April 15, 2000, an Aquifer Protection Area will be placed on a general or special election ballot within six months if either the Vashon-Maury Island Community Council or the Vashon-Maury Island Ground Water Management Committee requests such a vote."

Finally, the letter proposes enlarging the management committee to nine members, representing certain organizations and categories, to be chosen by the Metropolitan King County Council. Our proposed plan calls for a smaller committee to be chosen by the Vashon-Maury Island Community Council. We do not object to enlarging the committee. We do object to the way in which the county wants it chosen. Vashon is, of course, an unincorporated area, but the county has accepted our Community Council as an advisory body. Now, Vashon is being told that the Community Council will not be allowed to focus or convey local preferences. Instead, the management committee will be chosen by a council 12 of whose 13 members do not represent Vashon at all. That is insulting. We ask that the categories be scrapped and the nine committee members be elected at large by the entire island. The plan should state: "The management committee shall consist of nine members elected at large for staggered terms of three years."

While these three areas of disagreement are significant--if they were not, we would not make an issue of them--they do not affect the basic programmatic thrust of the Vashon groundwater plan. Therefore, while the County and the GWAC work to resolve their remaining differences, we urge you to forward the plan to the state Department of Ecology with a note acknowledging those differences and a copy of this letter. We're sure that Ecology's review will take many months. We have already waited more than 12 years for a plan. Let's keep the process moving forward.

Thank you for your interest in groundwater.

Very truly yours,

Dan Chasan

Appendix C

Guidelines for Development of Ground Water Management Areas and Programs

Vashon-Maury Island
Ground Water Management Plan

December 1998

Chapter 173-100 WAC
GROUND WATER MANAGEMENT AREAS AND PROGRAMS

WAC 173-100-010 Purpose.
The purpose of this chapter is to establish guidelines, criteria, and procedures for the designation of ground water management areas, subareas or zones and to set forth a process for the development of ground water management programs for such areas, subareas, or zones, in order to protect ground water quality, to assure ground water quantity, and to provide for efficient management of water resources for meeting future needs while recognizing existing water rights. The intent of this chapter is to forge a partnership between a diversity of local, state, tribal and federal interests in cooperatively protecting the state's ground water resources.
[Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-010, filed 12/20/85.]

WAC 173-100-020 Authority.
This chapter is promulgated by the department of ecology pursuant to RCW 90.44.400, 90.44.410, 90.44.420, 90.44.430 and 90.44.440.
[Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-020, filed 12/20/85.]

WAC 173-100-030 Overview.
This regulation establishes a process for the identification and designation of ground water management areas and for the development of comprehensive ground water management programs. From a general schedule of probable ground water management

areas, the department of ecology in cooperation with local government will designate specific ground water management areas, subareas, or depth zones within such areas and will appoint a lead agency to develop a ground water management program and an advisory committee to oversee the development of the program for each designated area. Following completion of the program and a public hearing to be held by the department of ecology, the program must be certified to be consistent with the intent of this chapter. The program will then be implemented through state regulations and local ordinances. The programs must thereafter be periodically reviewed.
[Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-030, filed 12/20/85.]

WAC 173-100-040 Definitions.
For the purposes of this chapter the following definitions shall apply:

(1) "Aquifer" means a geologic formation, group of formations or part of a formation capable of yielding a significant amount of ground water to wells or springs.

(2) "Department" means the Washington state department of ecology.

(3) "Ground water" means all waters that exist beneath the land surface or beneath the bed of any stream, lake or reservoir, or other body of surface water, whatever may be the geological formation or structure in which such water stands or flows, percolates or otherwise moves.

(4) "Ground water advisory committee" means a committee appointed by the department to assist in the development of a ground water management program.

(5) "Ground water area or subarea" means a geographic area designated pursuant to RCW 90.44.130.

(6) "Ground water management area" means a specific geographic area or subarea designated pursuant to this chapter for which a ground water management program is required.

(7) "Ground water management program" means a comprehensive program designed to protect ground water quality, to assure ground water quantity and to provide for efficient management of water resources while recognizing existing ground water rights and meeting future needs consistent with local and state objectives, policies and authorities within a designated ground water management area or subarea and developed pursuant to this chapter.

(8) "Ground water management zone" means any depth or stratigraphic zone separately designated by the department in cooperation with local government for ground water management purposes within a ground water management area. Ground water management zones may consist of a specific geologic formation or formations or other reasonable bounds determined by the department consistent with the purposes of this chapter.

(9) "Ground water right" means an authorization to use ground water established pursuant to chapter 90.44 RCW, state common or statutory law existing prior to the enactment of chapter 90.44 RCW, or federal law.

(10) "Ground water user group" means an established association of holders of ground water rights located within a proposed or designated ground water management area.

(11) "Lead agency" means the agency appointed by the department to coordinate and undertake the activities necessary for the development of a ground water management program. Either the department or an agency of local government may be the lead agency.

(12) "Local government" means any county, city, town, or any other entity having its own incorporated government for local affairs including, but not limited to, a metropolitan municipal corporation, public utility district, water district, irrigation district, and/or sewer district.

(13) "Local government legislative authority" means the city or town council, board of county commissioners, special district commission, or that body assigned such duties by a city, county or district charter as enacting ordinances, passing resolutions, and appropriating funds for expenditure.

(14) "Probable ground water management area" means a specific geographic area identified by the department, in cooperation with other state agencies, local government and ground water user groups, as a candidate area for designation as a ground water management area pursuant to this chapter.

[Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-040, filed 12/20/85.]

WAC 173-100-050 Probable ground water management areas.

The department in cooperation with local government and ground water user groups shall identify probable ground water management areas.

(1) Probable ground water management areas may be proposed for identification at any time by the department upon its own motion or at the request of other state agencies, local government or ground water user groups.

(2) Probable ground water management area boundaries shall be delineated so as to enclose one or more distinct bodies of public ground water as nearly as known facts permit. Probable ground water management subareas shall be delineated so as to enclose all or any part of a distinct body of public ground water. Boundaries shall be based on hydrogeologic properties such as limits to lateral extent of aquifers, major perennial rivers, and regional ground water divides or as deemed appropriate by the department to most effectively accomplish the purposes of this chapter.

(3) The criteria to guide identification of probable ground water management areas shall include, but not be limited to, the following:

(a) Geographic areas where ground water quality is threatened;

(b) Aquifers that are declining due to restricted recharge or over-utilization;

(c) Aquifers in which over-appropriation may have occurred and adjudication of water rights has not yet been completed;

(d) Aquifers reserved or being considered for water supply reservation under chapter 90.54 RCW for future beneficial uses;

(e) Aquifers identified as the primary source of supply for public water supply systems;

(f) Aquifers underlying a critical water supply service area where the coordinated water system plan established pursuant to chapter 70.116 RCW has identified a need for a ground water management program;

(g) Aquifers designated as sole source aquifers by the federal Environmental Protection Agency;

(h) Geographic areas where the ground water is susceptible to contamination or degradation resulting from land use activities;

(i) Aquifers threatened by seawater intrusion; or

(j) Aquifers from which major ground water withdrawals have been proposed or appear imminent.

(4) The state agency, local government or ground water user group requesting probable ground water management area identification shall provide sufficient information for the department to determine if the area should be so identified. The department and other affected state and local governments and user groups may cooperate in preparing the request for identification.

(a) The request for identification shall be presented in a concise, factual report form and shall consider the guidelines and criteria set forth in subsections (2) and (3) of this section as they relate to the proposed area. It shall also contain: (i) Supporting data as to the need for such identification; (ii) a general description of and rationale for the proposed ground water management area boundary; (iii) goals and objectives for the proposed ground water management area; (iv) an estimated cost of developing the ground water management program and potential funding sources; (v) recommendations for agencies, organizations and groups to be represented on the ground water management area advisory committee; and (vi) a recommendation for the lead agency, taking into consideration the responsibilities contained in WAC 173-100-080.

(b) The recommendation for lead agency shall first be submitted to the county or counties with jurisdiction for written concurrence. Such written concurrence shall be included with the information required in (a) of this subsection. If such concurrence cannot be obtained, the department shall attempt to mediate an agreement between the parties.

(c) The agency or ground water user group initiating the request for identification shall hold at least one public meeting for the purpose of receiving comments from the public, affected local, state and tribal agencies and ground water user groups.

(d) Upon completion, the request for identification shall be submitted to the department and other affected state and local agencies and ground water user groups for their review and comment. Comments shall be submitted to the department.

(5) If the department is proposing an area for identification, the department shall prepare a report containing the information in subsection (4)(a) of this section, hold a public meeting, and submit the report to affected state and local agencies and ground water user groups for their review and comment.

(6) Based upon review of the request for identification together with any comments received and a finding that the proposed area meets the guidelines and criteria of subsections (2) and (3) of this section, the department shall identify the proposed area as a probable ground water management area, establish the general planning boundaries and appoint a lead agency. When a probable ground water management area is included within only one county and that county indicates its desire to assume lead agency status, the department shall appoint the county as lead agency. The department shall notify

affected state and local agencies, ground water user groups, tribal governments and local news media of such identification.
[Statutory Authority: Chapters 43.27A and 90.44 RCW. 88-13-037 (Order 88-11), § 173-100-050, filed 6/9/88. Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-050, filed 12/20/85.]

WAC 173-100-060 General schedule.
The department shall establish a general schedule for the designation of specific ground water management areas. The general schedule shall guide the department in the designation of specific ground water management areas and in the allocation of the department's available water resources funding and staffing.

(1) The general schedule for designation of ground water management areas shall identify the relative priority of each of the probable ground water management areas. The relative priority of the probable ground water management areas shall be based upon:

(a) The availability of local or state agency resources to develop and implement a ground water management program;

(b) The significance, severity or urgency of the problems or potential problems described in the request for identification submitted for each area, with the highest priority given to areas where the water quality is imminently threatened;

(2) The department shall revise the general schedule as needed to comply with the intent of this chapter. After each revision the general schedule shall be published in the news media and the Washington State Register. A public hearing will be held in June of each year to receive public comment on the general schedule.
[Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-060, filed 12/20/85.]

WAC 173-100-070 Designation of ground water management areas for program planning purposes.
The department shall designate ground water management areas by order of the department in accordance with the general schedule. The department shall hold a public hearing within the county or counties containing the probable ground water management area prior to such designation. The order shall be issued to the lead agency as well as the agency or ground water user group originally requesting identification of the areas, with copies sent to other affected state agencies, local governments, tribal governments and those parties recommended for ground water advisory committee membership. Copies of the order shall be published by the department in newspapers of general circulation within the area. The order shall contain a general description of the planning boundary for the ground water management area and shall state that the department, in cooperation with the lead agency and local government, intends to appoint a ground water advisory committee to oversee the development of a ground water management program for the area.
[Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-070, filed 12/20/85.]

WAC 173-100-080 Lead agency responsibilities.
The lead agency shall be responsible for coordinating and undertaking the activities necessary for development of the ground water management program. These activities shall include collecting data and conducting studies related to hydrogeology, water quality, water use, land use, and population projections; scheduling and coordinating advisory committee meetings; presenting draft materials to the committee for review; responding to comments from the committee; coordinating SEPA review; executing inter-local agreements or other contracts; and other duties as may be necessary. The lead agency shall also prepare a work plan, schedule, and budget for the development of the program that shows the responsibilities and roles of each of the advisory committee members as agreed upon by the committee. Data collection, data analysis and other elements of the program development may be delegated by the lead agency to other advisory committee members.
[Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-080, filed 12/20/85.]

WAC 173-100-090 Ground water advisory committee.
(1) The ground water advisory committee shall be responsible for overseeing the development of the ground water management program; reviewing the work plan, schedule and budget for the development of the program; assuring that the program is technically and functionally sound; verifying that the program is consistent with this chapter and with the respective authorities of the affected agencies; and formulating and implementing a public involvement plan.

(2) The membership of each ground water advisory committee shall represent a broad spectrum of the public in order to ensure that the ground water is protected and utilized for the greatest benefit to the people of the state. The committee shall include, but not be limited to, representation from the following groups:

(a) Local government legislative authorities within the designated area;

(b) Planning agencies having jurisdiction within the designated area;

(c) Health agencies having jurisdiction within the designated area;

(d) Ground water user groups within the designated area, including domestic well owners;

(e) The department;

(f) Department of social and health services;

(g) Other local, state, and federal agencies as determined to be appropriate by the department;

(h) Tribal governments, where a ground water management program may affect tribal waters;

(i) Public and special interest groups such as agricultural, well drilling, forestry, environmental, business and/or industrial groups within the area, as determined to be appropriate by the department.

(3) The department shall appoint, by letter, members and alternates to the ground water advisory committee after seeking nominations from the groups listed above. Members and alternates shall serve until the ground water management program for the

area is certified. The department may appoint replacement members or alternates upon request of the appointee or the ground water advisory committee.

(4) The lead agency shall hold the first meeting of the ground water advisory committee within sixty days of the appointment of the committee. Public notice shall be given for each meeting. The lead agency shall chair the first meeting, during which the advisory committee shall determine, by general agreement, rules for conducting business, including voting procedures, and the chairperson of the advisory committee.
[Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-090, filed 12/20/85.]

WAC 173-100-100 Ground water management program content.
The program for each ground water management area will be tailored to the specific conditions of the area. The following guidelines on program content are intended to serve as a general framework for the program, to be adapted to the particular needs of each area. Each program shall include, as appropriate, the following:

(1) An area characterization section comprised of:

(a) A delineation of the ground water area, subarea or depth zone boundaries and the rationale for those boundaries;

(b) A map showing the jurisdictional boundaries of all state, local, tribal, and federal governments within the ground water management area;

(c) Land and water use management authorities, policies, goals and responsibilities of state, local, tribal, and federal governments that may affect the area's ground water quality and quantity;

(d) A general description of the locale, including a brief description of the topography, geology, climate, population, land use, water use and water resources;

(e) A description of the area's hydrogeology, including the delineation of aquifers, aquitards, hydrogeologic cross-sections, porosity and horizontal and vertical permeability estimates, direction and quantity of ground water flow, water-table contour and potentiometric maps by aquifer, locations of wells, perennial streams and springs, the locations of aquifer recharge and discharge areas, and the distribution and quantity of natural and man-induced aquifer recharge and discharge;

(f) Characterization of the historical and existing ground water quality;

(g) Estimates of the historical and current rates of ground water use and purposes of such use within the area;

(h) Projections of ground water supply needs and rates of withdrawal based upon alternative population and land use projections;

(i) References including sources of data, methods and accuracy of measurements, quality control used in data collection and measurement programs, and documentation for and construction details of any computer models used.

(2) A problem definition section that discusses land and water use activities potentially affecting the ground water quality or quantity of the area. These activities may include but are not limited to:

- Commercial, municipal, and industrial discharges
- Underground or surface storage of harmful materials in containers susceptible to leakage

- Accidental spills
-Waste disposal, including liquid, solid, and hazardous waste
-Storm water disposal
-Mining activities
-Application and storage of roadway deicing chemicals
-Agricultural activities
-Artificial recharge of the aquifer by injection wells, seepage ponds, land spreading, or irrigation
-Aquifer over-utilization causing seawater intrusion, other contamination, water table declines or depletion of surface waters
-Improperly constructed or abandoned wells
-Confined animal feeding activities

The discussion should define the extent of the ground water problems caused or potentially caused by each activity, including effects which may extend across ground water management area boundaries, supported by as much documentation as possible. The section should analyze historical trends in water quality in terms of their likely causes, document declining water table levels and other water use conflicts, establish the relationship between water withdrawal distribution and rates and water level changes within each aquifer or zone, and predict the likelihood of future problems and conflicts if no action is taken. The discussion should also identify land and water use management policies that affect ground water quality and quantity in the area. Areas where insufficient data exists to define the nature and extent of existing or potential ground water problems shall be documented.

(3) A section identifying water quantity and quality goals and objectives for the area which (a) recognize existing and future uses of the aquifer, (b) are in accordance with water quality standards of the department, the department of social and health services, and the federal environmental protection agency, and (c) recognize annual variations in aquifer recharge and other significant hydrogeologic factors;

(4) An alternatives section outlining various land and water use management strategies for reaching the program's goals and objectives that address each of the ground water problems discussed in the problem definition section. If necessary, alternative data collection and analysis programs shall be defined to enable better characterization of the ground water and potential quality and quantity problems. Each of the alternative strategies shall be evaluated in terms of feasibility, effectiveness, cost, time and difficulty to implement, and degree of consistency with local comprehensive plans and water management programs such as the coordinated water system plan, the water supply reservation program, and others. The alternative management strategies shall address water conservation, conflicts with existing water rights and minimum instream flow requirements, programs to resolve such conflicts, and long-term policies and construction practices necessary to protect existing water rights and subsequent facilities installed in accordance with the ground water management area program and/or other water right procedures.

(5) A recommendations section containing those management strategies chosen from the alternatives section that are recommended for implementation. The rationale for choosing these strategies as opposed to the other alternatives identified shall be given;

(6) An implementation section comprised of:

(a) A detailed work plan for implementing each aspect of the ground water management strategies as presented in the recommendations section. For each recommended management action, the parties responsible for initiating the action and a schedule for implementation shall be identified. Where possible, the implementation plan should include specifically worded statements such as model ordinances, recommended governmental policy statements, interagency agreements, proposed legislative changes, and proposed amendments to local comprehensive plans, coordinated water system plans, basin management programs, and others as appropriate;

(b) A monitoring system for evaluating the effectiveness of the program;

(c) A process for the periodic review and revision of the ground water management program.

[Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-100, filed 12/20/85.]

WAC 173-100-110 SEPA review.

The proposed ground water management program shall be subject to review pursuant to the State Environmental Policy Act, chapter 43.21C RCW, as required under the applicable implementing regulations.

[Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-110, filed 12/20/85.]

WAC 173-100-120 Hearings and implementation.

(1) Upon completion of the ground water area management program, the department shall hold a public hearing within the designated ground water management area for the purpose of taking public testimony on the proposed program. Local governments are encouraged to hold joint hearings with the department to hear testimony on the proposed management program. Following the public hearing, the department and each affected local government shall prepare findings on the ground water management program within ninety days. This period may be extended by the department for an additional ninety days. The findings shall evaluate the program's technical soundness, economic feasibility, and consistency with the intent of this chapter and other federal, state and local laws. The findings shall identify any revisions necessary before the program can be certified and shall contain a statement of the agency's concurrence, indicating its intent to adopt implementing policies, ordinances and programs if required, or a statement of nonconcurrence with the program if such be the case.

(2) The lead agency will consolidate the findings and present them to the advisory committee. Statements of nonconcurrence shall be resolved by the committee and the program revised if necessary.

(3) The program shall then be submitted by the ground water advisory committee to the department which shall certify that the program is consistent with the intent of this chapter.

(4) Following such certification, state agencies and affected local governments shall adopt or amend regulations, ordinances, and/or programs for implementing those provisions of the ground water management program which are within their respective jurisdictional authorities.

(5) The department, the department of social and health services and affected local governments shall be guided by the adopted program when reviewing and considering approval of all studies, plans and facilities that may utilize or impact the implementation of the ground water management program.
[Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-120, filed 12/20/85.]

WAC 173-100-130 Designation of ground water areas.
The procedures provided in RCW 90.44.130 may be utilized by the department to designate ground water areas, subareas, or zones for the purposes described therein either in conjunction with the procedures of this chapter or independently thereof.
[Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-130, filed 12/20/85.]

WAC 173-100-140 Intergovernmental agreements.
In order to fully implement this chapter, the department may negotiate and enter into cooperative agreements with Indian tribal governments, adjacent states and Canadian governmental agencies when a ground water management area is contiguous with or affects lands under their jurisdiction. Such cooperative agreements shall not affect the jurisdiction over any civil or criminal matters that may be exercised by any party to such an agreement. Intergovernmental agreements shall further the purposes of this chapter, and shall serve to establish a framework for intergovernmental coordination, minimize duplication, and efficiently utilize program resources to protect ground water resources.
[Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-140, filed 12/20/85.]

WAC 173-100-150 Appeals.
All final written decisions of the department pertaining to designation of ground water management areas, certification of ground water management programs, permits, regulatory orders, and related decisions pursuant to this chapter shall be subject to review by the pollution control hearings board under chapter 43.21B RCW.
[Statutory Authority: RCW 90.44.400. 86-02-004 (Order DE 85-24), § 173-100-150, filed 12/20/85.]

WAC 173-100-160 Regulation review.
The department of ecology shall initiate a review of the rules established in this chapter whenever new information, changing conditions, or statutory modifications make it necessary to consider revisions.
[Statutory Authority: Chapters 43.27A and 90.44 RCW. 88-13-037 (Order 88-11), § 173-100-160, filed 6/9/88.]

Appendix D

Management Strategy References

Vashon-Maury Island
Ground Water Management Plan

December 1998

APPENDIX D

MANAGEMENT STRATEGIES REFERENCES

2.2.1 SPECIAL AREA DESIGNATIONS TO ENHANCE GROUND WATER PROTECTION

Bailey, Jim. Sweet-Edwards/EMCON, Inc., Bellevue, Washington. June-August, 1991. Personal communication.

City of Federal Way, WA. City of Federal Way Comprehensive Plan, 1992.

Clayton, Geoff. RH2 Engineering, Kirkland, Washington. August 1991. Personal communication.

Cohen, Phil, Public Works Department, City of Redmond, Redmond, WA. Personal communication on wellhead protection areas, 1991.

Driscoll, Fletcher G. 1986. *Groundwater and Wells.* Johnson Division, St. Paul, Minnesota.

Freeze, R. Allan and John A. Cherry. *Groundwater.* Prentice-Hall, Englewood Cliffs, N. J. pp. 193-211. 1979.

Jennings, David. Washington Department of Health. Personal communication.. April 1992.

Keith, Susan. Geraghty and Miller, Inc., Bellevue, Washington. May, 1991. Personal communication.

King County. *King County Comprehensive Plan*. 1985.

King County. *King County Comprehensive Plan*. 1994.

King County. *Vashon Community Plan and Area Zoning*. 1986.

Lasby, Bill. Seattle-King County Health Department. Personal communication.. December 1992.

Maxwell, John. Economic and Engineering Services, Inc. Personal communication. August 1991.

Miller, Stan. Spokane County Public Works Department. Aquifer Protection Area Office. Personal communication. February 1990.

National Drinking Water Clearinghouse. *On Tap - Drinking Water News for America's Small Communities.* Volume 1, Issue 4. November 1992.

Rowe, Alan; Personal communication on wellhead protection areas, Washington State Department of Health, Olympia, WA., February 1990.

Safioles, Sally. Washington Department of Ecology. Northwest Regional Office. Personal communication. December 1992.

Saunders, Heather. Thurston County Health Department. Remarks at Workshop on Management Options for Wellhead Protection Areas, Tacoma, WA. Sponsored by Washington Department of Health and U. S. Environmental Protection Agency September 9, 1992.

South King County Ground Water Advisory Committee. *Draft South King County Ground Water Management Plan. Grant 1, Volume 1.* 1989.

Substitute House Bill 1019; 1991 Legislative Session, amendments to Title 36 RCW.

Substitute House Bill 1116; 1986 Legislative Session, Title 36 RCW.

Substitute House Bill 2724; 1990 Legislative Session.

Swanson, Rod. Clark County Department of Community Development. Personal communication. November 1992.

Turney, Gary. United States Geological Survey, Tacoma, Washington. April and Personal communication. August, 1991.

U. S. Environmental Protection Agency. Office of Ground-Water Protection. *An Annotated Bibliography on Wellhead Protection Programs*. EPA 440/6-87-104. August 1987.

U. S. Environmental Protection Agency. Office of Ground-Water Protection. *An Annotated Bibliography on Wellhead Protection Programs*. January 1990.

U. S. Environmental Protection Agency. Office of Ground-Water Protection. *Guidelines for Delineation of Wellhead Protection Areas.* EPA 440/6-87-010. June 1987.

U. S. Environmental Protection Agency. Office of Ground-Water Protection. *Sole Source Aquifer Designation, Petitioners Guidance*. February 1987.

U. S. Environmental Protection Agency. Office of Ground-Water Protection. *Sole Source Aquifer Program Overview.* January 1990.

U. S. Environmental Protection Agency. Office of Ground-Water Protection. *Wellhead Protection Programs:* Tools for Local Governments. EPA 440/6-89-002. April 1989.

United States Department of Agriculture, Soil Conservation Service. *Soil Survey - King County Area - Washington.* 1973.

Washington Department of Ecology. *State of Washington Ground Water Quality Management Strategy.* 1987.

Washington Department of Health. *Washington State Wellhead Protection Program - Proposed Program.* November 1992.

Williams, Jonathan. Environmental Protection Agency Office of Ground Water Region 10, Seattle. Personal communication. 1990 and 1991.

Winters, Nancy, Washington Department of Ecology. Personal communication on special area designation, February 1991.

LEGAL REFERENCES

City of Federal Way. Code of the City of Federal Way, Title 20.

City of Redmond. Ordinance No. 1693, June 23, 1992.

King County Code, Chapter 20.44. *County Environmental Procedures.* 1989.

King County Code, Chapter 21.54. *Special Control Areas and Flood Hazard Areas.*

King County Council. Motion No. 8496, October 1, 1991.

Revised Code of Washington. Chapter 36.36. *Aquifer Protection Areas.*

Revised Code of Washington. Chapter 36.70A. *Growth Management - Planning by Selected Counties and Cities.*

Revised Code of Washington. Chapter 43.21C. *State Environmental Policy Act.*

Revised Code of Washington. Chapter 90.44 *Regulation of Public Ground Waters.*

Safety of Public Water Systems (Safe Drinking Water Act). 42 U.S.C.A. § 300f et seq.

Washington Administrative Code Chapter 173-200. *Water Quality Standards for Ground Waters of the State of Washington*, 1990.

Washington Administrative Code Chapter 173-216. *State Waste Discharge Permit Program.*

Washington Administrative Code Chapter 173-304. *Minimum Functional Standards for Solid Waste Handling.*

Washington Administrative Code Chapter 197-11. *State Environmental Policy Act Rules. April, 1984.*

Washington Administrative Code Chapter 246-290. *Drinking Water Regulations.*

Washington Administrative Code Chapter 365-190. *Minimum Guidelines to Classify Agriculture, Forest, Mineral Lands and Critical Areas.*

2.2.2 LAND USE AND VASHON-MAURY ISLAND GROUND WATER

Capehart, Betty, personal communication, October 25, 1995.

Hartley, David M., King County Surface Water Management, unpublished memo, August 29, 1995.

King County. *King County Comprehensive Plan*, November 1995.

King County. *Vashon Community Plan and Area Zoning*, 1986.

Vashon Ground Water Advisory Committee Minutes, November 19, 1994.

King County. *Vashon Town Plan.*

Wigmosta, Mark S., Stephen J. Burges, and Jack M. Meena. *Modeling and Monitoring to Predict Spatial and Temporal Hydrologic Characteristics in Small Catchments*; U. S. Geological Survey, Water Resources Series, Technical Report No. 137, June 1994.

2.2.3 SEAWATER INTRUSION

Dion and Sumioka. *Seawater Intrusion.* Water Supply Bulletin No. 56. U. S. Geological Survey/Ecology. 1984.

Walters. *Reconnaissance of Sea-Water Intrusion.* Water Supply Bulletin No. 32. U. S. Geological Survey/Ecology. 1971.

Washington State Department of Ecology. *Draft WDOE Sea Water Intrusion Policy.* December 3, 1991.

Washington State Department of Ecology. *Sea Water Intrusion Team Final Plan.* June 1990.

Washington State Department of Health and Island County Health Department. *Salt Water Intrusion Policy for Public Water Systems.* July 19, 1989.

2.2.4 DATA COLLECTION AND MANAGEMENT

From Area Characterization (Supplement I), consultant recommendations and Ground Water Advisory Committee adopted actions.

2.2.5 STORMWATER MANAGEMENT

Arima, Debbie. King County Surface Water Management Division. Personal communication. October 1991.

Balcom, Jerry. King County Division of Building and Land Development. Personal communication. May and October 1991.

Barton, Cynthia, E. F. Vowinkel, and J. P. Nawyn. "Preliminary assessment of water quality and its relation to hydrogeology and land use, Potomac-Raritan-Magothy aquifer system, New Jersey." *Water-Resources Investigations Report 87-4023.* U. S. Geological Survey. 1987.

Booth, Derek. King County Surface Water Management Division. Remarks at a Ground Water Advisory Committee forum entitled "Stormwater Infiltration." September 1990.

Bowen, Bert. Washington Department of Ecology. Personal communication. October 1991.

Bresler, Helen. Washington Department of Ecology. Personal communication. May 1992.

Burlingame, Mark. City of Milton. Personal communication. May 1992.

Cain, Doug, Dennis Helsel, and Stephen Ragone. "Preliminary Evaluations of Regional Ground-Water Quality in Relation to Land Use." Volume 27, #2. *Ground Water.* March, 1989.

Carla, Kim. City of Auburn. Personal communication. August 1991.

Carpita, John. City of Issaquah. Personal communication. May 1992.

Chase, Richard. City of Kent. Personal communication. May 1992.

Cohen, Phil. City of Redmond. Personal communication. October 1990.

Driscoll, Fletcher. *Groundwater and Wells, Second Edition.* Johnson Division, St. Paul, Minnesota. 1986.

Eckhardt, David, William Flipse, and Edward Oaksford. "Relation between land use and ground-water quality in the upper glacial aquifer in Nassau and *Suffolk Counties, Long Island, New York.*" *Water*-Resources Investigations Report 86-4142. U. S. Geological Survey. 1989.

Galvin, David G. and Richard K. Moore. *Toxicants in Urban Runoff,* Municipality of Metropolitan Seattle. 1984.

Goldberg, Jennie. City of Seattle. Personal communication. May 1992.

Grady, Stephen. "Statistical Comparison of Ground-Water Quality in Four Land-Use Areas of Stratified-Drift Aquifers in Connecticut" in *Proceedings of Technical Meeting in Phoenix Arizona, September 26-30, 1988.* Editors G. E. Mallard and S. E. Ragone. United States Geological Survey Water Resources Investigation Report #88-4220. 1989.

Gredler, Dale. City of Normandy Park. Personal communication.. August 1991.

Hansen, James and Mark Sizing. *Evaluation of Urban Nonpoint Source Pollution Management in Milwaukee County, Wisconsin, Volume III.* U. S. Environmental Protection Agency. Chicago, Illinois. 1982.

Holman, Ned. City of Pacific. Personal communication. August 1991.

Horner, Richard. *Biofiltration Systems for Storm Runoff Water Quality Control.* Prepared for Washington Department of Ecology, Metro, King County, and the cities of Bellevue, Mountlake Terrace, and Redmond. December 1988.

Horner, Richard. University of Washington Center for Urban Water Resource Management. Personal communication. April 1992.

Hubbard, Tom and David Galvin. *Stormwater Quality Management in the Seattle-King County Region: An Issue Paper.* Municipality of Metropolitan Seattle. 1989.

King County Surface Water Management Division and the City of Federal Way. *Hylebos Creek and Lower Puget Sound Current and Future Conditions Report.* 1990.

King County Surface Water Management Division. *Covington Master Drainage Plan, Volume I.* Prepared by R. W. Beck and Associates. May 1991.

King County Surface Water Management Division. *King County Basin Reconnaissance Program*. Program Summary. 1987.

King County Surface Water Management Division. *King County Surface Water Design Manual*. 1990.

King County Surface Water Management Division. *King County Surface Water Management Strategic Plan*. January 1991.

King County Surface Water Management Division. *King County Surface Water Design Manual*. 1990.

King County Surface Water Management Division. *Proposed Soos Creek Basin Plan and Final Environmental Impact Statement*. 1990.

Kruger, Gary. Washington State Department of Ecology. Personal communication. May 1991.

Matthews, Wayne. City of Des Moines. Personal communication. August 1991.

Miller, Stan. "The Impact of Stormwater Runoff on Groundwater Quality and Potential Mitigation." Paper presented at a conference on the "Protection and Management of Aquifers with an Emphasis on the Spokane-Rathdrum Aquifer," Pullman, Washington on October 10, 1984.

Monaghan, Don. City of Seatac. Personal communication. August 1991.

Municipality of Metropolitan Seattle. "Stormwater Quality Management Bibliography." November 1991.

Nussbaum, Jayne. *Urban Storm Water Runoff and Ground-Water Quality*. Report prepared for the Environmental Protection Agency under a National Network for Environmental Management Studies fellowship. 1990.

Olsen, Keith. City of Black Diamond. Personal communication. August 1991.

Pierce County. Chapter 21.16 Aquifer Recharge Area. 1991.

Pressley, Helen. Washington Department of Ecology. Personal communication. 1990 and 1991.

Puget Sound Water Quality Authority. *1991 Puget Sound Water Quality Management Plan*.

Pullar, Ray. City of Algona. Personal communication. August 1991.

Roe, Cary. City of Federal Way. Personal communication. August 1991.

Schwartz, Bob. King County Department of Natural Resources, Water Pollution Control Division (formerly Metro). Personal communication. November 1991.

Stark, Dave. King County Surface Water Management Division. Personal communication. April 1992.

Stratton, Dayle Ann. "The Two Worlds of Surface and Ground Water Planning". *Proceedings From the Technical Sessions of the Regional Conference Nonpoint Source Pollution: The Unfinished Agenda for the Protection of Our Water Quality.* March 20-21 1991. Tacoma, Washington. Presented by the State of Washington Water Research Center and others. Sponsored by the United States Geological Survey and others. 1991.

Tacoma-Pierce County Health Department. *Draft Clover/Chambers Creek Basin Ground Water Management Program and Environmental Impact Statement. Technical Appendices.* Prepared by Brown and Caldwell Consultants. 1990.

Thomas, Susan. King County Surface Water Management Division. Personal communication.. July 1991.

Turney, G. L. *Quality of Ground Water in the Puget Sound Region, Washington.* United States Geological Survey. Tacoma, Washington. 1986.

U. S. Environmental Protection Agency. *Fresno, CA Nationwide Urban Runoff Program Project: Final report.* Prepared by Brown and Caldwell consultants. 1984.

U. S. Environmental Protection Agency. *Long Island Segment of the Nationwide Urban Runoff Program.* NTIS Report PB84-120633. 1982.

U. S. Environmental Protection Agency. *Nationwide Urban Runoff Program Priority Pollutant Monitoring Project: Summary of Findings.* NTIS Report PB 84-175686. Washington, D. C., 1983.

U. S. Environmental Protection Agency. *Results of the Nationwide Urban Runoff Program. Volume I. Final Report.* NTIS Report PB 84-185552. Washington, D. C. 1983.

Washington Department of Ecology. *Draft Stormwater Management Manual for the Puget Sound Basin.* 1991.

Washington Department of Ecology. *Focus - Improving Stormwater Runoff.* July 1991.

Washington Department of Ecology. Memo to reviewers of *Draft Stormwater Management Manual for the Puget Sound Basin.* June 10, 1991.

2.2.6 GROUND WATER EDUCATION PROGRAM

Compilation of education elements from other issue topics.

2.3.1 HAZARDOUS MATERIALS MANAGEMENT

Barreca, Jeanette, Department of Ecology LUST Program. Personal communication. September 1991.

Bolender, Wendy. Washington Department of Ecology. Personal communication. Numerous occasions in 1990 and 1991.

Environ, Inc.; *Analysis of the Potential Hazards Posed By No. 2 Fuel Oil Contained in Underground Storage Tanks,* Prepared for Oil Heat Task Force, September 1987.

Gonzales, Peter. Washington State Energy Office, Oil Help Program, Olympia, WA. Personal communication. January 1990.

Grant, Jeff. Oil Heat Institute of Washington, Seattle, WA. Personal communication. January 1990.

Groundwater Technology, Inc., *Fuel Oil Storage Tank Static Tank Testing Program, Prepared for Oil Heat Task Force.* December 1988.

Hart, Fred C., and Associates, *Structural and Engineering Differences Between Fuel Oil and Gasoline Underground Storage Tank Systems.* Prepared for Oil Heat Task Force. August 1988.

Hickey, Joe. Department of Ecology, Northwest Regional Office, Redmond, WA. Personal communication. January 1990.

Higgins, Leo. King County Fire Marshal's Office. Personal communication. Numerous occasions 1990 and 1991.

Klopfenstein, John. King County Fire Marshal's Office. Personal communication. December 1991.

Lufkin, Thom. *A Report on Underground Storage Tanks.* Washington State Department of Ecology. February 1987.

McKain, Ellen. Washington Department of Ecology. Personal communication. October 1991.

Moe, Don. Ace Tank and Equipment. Seattle, WA. Personal communication. December 1991.

Saunders, Heather. Thurston County Health Department. Personal communication. December 1991.

Svec, John. Florida Department of Environmental Regulation. Personal communication. December 1991.

Washington State Department of Ecology. *Draft Local Program Delegation Guidelines.* May 16, 1990.

LEGAL REFERENCES

City of Renton, Washington. Ordinance #4147. April 4, 1988.

Resource Conservation and Recovery Act (RCRA) Subtitle i, 40 CFR 290 Part 280, *Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks, Environmental Protection Agency (EPA).*

Revised Code of Washington Chapter 70.105, *Model Toxics Control Act.* November 1988.

Revised Code of Washington Chapter 90.76, *Underground Storage Tanks*, 1989.

Superfund Amendments and Reauthorization Act of 1986, Section 205.

Uniform Fire Code, Article 79, International Conference of Building Officials and Western Fire Chiefs Association, Wittier, California.

Washington Administrative Code Chapter 173-360 *Underground Storage Tank Regulations*. November 1990.

Washington Administrative Code Chapter 197-11 *State Environmental Policy Act Rules.* April 1984.

2.3.2 UNDERGROUND STORAGE TANK MANAGEMENT

Barreca, Jeanette, WA State Department of Ecology, LUST Program. Personal communication. September 1991.

Bolender, Wendy. WA State Department of Ecology. Personal communication. Numerous occasions in 1990 and 1991.

Environ, Inc. *Analysis of the Potential Hazards Posed By No. 2 Fuel Oil Contained in Underground Storage Tanks.* Prepared for Oil Heat Task Force. September 1987.

Gonzales, Peter. Washington State Energy Office, Oil Help Program, Olympia, WA. Personal communication. January 1990.

Grant, Jeff. Oil Heat Institute of Washington, Seattle, WA. Personal communication. January 1990.

Groundwater Technology, Inc.; *Fuel Oil Storage Tank Static Tank Testing Program,* Prepared for Oil Heat Task Force, December 1988.

Hart, Fred C., and Associates. *Structural and Engineering Differences Between Fuel Oil and Gasoline Underground Storage Tank Systems.* Prepared for Oil Heat Task Force, August 1988.

Hickey, Joe. Department of Ecology, Northwest Regional Office, Redmond, WA. Personal communication. January 1990.

Higgins, Leo. King County Fire Marshal's Office. Personal communication. Numerous occasions 1990 - 1992.

Klopfenstein, John. King County Fire Marshal's Office. Personal communication. December 1991.

McKain, Ellen. Washington Department of Ecology. Personal communication. October 1991.

Moe, Don. Ace Tank and Equipment. Seattle, WA. Personal communication. December 1991.

Saunders, Heather. Thurston County Health Department. Personal communication. December 1991.

Svec, John. Florida Department of Environmental Regulation. Personal communication. December 1991.

Washington Department of Ecology. *A Report on Underground Storage Tanks.* Prepared by Thom Lufkin. February 1987.

Washington Department of Ecology. Draft Local Program Delegation Guidelines. May 16, 1990.

LEGAL REFERENCES

City of Renton, Washington. Ordinance #4147. April 4, 1988.

Resource Conservation and Recovery Act (RCRA) Subtitle i, 40 CFR 290 Part 280, Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks, Environmental Protection Agency (EPA).

Revised Code of Washington. Model Toxics Control Act (Initiative 97). Chapter 70.105 November 1988.

Revised Code of Washington. Underground Storage Tanks. Chapter 90.76. 1989.

Superfund Amendments and Reauthorization Act of 1986, Section 205.

Uniform Fire Code, Article 79, International Conference of Building Officials and Western Fire Chiefs Association, Wittier, California.

Washington Administrative Code. State Environmental Policy Act Rules. Chapter 197-11. April 1984.

Washington Administrative Code. Underground Storage Tank Regulations. Chapter 173-360. November 1990.

2.3.3. ON-SITE SEWAGE DISPOSAL SYSTEM

Anderson, J. L., Machmeier, R. E., Hansel, M. J., "Long Term Application Rates for Soils," *Proceedings of the Third National Symposium on Individual and Small Community Sewage Treatment*, American Society of Agricultural Engineers, 1981.

Boatsman, Carolyn, Personal communication, Seattle-King County Health Department, May 1990.

Brown K. W., Slowey, J. F., Wolf, H. W., *The Movement of Salts, Nutrients, Fecal Coliform, and Virus Below Septic Leach Fields in Three Soils*, Proceedings of the Second National Home Sewage Treatment Symposium, American Society of Agricultural Engineers, 1977.

Converse, J. C., Anderson, J. L., Ziebel, W., Bouma, J., *Pressure Distribution to Improve Soil Absorption Systems*, Proceedings of the National Home Sewage Disposal Symposium, American Society of Agricultural Engineers, 1974.

Crosby, James W., Johnstone, Donald L., Drake, Charles H., Fenton, Robert L., *Migration of Pollutants in a Glacial Outwash Environment*, Water Resources Research-WSU, Vol. 4, No. 5, October 1968.

De Walle, Foppe B., Kalman, David, Norman, Donald, Sung, John, Plews, Gary, *Trace Organics Removal in a Large Septic Tank*, Proceedings of the 4th Northwest On-site Wastewater Disposal Short Course, University of Washington, September 1982.

Flipse, William J., Brian G. Katz, Juli B. Linder, Richard Markel, *Sources of Nitrate in Ground Water in a Sewered Housing Development, Central Long Island, New York*, Groundwater, Vol. 22, No. 4, July-August 1984.

Franks, Alvin L., *Geology for Individual Sewage Disposal Systems*, California Geology, Vol. 25, No. 9, September 1972.

Green, K. M., Cliver, D. O., *Removal of Virus from Septic Tank Effluent by Sand Columns*, Proceedings of the National Home Sewage Disposal Symposium, American Society of Agricultural Engineers, 1974.

Hargett, D. L., Tyler, E. J., Siegrist, R. L., *Soil Infiltration Capacity as Affected Septic Tank Effluent Application Strategies*, Proceedings of the Third National Symposium on Individual and Small Community Sewage Treatment, American Society of Agricultural Engineers, 1981.

Harkin, J. M., Fitzgerald, C. J., Duffy C. P., Kroll, D. G., *Evaluation of Mound Systems for Purification of Septic Tank Effluent*, University of Wisconsin-Madison, Technical Report 79-05, 1979.

Hausenbuiller, R. I., *Soil Science*, William C. Brown Company, Dubuque, IA, 1978.

Haynes, Chris, Personal communication, Department of Ecology, Olympia, March 1990.

Henriksen, James, Personal communication, Seattle-King County Health Department, Seattle, March 1990.

Hill, Robert C., *Final Environmental Impact Statement (EIS) on Mound Systems For Private Waste Disposal*, Wisconsin Department of Health and Social Services, October 1979.

Kimsey, Melanie, Personal communication, Department of Ecology, August 1991.

King County, City of Seattle, Metro, and the Seattle-King County Health Department. *Local Hazardous Waste Management Plan for Seattle-King County*, August 1989.

King County, *King County Comprehensive Plan*, April 1985.

King County, *King County Sewerage General Plan*, 1979.

Kropf, F. W., Laak, R., Healy, K. A., *Equilibrium Operation of Subsurface Absorption Systems*, Journal of the Water Pollution Control Federation, 1977.

Lance, Clarence, *Fate of Nitrogen in Sewage Effluent Applied to Soil*, Proceedings of the American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 101, No. IR3, September 1975.

Lenning, David, Personal communication, Department of Health, Olympia, January 1990.

Littler, J. D., Aden, J. T., Johnson, A. F., *Survey of Ground Water and Surface Water Quality for the Chambers Creek/Clover Creek Drainage Basin*, Pierce County, Washington Department of Social and Health Services, 1981.

Machmeier, R. E., *Design Criteria for Soil Treatment Systems*, American Society of Agricultural Engineers Paper No. 75-2577, 1975.

Mc Gauhey, P. H., Krone, R. B., *Soil Mantle as a Wastewater Treatment System*, School of Public Health, University of California, Berkeley, 1967.

Mc Gauhey, P. H., Winneberger, John, *Causes and Prevention of Failures of Septic Tank Percolation Systems*, prepared for the Federal Housing Administration, FHA No. 533, 1964.

Nelson, M. E., S. W. Horsley, T. C. Cambareri, M. D. Giggey, J. R. Pinnette, *Predicting Nitrogen Concentrations in Ground Water - An Analytical Model*, Wellhead Protection Program: Tools for Local Government, U. S. Environmental Protection Agency and the Washington Department of Health, 1992.

Otis, R. J., Plews, G. D., Patterson, D. H., *Design of Conventional Soil Absorption System Trenches and Beds*, Proceedings of the Second National Home Sewage Treatment Symposium, American Society of Agricultural Engineers, December 1977.

Peavy, H. S., Groves, K. S., *The Influence of Septic Tank Drainfields on Groundwater Quality in Areas of High Groundwater*, Proceedings of the Second National Home Sewage Treatment Symposium, American Society of Agricultural Engineers, 1977.

Salvato, Joseph A., *Environmental Engineering and Sanitation*, John Wiley and Sons, New York, 1972.

Schlender, George, Personal communication, Department of Health, Spokane, March 1990.

Seattle-King County Health Department, Tacoma-Pierce County Health Department, Thurston County Health Department, and Seattle Engineering Department, *A Survey of Small Quantity Hazardous Waste Generators, The Puget Sound Experience*, 1986.

Siegrist, R. L., Woltanski, T., Waldorf L. E., *Water Conservation and Wastewater Disposal*, Proceedings of the Second National Home Sewage Treatment Symposium, American Society of Agricultural Engineers, 1977.

Tacoma-Pierce County Health Department, *Clover/Chambers Creek Basin Geohydrologic Study*, Prepared by Brown and Caldwell, 1985.

Tacoma-Pierce County Health Department, *Clover/Chambers Creek Basin Ground Water Management Program*, Prepared by Brown and Caldwell, Adolfson Associates, and Sweet-Edwards/EMCON, 1990.

Tyler, E. J., Laak, R., Mc Coy, E., Sandhu, S. S., *The Soil as a Treatment System*, Proceedings of the Second National Home Sewage Treatment Symposium, American Society of Agricultural Engineers, 1977.

U. S. Environmental Protection Agency, *Alternatives for Small Wastewater Treatment Systems*, Vol. 1, Environmental Protection Agency Technology Transfer Seminar Publication, October 1977.

U. S. Environmental Protection Agency, *Design Manual for On-site Wastewater Treatment and Disposal Systems*, Cincinnati, OH, 1980.

U. S. Environmental Protection Agency, *Protection of Public Water Supplies from Ground Water Contamination*, EPA/625/4-85/016, September 1985.

U. S. Department of Agriculture, *Soil Survey, King County Area, Washington*, Soil Conservation Service, November 1973.

Washington Department of Health and Department of Ecology, *Design Guidelines for Larger On-Site Sewage Systems with Design Flows of Greater than 3,500 Gallons Per Day*, 1987.

Washington Department of Health, Wellhead Protection Program (informational flyer), 1992.

Wilson, J. T., et al., *Transport and Fate of Selected Organic Pollutants in a Sandy Soil*, Journal of Environmental Quality, Vol. 10, No. 4, 1981.

Yates, Marylynn V., *Septic Tank Density and Ground-Water Contamination*, Groundwater, Vol. 23, No. 5, September-October 1985.

Ziebell, W. A., Anderson, J. L., Bouma, J., Mc Coy, E., *Fecal Bacteria: Removal from Sewage By Soils*, American Society of Agricultural Engineers Paper No. 75-2579, December 1975.

LEGAL REFERENCES

Code of the King County Board of Health, Title 13.

Washington Administrative Code Chapter 173-200, *Water Quality Standards for Ground Waters of the State of Washington*, October 1990.

Washington Administrative Code Chapter 173-216, *State Waste Discharge Permit Program*, November 18, 1983.

Washington Administrative Code Chapter 173-240, *Submission of Plans and Reports for Construction of Wastewater Facilities*, November 16, 1983.

Washington Administrative Code Chapter 248-96 (Recodified as WAC 246-272), *On-site Sewage Disposal System Rules and Regulations of the State Board of Health*, Department of Health (DOH), September 1989.

2.3.4 PESTICIDES AND FERTILIZERS

Agricultural Law and Policy Institute. *Farming and Groundwater: an Introduction.* University of Minnesota Law School, Minneapolis, MN 55455, 1988.

American Farm Bureau Federation. *Revised Water Quality Self-Help Checklist.* Natural & Environmental Resources Division, Park Ridge, IL, 60068, 1989.

Anderson, Dan. Personal communication. Branch Manager, Orkin Pest Control.

Batie, Sandra S., William E. Cox, and Penelope L. Diebel. *Managing Agricultural Contamination of Ground Water: State Strategies.* National Governors Association, 1989.

Brunner, Jay F., and David R. Penman, editors. *Agricultural Pesticides: Issues and Options for Washington State.* Proceedings of the November 1990 Workshop held in Wenatchee, WA. College of Agriculture and Home Economics, Washington State University, Pullman, WA. May 1991.

Drost, Brian. Personal communication. United States Geological Survey, Tacoma. Project chief, Franklin/Benton Groundwater Study. March 1990

Fay, Larry. Personal communication. Director, Jefferson County Department of Environmental Health. September, 1991.

Fisher, John. Personal communication. Washington State Department of Natural Resources.

Freshwater Foundation. *Groundwater and Agrichemicals: Suggested Policy Directions for 1990*. Proceedings of a conference held October 1989. St. Paul, Minnesota. 1990.

Goss, D. *Resources for the Future/Use*. ARS, SCS/USDA/Potentials.

Hall, Greg. Personal communication. Grounds Superintendent, Inglewood Golf and Country Club.

Hallmark, Steve. Personal communication. Corporate Forester, Division Operations, Puget Power. September, 1991.

Harlowe, Bill. Personal communication. Manager, Eastside Spray Service.

Holden, Patrick. *Pesticides and Groundwater Quality: Issues and Problems in Four States*. National Academy Press, Washington, D. C. 1986.

Iowa, State of. *Iowa Groundwater Protection Strategy*. Environmental Protection Commission and Iowa Department of Natural Resources. 1987.

Jenkins, Tom, *"Farming and Agrichemicals: Seeking a Balance Between the Economy and the Environment,"* Journal of Environmental Health, Vol. 54, No. 2, p. 17. September/October 1991.

King County. Draft Memorandum of Understanding between King County and Washington State Department of Natural Resources for administering and coordinating forest practices and land development clearing operations in King County. October 1990.

Kuga, Henry. Personal communication. Division of Roads, King County Public Works. June 1991.

Matoon, Doug, Personal communication. Division of Roads, King County Public Works. June 1991.

Minnesota, State of. *Protecting Minnesota's Waters: A Strategy for the Wise Use of Pesticides and Nutrients*. Environmental Quality Board, Water Resources Committee. December 1988.

Moulton, Curt. Personal communication. King County Cooperative Extension. August, 1991.

Office of Technology Assessment. *Beneath The Bottom Line - Agricultural Approaches to Reduce Agrichemical Contamination of Groundwater*. Congress of the United States. Vol. II, Part D, Pest and Pesticide Management, Integrated Pest Management. Nov. 1990.

Padgitt, Steven, "Farmers' Views on Ground Water Quality: Concerns, Practices and Policy Preferences," prepared for the U. S. Congress, Office of Technology Assessment, *Beneath the Bottom Line: Agricultural Approaches to Reduce Agrichemical Contamination of Ground Water*, OTA-F-418 Washington DC: U. S. Government Printing Office. November 1990.

Parsons, Douglas and James Witt. *Pesticides in Groundwater in the United States of America*. Oregon State University Extension Service, Corvallis, Oregon. June 1988.

Price, Pete. *The Leaching Fields: A Nonpoint Threat to Groundwater*. California Assembly Office of Research, Sacramento, CA. March 1985.

Puget Sound Water Quality Authority. *1991 Puget Sound Water Quality Management Plan*. Seattle, WA. November 1990.

Puget Sound Water Quality Authority. *Issue Paper: Pesticides in Puget Sound*. Seattle, WA. March 1990.

Rosenthal, Russell N., Ph.D. Personal communication. Horticulturist, Washington State Department of Transportation, Olympia.

Sacha, Leslie, et al. *Survey of Pesticides used in Selected Areas Having Vulnerable Groundwaters in Washington State*. Environmental Protection Agency, Region 10, Seattle, WA. August 1986, revised July 1987.

Scott, Bruce. Personal communication. Regional Safety Manager, ChemLawn-Services Corporation.

Seattle-King County Health Department, *Local Hazardous Waste Management Plan for Seattle-King County.* August, 1989.

Silk, Larry. Personal communication. Farm Manager, Barron Turf Farm.

Soil Conservation Service. *Annual Progress Report*, Code 108, 1983-89. Spokane, WA. 1990.

Swofford, Wally. Personal communication. Supervisor, Seattle-King County Health Department, Solid Waste Program. August, 1989.

Towery, Audie. Personal communication. Farm Manager, J & B Sod.

U. S. Congress. *Summary of Beneath the Bottom Line: Agricultural Approaches to Reduce Agrichemical Contamination of Groundwater.* Office of Technology Assessment, Washington, D. C. Available from U. S. Government Printing Office. 1990.

U. S. Environmental Protection Agency. *Agricultural Chemicals in Ground Water: Proposed Pesticide Strategy.* Office of Pesticides and Toxic Substances, Washington, D. C. December 1987.

U. S. Environmental Protection Agency. *National Pesticide Survey, Summary Results of EPA's National Survey of Pesticides in Drinking Water Wells.* Office of Water and Office of Pesticides and Toxic Substances, Washington, D. C. Fall 1990.

U. S. Environmental Protection Agency. *Protecting Ground Water: Pesticides and Agricultural Practices.* February 1988.

Vashon Island Community Forest Planning Project, Minutes of Reforestation and Land Rehabilitation Working Group. Community Forestry Plan Workshop. Bill and Susan Tobin, organizers. October 7, 1989.

Walton, Graham. *Survey of Literature Relating to Methemoglobinemia*, American Journal of Public Health. Vol. 41, pp. 986-996. August, 1951.

Ware, George W. *The Pesticide Book - Alternatives to Pesticides: Where Do We Go From Here?* University of Arizona. p. 153.

Washington Department of Agriculture. *Pesticide Laws and Rules.* Olympia, WA, May 1990.

Washington Department of Ecology. *Ground Water Quality Management Strategy.* Water Quality Program, Olympia, WA. Principal author, Tony Barrett. January 1987.

Washington Department of Ecology. *Ground Water Quality Monitoring Strategy, vol. I-V.* Olympia, WA. Water Quality Investigations Section, Olympia WA. 1987-1989.

Washington Department of Ecology. *Ground Water Resource Protection, a Handbook for Local Planners and Decision Makers in Washington State.* Prepared by King County Resource Planning. December 1986.

Washington Department of Ecology. *Guidelines for Development of Ground Water Management Areas and Programs.* Water Resources Program, Olympia, WA. Revised October 1986.

Washington Department of Ecology. *Nonpoint Source Pollution Assessment and Management Program.* Water Quality Program, Olympia, WA. October, 1989.

Washington Department of Ecology. *Protecting Ground Water: A Strategy for Managing Agricultural Pesticides and Nutrients.* Referred to as "State Strategy." Draft, July 1991.

Washington Department of Ecology. *Washington State Agricultural Chemicals Pilot Study, Final Report.* Environmental Investigations and Laboratory Services Program, Olympia, WA. Authors: Denis Erickson and Dale Norton. November 1990.

Washington Department of Ecology. *Water Quality Laws and Regulations.* Olympia, WA. 1987, updated 1990.

Washington Department of Health. *Pesticide Incident Reporting and Tracking Review Panel, Annual Report 1990.* Environmental Health Programs, Pesticide Division, Olympia, WA. January 1991.

Washington Department of Health. *Pesticide Incident Reporting and Tracking Review Panel, Annual Report 1991.* Environmental Health Programs, Pesticide Division, Olympia, WA. February 1992.

Washington Department of Health. *Toxic Substances Fact Sheet: Nitrates in Drinking Water.* Office of Environmental Health Programs, Olympia, WA. 1990.

Washington Department of Health., Washington State Board of Health. *Washington State Health Report.* Olympia, WA. 1990.

Washington Department of Social and Health Services, *Results and Implications of the Investigation of Ethylene Dibromide in Ground Water in Western Washington.* Water Supply and Waste Section, Olympia WA. February, 1985.

Washington, State of. *Environment 2010: The State of the Environment*. Department of Ecology, Olympia, WA. November, 1989.

Western Fertilizer Handbook.

Wick, Ann. Personal communication. Program Manager, Program Development Branch, Pesticide Management Division, Washington State Department of Agriculture, Olympia. November, 1991.

LEGAL REFERENCES

7 USC Section 136 *Federal Insecticide, Fungicide and Rodenticide Act*. November, 1991.

42 USC Section 6901 *Resource Conservation and Recovery Act.*

42 USC Section 9601 *Comprehensive Environmental Response, Compensation, and Liability Act.*

City of Renton. Aquifer Protection Ordinance. Draft May 7, 1991. Section 6.

Federal Farm Bill of 1990.

Revised Code of Washington Chapter 15.09 *Horticultural Pest and Disease Board.*

Revised Code of Washington Chapter 15.54 *Fertilizers, Agricultural Minerals and Limes.*

Revised Code of Washington Chapter 15.58 *Washington Pesticide Control Act.*

Revised Code of Washington Chapter 70.105D *Model Toxics Control Act.*

Washington Administrative Code Chapter 16-228 *Rules Relating to General Pesticide Use.*

Washington Administrative Code Chapter 173-200 *Water Quality Standards for Ground Water of the State of Washington.*

Washington Administrative Code Chapter 222 *Forest Practices Act.*

2.3.5 WELL CONSTRUCTION, ABANDONMENT, AND WELL OWNER'S RESPONSIBILITIES

Batra, Mo. Washington State Department of Health. Personal communication.

Bishop, Roy. Washington Department of Ecology, NW Regional Office, Redmond, WA. Personal communication.

Fueste, Louis. Information Officer, U. S. Geological Survey, Water Resources Division. Personal communication.

Huggins, Herman. Washington Department of Ecology, NW Regional Office, Redmond, WA. Personal communication.

Liszak, Jerry. Washington Department of Ecology, NW Regional Office, Redmond. Personal communication.

Moseng, Ethan. Drinking Water Operations, Supervisor, Washington Department of Health. Personal communication.

Scott, Randy. Washington State Association of Counties. Personal communication

Thompson, Gordon. King County Building and Land Development (Now Department of Development and Environmental Services). Personal communication.

Walsh, Brian. Water Resources and Planning. Well Identification Task Force, Washington Department of Ecology, Olympia. Personal communication.

Well Identification Task Force. *A Draft Proposal for inclusion in the Five Year Data Management Plan of the Water Resource Data Management Task Force*. Washington Department of Ecology. Well Identification Task Force. April 8, 1992.

Well Identification Task Force. *Proposed Well Identification Program for Washington State*. Draft Report, Washington Department of Ecology. June 1991.

Woods, Mike. Association of Washington Cities. Personal communication.

LEGAL REFERENCES

Revised Code of Washington, Chapter 18.104, *Water Well Construction Act.* 1971.

SHB. 2796 Chapter 67, Laws of 1992, "An Act relating to delegation of water well construction enforcement authority."

The Code of the King County Board of Health, Title 12, Rules and Regulations No. 53, "King County Public Water System Rules and Regulations."

Washington Administrative Code, Chapter 173-160, *Minimum Standards for Construction and Maintenance of Wells.*

Washington Administrative Code, Chapter 173-162, *Rules and Regulations Governing the Regulation and Licensing of Well Contractors and Operators.*

Washington Administrative Code, Chapter 246-290, *Drinking Water Regulations - State Board of Health.*

2.3.6 SEWER PIPES

American Public Works Association, Washington State Chapter, *1991 Standard Specifications for Road, Bridge and Municipal Construction.* Washington State Department of Transportation.

Ames, Rick. Vashon Sewer District. Personal communication.

Carr, Jim. Carr & Associates. Personal communication.

Christensen, Dave. Personal communication. City of Renton.

Cox, Edward. Municipality of Metropolitan Seattle. Personal communication.

Dight, Ruth and Applied Geotechnology, Inc. *Groundwater Resource Protection. A Handbook for Local Planners, and Decision Makers in Washington State.* Hall & Associates, King County Resource Planning and Washington State Department of Ecology. 1986.

Gelb, Steve B. and Mary P. Anderson. *Sources of Chloride and Sulfate in Groundwater Beneath an Urbanized Area in Southeastern Wisconsin.* 1981.

Heydon, Tim. City of Kent. Personal communication.

Hornsby, L. City of Renton. Personal communication.

Kimmel, Grant E. "Geological Survey Professional Paper 800-D." Geological Survey Research. 1972.

McCormick, Bud. Sewage and Drainage Utility, Seattle Engineering Department. Personal communication.

Newman, Allen. Department of Ecology, Olympia, WA. Personal communication.

Parametrix and Carr and Associates. *Issaquah Groundwater Management Plan Area Characterization Report.* 1990.

Sylvester, Bob. Department of Ecology, Northwest Regional Office. Personal communication.

Velasquez, Angelica. King County Parks, Planning and Resources. Personal communication.

Weineke, Steve. Federal Way Water and Sewer. Personal communication.

Yate, Eugene B., Scott N. Hamin and Lisa Horowitz McCann. *Geohydrology, Water Quality and Water Budgets of Golden Gate Park and the Lake Merced Area in the Western Part of San Francisco, California.* 1984.

LEGAL REFERENCES

King County Council Ordinance 4035, *King County Sewerage General Plan.*

Revised Code of Washington, Chapter 35.67, *Plan for a System of Sewerage Adopted by Cities.*

Revised Code of Washington, Chapter 36.94, *Sewerage General Plan Adopted by Counties.*

Revised Code of Washington, Chapter 53.08, *Plan for Sewer Systems Adopted by Port Districts.*

Revised Code of Washington, Chapter 54.16, *Plan for Sewer Systems Adopted by Public Utility Districts.*

Revised Code of Washington, Chapter 56.08, *Comprehensive Plan for a System of Sewers Adopted by Sewer Districts.*

Revised Code of Washington, Chapter 57.08, *Comprehensive Plan for a System of Sewers Adopted by Water Districts.*

Washington Administrative Code, Chapter 173-240, *Submission of Plans and Reports for Construction of Waste Facilities.*

2.3.7 SOLID WASTE LANDFILLS

Brunner, Dirk R., Daniel J. Keller, Sanitary Landfill Design and Operation, U. S. Environmental Protection Agency. Report SW-65ts. 1972.

Burke, Steve, Senior Environmental Health Specialist, Chemical/Physical Hazards Section, Seattle-King County Health Department, personal communication, May 1991.

CH2M Hill. *Cedar Hills Regional Landfill Refuse Area 4*, Preliminary Design Report, September, 1989.

Conservation Foundation, *Groundwater Protection*, 1987.

D'Itri and Wolfson, *Rural Groundwater Contamination*, Lewis Publishers, 1988.

Economic and Engineering Services, Inc. *South King County GWMA Phase I Report*, Seattle-King County Health Department and South King County RWA, June 1989.

Ellefson, Mark, Special Waste Supervisor, Engineering Services, King County Solid Waste Division, personal communication, June 1991.

Glysson, Eugene A., James R. Packard, Cyril H. Barnes, *The Problem of Solid Waste Disposal,* College of Engineering, University of Michigan, Ann Arbor, 1972.

Jorgensen, Eric P., Editor, *The Poisoned Well*, Island Press, 1989.

Jurgensen, Shirley, Supervising Engineer, Engineering Services, King County Solid Waste Division, personal communication, April 1991.

Kiernan, Kevin, Acting Manager, Engineering Services, King County Solid Waste Division, personal communication, May 1991.

King County Solid Waste Division. *Proposed Comprehensive Solid Waste Management Plan*, Vol. 2, Appendix A, 1989.

King County Solid Waste Division. *Proposed Comprehensive Solid Waste Management Plan*, 1989.

King County Solid Waste Division. *Vashon Island Landfill Leachate Control Facilities*, Engineering Report, December, 1987.

King County Solid Waste Division. *Vashon Island Landfill Monitoring Results*, unpublished, 1990.

King County Solid Waste Division. *Vashon Island Landfill Plan of Operation*, December 1987.

Knox, Canter, Kincannon, Stover, and Ward. *Aquifer Restoration*, Noyes Publications, 1986.

Lewis, Jeff, *Demolition Landfill Leachate Analysis*, unpublished, October, 1989.

Moran, Dan, Senior Environmental Health Specialist, Solid Waste Section, Seattle-King County Health Department, personal communication, June 1991.

Parametrix. *Draft Solid Waste Disposal and Ground Water Management*, unpublished paper, February 1990.

Rathje, William L., "Once and Future Landfills," *The National Geographic*, Vol. 179, No. 5, May 1991.

Safioles, Sally, Hydrogeologist, Department of Ecology Northwest Regional Office Solid Waste Unit, personal communication, September 1991.

Seattle-King County Department of Public Health. *Abandoned Landfill Study in King County.* April, 1985.

Seattle-King County Health Department. *Issaquah GWMP Area Characterization Report*, February 1990.

Seattle-King County Health Department. *Redmond-Bear Creek GWMA Background Land and Water Use Report*, unpublished, July 1991.

Sweet-Edwards/EMCON and Adolfson Associates, Inc., *"Description of Federal and State Programs that Potentially Relate to the Ground Water Management Programs in King County,"* unpublished, March 1990.

Swofford, Wally, Supervisor, Solid Waste Section, Seattle-King County Health Department, personal communication, April 1991.

Tacoma-Pierce County Health Department. *Clovers/Chambers Creek GWMP Draft Solid Waste Disposal*, unpublished paper, 1989.

Thurston County Health Department. *Thurston County GWAC Draft Solid Waste Disposal Issue Section*, unpublished paper, 1989.

U. S. Environmental Protection Agency. *Protection of Public Water Supplies From Ground-Water Contamination.* 1985.

LEGAL REFERENCES

Code of the King County Board of Health, Title 10, "King County Solid Waste Regulations."

King County Code, Title 10, "King County Solid Waste Handling Code."

King County Ordinance 8771.

Revised Code of Washington 173-304 *Minimum Functional Standards for Solid Waste Handling.*

Revised Code of Washington 70.105D *Model Toxics Control Act.*

Revised Code of Washington 70.65 *Waste Not Washington Act.*

Revised Code of Washington 70.95 *Solid Waste Management Act.*

Washington Administrative Code 173-200 Water Quality Standards for the Ground Waters of the State of Washington.

2.3.8 BURIAL OF HUMAN REMAINS

Cox, Ed, King County Department of Natural Resources, Water Pollution Control Division. Personal communication.

Davidson, Karl, Cemetery Board. State of Washington Department of Licensing. Personal communication.

Donnellan, John, Director. Cemetery Board, State of Washington Department of Licensing. Personal communication.

Earwin, Dadds. Department of Health, Missouri. Personal communication.

Elvig, Paul. Evergreen-Washelli Funeral Home, Seattle. Personal communication.

Glover, Tim. Department of Environmental Resources, State of Florida. Personal communication.

Grasser, Bob. Department of Economic and Community Affairs, State of Alabama. Personal communication.

Hogan, Jim. Epidemiology Unit, Seattle-King County Department of Public Health. Personal communication.

Horn, Charles. Department of Environmental Management, Alabama. Personal communication.

Laux, Ed. Woodlawn Cemetery, Bronx New York. Personal communication.

McFarlane, Dr. Louise. Department of Health and Hospitals, Louisiana. Personal communication.

Palmquist, Robert. *Critical Aquifer Recharge Areas: The DRASTIC Approach.* State of Washington Department of Community Development. 1991.

Price, Dave. Health & Rehabilitative Services, South Carolina. Personal communication.

Prior, Bob. Department of Environmental Resources, Florida. Personal communication.

Roberts, Mary Jane, Evergreen Washelli. Personal communication.

Strub, Clarence G. and L. G. Frederick. P*rinciples and Practices of Embalming.* 1967.

Turney, Gary. *Cemetery Study Proposal.* U. S. Geological Survey, Tacoma, WA. 1991.

Washington Internment Association and Washington State Funeral Directors Association. *Directory of Cemeteries and Funeral Homes in Washington State.* 1989.

Wells, Dr. Wanda. Department of State, NY. Personal communication.

Wermcrantz, Sally. Seattle Public Library Government Research Assistance Library. Personal and written communication.

Wilcoxen, Tim, Vashon Funeral Home, Director. Personal communication.

Winek, Charles, Wagdy W. Wahba, Leon Rozin, and Charles L. Winek, Jr., "Determination of Ethchlorvynol in body tissues and fluids after embalment," *Forensic Science International*, 37 (1988) Elsevier Scientific Publishers, Ireland, Ltd.

LEGAL REFERENCES

King County Board of Health, Title 12, Rules and Regulations No. 53, *King County Public Water System Rules and Regulations.*

Revised Code of Washington 16.38, 18.130, *Embalmers and Funeral Directors.*

Revised Code of Washington, § 68, *Cemeteries, Morgues and Human Remains.*

Washington Administrative Code, § 248, *DSHS - Health, Board and Division of (Vital Statistics)*

Washington Administrative Code, § 98, *Cemetery Board.*

2.3.9 Sand and Gravel Mining

Aller, Linda, Truman Bennett, Jay H. Lehr, and Rebecca J. Petty. *DRASTIC: A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings.* U. S. Environmental Protection Agency Publication EPA/600/2-85/018. U. S. Government Printing Office, Washington D. C. 1985.

Barrett, Tony. *State of Washington Ground Water Quality Management Strategy.* Publication Number 87-6. Washington State Department of Ecology, Olympia, Washington. 1987.

Cooke, R. U., and J. C. Doornkamp. *Geomorphology in Environmental Management.* Clarendon Press, Oxford, England. 1974.

Creahan, Kathy, Department of Development and Environmental Services, King County, Resource Planning. Personal communication on zoning designations of sand and gravel operation. July 6, 1994.

King County Planning Division/Washington Department of Ecology. *Ground Water Resource Protection - A Handbook For Local Planners.* Olympia, Washington. 1986.

King County. *King County Comprehensive Plan*, Public Review Draft, April 1994.

Le Grande, H. E., "System for Evaluation of Contaminant Potential of Some Waste Disposal Sites." *Journal American Water Works Association*, Vol. 56, pp. 959-974. 1964.

Lingley, Phil, Washington State Department of Natural Resources, Geology and Earth Resources, author of *The Direct and Cumulative Effects Of Gravel Mining On Ground Water Within Thurston County, Washington*, Groundwater Management Program, Environmental Health Division, Thurston County Public Health and Social Services Department. Personal communication on the changes taking place in the water balance as a result of sand and gravel operations. June 24, 1994.

Lingley, William. Manager of Regulatory Programs, Washington State Division of Natural Resources, Personal communication, August, 1990.

Molenaar, Dee, Grimstead, Peder, and Kenneth L. Walters. "Principal Aquifers and Well Yields In Washington." *Geohydrologic Monograph 5.* Washington Department of Ecology. Olympia, Washington. 1980.

Molenaar, Dee. "The Spokane Aquifer, Washington: Its Geologic Origin and Water-Bearing And Water-Quality Characteristics." *U. S. Geologic Survey Water Supply Paper 2265.* U. S. Government Printing Office, Washington, D. C. 1988.

Norman, David. District Geologist SW Regional Office, Division of Natural Resources. Personal communication, August 1990.

Planning Association of Washington. *A Short Course On Local Planning*, 2nd Edition. Washington State Department of Community Development, Olympia, Washington. 1987.

Rayforth, Bob, Department of Ecology, Yakima, General Permit for sand and gravel operations. Personal communication on the changes taking place in the new General Permit process and compliance with State and Federal regulation regarding stormwater discharges. May 31, 1994.

Sandin, Randy, Department of Development and Environmental Services, King County. Personal communication on the Grading Permit, and adequacies of the SEPA and EIS review processes associated with sand and gravel operations. June 21, 1994.

Seattle-King County Health Department. *Sand and Gravel Mining: Effectiveness of Regulatory Programs In Protecting Ground Water.* Unpublished Issue Paper for the Issaquah Creek Valley Ground Water Advisory Committee. Seattle, Washington. 1990.

Stirland, Meade A. *Changing Water Quality Regulations: Impact on Mining.* Editor, Alexander Zaporozec, Proceedings of the Conference On Minimizing Risk to the Hydrologic Environment, American Institute of Hydrology, pp. 169-173. Kendall/Hunt Publishing, Dubuque, Iowa. 1990.

U. S. Environmental Protection Agency, Office of Ground Water. *A Review of Sources of Ground Water Contamination From Light Industry.* Technical Assistance Document EPA 440/6-90-005, Washington, D. C. 1990.

U. S. Environmental Protection Agency, Office of Ground Water. *Wellhead Protection: Tools For Local Government.* Office of Ground Water Publication EPA 440/6-89-002. U. S. Government Printing Office, Washington, D. C. 1989.

U. S. Environmental Protection Agency, Office of Ground Water. *Wellhead Protection - A Decision-Makers' Guide.* Office of Ground Water Publication EPA 440/6-87-009. U. S. Government Printing Agency, Washington, D. C. 1987.

Washington Ground Water Vulnerability Task Force. *Draft Proposals for Projects to Assess Ground Water Vulnerability In Washington State.* (Unpublished project proposals). Washington Department of Ecology, Olympia, Washington. 1990.

LEGAL REFERENCES

King County Zoning Code, Title 21 A, Adopted June 7, 1994.

Revised Code of Washington, Chapter 78.44, *Surface Mining.*

Washington Administrative Code, Chapter 173-303, *Dangerous Wastes Regulation.*

Washington Administrative Code, Chapter 173-304, *Minimum Functional Standards for Solid Waste Handling.*

Washington Administrative Code, Chapter 332-18, *Surface Mined Land Reclamation.*

2.3.10 BIOSOLIDS AND SEWAGE EFFLUENT

HDR Engineering, Inc., NLK, Inc., and Howard Edde, Inc. *Reclaimed Wastewater Feasibility Study.* For the City of Tacoma Public Utilities and Simpson Tacoma Kraft Mill. April 1991.

Regional Sludge Management Committee, Meeting Summary, Handouts, (Sludge) Survey Update. March, 1990.

Seattle-King County Department of Public Health, King County Board of Health, Rules and Regulations No. 8 ("King County Solid Waste Regulations"), Effective January 1, 1987.

Selby, M. J. *Hillslope Materials and Processes.* Oxford University Press. Oxford. 1982.

Senate Environment and Natural Resources Committee. *Use versus Disposal, Sludge Management, A Legislative Report.* January, 1990.

Stephenson, Cullen. Northwest Regional Office, Department of Ecology. Personal communication. April, 1992.

Stephenson, Julie. Regional Sludge Management Committee. Personal communication.

Swofford, Wally. Seattle-King County Department of Health. Personal communication.

Tacoma-Pierce County Health Department, Sludge Utilization Policy, January, 1985.

U. S. Environmental Protection Agency. *Design Manual for Sludge Treatment and Disposal.* EPA-625/1-79-011. 1979.

U. S. Environmental Protection Agency. *Estimating Sludge Management Costs Handbook*, October, 1985.

U. S. Environmental Protection Agency. *Process Design Manual for Land Treatment of Municipal Wastewater*, October, 1977.

U. S. Environmental Protection Agency. *Process Design Manual, Municipal Sludge Landfills*, October, 1978.

U. S. Environmental Protection Agency. *Process Design Manual, Sludge Treatment and Disposal*, September, 1979.

Washington Department of Ecology and Department of Social and Health Services (now Department of Health). *Guidelines for Land Disposal of Treated Domestic Sewage Effluent in Washington State*, February 25, 1976.

Washington Department of Ecology. *Best Management for Use of Municipal Sewage Sludge*, WDOE 82-12, September, 1982.

Washington Department of Ecology. *Municipal and Domestic Sludge Utilization Guidelines*, WDOE 82-11, October, 1982.

LEGAL REFERENCES

Washington Administrative Code, Chapter 173-304. Minimum Functional Standards for Solid Waste Handling, Washington Department of Ecology.

Washington Administrative Code, Chapter 173-216. State Waste Discharge Permit Program, Washington Department of Ecology.

2.4. GROUND WATER QUANTITY

"Complaints Swirl About Low-Water-Use Toilets." *ENR*. page 19. May 18, 1989.

American Water Works Association (AWWA). *Before the Well Runs Dry. A Handbook for Designing a Local Water Conservation Plan*. Vol. 1. December 1984.

Arizona Department of Water Resources. "Water Conservation Alternatives Inventory." Tucson Active Management Area.

Atkins, Riley. Personal communication. September, 1991.

Balcom, Jerry. Personal communication. October, 1991.

Bigger, Dan. Washington Department of Natural Resources. Forest Practices; Regulations. Timber/Fish/Wildlife Committee, Personal communication.

Boatsman, Carolyn. Seattle-King County Health Department. Environmental Health Division. Personal communication.

Bowen, Bert. Washington Department of Ecology. Water Quality Program, Ground Water Division. Personal communication.

Carr, J. R. and Associates. *Vashon/Maury Island Water Resources Study.* King County Department of Planning and Community Development. 1983.

CH2M Hill. *Project Development Plan. U. S. Bureau of Reclamation. Ground Water Recharge Demonstration Project. Highline Well Field.* Prepared for Seattle Water Department. August, 1989.

Clark, Steve. City of Issaquah Planning Department. Personal communication. December, 1991.

Conservation Foundation. *Groundwater Protection.* National Groundwater Policy Forum. Washington, D. C. 1987.

Data Management Task Force. *Draft Water Resource Data Management Five Year Plan. Water Resource Data Management Program.* Washington State Department of Ecology. July, 1992.

Davidson, Nancy. Seattle Water Department. As reported in the South King County Ground Water Advisory Committee Minutes March 27, 1991.

Driscoll, Fletcher G. *Groundwater and Wells.* Johnson Division. St. Paul, Minnesota. 1986.

Dunne, T., and Leopold, L. B. *Water in Environmental Planning.* W. H. Freeman and Company. San Francisco, California. 818 pp. 1978.

Economic and Engineering Services, Inc. Hart-Crowser, Pacific Ground Water Group, and Robinson and Noble. *South King County Ground Water Management Program. Grant No. 1. Background Data Collection and Management Issues.* Draft 1989 and revised April, 1991.

Economic and Engineering Services, Inc. *Water Conservation Plan.* For the Tacoma Water Division. January 1991.

Economic and Engineering Services, Inc. and CH2M Hill, URS Consultants. *South King County Coordinated Water Supply Plan. Regional Supplement.* Prepared for the South King County Water Utility Coordinating Committee. October, 1989

Fewins, Greg. City of Federal Way Planning Department. Personal communication. December, 1991.

Garrigues, Robert S., Robin Shoal, Arthur G. Larson, Kenneth O. Slattery and Doug McChesney. *Hydraulic Continuity, Ground Water in Continuity with Surface Water, an Issue Paper*. Department of Ecology. Draft October 1991.

Geraghty and Miller, Inc. *Hydrogeology Background Data and Water Use in the Vashon Ground Water Management Area*. May 1991.

Geraghty and Miller, Inc. *Vashon-Maury Island Land Use Background Data*. August 1990.

Grace, Barbara. City of Bothell Planning Department. Personal communication. August, 1992.

Grant, Lori. King County Community Planning. Personal communication. 1990

Hanson, Al. Ecology (Out of Program). Personal communication.

HDR Engineering, Inc., NLK, Inc., and Howard Edde, Inc. *Reclaimed Wastewater Feasibility Study*. For the City of Tacoma Public Utilities and Simpson Tacoma Kraft Mill. April 1991.

Heavey, Barbara. King County Comprehensive Planning. Personal communication. 1990.

Henriksen, Jim. Seattle-King County Health Department. Personal communication. August 1992.

Horton Dennis and Associates, Inc. and CH2M Hill. *Skyway Coordinated Water System Plan.* November, 1988.

Horton Dennis and Associates, Inc. and CH2M Hill. *Vashon Coordinated Water System Plan Regional Supplement.* June 1, 1990.

Huggins, Herm. Department of Ecology. Personal communication. 1990.

Island County Coordinated Water System Plan. July 1990.

Jones, Larry. Personal communication. November, 1991.

King County Department of Parks, Planning and Resources. Office of Open Space. *Establishing a Public Benefit Rating System.* July 1992.

King County Surface Water Management. *Executive Proposed Basin Plan for Hylebos Creek and Lower Puget Sound.* 1991.

King County Surface Water Management. *Issaquah Creek Basin. Current/Future Conditions and Source Identification Report.* October 1991.

Kiuchi, Atsushi. Senate Environment and Natural Resources.

Marsh, W. M. and Dozier, J. *Landscape - an Introduction to Physical Geography.* Addison-Wesley Publishing Company, Inc. Reading, Massachusetts. 1981.

McFadden, Michelle. King County Sensitive Areas Ordinance. Personal communication.

Miller, Jim. General manager, Federal Way Water and Sewer District. Personal communication. December, 1991.

Moran, Dan. Seattle-King County Department of Health. Personal communication.

Mutsafa, Salihu and N. A. Rafindad. "Nonlinear Steady State Seepage into Drains" *Journal of Irrigation and Drainage Engineering.* Vol. 115. No. 3, page 358. June 1989.

Nisqually Valley News, Thursday, January 11, 1990.

North Thurston Draft Ground Water Management Plan. March 26, 1991.

O'Brien, Edward. Ecology. Personal communication.

Parametrix, Inc. and Carr and Associates. *Issaquah Ground Water Management Program Area Characterization Report.* Draft, July, 1990.

Phillips, John. Union Hill Water Association. Personal communication. 1991.

Questad, Barbara. King County SEPA. Personal communication. 1990.

Robinson & Noble. *Description of the Aquifer Systems in the Federal Way Area.* Private report for the Federal Way Water and Sewer District. 1987.

Seattle Water Department. *Water Conservation Progress. Water Saving Devices.* January 1991.

Selby, M. J. 1982. *Hillslope Materials and Processes.* Oxford University Press. Oxford.

Selleck, Julie. Ecology, N. W. Regional Office. Personal communication.

Skorr. P. "Reusing Water." *Civil Engineering.* pp. 69-71. August 1988.

Smith, Craig. King County Building and Land Development and Environmental Services, Code Development Section. Personal communication. August 1992.

Smith, Jackie. *Natural Aquifer Recharge. Draft # 2.* Unpublished. Geraghty & Miller, Inc. July 20, 1990.

Stephenson, Cullen. Northwest Regional Office, Department of Ecology. Personal communication. April, 1992.

Swartz, Bob. Seattle Water Department. Personal communication. October, 1991 and August 1992.

Sweet Edwards/EMCON, Adolfson and Associates, and CWC-HDR. *Redmond Ground Water Management Area Background Land and Water Use Report.* July 1991.

Swofford, Wally. Seattle-King County Department of Health. Personal communication.

Tacoma-Pierce County Department of Public Health. *Clovers/Chamber Creek Ground Water Management Plan.*

Tiemann, Dave. Office of Open Space. King County. Personal communication. July 1992.

U. S. Water Resources Council. *Essentials of Ground-Water Hydrology Pertinent to Water-Resources Planning.* Bulletin 16 revised. Hydrology Committee. 1980.

U. S. Environmental Protection Agency. *EPA Activities Related to Sources of Groundwater Contamination.* February, 1987.

Wallace, Gene, and Matlock, Dan, of the Pacific Groundwater Group and Krautkramer, Mike, of Robinson and Noble. *Groundwater Resource Management Issue Paper, Draft #1.* Unpublished. Economic and Engineering Services, Inc. September, 1990.

Wallace, Gene. Personal communication. March 1992.

Walsh, Brian. Water Resources Program, Ground Water Policy, Washington State Department of Ecology. Personal communication. December, 1991.

Washington State Department of Ecology. *Groundwater Resources Protection: A Handbook for Local Planners and Decision Makers in Washington State.* December, 1989.

Washington State Department of Health. *Interim Guidelines for Public Water Systems Regarding Water Use Reporting, Demand Forecasting Methodology, and Conservation Program.* July 1989.

Watanabe, Ann. City of Kent Planning Department. Personal communication. August 1992.

Water Resources Forum. *Draft Hydraulic Continuity Policy.* July 6, 1992.

Water Resources Forum. *Draft Water Allocation Issue Paper.* Subcommittee Work Product. April 24, 1992.

Water Resources Forum. *Draft Water Use Issue Paper.* Subcommittee Work Product. April 24, 1992.

Wieneke, Steve. Federal Way Water and Sewer. Personal communication.

Williams, Jonathan. Environmental Protection Agency. Personal communication. August, 1991.

Yelton, Tiffany. Department of Ecology. Comments on Draft King County Groundwater Management Area Conservation Issue Paper. March 1991.

LEGAL REFERENCES

Engrossed Substitute House Bill No. 1594 as Amended by Free Conference Committee. State of Washington. 50th Legislature. 1988 Regular Session.

Revised Code of Washington, Chapter 90.03, Water Code 1917 Act.

Revised Code of Washington, Chapter 90.14, Water Rights, Registration, Waiver and Relinquishment, Etc.

Revised Code of Washington, Chapter 90.22, Minimum Water Flows and Levels.

Revised Code of Washington, Chapter 90.42.005 - 900. Pilot project for water conservation programs and water right trust program.

Revised Code of Washington, Chapter 90.44, Regulation of Public Ground Waters.

Revised Code of Washington, Chapter 90.54, Water Resources Act of 1971.

Washington Administrative Code, Chapter 5-18. Washington State Conservation Performance Standards. Washington State Building Code Council. July 1990.

Washington Administrative Code, Chapter 173-136. The establishment of a system of authorizing the withdrawal of artificially stored ground water embodied in an approved declaration under Revised Code of Washington 90.44.130, which are commingled with public groundwater in ground water area, subarea, and zones established under Revised Code of Washington 90.44.130.

Washington Administrative Code, Chapter 173-216. State Waste Discharge Permit Program, Washington Department of Ecology.

Washington Administrative Code, Chapter 173-500. Water Resources Management Program Established Pursuant to the Water Resources Act of 1971.

Washington Administrative Code, Chapter 173-508 Instream Resource Protection Program, Cedar-Sammamish Basin, WRIA 8. (9-6-79).

Washington Administrative Code, Chapter 173-509. Instream Resources Protection Program, Green-Duwamish River Basin, WRIA 9.

Washington Administrative Code, Chapter 173-590. Procedures Relating to the Reservation of Water for Future Public Water Supply.

Washington Administrative Code, Chapter 508-12. Administration of Surface and Ground Water Codes.

Appendix E

Recommended Data Collection and Analysis Program

Vashon-Maury Island
Ground Water Management Plan

December 1998

Appendix E

Recommended Data Collection and Analysis Program

The following data program elements are based on recommendations from the consultant, as adopted by the Vashon Ground Water Advisory Committee.

WATER QUALITY

A. The monitoring well network (twenty-one wells) used in the development of the Ground Water Management Plan should be expanded with continued implementation of the ground water quality monitoring program. Selection of additional wells should be based on the following:
   1. Location within high physically susceptible areas and near coastal areas (to monitor specifically for seawater intrusion);
   2. Completed in the shallowest hydrostratigraphic zone (Zone 1) since this zone is most susceptible to contamination and can serve as an "early warning" to deeper zones;
   3. Spatial distribution within areas to be monitored; and
   4. Accessibility to monitoring personnel.

B. The selected wells should continue to be monitored for the water quality parameters monitored in this study to build on the established database and confirm observed trends in concentrations. In addition, data from the wells should be compared to the trigger levels. Specifically, additional sampling should be conducted for wells in which increasing levels of contaminants (such as lead) were identified in this study. Wells near the shoreline should be closely monitored for indications of over pumping and associated seawater intrusion.

C. As part of the monitoring program, a control area should be established for closely monitoring water quality and extrapolating the results to other areas of the Island. The control area should be established based on the following criteria:
   1. Location within high physically susceptible area;
   2. Availability of sufficient monitoring points to monitor the shallowest hydrostratigraphic zone across the control area; and
   3. Knowledge of land use activities through wellhead protection studies, review of existing land use maps, and field surveys within the control area to establish cause and effect relationships.

D. Continue to monitor the water quality of selected wells for potential impacts by point and non-point sources of contamination to provide long term trends in constituent levels. Specifically, continue to monitor the wells identified (including the wells associated with water purveyors) as having constituents above regulatory levels or increasing trends in concentrations of constituents.

E. Continue to monitor water quality at the mouths of the major streams as an indicator of impacts from land use within the drainage basin. Streams monitored in this study (nine sites) should continue to be monitored since they represent the major drainage basins on the Island and have established access points. The streams should continue to be monitored for the water quality parameters monitored in this study to build on the established database and confirm observed trends in concentrations. Specifically, continue to monitor the creeks identified as having increasing trends in constituent concentrations, from the eight streams originally monitored. Continue to monitor contaminants in shellfish in areas identified as above regulatory levels.

F. Vashon Landfill. Monitor the water quality data from wells at and around the Vashon landfill collected by the King County Solid Waste Division and the Seattle-King County Health Department to determine if ground water quality is being impacted by landfill contaminants, if the shallow and deep aquifers are interconnected, or connected to water producing zones for public supply. Provide this data to the King County Department of Natural Resources, for inclusion into the database.

G. NIKE Battery Site. Confirm that ground water has not been impacted at the NIKE site by installing a monitoring well in the area of former paint and fuel storage areas.

H. Biosolids. If biosolids are disposed on Vashon, evaluate the background water quality around the perimeter of the site for impact of applied biosolids.

I. Agriculture. Conduct spot checking and long term monitoring of ground water in the vicinity of Island ranches for nitrate, especially at sites located in high recharge areas.

J. Sand and Gravel. Monitor the Vashon Sand & Gravel well and plant settling pond for ground water quality. Assess land use activities in proximity to this operation.

WATER QUANTITY

A. Monitor water levels in the monitoring well network (twenty-five wells) to determine long term trends in water levels of the hydrostratigraphic zones. The long-term trends will aid in determining if ground water overdrafts are occurring, or the effects of drought periods on ground water levels. The well network established for this study should be augmented by additional wells (possibly up to twenty wells). Selection of additional wells should be based on the following:

   1. Location within high and low physically susceptible areas. Wells in high physically susceptible areas will be more sensitive to the effects of ground

water recharge, wells in low physically susceptible areas will be more sensitive to ground water overdrafts;

2. Completed in the shallowest hydrostratigraphic zone (Zone 1) since this zone is most susceptible to recharge and overdrafts;
3. Spatial distribution within areas to be monitored. Data should be collated to show where there are data gaps and to develop cross sections and ground water flow directions; and
4. Accessibility to monitoring personnel.

The wells should continue to be monitored on either a monthly or quarterly basis. Pumping conditions (on or off and for how long) should be noted at the time of water level recording. Continued monitoring of the wells monitored in this study will build on the established database and observed trends in water levels.

B. Monitor Island precipitation levels to determine long term trends specific to the Island. The monitoring should be conducted as follows:
   1. Install automatic rain gauge recorders at the locations monitored during this study (nine sites). These locations are representative of the major Island collection basins. The data collected will build on the database established during this study; and
   2. Establish schedule, funding, and personnel to enter data into the database and to collect periodic manual readings for cross-referencing the automatic recorders.

C. As part of the monitoring program, a control area should be established for closely monitoring water quantity and extrapolating the results to other areas of the Island. The control area should be established based on the following criteria:
   1. Location within high physically susceptible area;
   2. Availability of sufficient monitoring wells to monitor the shallowest hydrostratigraphic zone across the control area; and
   3. Knowledge and/or control of land use activities (such as logging, ground water withdrawal rates) within the control area to establish cause and effect relationships.

The following monitoring activities should be conducted within the control area:

1. Install and monitor automatic rain gauges to record precipitation (the amount of water coming into the control area);
2. Install and monitor automatic stream gauges to record stream runoff (the amount of surface water leaving the control area through direct runoff and the amount of ground water leaving the control area through stream baseflow); and
3. Monitor water levels in selected monitoring wells to determine the effects of recharge and/or ground water withdrawals.

D. Reactivate the U. S. Geological Survey stream gauging station located on Judd Creek to establish long term trends in stream flow and response to seasonal variations in precipitation.

ADDITIONAL ANALYSIS

A. Ion balances should be constructed for each of the major hydrostratigraphic zones to determine the geochemical signature of each zone. The water within separate hydrostratigraphic zones often has a distinct signature defined by the distribution of ion concentrations. These signatures should be developed and monitored as indicators of contamination as follows:

1. Sample wells identified in this study as completed in each of the hydrostratigraphic zones and analyze for major anions and cations;
2. Construct a Stiff diagram by plotting the concentrations of detected anions and cations. The shape of the diagram will define the signature for the zone; and
3. Changes in the ion distribution should be used as indicators of contamination (such as seawater intrusions) and could be used to aid in establishing trigger mechanisms.

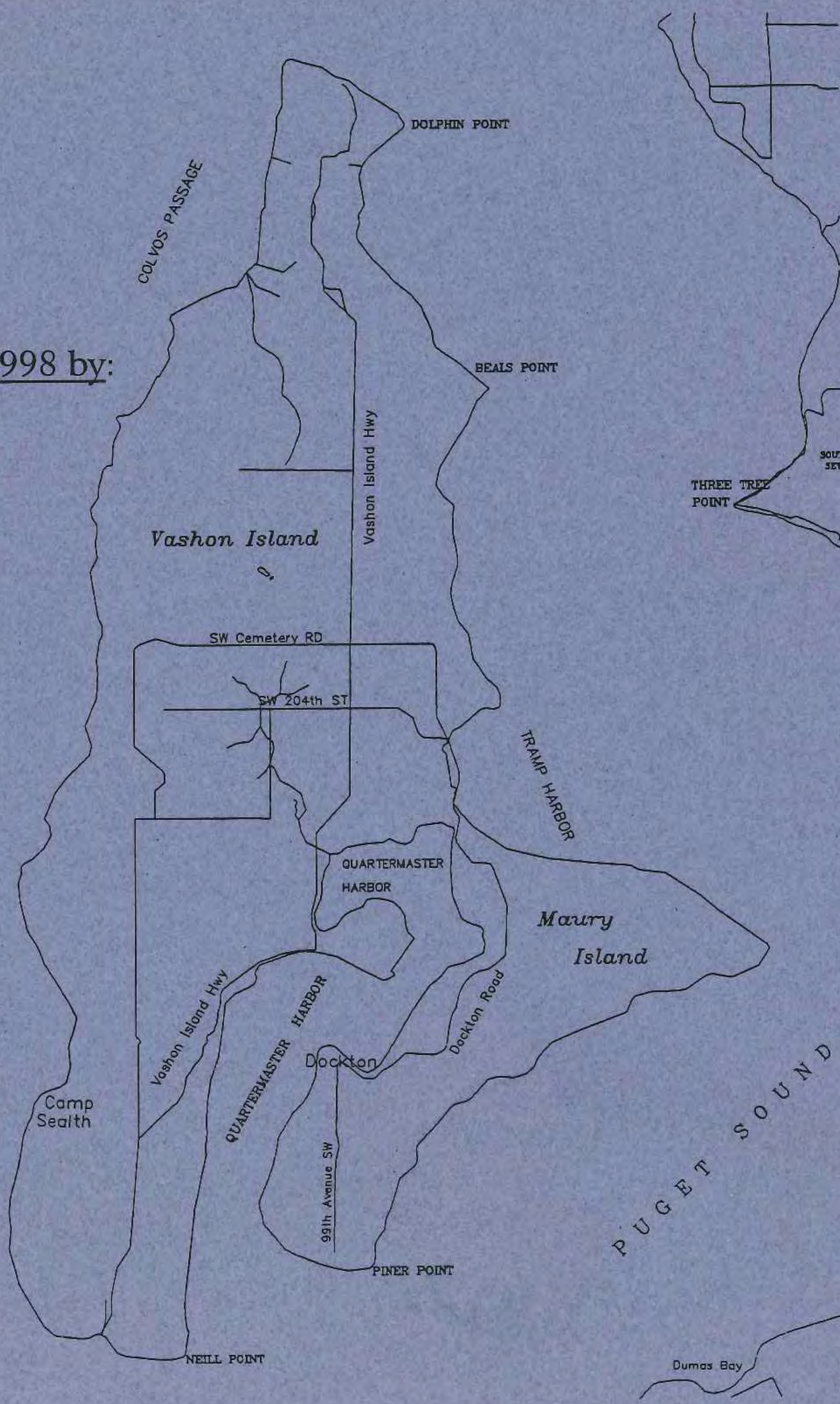
B. The computerized database management system should be expanded in the following areas:

1. Integrate with the King County databases through the assessor's parcel numbering system;
2. Develop procedures for processing water use information;
3. Expand the data reporting capability to provide better access to the data that is stored in the systems;
4. Develop procedures to facilitate linkage between water utility data stored within PCSTORET with the physical data contained within the database management system;
5. Develop procedures for storing and manipulating stream flow and precipitation data; and
6. Ensure ongoing training and support is provided so that the database and the King County AutoCAD mapping system are effectively used.

Future database management efforts should include field verification of well information. Reporting procedures and funding mechanisms such as the aquifer protection funds user fees will need to be identified in order for long term data management to be successful.

Vashon-Maury Island
Ground Water Management Plan
Supplement 1 - Area Characterization

Final



Submitted December, 1998 by:
Vashon - Maury Island
Ground Water
Advisory Committee

Vashon-Maury Island
Ground Water
Advisory Committee

Supplement to the Vashon-Maury Island Ground Water Management Plan:

Area Characterization

December 1998
Final

Data and information contained in this document are current as of the period of project performance: 1989 - 1995.

Submitted by:

Vashon-Maury Island Ground Water Management Committee

King County Department of Natural Resources
Water and Land Resources Division
Suite 2200
700 Fifth Avenue
Seattle, WA 98104
(206) 296-6519

Seattle-King County Department of Public Health
Environmental Health Division
Suite 700
999 Third Avenue
Seattle, WA 98104
(206) 296-4722

Funded in part by the Washington Department of Ecology Centennial Clean Water Fund.

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Area Characterization

1.0 INTRODUCTION

This Area Characterization provides a description of the Vashon-Maury Island Ground Water Management Area for the Vashon-Maury Island Ground Water Management Plan based on the 1983 J. R. Carr/Associates (Carr) report findings and recommendations. In addition to data reported by Carr, this chapter also summarizes the results of ground water, surface water, spring water, sediment and shellfish data collection and analysis activities conducted between 1989 and 1992 as part of the Vashon-Maury Island Ground Water Management Plan.

This Area Characterization is a compilation of information from previous water investigations conducted in the Vashon-Maury Island Ground Water Management Area and from data collection activities conducted as part of this ground water planning process. The Area Characterization includes information regarding the boundaries, regulations and regulatory agencies, physical characteristics, land uses (including their effects on ground water), water applications and hydrogeology of the Vashon-Maury Island Ground Water Management Area. Data collection activities conducted from 1988 to 1993 (rainfall, stream flow, spring flow, ground water levels, and sampling of water, sediment and shellfish) were based on recommendations by Carr (1983). This Area Characterization is organized as follows:

- Section 1.0., Introduction, outlines the information presented within the Updated Area Characterization and Data Analysis Report.
- Section 2.0., Vashon-Maury Island Ground Water Management Area Boundaries, presents a detailed description of the boundaries of the Vashon-Maury Island Ground Water Management Area.
- Section 3.0., Jurisdictions in the Vashon-Maury Island Ground Water Management Area, identifies and describes the various federal, state, and local agencies which have jurisdiction over the Vashon-Maury Island Ground Water Management Area.
- Section 4.0., Physical Geography, describes the geography, topography, and climate of the Island.
- Section 5.0., Potential Effects of Land-Use Activities on Ground Water Background, depicts the general and specific land uses occurring in the Vashon-Maury Island Ground Water Management Area and the effects on ground water.
- Section 6.0., Water Applications, evaluates the water demand, water services, water rights, wastewater disposal, and storm water systems across the Island.

- Section 7.0., Ground Water Policies, describes the state and local ground water policies under which the Vashon-Maury Island Ground Water Management Plan is permitted to operate.
- Section 8.0., Hydrogeology, presents the methodology and results of the data collection and analysis activities conducted as part of the Vashon-Maury Island Ground Water Management Plan. Summaries of the Island geology, hydrostratigraphy, water resources (ground water and surface water), and physical susceptibility areas are presented.
- Section 9.0., Conclusions and Recommendations, presents a brief summary of and detailed conclusions drawn from the data collection activities, followed by recommendations concerning future information needs.

1.1 Data Collection

Rainfall, surface water, sediment, shellfish, springs, and ground water were investigated in the data collection and analysis task. Data was collected by various entities, including Island resident volunteers and personnel from the Seattle-King County Health Department, King County Solid Waste Division, U. S. Army Corps of Engineers, and the environmental firms of URS Consultants, EcoChem, Inc., and Geraghty & Miller, Inc. The decision to record water levels in twenty-four wells over time was based on the recommendations and data presented in Carr. This Area Characterization summarizes the results of the data collection task and discusses these new data with respect to previous historical reports. (EcoChem and Geraghty and Miller 1990)

The objective of the data collection and analysis task is to further the understanding of the water resources (quantity and quality) and identify data gaps to facilitate protection of the ground water in the Vashon-Maury Island Ground Water Management Area. To attain this goal, the following types of data were collected and analyzed.

1.1.1 Historical Records

Background hydrogeologic data, water-use reports (Geraghty & Miller 1991), land-use reports (Geraghty & Miller 1990), and existing information on physical geography, climate, surficial geology, well logs, water use, land uses, and development trends were considered in the preparation of this Area Characterization. In addition, available reports prepared by consultants on various aspects of water quality and quantity of the Vashon-Maury Island Ground Water Management Area water resources were examined. Consultant reports include: Carr 1983; Harding Lawson Associates 1991; Harper-Owes/Golder Associates, Inc. 1986; Harper-Owes Associates 1988; Horton Dennis & Associates, Inc. with CH2M Hill 1989; PEI/Barrett Consulting Group with the Washington State Department of Ecology and Seattle-King County Health Department 1992; Shapiro and Associates, Inc. and Applied Geotechnology Inc. 1992; Shapiro and Associates and Science Applications International Corporation 1988; and University of

Washington 1987. Water resource data were augmented by water consumption figures provided by Group A purveyors on the Island. (See Table 6.3b.)

1.1.2 Rainfall and Stream Flow

These data were collected between 1988 and 1992 by volunteers, agency personnel, and personnel from previous consultants at nine rainfall and nine stream sites located across the Island to assess the amount of water potentially available to the Island (rainfall) and leaving the Island (stream flow). Stream flow data were collected to estimate the net volume of rainfall which runs off and is not absorbed into the ground, and the amount of ground water leaving the Island as stream base flow.

1.1.3 Ground Water Levels and Water Quality

Depth-to-ground water and ground water quality data were collected from 24 wells at 21 sites across the Island by the Seattle-King County Health Department and the consultants between 1989 and 1992. Water quality data were also collected by the Seattle-King County Health Department and King County Solid Waste Division from monitoring wells at the Vashon Island Landfill and surrounding area. Ground water quality data were collected at the NIKE site by the U. S. Army Corps of Engineers to assess rainfall/recharge relationships, changes in depth to ground water over time (i.e., potential depletion of the water resource), changes in ground water flow direction seasonally and over time, and water quality changes over time. The specific water quality parameters evaluated varied among the different investigations, but the primary constituents investigated were chloride (as an indicator of seawater intrusion), nitrate (as an indicator of septic system and/or agricultural contamination), inorganics (chloride, nitrate/nitrite, and sulfate), and total dissolved solids (as a general indicator of land use impact).

1.1.4 Surface Water Quality

Surface water data and sediment samples were collected in 1991 and 1992 by the Seattle-King County Health Department from eight streams. Samples were collected upstream in the freshwater environment and downstream where the streams enter Puget Sound (e.g., the marine environment). Marine shellfish samples were collected from areas in Puget Sound at the mouth of the stream. The specific water quality and marine shellfish parameters evaluated were total and fecal coliforms (as indicators of bacterial contamination) and metals (arsenic, chloride, mercury, selenium, cadmium, copper, lead, silver, and zinc [as indicators of toxic metal contamination]). Temperature, pH, and chloride were evaluated in freshwater only. Additional studies of marine water quality and shellfish were conducted by the Quartermaster Harbor Yacht Club and Quartermaster Marine Association, the Washington State Department of Health; Seattle-King County Health Department; the King County Department of Natural Resources, Water Pollution Control Division; and the Puget Sound Water Quality Authority. The results are presented in Section 8.5.1, Surface Water Quality.

1.1.5 Spring Water Quality

These data were collected by the Seattle-King County Health Department at six spring sites in 1989 and 1990. The specific water quality parameters evaluated were total and fecal coliforms (as indicators of bacterial contamination); metals, sulfate, and fluoride (as indicators of toxic metal contamination); nitrate (as nitrogen), and nitrite (as nitrogen) (as indicators of septic system and/or agricultural contamination); and total dissolved solids (as a general indicator of land use impact).

1.1.6 Exploration Well

An exploratory well was drilled in January 1992. Borehole data were collected in an effort to provide information on the water-bearing units in the geologic formations beneath the Island, the viability of a water resource in deep sediment deposits, and the general variations in water quality correlating to depth of water-bearing zone.

2.0. VASHON-MAURY ISLAND GROUND WATER MANAGEMENT AREA BOUNDARIES

The Vashon-Maury Island Ground Water Management Area (see Figure 2.1) comprises approximately 36.7 square miles, of which 29.7 square miles are Vashon Island and 7.0 square miles are Maury Island. The two islands are linked by a narrow isthmus and are not, therefore, two truly independent islands. The boundaries of the Vashon-Maury Island Ground Water Management Area coincide with the coastline of Vashon-Maury Island.

As part of King County, the linked islands are often referred to throughout the Puget Sound area as "Vashon Island." However, for the purposes of this Area Characterization, Vashon-Maury Island will be referred to as "the Island." Whenever Vashon Island or Maury Island are referred to individually in the following sections, the reference is to that specific portion of the Vashon-Maury Island system.

3.0 JURISDICTIONS IN THE VASHON-MAURY ISLAND GROUND WATER MANAGEMENT AREA

This section discusses the role of the public agencies with jurisdiction in the Vashon-Maury Island Ground Water Management Area. The ground water related responsibilities and activities of the agencies are discussed only as they pertain to the Vashon-Maury Island Ground Water Management Area. The jurisdictional boundaries of many agencies include the entire Vashon-Maury Island Ground Water Management Area, which is unincorporated. Such agencies include Fire District No. 13, School District No. 402, and state and federal agencies. Agencies whose jurisdictional boundaries do not extend to the entire Vashon-Maury Island Ground Water Management Area include the Vashon Sewer District and King County Water District No. 19. The federal, state, county and local agencies and their jurisdictional boundaries are discussed below.

3.1 Federal Agencies

The following federal agencies influence ground water management in various ways, both through their roles as regulatory bodies and in their capacities as policy-makers.

3.1.1 U. S. Environmental Protection Agency

The U. S. Environmental Protection Agency administers numerous programs that influence ground water management in the Vashon-Maury Island Ground Water Management Area, provides technical assistance to state and municipal officials on a variety of ground water related issues, and acts as a regulatory agency. As a lead agency, the U. S. Environmental Protection Agency deals with water pollution, underground storage tanks, pesticide and herbicide use, liquid waste, landfills, hazardous waste management (including Comprehensive Environmental Response, Compensation, and Liability Act/Superfund Amendments and Reauthorization Act of 1986 sites and generators), and drinking water management. As a support agency, the U. S. Environmental Protection Agency is involved with regulation of lagoons and holding ponds, sewage waste disposal, sludge application, spill control and prevention, solid waste handling, storm water runoff, ground water, surface water, wetlands, and wells and water rights. The U. S. Environmental Protection Agency administers the Sole-Source Aquifer Program, the Pesticides in Ground Water Survey, and the Agricultural Chemicals in Ground Water Strategy. (U. S. Environmental Protection Agency 1987)

3.1.2 U. S. Department of Agriculture

The U. S. Department of Agriculture provides technical assistance to landowners and communities concerning municipal biosolids applications, livestock, crops, irrigation design, wildlife, and animal waste ponds. The U. S. Department of Agriculture is a lead agency for pesticide and herbicide programs and administers programs such as fish and wildlife conservation programs, and watershed projects.

3.1.3 The Natural Resources Conservation Service

As part of the U. S. Department of Agriculture, the Natural Resources Conservation Service provides technical assistance in soil erosion control and pesticide and herbicide use. It also plays a support role in agriculture, diking and drainage, forestry, lagoons, surface water, and wetlands.

3.1.4 U. S. Geological Survey

The U. S. Geological Survey is a hydrologic and geologic data generation and research agency and is responsible for some of the geological mapping that has led to a better understanding of the two principal aquifers in the Vashon-Maury Island Ground Water

Management Area. The U. S. Geological Survey has no regulatory or policy making authority.

3.2 Washington State Agencies

The following agencies operate at the state level, but influence ground water affairs at a local level as well.

3.2.1 Washington State Department of Ecology (Ecology)

Ecology is charged with protecting the waters of the state, and, therefore, the activities of Ecology directly and indirectly affect ground water management decisions in the Vashon-Maury Island Ground Water Management Area. Funding for the development of the Vashon-Maury Island Ground Water Management Plan comes from the Centennial Clean Water Fund, a grant administered by Ecology. Ecology issues discharge permits and performs compliance monitoring at the Vashon Island Sewage Treatment Plant, enforces discharge regulations, and responds to pollution incidents. Ecology is a lead agency in over 20 environmental categories, including aquifer depletion, seawater intrusion, water resources, well construction and abandonment, and water rights. Ecology implements the Ground Water Quality Standards as specified under Chapter 173-200 WAC. As a regulatory agency, Ecology is responsible for the cleanup of hazardous material leaks and spills (except in navigable waters), oversight of Resource Conservation and Recovery Act facilities and state hazardous waste cleanup sites, and regulation of underground storage tanks.

3.2.2 Washington State Department of Health, Office of Environmental Health Programs

The Washington State Department of Health is involved in a variety of programs that influence ground water management. As part of the Northwest Drinking Water Operations Program, the Washington State Department of Health is responsible for plan approval for Group A public water supplies, including well site inspections and final system certificate-of-completion review. The Washington State Department of Health has developed the Wellhead Protection Program to prevent contamination of the public drinking water supplies. Although the Washington State Department of Health is the lead agency for the Wellhead Protection Program, local governments and purveyors implement the program.

Under the On-Site Sewage Program, the Washington State Department of Health is the state agency responsible for enforcing Chapter 248-96 WAC, the regulations that prescribe design and installation standards for septic systems. These regulations are currently under revision to increase effectiveness in protecting public health and water quality. The Washington State Department of Health is also responsible for guideline development and performance review of alternative sewage disposal systems.

The Shellfish Section of the Washington State Department of Health regulates both commercial and recreational shellfish resources. The Shellfish Section activities involve monitoring shellfish harvesting areas, including several sites on Vashon Island, and testing shellfish from these sites for the presence of the paralytic shellfish poisoning toxin that causes red tide.

3.2.3 Washington State Department of Natural Resources

The Washington State Department of Natural Resources manages state-owned lands, including approximately 250 acres of land in upland areas of Vashon Island and 115 tideland parcels of the Island. In the recent past, there have been some sales of timber from the upland property, but no land sales for development purposes. The tideland parcels are managed by the Aquatic Lands Division of the Washington State Department of Natural Resources, which is also involved with the Washington State Department of Health in developing regulations governing the recreational harvesting of shellfish.

3.2.4 Washington State Department of Trade, Community and Economic Development

The Washington State Department of Trade, Community and Economic Development is responsible for implementing the Growth Management Act. The Growth Management Act affects the study area by requiring King County to establish urban and rural boundary lines and protection for critical aquifer recharge areas. The existing cities have urban growth boundaries designating centers for expected population growth as shown in the King County Comprehensive Plan. The intent of the Growth Management Act is to minimize human impacts on the native environment, limit urban sprawl, and plan for growth.

3.2.5 King Conservation District

The King Conservation District works with the agricultural community to implement animal management and land use practices that increase productivity while minimizing soil erosion and water pollution. The District is neither a branch of the county government nor an enforcement agency, rather a political subdivision of Washington State government authorized by Chapter 89.08 RCW. The organization is dedicated to the conservation and best uses of the natural resources of King County. Much of the technical assistance provided landowners and land users consists of helping them adopt conservation Best Management Practices (BMP). Conservation districts are being recognized increasingly as the logical focal point for coordinating local, state, and federal efforts to protect natural resources.

3.3 King County Agencies

The following King County agencies operate on the Island. Each of these agencies conduct activities that either directly or indirectly affect water management in the area.

3.3.1 Metropolitan King County Council

The Metropolitan King County Council has legislative authority to enact ordinances and regulations governing protection of ground water resources, including land-use provisions. In the past, the Council has administered water-resource, land-use, and wetlands programs in addition to assisting in community plan reviews. The version of the Vashon Community Plan currently in use was developed by the King County Community Planning staff and the 13-member Citizen Advisory Committee made up of local Island residents in addition to a nonresident chairperson appointed by the Metropolitan King County Council (King County 1986).

3.3.2 King County Office of Strategic Planning

The Office of Strategic Planning is primarily involved in developing the King County Comprehensive Plan and in other land use policy plans including the 1986 Vashon Community Plan.

3.3.3 King County Department of Development and Environmental Services

The Department of Development and Environmental Services administers the Critical Water Supply Program, the implementation element of the Public Water Systems Coordination Act of 1978 (Chapter 70.116 RCW, Chapter 248-56 WAC, and Chapter 248-57 WAC). The program establishes coordinated planning among water utilities, reducing the creation and proliferation of new public water systems. Vashon Island has been designated as one of four critical water-supply service areas for which a Coordinated Water System Plan was developed in 1990 (Horton Dennis & Associates 1990). Department of Development and Environmental Services also implements the 1986 Vashon Community Plan by issuing building permits and by administering rezones and plats. Additionally, this Office is involved in coordinating the King County review of comprehensive plans for all water and sewer systems operating in unincorporated King County.

3.3.4 Seattle-King County Health Department, Environmental Health Division

The Seattle-King County Health Department is an advisory and regulatory body involved in a wide variety of water-related topics, including regulation of Group B public water supply systems. The Seattle-King County Health Department is responsible for evaluating soil quality on the Island preparatory to permitting disposal systems for on-site wastewater.

The Seattle-King County Health Department administers a number of programs that affect ground water issues in the Vashon-Maury Island Ground Water Management Area, including the Surface Water Study, and Sewage Facilities Plan (PEI/Barrett 1992).

The Seattle-King County Health Department also served as lead agency for the Vashon-Maury Island Ground Water Management Plan through 1995. In that capacity, the Seattle-King County Health Department coordinated the activities necessary for the development of the ground water management plan. Those activities included collecting ground water quality and quantity data, surface water and sediment data, managing the ground water database, drafting technical issue papers, and preparing the budget for development of the Vashon-Maury Island Ground Water Management Plan. The Department of Natural Resources assumed lead agency responsibility for the Vashon-Maury Island Ground Water Management Plan study in January of 1996.

The Sewage Facilities Plan was developed from the findings of the Seattle-King County Health Department sanitary survey conducted by PEI/Barrett and the Seattle-King County Health Department. The Sewage Facilities Plan determines the feasibility of a community solution for the sewage treatment and disposal problems faced by four Vashon Island coastal communities which have been declared severe public health hazard areas by the Washington State Department of Health. Seattle-King County Health Department issues permits for proposed septic systems, responds to complaints about and regulates the repair of failing systems, reviews all subdivision proposals for which on-site sewage disposal is proposed, and educates homeowners in the proper maintenance of their systems.

The Solid Waste Section of Seattle-King County Health Department is responsible for permitting landfills, overseeing and permitting sludge applications and sampling ground water in areas around the Vashon Island Landfill.

The Local Hazardous Waste Management Program of Seattle-King County Health Department helps businesses discern if they have hazardous waste and then assists them in managing this waste properly. These are businesses that generate small amounts (less than 220 pounds per year) amounts of hazardous waste (Seattle-King County Health Department 1994).

The King County Water Review Board, affiliated with the Seattle-King County Health Department drinking water program, reviews water applications for Group B (small) public water systems that do not meet the requirements of Title 12 (King County Board of Health Public Water System Rules and Regulations).

3.3.5 King County Department of Transportation

The Department of Transportation consists of the former Department of Metropolitan Services Transit Division (formerly Metro) and the former King County Department of Public Works, Roads and Engineering Division. In addition to construction and maintenance of roads and associated drainage, the Road Services Division is responsible for vegetation control. As part of the Division's Integrated Vegetation Management Plan, herbicides are applied along area roadsides.

3.3.6 King County Department of Natural Resources

The following divisions of the Department of Natural Resources conduct the activities described below in the Vashon-Maury Island Ground Water Management Area.

Solid Waste Division: The Solid Waste Division owns the 145-acre site on which the nine acre Vashon Island Landfill operates. The Solid Waste Division is responsible for ground water sampling at the landfill and for the construction of the new leachate control facility for this landfill.

Surface Water Management Division: On January 1, 1996, the King County Surface Water Management Division became part of the new Department of Natural Resources. The County Council reassigned the lead agency role for the ground water program to the Surface Water Management Division on January 1, 1996. Subsequently, the Surface Water Management Division was renamed the Water and Land Resources Division. Given the continuity between surface water and ground water in much of King County, Water and Land Resources Division management of surface water has a direct influence on ground water resources. However, the Vashon-Maury Island Ground Water Management Area is outside of the current service area for the surface water management service area.

Water Pollution Control Division: From 1983 to 1992, the Water Pollution Control Division (at that time, Metro) conducted an ambient monitoring program focusing on bacterial contamination at 22 intertidal water sampling stations on the eastern shore of the Puget Sound. The Water Pollution Control Division recently published a water quality status report summarizing the results of the sampling from 1990 to 1992. Information collected from this study is being used to assess the risk from eating shellfish obtained from these areas. Both intertidal water and shellfish were sampled. The Puget Sound Water Quality Authority took over the ambient monitoring program in 1992 (Thrasher 1993). The stations are still being monitored; no changes have been made to the program (Shuman 1994). The Island was included in this program in 1988. The Water Pollution Control Division report is discussed further in Section 8.5.1.

Natural Resources Division: The Natural Resources Division is a new division created in 1995 as part of the King County consolidation effort. The purpose for forming this Division is to consolidate a wide array of existing natural resource programs into a single division for protection, acquisition, management and stewardship. The Natural Resource Division has two broad functions - Open Space and Resource Lands. The Office of Open Space is responsible for the acquisition of land. The Resource Lands Section is a new entity with staff and programs drawn from four former King County Departments who are responsible for land based and incentive programs. These programs focus on land-based resource uses such as open space, farmlands, forestry, wetlands and wildlife habitat. Many of these programs also enhance water quality throughout streams and wetlands.

3.4 Other Agencies

3.4.1 Vashon Sewer District

The Vashon Sewer District operates the only sewage treatment plant on the Island. The facility has provided secondary treatment since 1976 and serves a population equivalent to approximately 1,000 people.

3.4.2. King County Water District Number 19

Water District No. 19 is a municipal corporation providing drinking water service to over 1,000 connections on the Island. Drinking water is currently obtained from three sources: Beall Creek, Ellis Creek, and a deep well. The Water District is investigating other possible water sources.

3.4.3 Puget Sound Water Quality Authority

The Puget Sound Water Quality Authority awarded a $32,000 Public Involvement and Education grant to Vashon Island School District No. 402 in 1988. The grant promotes public education and awareness in matters concerning water quality on the Island. The Water and Vashon Ecosystems (WAVES) project was developed from this grant.

4.0 PHYSICAL GEOGRAPHY

4.1 Geographic Setting

The Vashon-Maury Island Ground Water Management Area is located near the southern end of Puget Sound in the southwestern corner of King County, southwest of Seattle and north of Tacoma, in Washington state. The Island lies in the Puget Lowland, a trough located between the Olympic Mountains to the west and the Cascade Mountains to the east. Vashon Island is roughly 13 miles north-to-south and four miles east-to-west, while Maury Island is about five miles in a northeast-southwest direction and roughly two miles east-to-west (DeLorme 1988).

The Island is separated from the surrounding mainland by narrow channels of Puget Sound. Colvos Passage, about one mile wide and 110 to 410 feet deep, separates the Island from the Kitsap Peninsula to the west. The shortest distance between the Island and the mainland is to the south, about one and one-half miles across Dalco Passage, which ranges from about 300 to 410 feet deep. The mainland to the east of the Island lies from two and one-half to four miles across Puget Sound, which is approximately 550 to 800 feet deep in that area. The open water of Puget Sound extends approximately 29 miles from the northern tip of the Island to Whidbey Island; West Seattle lies about five miles north-northeast of the northern tip of the Island (DeLorme 1988, Carr 1983). State ferries link the Island to West Seattle and Seattle (passenger ferry only), to Southworth on the Kitsap Peninsula, and to Tacoma.

4.2 Topography

The topography of the Island is well documented. The U. S. Geological Survey mapping has resulted in production of the topographic maps upon which Figure 2.1 is based (U. S. Geological Survey 1968a and b, 1973, 1981a, b, and c). The Island has a total of about 47 miles of seawater shoreline, much of which lies beneath steep, slide-prone slopes. From the shoreline, the Island rises to rolling interior plateaus at elevations 300 to 500 feet above mean sea level. Streams have dissected the plateaus and accentuated the drumlinoid (elongated, asymmetric) form of the hills, into which much of the upland area has been molded by repeated glaciation. The Island is largely rural and much of the interior remains forested.

4.3 Climate

The official narrative summary of the Island climate, written in 1962 by State Climatologist E. L. Phillips of the U. S. Weather Bureau, stated that the Vashon-Maury Island Ground Water Management Area has a mid-latitude, wet-coast marine climate with generally cool, dry summers and mild, rainy winters (Carr 1983). Phillips stated that the Olympic Mountains, which rise about 40 miles to the northwest of the Island, protect it from intense winter storms, while the Cascade Mountains, which lie about 50 miles east of the Island, shield the Puget Sound area from the higher summer and lower winter temperatures experienced by eastern Washington. According to Phillips, summer temperatures average in the 70°s (Fahrenheit) during the day and 50°s at night, while winter temperatures are generally in the 40°s during the day and 30°s at night. These figures are supported by records kept by the U. S. Weather Bureau Vashon Island station from 1931 to 1954 (Carr 1983). The station was closed in 1955.

From 1931 through 1954, rainfall data for the Island were also recorded at the Vashon Island station (Carr 1983) (see Table 4.1.). These data indicate an average annual rainfall of 46.53 inches over the 24-year period. During 1981 and 1982, Carr collected rainfall data at seven Island locations as part of a study of the Island water resources (see Figure 4.1). Over the 1-year period, measured annual rainfall ranged from about 53 inches on the western side of Vashon Island to about 35 inches at Point Robinson on the eastern tip of Maury Island, a difference of over 18 inches, or about 50 percent. During the same period, rainfall recorded on the mainland at Sea-Tac Airport (approximately five miles northeast of the easternmost tip of Maury Island) was about 39 inches (Carr 1983). Rainfall monitoring conducted between 1989 and 1991 is discussed in Section 8, Hydrogeology.

5.0 POTENTIAL EFFECTS OF LAND-USE ACTIVITIES ON GROUND WATER - BACKGROUND

This section discusses the type and extent of land-use activities potentially affecting ground water in the Vashon-Maury Island Ground Water Management Area. Land-use activities are first described as they are carried out on the Island, followed by specific land uses and their effects on the Island water resources.

5.1 General Description

Included in the general description of the Island land use are existing land uses for both developed and undeveloped land; development trends for residential, commercial/industrial, and agricultural areas; and the land-use plans, policies, and regulations that have been sanctioned by King County. These areas of discussion are presented below.

5.1.1 Existing Land Use

In 1990, according to the Puget Sound Regional Council, 1,194 acres (about five percent) of the Island's 23,659 acres were classified as residential and 439 acres (about 1.9 percent) were occupied by places of employment. Approximately 63 percent of the Island was classified as vacant developable land, which is the total acreage of land that is physically developable according to the standards and policies currently applicable to local governments. The remaining land, almost 30.3 percent of the Island, was classified as balance which consists of unbuildable land, streets and parks (Capehart. 1993).

In the Vashon Community Plan (King County 1986), the existing land-use map (see Figure 5.1a) indirectly reflects zoning and the proposed land use map (see Figure 5.1b) shows the projected land use on the Island as predominantly low-density rural-residential. The majority of residential, commercial, and industrial development has occurred in the communities of Vashon, Vashon Heights, Burton, and Dockton. The proposed land-use map (see Figure 5.1b) shows very little change, with the exception of a small area immediately south of the Town of Vashon. Development of the Island, existing and future, is discussed below.

5.1.1.1 Developed Areas

Development in the Vashon-Maury Island Ground Water Management Area falls into three basic categories: residential, commercial, and industrial. Summaries of each of these categories follow:

Residential: Low-density residential development covers much of the Vashon-Maury Island Ground Water Management Area. Upper plateau areas are zoned for one single-family dwelling per 10 acres in areas of high ground water susceptibility to contamination and one single-family dwelling per five acres elsewhere. Higher density single-family residential areas are concentrated in the communities of Vashon, Vashon Heights, Burton, and Dockton, although downzoning to single-family residential units may be suggested in the revised Vashon Plan (Bredouw 1994). Multifamily housing is concentrated in the Town of Vashon, where sewer facilities are available. Maximum permissible housing density in the unsewered communities of Vashon Heights, Burton, and Dockton is three single-family houses per acre. According to the 1986 Vashon Community Plan, residential developments in high recharge areas must comply with site plan approval conditions to protect the aquifers from excessive loss of water infiltration. The conditions stipulate that the maximum surface coverage on all single-family residentially zoned lots shall not exceed 15,000 square feet.

Commercial: The Town of Vashon is designated as an unincorporated rural town in the King County Comprehensive Plan. At present, commercial and industrial development is concentrated in the Town of Vashon and in adjacent areas where water, sewers, and other services are available. Again, to protect the aquifers from excessive loss of water infiltration, any new commercial or industrial development in high recharge areas is limited to a maximum of 60-percent surface coverage, as stipulated under the site plan approval conditions established in the 1986 Vashon Community Plan. Small commercial centers exist in other Island communities, including Burton, Vashon Heights, and Dockton. Ferry terminals are located at Vashon Heights and Tahlequah, near the northern and southern ends, respectively, of Vashon Island.

Industrial: In 1978, there were approximately 44 acres of land zoned as manufacturing park and light manufacturing on the Island; of these, 18.5 acres were developed. An additional 40 acres were zoned for possible future use as potential light manufacturing. The 1986 Vashon Community Plan Land-Use Map (King County 1986) shows approximately 170 acres of land in the Vashon-Maury Island Ground Water Management Area zoned as manufacturing park and light manufacturing. Current manufacturing operations on the Island include the K-2 Ski Manufacturing Corporation; Pacific Research, which manufactures plastic skeletons; and Island Springs Tofu. All are in or near the Town of Vashon. Four major commercial sand and gravel extraction sites operate along the south shore of Maury Island; a number of smaller resource extraction sites on the Island operate intermittently. The Vashon Island Landfill is located on a gently sloping upland plateau near the headwaters of Judd Creek in the central-western portion of Vashon Island. The Landfill has been in operation for at least 35 years and is still active; in 1989, it was upgraded and redesigned to meet current standards.

5.1.1.2 Undeveloped Areas

Substantial portions of the Vashon-Maury Island Ground Water Management Area are presently undeveloped. These include both forested tracts (approximately 264 acres, as designated in the 1986 Vashon Community Plan) and open fields, as well as parcels of agricultural land, the latter being the least extensive. No areas are shown as being zoned for timber harvest on the 1986 Vashon Community Plan Land-Use Map. According to a 1976 study of agricultural uses, commercial orchards, berry farms, vineyards, nurseries, and small commercial ranches occupied about 900 acres (about four percent) of the Island (King County 1986).

According to the 1986 Vashon Community Plan, the entire coastline of the Vashon-Maury Island Ground Water Management Area as well as many of the drainage basins, and most of the surface water bodies have had development limitations imposed on them because they are classified as erosion hazard areas, flood hazard areas, fish-bearing waters, Class III landslide hazard areas and wetlands, and/or Class III earthquake hazard areas. All of these areas are mapped as "sensitive areas" in the Sensitive Areas Map Folio published by the King County Planning and Community Development Division (King County 1990). The 1986 Vashon Community Plan suggests that areas designated as sensitive should be developed only with great care or should remain undeveloped through the application of a low-density designation. In the past, according to Island residents, some sensitive areas have not been developed according to guidelines.

5.1.2 Development Trends

Development trends are discussed in terms of residential, commercial and industrial, agricultural, and other development. Each category is discussed below.

5.1.2.1 Residential

Populations and housing estimates and forecasts were drawn from three sources: (1) the Puget Sound Council of Governments (1988); (2) Puget Sound Regional Council (formerly the Puget Sound Council of Governments) (1993); and (3) King County Annual Growth Databooks (1988a, 1989a, 1991, 1992). Residential building data was gathered from Annual Growth Databooks (King County 1992, 1993). The following discussion describes the growth on the Island as indicated by these data.

The Island population continues to grow, accompanied by a rise in the demand for housing (see Tables 5.1 and 5.2). While the Island population increased by only about 13 percent from 1970 (6,516) to 1980 (7,377), the total number of households increased by about 36 percent. From 1980 to 1990, the Island population increased another 26 percent (to 9,309), yet the total number of households increased by 28 percent. The disparity between growth in population and in number of households has arisen from a decrease in the average household size from 1970 to 1980, from 3.05 persons (1970) to 2.53 persons (1980) to 2.50 persons (1990). Single-family dwellings increased by 28 percent from 1970 (2,027) to 1980 (2,594) and by 34 percent from 1980 to 1990 (3,488). The number of multifamily households jumped by 466 percent between 1970 (53) and 1980 (300) and then decreased by 28 percent by 1990 (215).

The 1993 Annual Growth Databook (see Table 5.2.) reports the 1992 population of the Vashon-Maury Island Ground Water Management Area as 9,900, a 33.8-percent increase over the 1980 Annual Growth Databook population reported. The total number of households in 1992 (4,100) was up 41.9 percent from 1980; with a total number of single-family housing units in 1992 (4,300) up 62.3 percent from 1980. The 1992 Puget Sound Regional Council predicts a population of 11,095 by the year 2000 (see Table 5.3.); the 1993 Annual Growth Databook predicts a similar population increase to 11,100 (see Table 5.4.a). The average growth estimates (Annual Growth Databook 1993) for other communities in King County are higher than those on the Island (see Table 5.4.b). The number of residential permits issued and the number of housing units built in the Vashon-Maury Island Ground Water Management Area from 1980 through 1992 were reported in the 1993 Annual Growth Databook (see Table 5.5.).

As stated in the 1986 Vashon Community Plan, the Vashon Sewer District local service area within the Town of Vashon contains planning for an additional 1,400 residential units. The Vashon Sewer District currently has approximately 350 to 400 connections (Seattle-King County Health Department 1993b). Communities without sewer systems (including Dockton, Burton, and Vashon Heights) are allowed to develop to a maximum density of three single-family units per acre (King County 1986).

5.1.2.2 Commercial and Industrial

The Town of Vashon is presently and will continue to be the center of the major commercial business interests on the Island. Small commercial centers exist in other communities and will be maintained at their current size, except for the possible limited expansion in Burton. Mixed business/residential units will be encouraged in the Town of Vashon and its business center. Under the 1986 Vashon Community Plan, there are 107 acres available for commercial/business use within the Town of Vashon. Neighborhood grocery stores and small clusters of business that exist in Island communities are recognized as integral parts of the character of the communities (Capehart 1994). Home occupations and cottage industries presently operate, and shall continue to operate in the future, provided that they meet the safety, zoning, and aesthetic standards of the community. The number of selected new industrial and commercial permits in the Vashon-Maury Island Ground Water Management Area for 1980 through 1990 were tabulated (King County 1991) (see Table 5.6.). A total of 16 new permits were assigned (six for industrial; five for office, bank, and professional; and five for store and restaurant).

The lack of island-to-mainland transportation other than the public ferry system is one of the factors limiting industrial growth in the Vashon-Maury Island Ground Water Management Area. The 1986 Vashon Community Plan has zoned approximately 704 acres for industrial and manufacturing uses. Of the total 704 acres, 530 acres are specifically intended for quarrying and mining purposes (Capehart 1993). Future industrial growth will be clustered south and west of the Town of Vashon and near existing industrial sites. Given the rural character of the Island and the limited work force, no large-scale industrial development is foreseen; future industrial uses will generally be for small-scale, light industry.

The four major commercial sand and gravel extraction sites on the south shore of Maury Island and the smaller sites on Vashon-Maury Island will continue to operate if the appropriate permits are in order (as discussed in Section 5.2.7). Residential development of one house per 2.5 acres is planned for the extraction sites in the distant future. Gold Beach on Maury Island is an example of a former gravel pit developed as a residential area.

5.1.2.3 Agricultural

The trend among existing farms is to diversify, both to meet local demands and to supply specialty markets on the Island and elsewhere. There is strong community support for encouraging farming and preserving agricultural land, as well as interest in promoting local consumption of Island produce. This support is reflected in the focus of the King County Agriculture Preservation Plan (Jones 1989).

The King County Agricultural Preservation Plan has two parts: (1) a land-preservation program, and (2) an agriculture support program. Under the land-preservation program, farmers have the option of selling development rights to 800 acres of commercial farmland on the Island to King County. Properties sold to the County under the land-preservation program are zoned as potential agricultural, thereby ensuring that some farmland is preserved. Once the development rights are acquired by the County, the land is rezoned as agricultural. King County currently owns development rights to 231 acres of agricultural land, 190 acres of which comprise Wax Orchards (located on 131st Avenue Southwest and Southwest 232nd Street) (Jones 1989).

Rezoning to agricultural upon the request of individuals is also supported. An Agricultural District, was established in 1977, as part of the King County Agricultural Preservation Plan. The District is authorized to review and comment on rezoning, subdivision, planned unit development, and other land-use applications to prevent adverse effects to agricultural activities on the Island. Food processing plants important to agricultural uses will continue to be permitted on the Island. A permanent farmers' market was established on the Island (Bredouw 1994).

5.1.2.4 Other

Another development trend is the establishment and protection of historic sites, as recommended in the 1986 Vashon Community Plan. Development guidelines encourage maintaining compatibility with historic buildings. The 1986 Vashon Community Plan states that a historic preservation officer will review proposals for development to evaluate their potential impact on the character of the community. According to Julie Koler, King County Historic Preservation Officer, a list of historic sites and potential landmarks on the Island was developed after a survey of the Island. The Historic Preservation Office is generally consulted by Department of Development and Environmental Services if a proposed development involves a site on that list (Koler

1989). The communities of Burton and Dockton were nominated as historic districts, but the Metropolitan King County Council revoked the recommendation (Capehart 1994).

5.1.3 Plans, Policies, and Regulations

Land-use activities and development trends evolve within the framework of applicable land-use policies. The most influential land-use policies for the Vashon-Maury Island Ground Water Management Area are the King County Comprehensive Plan and the 1986 Vashon Community Plan. The King County Comprehensive Plan is the King County long-range, county-wide, comprehensive land use plan. The 1986 Vashon Community Plan contains detailed land use, capital improvement, and zoning plans. In addition, functional plans, which address location, design, and operation of public facilities and services (such as surface water control and sewage disposal), receive policy direction from the King County Comprehensive Plan and are coordinated with the 1986 Vashon Community Plan. County and community plans, policies, and regulations are presented in the following subsections.

5.1.3.1 King County

Community plans, functional plans, and land-use regulations at the county level are designed to be compatible with the King County Comprehensive Plan. Some important features of the King County Comprehensive Plan relevant to the Vashon-Maury Island Ground Water Management Area, which is considered a rural area, are summarized in the following land-use goals:

- Resource lands, water quality, water resources, and ground water recharge areas should be protected on a long-term basis.
- Commercial and industrial uses in rural activity centers should be developed based on evaluation of local business needs and county-wide (Island-wide) economic development needs.
- Adequate facilities for growth and development, including sewers, water, and solid waste disposal, should be planned and provided.
- Service levels in rural areas should be sufficient to support rural residential densities.
- Densities in rural areas should be low enough to protect rural character and avoid the need for expensive facilities and services, such as public sewers, surface water management, extensive arterial networks, and urban-level fire protection.
- Public open space in rural areas should be planned for and provided.

The King County Comprehensive Plan was revised and adopted by the Metropolitan King County Council to comply with the Growth Management Act and the King County county-wide planning policies. The pertinent King County Comprehensive Plan policies are listed below:

Countywide Planning Policies (Ordinance 114446, 7/19/94)

The Countywide Planning Policies recognize the Ground Water Management Plans are being prepared. Authors of the Countywide Planning Policies noted that each plan was to identify aquifer recharge areas and propose strategies to protect ground water resources. Two policies are in the Countywide Planning Policies relevant to aquifer protection:

CA-5 All jurisdictions shall adopt policies to protect the quality and quantity of ground water where appropriate:

a. Jurisdictions that are included in the Ground Water Management Plans shall support the development, adoption, and implementation of the Plans and
b. The Seattle-King County Department of Public Health and affected jurisdictions shall develop countywide policies outlining best management practices within aquifer recharge areas to protect public health; and
c. King County and ground water purveyors including cities, special purpose districts, and others should jointly;
    1. Prepare ground water recharge area maps using common criteria and incorporating information generated by Ground Water Management Plans and Purveyor studies;
    2. Develop a process by which land use jurisdictions will review, concur with, and implement, as appropriate, purveyor Wellhead Protection Programs required by the Federal Safe Drinking Water Act;
    3. Determine which portions of mapped recharge areas and Wellhead Protection Areas should be designated as critical; and
    4. Update critical areas maps as new information about recharge areas and Wellhead Protection Areas becomes available.

CA-6 Land use actions should take into account the potential impacts on aquifers determined to serve as water supplies. The depletion and degradation of aquifers needed for potable water supplies should be avoided or mitigated; otherwise a proven, feasible replacement source of water supply should be planned and developed to compensate for potential lost supplies.

King County Comprehensive Plan

The King County Comprehensive Plan provides policy direction related to ground water in three topic areas: planning and coordination, land use, and storm water management. The Comprehensive Plan recognizes that the quantity and quality of water resources in the County are two fundamental issues to be addressed in future land use decisions and programmatic actions. However, emphasis is placed on contamination and relies on the adoption of the Ground Water Management Plans and Wellhead Protection Programs to develop information on quantity issues. In summary:

- the County should work in concert with affected jurisdictions and purveyors to plan for the continued protection of the aquifer;
- urban land uses should remain at high densities with an appropriate level of resource protection and rural areas should be allowed to develop only at very low densities with development restrictions protecting the natural environment; and
- storm water management techniques should encourage infiltration.

Planning and Coordination

NE-332 In unincorporated King County, areas identified as sole source aquifers or as areas with high susceptibility for ground water contamination where aquifers are used for potable water are designated as Critical Aquifer Recharge Areas as shown on the map entitled Areas Highly Susceptible to Ground Water Contamination. Since this map focuses primarily on water quality issues, the County shall work in conjunction with cities and ground water purveyors to designate and map recharge areas which address ground water quantity concerns as new information from ground water and wellhead protection studies adopted by County or state agencies become available. Updating and refining the map shall be an ongoing process.

NE-333 King County should protect the quality and quantity of ground water countywide by:

a. Placing a priority on implementation of the Ground Water Management Plans;
b. Developing a process by which King County will review, and implement, as appropriate, adopted Wellhead Protection Programs in conjunction with cities and ground water purveyors;
c. Developing, with affected jurisdictions, Best Management Practices for new development and for forestry, agriculture, and mining operations recommended in the Ground Water Management Plans and Wellhead Protection Programs as appropriate (sic). The goals of these practices should be to promote aquifer recharge quality and to strive for no net reduction of recharge to ground water quantity.
d. Refining regulations as appropriate to protect critical aquifer recharge areas when information is evaluated and adopted by King County.

Land Use

U-206 Environmental standards for urban development should emphasize ways to allow maximum permitted densities and uses of urban land. Mitigating measures should be encouraged to serve multiple purposes, such as drainage control, ground water recharge, stream protection, open space, cultural and historic resource protection and landscaping. When technically feasible, standards should be simple and measurable, so they can be implemented without lengthy review processes.

NE-335 In making future zoning and land use decisions which are subject to environmental review, King County shall evaluate and monitor ground water policies, their implementation costs, and the impacts upon the quantity and quality of ground water. The depletion or degradation of aquifer needed for potable water supplies should be avoided or mitigated, and the need to plan and develop feasible and equivalent replacement sources to compensate for the potential loss of water supplies should be considered.

NE-336 King County should protect ground water in the Rural Area by:

a. Preferring land uses that retain a high ratio of permeable to impermeable surface area and that maintain or augment the infiltration capacity of the natural soils; and

b. Requiring standards for maximum vegetation clearing limits, impervious surface limits, and, where appropriate, infiltration of surface water. These standards should be designed to provide appropriate exceptions consistent with Policy R216.

R-216 Rural development standards should be designed to protect the natural environment by addressing seasonal and maximum clearing limits, impervious surface limits, surface water management standards that emphasize preservation of natural drainage systems and water quality, ground water protection, and Best Management Practices for resource-based activities. These standards should be designed to provide appropriate exceptions for lands that are to be developed for kindergarten through twelfth grade public schools and school facilities, provided that the school project shall comply at minimum with the requirements of the King County Surface Water Drainage Manual or revisions thereto.

NE-302 Development should occur in a manner that supports continued ecological and hydrological functioning of water resources. Development should not have a significant adverse impact on water quality or water quantity. On Vashon Island, development should maintain base flows, natural water level fluctuations, ground water recharge in Critical Aquifer Recharge Areas and fish and wildlife habitat.

<u>Storm Water Management</u>

NE-310 Management of storm water runoff shall occur through a variety of methods. Storm water runoff caused by development shall be managed to prevent unmitigated significant adverse impacts to water resources caused by flow rates, flow volumes or pollutants to promote ground water recharge, infiltration of storm water, when feasible given geological, engineering and water quality constraints. The current practice of King County is to pursue non-structural methods whenever possible. In the Urban Growth Area, methods which are land consumptive will need to be balanced with the need to protect the supply of developable land.

NE-334 King County should protect ground water recharge quantity in the Urban Growth Area by promoting methods that infiltrate runoff where site conditions permit, except where potential ground water contamination cannot be prevented by pollution source controls and storm water pretreatment.

5.1.3.2 Vashon Community Plan and Area Zoning

The Vashon-Maury Island Ground Water Management Area falls entirely under the purview of the Vashon Community Plan adopted in October 1986 (King County 1986). The 1986 Vashon Community Plan was based on the Vashon/Maury Island Water Resources Study, completed in 1983 by J. R. Carr/Associates (Carr 1983). The water resources study was prompted largely by a recommendation in the 1981 Vashon Community Plan for further research into the Island water resources. Zoning and policies presented in the 1986 Vashon Community Plan reflect the new information obtained from Carr. The goals of the 1986 Vashon Community Plan are summarized below:

- The rural nature of the Island should be preserved.
- The most intensive residential, commercial, and industrial development should be restricted to the Town of Vashon and its immediate surroundings, where public utility services are available and adequate.
- Some additional growth should be permitted in the other Island town centers, although multifamily residential development should be limited to the areas of the Island where public sewage facilities are available and adequate.
- Island water resources should continue to be the sole water supply source in the future.
- Protection of the aquifer is recognized as being of primary importance.
- Commercial and small-scale agriculture should be promoted by compatible land-use designations.
- Future transportation facilities should provide efficient, environmentally sound transportation that make new auto facilities less necessary.
- To protect the quantity of water stored in the Island aquifers, site development in high recharge areas will require site plan approval that will stipulate the surface coverage and amount of runoff permitted.

5.2 Specific Land Uses and Their Effects on Ground Water

Specific land-use activities have the potential to adversely affect ground water quality in the Vashon-Maury Island Ground Water Management Area. Figure 5.1c shows the location of the potential point sources of contaminants in the Vashon-Maury Island Ground Water Management Area that are discussed in detail in the following subsections.

5.3 <u>Vashon Island Landfill</u>

The Vashon Island Landfill is owned by King County and serves as the municipal solid waste disposal facility for residents of both Vashon and Maury Islands and for private refuse haulers that serve the Island. The discussion below describes Landfill operations, their effects on ground water quality, risk to the environment, and future plans for the facility.

5.3.1. Description

The 9.3-acre refuse area of the Landfill is located on a 145-acre site in west-central Vashon Island, primarily in the southwest quarter of Section 36, T23N R2E (see Figures 5.1 c and 5.2). Access to the site is by way of 130th Avenue Southwest (Harper-Owes/Golder 1986). In their report, Harper-Owes (1988) states that historic records indicate disposal at the site may have begun in the early 1900s. The site has been active at least since the early 1950s, but detailed records are unavailable prior to that date. Currently, all forms of solid waste as defined in the King County Solid Waste Regulations, Title 10, of the King County Code of the Board of Health, Rules and Regulations No. 8, are accepted at the landfill, with the following exceptions:

- Liquids, demolition debris, or flammable materials.
- Dangerous wastes as defined by Ecology under Chapter 173-303 WAC.
- Hazardous wastes as defined by Federal Law 94-580, Resource Conservation and Recovery Act 1976.

A monthly inspection is conducted by the Seattle-King County Health Department staff to verify that unacceptable waste is not accepted at the landfill.

In 1984, 1985, and 1986, the landfill accepted approximately 4,800, 5,500, and 5,900 tons of refuse, respectively, representing volumes of approximately 16,000, 18,000, and 19,600 cubic yards, respectively. In 1991, the landfill accepted 6,817 tons of refuse, an increase of 944 tons (16.1 percent) from 1986 (see Table 5.7.) (King County Solid Waste Division 1993). The refuse generation rate is expected to increase annually as both population and per-person refuse generation increase (Harper-Owes 1988).

To comply with the King County Solid Waste Regulations, operations at the Vashon Island Landfill required placement of an impermeable cap and liner over the old refuse fill area and installation of a leachate collection and pretreatment system. The regulations also required installing an aerated lagoon to store and treat collected leachate. The leachate control system, designed by Harper-Owes and approved by the King County Department of Natural Resources Solid Waste Division, was completed in 1989 by capping and closing of the old fill area. The zone above the liner acts as the current refuse disposal area (Harper-Owes 1988, Harding Lawson 1991). The resultant profile of the landfill shows the old landfill lowest, an impermeable cap above the old landfill, a new liner above the impermeable cap, and the current refuse disposal area closest to the ground surface.

5.3.2 Effect on Ground Water Quality

Ground water quality and hydrogeologic studies have been performed at the Vashon Island Landfill by R. W. Beck and Associates/Sweet, Edwards & Associates (1984), Harper-Owes/Golder Associates (1986), Harper-Owes Associates (1988), and Harding Lawson Associates (1991). The Seattle-King County Health Department has been investigating ground water in off-site landfill wells since 1987. Harding Lawson's (1991) conclusions "indicate that the Landfill's leachate has potentially migrated to ground and spring waters"; however, ground water quality is improving. The leachate is more dilute than that typically found at Pacific Northwest landfills. During ongoing monitoring of off-site wells, Seattle-King County Health Department has found no evidence of off-site impacts from landfill leachate. The following subsections summarize the results of the investigations previously conducted concerning the Vashon Island Landfill.

Background

Ground water monitoring wells have been installed for the Vashon Island Landfill on-site and off-site by various consultants (see Figure 5.2). The boring logs from the installation of these wells indicate that ground water beneath the site occurs in two separate perched zones (referred to as "shallow" and "deep" water-bearing zones). Mounding of ground water beneath the landfill was reported by Harding Lawson Associates (1991) (see Figures 5.3 and 5.4), although no explanation of this occurrence was included in the study. According to Harding Lawson (1991), the water table in the shallow zone has dropped along the west side of the landfill as a result of the landfill closure, and the primary direction of ground water flow is to the west.

Six monitoring wells (four shallow and two deep) and three ground water seeps (areas where spring water flows out through exposed seams of sand) were periodically sampled by various consultants, King County Solid Waste Division (King County 1988c), and Seattle-King County Health Department. The water samples were submitted to a laboratory to be analyzed for pH, specific conductance, total solids, total dissolved solids, total suspended solids, chemical oxygen demand, total organic carbon, total organic halogens, biological oxygen demand, and dissolved oxygen. In 1995, eight new ground water monitoring wells were completed around the Vashon Landfill (four shallow and four deep). King County began collecting samples from these wells in November 1995. Hydrostratigraphic information from this latest round of well installations is included in the "Draft Monitoring Well Construction and Hydrogeologic Report for Vashon Island Landfill, 1995" prepared for King County Solid Waste Division by CH2M Hill, Inc.

(CH2M Hill 1995) The evaluation of the analytical results from the shallow and deep wells installed before 1995, and seeps are discussed in the following paragraphs.

Shallow Ground Water

Four shallow monitoring wells (MW-1, MW-3, MW-4, and MW-5S) were sampled by the King County Solid Waste Division between 1984 and 1992 and evaluated by consultants R. W. Beck, Harper-Owes, and Harding Lawson to determine the water quality in the upper water-bearing zone. Contours of specific conductance data in the shallow zone indicated a potential leachate plume spreading out from the landfill (R. W. Beck/Sweet, Edwards 1984, Harper-Owes/Golder 1986). The highest specific conductance levels occurred in samples collected from two wells (MW-4 and MW-5S) located downgradient (west) of the landfill (see Figure 5.2) (Harper-Owes/Golder 1986).

Harding Lawson's investigation of ground water in 1991 concluded that "downgradient wells are still impacted by leachate, but trends in water quality improvement exist" (Harding Lawson 1991). Samples collected by the King County Solid Waste Division from at least one downgradient monitoring well screened in the shallow water-bearing zone have exceeded water quality standards for total coliforms, arsenic, vinyl chloride, methylene chloride, and 1,1,1-trichloroethane during one or more sampling events since 1986.

Deep Ground Water

Deep monitoring Wells MW-2 and MW-5D were sampled by the King County Solid Waste Division between 1984 and 1992 and sample results were evaluated by R. W. Beck, Harper-Owes, and Harding Lawson to determine the water quality in the lower water-bearing zone. Leachate migration was suspected in the deep zone because the highest levels of specific conductance were detected in the western downgradient perimeter wells (MW-2 and MW-5D) (R. W. Beck/Sweet, Edwards 1984; Harper-Owes/Golder 1986). Samples collected from at least one downgradient monitoring well screened in the deep water-bearing zone have exceeded water quality standards for chromium, endrin, arsenic, vinyl chloride, methylene chloride, 1,1,1-trichloroethane, and lindane during one or more sampling events since 1986 (Harding Lawson 1991); chemical oxygen demand has been detected in MW-5D.

The capping of the old landfill fill area in 1989 may have caused COD concentrations to decrease in Monitoring Well MW-5D. Harding Lawson (1991) concluded that "the trend of dropping chemical oxygen demand indicates that vinyl chloride and methylene chloride levels may drop also." In addition, Harding Lawson stated that leachate generation from the old fill has been inhibited by the cap installed in 1989. Leachate is generated by water percolating through refuse. The cap acts to collect rainfall thus preventing further leachate generation in the refuse under the cap, and collecting and containing leachate generated by refuse on top of the cap for treatment. The amount of leachate produced is controlled by the amount of uncapped refuse and rainfall. The leachate produced is collected and transported off the Island for treatment.

More recently, the King County Solid Waste Division monitoring results have indicated dramatic improvements in the overall water quality indicators of leachate impacts for many monitoring wells (both shallow and deep). Arsenic detection, while sporadically above the ground water quality standards, has shown a decreasing overall trend. Vinyl chloride, however, has been detected with greater frequency and at higher concentrations since the closure of the old landfill. The King County Solid Waste Division believes the probable source of vinyl chloride is the landfill gas components dissolving into the ground water. The King County Solid Waste Division has scheduled the construction of the second stage of an active landfill gas collection and treatment system to be completed by September 1996. The initial stage, completed in 1995, consisted of the installation of eight new landfill gas perimeter probes to monitor the performance of the stage II system. The latter system consists of an interior landfill gas collection, extraction, and treatment system.

Spring Water (Seeps)

Approximately 4,000 to 5,000 feet west of the landfill, a steep slope cuts across a silt (aquitard)/sand contact layer (see Figure 5.5). Spring water seeps out of the contact and enters an unnamed creek, eventually discharging into Colvos Passage off the west coast of Vashon Island. R. W. Beck/Sweet, Edwards (1984) and Harper-Owes/Golder (1986) concluded that spring (seep) water was affected by leachate migration. Harding Lawson (1991) also suggested the possibility of leachate infiltration in the springs, based on moderately elevated levels of specific conductance, chloride, and chemical oxygen demand. These springs are routinely sampled by the King County Solid Waste Division. The quality of the spring water as it leaves the site generally meets the ground water quality standards. These springs are not used as a drinking water source. No potential users of the spring water are known; however, the King County Solid Waste Division has attempted to document users of the creek in which the spring water recharges (Jurgensen 1993). Spring water is probably composed of water from both water-bearing zones (Harding Lawson 1991).

Offsite Wells

Since December 1987, 11 off-site wells have been periodically monitored by Seattle-King County Health Department (see Figure 5.6). The ground water samples were analyzed for volatile and semivolatile organic compounds, organochlorine pesticides, and metals. None of the off-site monitoring wells have exhibited levels above primary drinking water standards for the constituents analyzed. At this time it is unknown whether the shallow and deep water-producing zones impacted by the landfill are interconnected with the aquifers utilized for public water supply wells., The Seattle-King County Health Department initially sampled four wells and five surface water sources around the landfill on a quarterly basis and, then on a biannual basis (Hickock 1993). Due to budget constraints, the Seattle-King County Health Department is no longer conducting off-site sampling around the landfill. Additional sampling will be based on need, as determined by the Seattle-King County Health Department (Hickok 1993).

Hazardous Waste Investigations and Cleanup Program

The Vashon Island Landfill is recorded on the Ecology list of Hazardous Waste Investigations and Cleanup Program (known or suspect contaminated sites) dated December 1988 as a state site undergoing long-term monitoring. From this list, the Toxic Cleanup Program ranks sites in an effort to prioritize sites for cleanup under the Washington State Model Toxics Control Act. For active landfills such as Vashon, where Seattle-King County Health Department is the permitting authority with assistance from the Ecology Solid Waste Services Division, Toxic Cleanup Program would not manage any cleanup activities. According to Ecology, the landfill has apparently affected surface water quality and may also have affected ground water quality (Safioles 1993).

The Ecology list reports contamination at sites as confirmed, suspected, unknown, potential, true, or false for each of 15 contaminant categories. The only contaminants listed as confirmed for the Vashon Island Landfill are "metals - other," which refers to metals other than the priority pollutants. The contaminants listed as suspected include priority pollutant metals, petroleum products, phenolic compounds, and conventional organic and inorganic contaminants (Ecology 1988b).

Future Plans

The King County Solid Waste Division and Seattle-King County Health Department will conduct additional investigations at the landfill and the surrounding area to determine the extent of the contamination as required by new federal (Resource Conservation and Recovery Act Subtitle D) and state (Chapter 173-351 WAC) regulations. Eight new monitoring wells have recently been installed (see background above). Four wells will monitor ground water located below the deepest ground water zone previously monitored at the site. The other four wells are installed in the ground water zones previously monitored. The wells are installed both upgradient and downgradient from the landfill (Jurgensen 1993, Keirnan 1996).

The Vashon Island Landfill has taken adequate corrective action with respect to closure of older landfill areas (Jurgensen 1993). The King County Solid Waste Division believes landfill gas to be the most likely source of vinyl chloride. The appropriate response and course of action for combustible gas detections is to first take strategic actions to control landfill gas, and then to consider whether additional actions are required to control vinyl chloride. The King County Solid Waste Division retained a consultant to recommend actions to control landfill gas. The consultant completed the Vashon Landfill Gas migration control study in 1993. Their recommended strategy for the control of landfill migration is a three stage plan. Stage I, consisting of the installation of eight new landfill gas perimeter probes, was completed in 1995. Stage II, consisting of an interior landfill gas collection, extraction, and treatment system will be completed in 1996. Stage III, if necessary, will include the design and construction of a perimeter landfill gas control system at the site in 1998.

An evaluation of three site Conceptual Development Alternatives was completed in 1995. Details of this evaluation are in the "Vashon Island Conceptual Development Alternatives Report, 1995" prepared for the Solid Waste Division by CH2M Hill. The study projects that the capacity in the existing developed landfill area will be exhausted in the first quarter of the year 2000, and recommended closure of the landfill and its replacement with a transfer station. King County accepted this recommendation, and plans for the development of a transfer station in the year 2000 are proceeding on schedule.

Risk

The King County Solid Waste Division believes it is unlikely that the landfill presents a significant risk to public water supplies because:

- Available ground water flow data suggest that the water-producing zones impacted by the landfill surface are springs; available public well records indicate there are no public water supply wells between the landfill property and where the springs appear.
- It is unlikely that water-borne pollutants would be able to move hydraulically upgradient.
- Available ground water quality data from landfill monitoring wells show dramatic improvements in overall water quality (with the exception of vinyl chloride) thus suggesting diminished risks to public water supply wells. Solutions to the landfill gas problem (source of vinyl chloride) are being investigated.
- Analytical results for samples collected from drinking water supply wells in the vicinity of the landfill have shown no indication of landfill impact, although the parameters of concern were not analyzed.

The King County Solid Waste Division recommends that the effectiveness of the landfill gas-control measures implemented in controlling vinyl chloride detections in ground water be monitored to see if additional measures are required to control vinyl chloride contamination.

Since drinking water supplies have not been affected and wastewater is not on the ground surface, the landfill does not meet the criteria of a severe public health hazard area and should not be investigated as such (Hall 1994).

5.4 Former NIKE Missile Launch Site

A former missile launch site is located at the northwest intersection of Southwest 220th Street and 119th Avenue Southwest, at the present location of Paradise Ridge Park (see Figure 5.1c). From 1955 to 1974, NIKE-Ajax and Hercules missiles were deployed from the site. A description of the activities formerly conducted at the site and the effect of those activities on ground water follows.

5.4.1 Description

According to J. A. Maas of the U. S. Army Corps of Engineers (Maas 1993), the NIKE site was composed of three areas: a family housing area, a missile launch site (see Figure 5.7), and a control site approximately one mile east of the launch site. The family housing area is now privately owned, the control site was conveyed to the Washington State Department of Health and Education in 1976, and the launch site was transferred from the U. S. Department of Defense to the King County Department of Parks, Planning, and Resources in 1976. The launch site has been an equestrian park since 1976.

According to Shapiro Associates (Shapiro/Applied Geotechnology 1992), diesel fuel; solvents; paints; anti-corrosion products; petroleum, oils, and lubricants; and their associated wastes were stored at the missile launch facility. Solvents, anti corrosion products, and paints were deposited into the building drainage system and later washed out of the building into a "small seepage system" (Shapiro/Applied Geotechnology 1992). Selected wastes were drummed for off-site disposal. Most fuels were stored in underground storage tanks at the launch and control sites.

The following additional information concerning the former NIKE missile launch site was provided by Maas of the U. S. Army Corps of Engineers (Maas 1993):

- The missile magazines were demolished at the launch site. Only the former missile assembly building and the caretaker's trailer remain.
- Asbestos was removed from selected buildings at the launch and control sites prior to their demolition.
- The underground storage tanks at the launch and control sites were removed between 1988 and 1989.

5.4.2 Effect on Ground Water Quality

The former NIKE missile launch site was investigated for potential toxic and hazardous waste contamination in 1988 and 1992 under the Defense Environmental Restoration Program by Shapiro Associates (Shapiro/Science Applications 1988, Shapiro/Applied Geotechnology 1992). The findings of the 1988 site investigation are as follows:

- 1,1,1-trichloroethane was detected at concentrations below environmental and human health concerns.
- Concentrations of lead and petroleum hydrocarbons were detected in the surficial soils at levels below environmental and human health concerns.
- Chlorobenzene, ethylbenzene, and total xylenes were detected in the soil at the former Paint and Fuel Storage Area at concentrations of concern to the environment and human health.
- Ground water samples collected from the on-site well did not contain volatile organic compounds, polychlorinated biphenyls, petroleum hydrocarbons, or trace metals at concentrations that present a concern for human health or the environment.

The soil at the Paint and Fuel Storage Area was the focus of the 1992 site investigation. The Paint and Fuel Storage Area, located in the southeast-central portion of the facility (see Figures 5.7 and 5.8), encompasses 620 square feet of the 66.33-acre launch site. The findings of the 1992 site investigation are as follows:

- Concentrations of total xylenes, trichloroethene, diesel 6, diesel 2, and/or gasoline above the 1991 Model Toxics Control Act Method A cleanup levels for soil were identified in samples collected from the eastern portion of the former Paint and Fuel Storage Area (Soil Samples S-9, S-14, S-15, S-23, and S-24) (see Figure 5.8).
- The vertical extent of soil contamination at Sample Locations S-23 and S-24 has not been defined.

The U. S. Army Corps of Engineers will mitigate the Paint and Fuel Storage Area by removing five feet of contaminated top soil, then another five feet of clean soil, from the approximate diameter of the Paint and Fuel Storage Area. Clean soil will replace the soil removed, completing remediation of the site (Mann 1993).

No ground water samples were collected at the former Paint and Fuel Storage Area. Studies conducted at the site and the general ground water information in the vicinity of the site indicate ground water is located relatively deep (approximately 100 feet) (Mann 1993). There is no threat to ground water quality at the site (Mann 1993).

5.5 On-Site Sewage Systems

The King County Comprehensive Plan governing on-site sewage treatment and disposal systems now recognizes on-site wastewater disposal, i.e., septic systems, as a long-term wastewater treatment and disposal method for areas not served by public sewers . At present, the entire Island lying outside the Vashon Sewer District local service area in the Town of Vashon (see Figure 5.9) uses on-site wastewater treatment and disposal systems.

A description of activities involving regulation and monitoring of septic systems and the effects of septic systems on ground water follows.

5.5.1 Description

The minimum size for unsewered lots in new subdivisions is regulated as a function of the texture of the underlying soil under the King County on-site sewage regulations. The type of on-site treatment and disposal system permitted on the site then depends on the undisturbed original soil depth and the lot size (King County Board of Health 1987, Clemans 1993). The regulations stipulate a requirement for a drainfield reserve area. The Carr study resulted in the 1986 changes in the subdivision regulations for Vashon (King County 1986), often requiring minimum lot sizes for new subdivisions much larger than those required under the King County on-site sewage regulations (Clemans 1993).

The 1986 Vashon Community Plan requires that the maximum housing density in unsewered areas be no more than three houses per acre, provided that more than 30 inches of topsoil is present. A 2.5-acre minimum lot is required in unsewered areas with 24 to 30 inches of topsoil. Unsewered areas with 20 to 24 inches of topsoil may support no more than one house per five acres (King County 1986).

5.5.2 Effect on Ground Water Quality

According to the U. S. Environmental Protection Agency, septic systems and cesspools are the most frequently reported sources of ground water contamination (Freeze and Cherry 1979). Drainfield effluent has been implicated in producing elevated nitrate and phosphate concentrations in ground water and can contain pathogenic bacteria and viruses in areas where more than one residence per acre are present (Clemans 1993). The aerobic bacteria called fecal coliforms is considered the standard indicator parameter for potential drainfield effluent contamination (Lewis 1980) and is evaluated (in surface water and sediment, shellfish, spring water, and ground water) in the data analysis portion of this chapter.

5.6 Biosolids Applications

Biosolids, formerly known as sludge, is a by-product of sewage treatment. In some cases, biosolids may be spread in vegetated areas with beneficial effects. How the Vashon Sewage Treatment facility handles its biosolids and the possible effect of those biosolids applications on ground water quality are described below.

5.6.1 Description

The Vashon Sewage Treatment facility produces about 10 tons of biosolids (dry weight) annually. Currently, the biosolids are transported off the Island for further treatment and/or disposal at an approved facility (Ames 1993). The utilization site currently meets the qualifications for a low-application rate project (less than four dry tons per acre per year).

5.6.2 Effect on Ground Water Quality

Total coliforms, fecal coliforms, and inorganic compounds (nitrates and metals) are the indicator parameters typically used to detect ground water contamination by sewage waste. Due to the small quantities of biosolids produced by the Vashon Sewage Treatment facility, extensive ground water monitoring is not required (Moran 1993). However, a site permit is required from Seattle-King County Health Department for any land utilization of biosolids. The biosolids were analyzed by Laucks Testing Laboratories of Seattle in December 1987; estimates of fecal strep, fecal coliforms, and total coliforms exceeded 160,000 per 100 milliliters of biosolids. The sample contained less than 2-percent solid material. Further results of biosolids testing are shown in Tables 5.8a and 8.5b.

5.7 Underground Storage Tanks

The Ecology listing of underground storage tanks in Washington (see Table 5.9.) reports 28 underground storage tanks in use at commercial locations on the Island; Ecology does not maintain records of residential underground storage tanks. The following paragraphs describe the uses of commercial underground storage tanks on the Island and associated reported incidents, followed by a description of the effects of spills or leaks from those commercial underground storage tanks on ground water.

5.7.1 Description

The majority of reported commercial underground storage tanks in the Vashon-Maury Island Ground Water Management Area are located in or near the Town of Vashon (see Figure 5.1c), but they are also listed at Burton, Camp Sealth, Dockton, Vashon Landfill, and at the KING radio tower on Maury Island. The underground storage tanks range in size from less than 500 gallons to 20,000 gallons and are reported to contain the following substances: diesel fuel, kerosene, leaded gasoline, unleaded gasoline, alcohol, or 1,2,4 oil (Ecology and U. S. Environmental Protection Agency 1993).

Approximately 700 residential underground storage tanks on the Island are serviced by the Williams Heating Oil Company; perhaps 50 to 100 more are served by other suppliers or have been abandoned (Murphy 1989). The status of the underground storage tanks (active vs. inactive) is unknown. No new underground storage tanks have been added to the service area since 1989, although recently approximately three to six customers have switched from heating oil to gas (Gregory 1994).

5.7.2 Effect on Ground Water Quality

Spills and leaks from underground storage tanks can be highly detrimental to ground water quality, and incidents of this nature are not uncommon in urban areas of Washington. However, of the 28 reported commercial underground storage tanks on the Island, there have been only seven confirmed incidents of commercial leaking underground storage tanks since 1993. Six sites where underground storage tank leaks occurred; those sites have been cleaned up to the Ecology requirements. Only soil was impacted at one incident involving a leaking commercial underground storage tank on the Island was reported in 1989 (Ecology 1989). The incident involved removal of a underground storage tank containing heating oil from a public elementary school. According to Ecology, site evidence indicated that the tank had leaked. The cleanup operation for this site is still in progress (Knowlton 1993).

New commercial tanks and their associated piping installed after December 1988 must meet the Ecology underground storage tank regulations for release detection, corrosion protection and spill/overflow protection. Existing commercial tanks installed prior to December 1988 must meet the Ecology release detection requirements by December 1993, with the exception of release detection for emergency power generator tanks and piping installed between 1975 and 1988. These latter tanks must comply with release detection requirements by December 1995. All existing commercial tanks must meet the Ecology underground storage tank requirements for corrosion protection and spill/overflow protection by December 1998. However, commercial underground storage tank owners work to comply with federal regulations regarding underground storage tank inspection, replacement, and abandonment previously unrecognized areas of contamination may be discovered (Knowlton 1993).

Residential underground storage tanks are not subject to the regulatory requirements for commercial underground storage tanks unless there is a confirmed leak. Then, residential underground storage tanks are subject to the same Ecology standards for cleanup as commercial underground storage tanks. Although residential underground storage tanks are smaller in size and capacity, they represent a bigger ground water quality concern because of their larger numbers (in excess of 700 residential underground storage tanks compared to 28 commercial underground storage tanks). In addition to being unregulated, residential underground storage tanks are usually older than commercial underground storage tanks, and quite often they are not as well constructed. Residential underground storage tank owners tend to pay less attention to determine if their tank is leaking, particularly during periods when the tank is not in use, i.e., the summer months (Knowlton 1993).

5.8 Agriculture

The majority of agricultural land in the Vashon-Maury Island Ground Water Management Area is located in the interior region of Vashon Island, with minor additional acreage and a 55-acre golf course on Maury Island (see Figure 5.1c). Agricultural land uses on the Island are described below; the effects of agricultural operations on ground water quality are described in Section 5.8.2.

5.8.1 Description

According to the 1986 Vashon Community Plan, a 1976 study found that about 900 acres of the Island were devoted to agricultural uses, including commercial orchards, berry farms, vineyards, nurseries, and small commercial ranches. That 1976 study stated that the Island had the only large, commercial cherry and apple orchards and produced the entire harvest of currants in King County. Also, about one-third of the Island agricultural acreage was devoted to the production of grass and hay. In 1989, at least one commercial orchard was still in operation as well as commercial farms of various sizes, several horse and cattle ranches, and a few greenhouses (Becker 1989).

5.8.2 Effect on Ground Water Quality

Traditional agricultural operations present two possible risks to ground water quality where: (1) fertilizer and pesticide use and (2) animal waste products. Fertilizers and pesticides used on crops can cause elevated nitrate levels in surface and ground waters, while pesticides can be toxic at relatively low concentrations in ground water. The Washington State Department of Agriculture has no mechanisms in place to collect data on the amounts of pesticides or fertilizers used (Reid 1993).

A 1987 U. S. Environmental Protection Agency list of pesticides used on crops grown on the Island includes nine leachable pesticides known to have been used at least occasionally (diuron, fenamiphos, pronamide, simazine, dinoseb, dicamba, chloramben, carbofuran, and disulfotan) and an additional three that may have been used at some time (dalapon, terbacil, and atrazine) (U. S. Environmental Protection Agency 1987). The Cooperative Extension Service in Tacoma provided a slightly different list of herbicides and pesticides commonly used on some of the Island commercial crops: ronilan, carbofuran, dodine, azimphosmethyl, and 2,4-D. According to Bill Shear of the Cooperative Extension Service in Tacoma, the U. S. Department of Agriculture requires permits for spraying restricted pesticides, but not for spraying those that are unrestricted (Shallow 1989).

Fertilizers and pesticides are applied to the 55-acre Vashon Golf Course on Maury Island. Scotts™ Starter Fertilizer is applied in the spring, Scotts™ 15-0-28 in the summer and fall, and lime is applied in the winter. All are applied at the recommended rate. Bob Newman of the Northwest Division of Ecology recalled one incident in which a truck leaked a small quantity of pesticide on the Island, but said that he did not consider it to be a major contamination event (B. Newman 1989). The extent of residential pesticide and fertilizer use is not known, as the Washington State Department of Agriculture does not have the mechanisms in place to collect this data.

Farm animal waste may cause elevated nitrate concentrations in ground water; however, the effects of Island ranching operations on the ground water have not been investigated by regulatory agencies. Elevated nitrate levels have been detected in ground water samples collected from the Coast Guard well on Point Robinson. These elevated nitrate levels may be the result of the historic practice of keeping horses in the area where a well is now located (Carr 1983).

5.9 Sand and Gravel Extraction

Four large commercial and several smaller sand and gravel extraction operations are located in the Vashon-Maury Island Ground Water Management Area. A brief description of the operations and their effect on ground water is presented in the following subsections.

5.9.1 Description

Approximately 520 acres along the south shore of Maury Island are zoned for quarrying and mining. Four major facilities operate throughout the year in this area. Several smaller sites are operated intermittently across the Island. The locations of these extraction operations are shown on Figure 5.1c.

The Vashon Sand and Gravel plant, the largest extraction operation on the Island, reportedly has an on-site wash plant, a well approximately 500 feet deep with a 7½ horsepower pump capable of pumping 35 gallons per minute (gpm), and a settling pond for wastewater.

5.9.2 Effect on Ground Water Quality

Contamination associated with sand and gravel extraction on the Island is unknown (B. Newman 1989). Only the Vashon Sand and Gravel plant is reported to produce a significant volume of wastewater, which is collected in a settling pond. Further details regarding the integrity of the settling pond were not available. Similarly, the quality of ground water in the plant well is not known.

Sand and gravel pits will be required to obtain a General National Pollutant Discharge Elimination System Permit for Sand and Gravel Operations from Ecology by July 1994. Surface water discharge from these facilities will be required to meet state water quality standards. Surface water sampling will not be required to obtain a permit, although Ecology may opt to sample potential areas of contamination (B. Newman 1994).

King County also requires a grading permit for excavations of sand and gravel with a volume exceeding 500 cubic yards. The applicant must demonstrate that the conditions regarding operation and reclamation of the site are met. Grading permits are renewed annually allowing the Department of Developmental and Environmental Services to institute new conditions of the permit (Seattle-King County Health Department 1994).

The Metropolitan King County Council is currently revising the zoning code including a chapter on reclaimed lands. This section is very general and does not address ground water concerns. The source of fill being used in reclamation is specified in the initial permit and upon annual updates. Applicants must provide fill approved by Ecology (Seattle-King County Health Department 1994).

The Washington State Department of Natural Resources and King County assign permits for sand and gravel mining operations. The Washington State Department of Natural Resources permit designates the site active until reclamation is completed to Washington State Department of Natural Resources requirements. The King County permit defines conditions under which the sand and gravel operation must operate as established during environmental review.

5.10 Seawater Intrusion

Seawater intrusion into ground water sources is of concern in the Vashon-Maury Island Ground Water Management Area because many of the wells operating on the Island are relatively close to the shoreline. Seawater intrusion is first described below, then the results of testing conducted to evaluate the intrusion of seawater into the ground water are presented.

5.10.1 Description

Wells that tap aquifers adjacent to seawater bodies, such as Puget Sound, may become saline if the freshwater/seawater interface moves inland in response to high pumpage of ground water use. Artificial recharge, freshwater injection wells, and other methods have been employed to counter the problem of seawater intrusion in low-lying coastal areas such as Florida (Driscoll 1986). Chloride is used as the indicator parameter for seawater contamination in ground water.

5.10.2 Effect on Ground Water Quality

Ground water samples collected from nine wells on the Island by Carr in 1982 contained chloride levels above 10 milligrams per liter (mg/L); all of the wells are within about 1/2 mile of the shoreline (see Figure 5.1c). The wells with higher chloride levels identified by Carr were located on the northern end of Vashon Island and on the southeastern portion of Maury Island. Carr states that these wells show a definite indication of seawater intrusion; however, the reported chloride levels are substantially lower than the average chloride content of seawater, i.e., approximately 19,000 mg/L (Driscoll 1986). "Freshwater generally contains less that 30 mg/L of chloride" (Ecology 1988a). According to Ecology, "Some scientists use a value of 100 mg of chloride per liter as an indicator of intrusion" (Ecology 1988a).

The Seattle-King County Health Department collected ground water samples from 21 wells on the Island in 1989 and 1990 (as discussed in Section 8.5.3.2); chloride levels between 10 mg/L and 20 mg/L were reported in three wells. The wells with the higher chloride levels were located near the shoreline at northeastern Vashon Island (W-3) and northern Maury Island (W-8 and W-10B). Evidence of seawater intrusion was not detected in these wells during 1989 to 1990, if the suggested indicator values of seawater intrusion (above) from Ecology are used. Although not part of the current study of monitoring wells, the Seattle-King County Health Department became aware of a Group B community well in the northeast area of Vashon Island whose use was discontinued due to seawater intrusion (Shallow 1993)

5.11 Roadside Spraying

Roadside vegetation is commonly sprayed with herbicides and/or pesticides, to control weed growth, limit the spread of brush and trees, protect newly planted beds from disease and insects, or control insects and weeds in specific spots. Herbicides and pesticide application on the Island and the effects of roadside spraying on ground water is described in the following subsections.

5.11.1 Description

The Vashon-Maury Island Ground Water Management Area is a herbicide moratorium area, meaning that herbicides are applied only to tansy ragwort, a noxious weed which is deadly to livestock (G. Newman 1989). The King County Department of Transportation Road Services Division uses the herbicides Banvel and Garlon 3-A, typically combined in a ratio of one quart of Banvel to two quarts of Garlon 3-A to 100 gallons of water. King County Department of Transportation personnel drive along every public right-of-way on the Island, selectively spraying each tansy ragwort plant and its surrounding area to a radial distance of approximately three feet. The job usually requires one to two weeks. In July 1989, King County Department of Transportation personnel prepared 200 gallons of diluted herbicide one workday before beginning to spray on the Island. They then sprayed on the Island for eight days, at the end of which time there was an estimated 50 gallons of herbicide remaining in the tank (Easter 1989).

According to A. Card of the Washington State Department of Natural Resources, the Washington State Department of Natural Resources does not currently spray the roadside on the 205 acres of land that it manages on the Island. The Washington State Department of Natural Resources conducts only occasional small-scale herbicide application on this acreage, using either hand-held squirt bottles to spray thin streams on selected plants or a cut-and-daub method in which herbicide is applied by hand to the base of a severed tree limb (Card 1989).

5.11.2 Effect on Ground Water Quality

Application of herbicides and pesticides to control roadside plants can threaten ground water quality in two principal ways. First, chemicals may be transported by storm water runoff into areas of high aquifer recharge. Second, chemicals may percolate into shallow aquifers through fissures or dry and sandy soils. The exposed clay-rich till along the roadside on the Island, however, may absorb some of the chemicals before they reach ground water.

No incidents of contamination from roadside spraying have been reported to Ecology. As discussed in Section 5.8.2, Agricultural Effects on Ground Water Quality, a small pesticide leak from a truck was recorded in the Ecology records, but no other pesticide- or herbicide-related incidents are on record (B. Newman 1989).

5.12 Hazardous Materials

The term "hazardous material" refers to "hazardous waste" as well as to "hazardous substances," both of which are generally defined as materials that pose a substantial present or potential threat to human health or the environment. These include both hazardous wastes generated by commercial operations and hazardous substances used in residential households. The following subsections describe the hazardous materials on the Island and their effect on ground water quality.

5.12.1 Description

Importation of hazardous materials to the Island is regulated by the Washington State Ferry Service, which provides the only access to the Island. Hazardous materials must be shipped aboard ferries that are not carrying passengers and that dock at the Fauntleroy dock in West Seattle, where special ferry runs can be arranged to accommodate hazardous loads. The Washington State Ferry Service has no authority to search enclosed vehicles and operates under the assumption that shipping papers prepared by companies correctly describe the hazardous materials being transported. The Washington State Ferry Service can request that the Washington State Patrol inspect shipments of hazardous materials (Baird 1989).

Under a King County program, county residents can dispose of household hazardous wastes, such as paint thinners and solvents, at the King County Wastemobile. The Wastemobile is a disposal truck that travels around King County accepting household hazardous waste from county residents at no charge. The Wastemobile, which began waste collection on the Island in mid-1989, did not return to the Island until 1990 (Clemans 1994).

The U. S. Environmental Protection Agency and Ecology maintain records of hazardous waste sites and generators, both active and inactive. According to the U. S. Environmental Protection Agency listing of March 31, 1989, there are no Comprehensive

Environmental Response, Compensation, and Liability Act or Superfund sites on the Island (U. S. Environmental Protection Agency 1989b). The only Island site included on the Ecology State Hazardous Waste Investigations and Cleanup List dated September 12, 1989 is the Vashon Island Landfill. The landfill is characterized as undergoing long-term monitoring after completion of cleanup.

The U. S. Environmental Protection Agency/Ecology list of Hazardous/Dangerous Waste Notifiers dated November 15, 1993 lists nine Island businesses (Ecology/U. S. Environmental Protection Agency 1993). Of these nine businesses, only four are active and are regulated generators of hazardous or dangerous waste. These four businesses are Joy's Village Cleaners, K-2 Corporation, Laidlaw Transit Inc., and the Oberpark Metro Park and Ride; all are located in or near the Town of Vashon. The status of the remaining five businesses has been either withdrawn or canceled. Canceled status indicates the business is no longer operating. Withdrawn status indicates the business is no longer generating hazardous or dangerous wastes. The businesses with withdrawn status include Island Industries and Olympic Instruments; Natural Products Co. has canceled status of the two remaining business listed, the King County Solid Waste Division never generated hazardous waste, and Burton-Shell was a one-time generator (Misko 1993).

There are no hazardous materials produced at the Oberpark Metro Park and Ride; however, occasionally an Islander leaves a drum of hazardous waste. King County Department of Transportation has their licensed hazardous waste contractor haul the drum off the Island. Buses are not cleaned on the Island.

In the past the Local Hazardous Waste Program in King County, with personnel from the King County Department of Natural Resources, Water Pollution Control Division/Seattle-King County Health Department has inspected eight small quantity generator businesses as a result of complaint or request. These businesses are: BP gas station, Vashon Hardware, Island Auto Wrecking, Engel's Auto Repair and Towing, Doug's Foreign Car Repair, Brennos, the Vashon Fire Department, and the Vashon Island School District. Small-quantity generators produce less than 220 pounds of hazardous waste each year. Hazardous waste spillage at small quantity waste generators is a priority of the Local Hazardous Waste Program in King County. Businesses where hazardous waste spillage is observed are referred to Ecology for follow-up (Coville 1993).

5.12.2 Effect on Ground Water Quality

Only a few incidents involving hazardous materials in the Vashon-Maury Island Ground Water Management Area have been reported. Ecology was responsible for disassembling an illegal drug lab at the southern end of Vashon Island and removing stockpiled materials. Neither incident resulted in apparent contamination. No spills have been reported at the K-2 Ski Manufacturing Corporation or Pacific Research plants (B. Newman 1989).

Bob Newman of the Northwest Division of Ecology recalls that a drum of flammable solvent was removed from a roadside several years ago by Ecology (B. Newman 1989). According to Seattle-King County Health Department (1990), the drum of flammable solvent was from the Stoltz property, which is used as a junkyard and is located south of and adjacent to the Vashon Island Landfill (Southwest 196th Street and east of 130th Avenue Southwest). Further investigation of potential contamination in soil, surface and ground water near the 28-acre junkyard is recommended. In the past, electrical transformers have been stored and scrapped at the Stoltz junkyard; there may be polychlorinated biphenyls contamination on the site as polychlorinated biphenyls were commonly used in transformers.

5.13 ASARCO Smelter

The ASARCO smelter and other closed smelters on the mainland may have contributed to elevated contaminant levels reportedly found in soil samples collected from the southern portions of the Island. Information concerning the suspected contamination and its effect on ground water are described below.

5.13.1 Description

Airborne particulate material from the ASARCO smelter and other closed smelters in Ruston, Washington, located on the mainland southeast of the Vashon-Maury Island Ground Water Management Area, may have been carried over the Island when the wind blew from the east over the operating smelters. The ASARCO smelter, now a Comprehensive Environmental Response, Compensation, and Liability Act site, is one of the suspected sources of elevated arsenic, cadmium, and lead levels reportedly found in soil samples taken at several locations near the southern ends of the Island (Carr 1983, Seattle-King County Health Department, Washington Department of Health and Tacoma-Pierce County Health Department 1984).

5.13.2 Effect on Ground Water Quality

In Carr (1983), water samples from 10 springs and streams were analyzed for arsenic, cadmium, and lead. All values were below the laboratory detection limit. Samples collected below the Vashon Island Landfill were also below the limits of detection. Carr stated that the metals had been retained by the soil and were effectively prevented from infiltrating to the ground water.

In 1984, the Washington State Department of Health (formerly the Department of Social and Health Services) with assistance from Seattle-King County Health Department and the Tacoma-Pierce County Health Department conducted a study of unprotected drinking water sources to determine whether arsenic, cadmium, and lead were present, and, if so, whether their presence constituted a health risk (Seattle-King County Health Department 1984). Of the 50 wells, springs, and surface water sources sampled for the study, 20 wells, 11 springs, and two surface water sources were located on the Island. The

Washington State Department of Health concluded that arsenic, cadmium, and lead were not present at significant levels in the unprotected drinking water sources utilized in the study.

A Washington State Department of Health/Seattle-King County Health Department/Tacoma-Pierce County Health Department study conducted from 1982 through 1984 examined heavy metals in honeybees in the Puget Sound area. The study found arsenic concentrations as high as 18 to 20 parts per million (ppm) in bee colonies near the southern ends of the Island, compared to background levels of 0.1 to one ppm in bees on Whidbey Island. The supervisor of the study concluded that the arsenic taken up by the bees was primarily airborne (Bromenshenk 1989).

The Ruston/Vashon Arsenic Exposure Pathways Study, prepared by the University of Washington under contract with Ecology (University of Washington 1987), was aimed at determining the pathways by which humans are exposed to arsenic, and the daily arsenic intake of the population living in the vicinity of the copper smelter in Ruston, Washington. Households in Ruston and on the Island participated in the study, which involved collecting urine and hair samples and measuring environmental concentrations of arsenic. Drinking water was sampled in all of the study areas. The final report, issued in March 1987, concluded that the highest concentrations of arsenic were found near the smelter, even though it was closed; demolition activities were thought to be responsible for elevated levels of airborne arsenic. Arsenic concentrations in drinking water samples collected in the study area were lower than state and federal minimum standards and were comparable to concentrations reported from other areas in the Puget Sound area.

6.0 WATER APPLICATIONS

This section discusses water applications on the Island in terms of demand, services, rights, and uses. The systems which handle storm water for the Island are also described. Each subsection below discusses a separate area of concern.

6.1 Water Demand

Future water demand is generally predicted using demographic projections and reasonable values for per-person or per-household daily consumption. Figures for future water demand are then compared to the calculated production capacity of the aquifer(s) to evaluate the adequacy of the supply relative to the demand.

6.1.1 Demographic Projections

Population forecasts by the Puget Sound Regional Council and King County for the Vashon-Maury Island Ground Water Management Area are identical. As discussed in Section 5.1.2.1, Residential Development Trends, the Puget Sound Regional Council predicts a 50-percent increase in population on the Island during the years 1980 to 2000 (see Table 5.3.). The 1993 Annual Growth Databook (see Table 5.4.a) also predicts a population growth of 50 percent during the same 20-year period. Using these figures, projected water demand can be estimated.

6.1.2 Projected Water Demand

Projected water demand in the Vashon-Maury Island Ground Water Management Area has been calculated using a per-person consumption value of 120 gallons per day (gpd) (Carr 1983) for both the Puget Sound Regional Council and Annual Growth Databook population forecasts (see Tables 6.1 and 6.2, respectively). Calculations using both the Puget Sound Regional Council and Annual Growth Databook figures yielded a value of over one million gallons for daily water demand for the entire Island in 1990, which translated into an annual demand of 408 million gallons. By the year 2000, the annual demand for Vashon is projected to be 486 million gallons (1.33 million gallons per day [mgpd]).

The water demand using the per-person consumption values were revised based on consumption figures provided by Group A purveyors. The revised consumption values are 103 gpd per person (average consumption) and 180 gpd (maximum consumption. Calculations using these values yield a water demand of 350 million gallons per year (mgpy) (average) and 612 mgpy (maximum) or 0.96 and 1.68 mgpd, respectively. Annual water demand is estimated at 417 mgpy (average) and 729 mgpd (maximum), or 1.14 and 2.00 mgpd for the year 2000.

6.1.3 Aquifer Recharge and Capacity

The ability of the Island to meet projected water demands depends largely on the supply available from the Island aquifers. These aquifers were broadly grouped into the "Principal" and "Deep Aquifer" by Carr. The recharge of the Principal Aquifer was calculated by Carr to be approximately 8.90 mgpd or 3.17 billion gallons per year (bgpy), and the Deep Aquifer recharge was estimated to be between 1.73 and 3.46 mgpd or 0.6 bgpy and 1.23 bgpy. The Deep Aquifer recharge estimates are much more uncertain than the Principal Aquifer, because less information is known. Based on the Carr recharge data, the production capacity of the Principal Aquifer was evaluated.

Carr (1983) states that an estimated 45 percent of recharge occurs in high recharge areas, which represent about 25 percent of the land surface area. Not all the water in the aquifer is available for withdrawal, however; Carr estimates a total water productivity from the Principal Aquifer of about 1.58 mgpd (578 mgpy). This estimate takes into consideration the effects on production of drought and inefficient withdrawal. Carr did not perform similar calculations for the Deep Aquifer.

The amount of water on the Island, as calculated by Ed McGavock for this study is estimated at 11.67 mgpd or 4.26 bgpy, although not all of that water can be withdrawn from the water bearing zones. The Island aquifer systems, physical susceptibility (recharge) areas, and water availability are reassessed and discussed in detail in Section 8, Hydrogeology.

6.2 Water Service

The 1986 Vashon Community Plan (King County 1986) establishes the entire Vashon-Maury Island Ground Water Management Area as a Water Service Area, an area in which public water service is permitted. Under this classification, private water systems are not restricted to the Vashon-Maury Island Ground Water Management Area. As used in the 1986 Plan, "public water service" includes Group A and B water systems, both publicly and privately owned.

A wellhead protection program must be developed under the 1986 amendments to the federal Safe Drinking Water Act. The wellhead protection program goal is to prevent contamination of public drinking water supplies. The seven major purveyors have begun planning for wellhead protection to comply with the Washington State Department of Health Wellhead Protection Program requirements. Planning details include:

- Characterizing the hydrologic setting;
- Performing a susceptibility assessment;
- Assessing the circularity of the zone of contribution;
- Selecting an appropriate delineation method;
- Modeling and mapping the Wellhead Protection Area using the (interim) Calculated Fixed Radius Method; and
- Establishing a wellhead protection committee.

Tables 6.3a and 6.3b list available information regarding the seven major water purveyors on the Island; all are Group A systems. Table 6.3c lists the Group B purveyors on the Island. Table 6.4 displays the construction, operations, and maintenance design criteria regulated for public water systems by the Washington State Department of Health. Figure 6.1 illustrates the areas of distribution, sources, and storage facilities of the seven major water purveyors on the Island.

The only publicly owned water purveyor on the Island is King County Water District No. 19, but six privately owned Group A purveyors operate to meet additional water demands. The following discussion of the largest Group A (formerly Class 1) water purveyors is based mainly on information contained in the Vashon Coordinated Water System Plan (Horton Dennis 1990).

6.2.1 King County Water District No. 19

King County Water District No. 19 is the only public water system in the Vashon-Maury Island Ground Water Management Area. Established in 1925, the District has 1,075 connections and is the largest water system on the Island. The service area of this District covers approximately six square miles in east-central Vashon Island (see Figure 6.1); consumers range from single-family houses in low-density residential areas to commercial and industrial concerns.

The District obtains water from two plants. Plant No. 1 uses a surface water source and is located on Beall Creek. The supply averages 200 gpm and continues during dry months because ground water flows out through seeps, the exposed seams of sand in the walls of the stream valley.

Plant No. 2 uses a surface water source, a developed spring, and a well. Water from Ellis Creek provides approximately 235 gpm, and the nearby-developed spring provides approximately 50 gpm. The well (Well No. 2) is located in the Town of Vashon, near the intersection of 103rd Avenue Southwest and Southwest 176th Street, in the water storage tank area. The well is 670 feet deep (completed depth) and yields an average of 250 gpm. An additional deep well (Well No. 1) is located adjacent to Well No. 2 and is used as a backup source (Quesinberry 1994).

The District has a total storage capacity of approximately 1.725 million gallons distributed between two pressure zones. Storage facilities for Pressure Zone 1 consist of two tanks with a combined capacity of 1.625 million gallons. These tanks serve 704 connections. The storage facility for Pressure Zone 2 is a 100,000-gallon reservoir located on Southwest 216th Street near its intersection with 99th Avenue Southwest. The reservoir serves approximately 260 connections. Storage facilities for the two pressure zones are interconnected.

6.2.2 Heights Water Association

The Heights Water Association is a private, nonprofit corporation that serves the north end of Vashon Island (see Figure 6.1). The Heights Water Association maintains approximately 571 connections (Fitzpatrick 1994), most of which are private homes, but which also include the Vashon Nursing Home, the Washington State Ferry Service facilities, and Vashon Elementary School. The Heights Water Association is currently not accepting new water-share applications.

The Heights Water Association obtains water from springs and wells located in the northeast quarter of Section 18, Township 23N, Range 3E, where the Heights Water Association holds water rights to approximately 17 acres. Two unnamed springs at the base of a steep ravine yield an average of 150 gpm; three wells located on higher ground west of the springs supply about 200 gpm.

The Heights Water Association has a total storage capacity of approximately 330,000 gallons in five covered storage reservoirs. Four of the reservoirs are interconnected and supply the majority of the system; the fifth reservoir, at the south end of the system, provides supplemental storage. An additional 40,000 gallons of storage capacity is provided by collection basins located at the spring source; however, this water is not available by gravity flow. The south end of the Heights Water Association system is interconnected with King County Water District No. 19; this connection can be opened manually in the event of an emergency.

6.2.3 Westside Water Association

The Westside Water Association is a nonprofit cooperative serving an area of approximately two square miles in northwest Vashon Island near Fern Cove (see Figure 6.1). The Westside Water Association has approximately 219 metered connections, all of which are private, with five future connection rights sold.

The Westside Water Association maintains a 40-acre watershed area in Cedarhurst Canyon (also known as Shinglemill Creek Canyon or Needle Creek Canyon), one of the largest drainage basins on the Island. The Westside Water Association obtains about 80 gpm from a number of artesian well points located in the walls of the canyon (Dolstad 1994). The Westside Water Association has a total storage capacity of about 253,000 gallons in two aboveground tanks.

6.2.4 Burton Water Company

The Burton Water Company is a private company serving the Burton Peninsula and the surrounding area (see Figure 6.1). A majority of the estimated 375 Burton Water Company customers are private homes, but the Burton Water Company also serves a small neighborhood center and an elementary school.

The Burton Water Company obtains water from a combination of wells and well points that extend to about 18 feet below land surface (bls) on a 5-acre plot near the intersection of Southwest 232nd Street and 115th Avenue Southwest. Production varies with rainfall, averaging between 125 and 150 gpm during the drier summer months when demand is greater. Surface runoff to Puget Sound during the winter months is significant.

The Burton Water Company has a total storage capacity of approximately 170,000 gallons. Storage facilities include three tanks, all located at the supply site. Four pumps are used to transfer water from the wells and well points to the tanks during peak-demand periods; during winter, the pumps are used only occasionally.

6.2.5 Dockton Water Association

The Dockton Water Association is a nonprofit association serving 294 customers on the southern portion of Maury Island (see Figure 6.1); all but one of the customers (county marina) is residential (Todd 1994). Additional 71 reserve memberships entitle landowners to service at an unspecified future date.

The Dockton Water Association obtains water from two springs, Dockton Park and Hake Springs, and one well, Sandy Shores, in the service area. Dockton Park Spring, located across Portage-Dockton Road from the Dockton-King County Park in the village of Dockton, yields an average of 30 to 35 gpm and is collected from well points scattered over 10 acres of watershed (Todd 1994).

The Hake Spring, located on a 25-acre site abutting Southwest 268th Street southwest of Dockton, yields five to seven gpm. The spring is intercepted by plastic pipe before reaching the surface and partially diverted to a Dockton Water Association storage unit.

The Sandy Shores well, located on 94th Avenue Southwest south of Dockton, is 415 feet deep. The well is capable of producing 100 gpm with no more than 10 feet of drawdown.

The Dockton Water Association has a total storage capacity of approximately 381,000 gallons distributed between two pressure zones. Storage facilities for the lower pressure zone, supplied with water from the springs, consist of three ground-level concrete tanks with a combined capacity of 65,000 gallons. Storage facilities for the upper pressure zone, supplied with water from the Sandy Shores well and from lower-level reservoirs, consist of two concrete standpipe tanks with a combined capacity of 316,000 gallons. Storage facilities for the two pressure zones are interconnected.

6.2.6 Gold Beach Water System

The Gold Beach Water System is a privately owned and operated system serving 147 homes in the community of Gold Beach on the southeast shore of Maury Island (see Figure 6.1). The Gold Beach Water System obtains water from two wells, each about 110 feet deep, located on the northern edge of the Gold Beach community. The wells have a combined yield of about 250 gpm. The Gold Beach Water System has a total storage capacity of about 85,000 gallons, with 50,000 gallons available in a lower pressure zone and 35,000 gallons in an upper pressure zone. The two zones are interconnected.

6.2.7 Maury Mutual Water Company

The Maury Mutual Water Company is a privately owned cooperative that supplies 88 single-family homes and one commercial connection (the Vashon Country Club) on the northern end of Maury Island (see Figure 6.1). The Maury Mutual Water Company currently is not accepting new memberships into the cooperative.

The Maury Mutual Water Company obtains water from eight shallow-driven well points and two springs located on northern Maury Island near Southwest 232nd Street and 59th Avenue Southwest. These sources yield a total of about 35 gpm. The Maury Mutual Water Company has a total storage capacity of about 130,000 gallons. A mid-system facility provides about 72,000 gallons of storage, and two upper-level reservoirs provide a combined capacity of 58,000 gallons (Baxter 1994).

6.2.8 Other Water Systems

The seven systems previously discussed represent only the major water purveyors in the Vashon-Maury Island Ground Water Management Area. More than 100 Group A (formerly Class 2) and Group B public water systems also operate on the Island (Figures 6.1 and 6.2, respectively). In addition, private wells provide water to a considerable number of houses and several businesses across the Island. The exact number of private wells on the Island is not known. Seattle-King County Health Department obtained copies from Ecology of approximately 280 well logs for public supply and private wells on the Island. In most cases, it was not possible to distinguish between logs of public supply and private wells without prior knowledge.

6.3 Water Rights

The 1986 Vashon Community Plan establishes that new public water sources may be developed only if it can be demonstrated that such development will not adversely affect existing water supplies. To ensure this, Ecology requires that a water right be obtained if more than 5,000 gallons of water are to be withdrawn from the new water source per day, if the source is to serve five or more houses (approximately the equivalent of 5,000 gpd), or if more than 1/2 acre of land is to be irrigated (King County 1986).

Ecology maintains water-right records for the entire state. The listing of water entities holding a water right includes the names of permit holders, sources of water, places of use, purposes for which the water will be used, permitted instantaneous withdrawal rates, and permitted annual withdrawal quantities. The Ecology listing of existing water-right holders includes several hundred Island water-right permit holders. The instantaneous withdrawal rates and annual withdrawal quantities permitted for five of the seven major water purveyors are discussed in Section 6.2, Water Service (see Table 6.3a.).

6.4 Water Use

Commercial water systems maintain records of the amount of water withdrawn from Island sources and the quantity sold to customers during established time periods. Owners of private wells do not maintain similar records, and information regarding actual withdrawal quantities is less readily accessible.

Quantities of water withdrawn annually from Island sources by the seven major water purveyors are presented in Table 6.3b. These amounts were reported by the purveyors and represent the actual or estimated amounts of water withdrawn by the purveyor during the period listed.

A preliminary comparison of permitted water-withdrawal quantities (see Table 6.3a.) with actual water-withdrawal quantities (see Table 6.3b.) for these purveyors indicates that purveyors actual withdrawal quantities generally exceed permitted withdrawal quantities. Not all purveyors provided both instantaneous and annual withdrawal quantities; the available information was used for the comparison. Two purveyors (Heights Water Association and Water District No. 19) have exceeded maximum permitted quantities for instantaneous withdrawal. Three purveyors (Dockton Water Association, Heights Water Association, and Water District No. 19) have exceeded the maximum annual withdrawal quantities permitted on the September 5, 1989 water-right record. No information on permitted withdrawal quantities was available for the Gold Beach Water System. Potential penalties for exceeding permitted water-withdrawal quantities are outlined in Chapter 90.03 RCW, Water Code - 1917 Act, and Chapter 90.44 RCW, Regulation of Public Ground Waters, and may be subject to individual interpretation. Potential environmental impacts of withdrawing too much water from water-bearing zones are discussed in Section 8.4.

6.5 Wastewater Disposal

The majority of the Town of Vashon lies within the Vashon Sewer District local service area and is served by the Vashon Sewer District, but the remainder of the Island relies on on-site wastewater disposal systems, primarily septic systems. The following subsections provide a detailed discussion of these two major methods of wastewater disposal on the Island.

6.5.1 Vashon Sewer District

The Vashon Sewer District local service area, established under the 1986 Vashon Community Plan, covers approximately 405 acres (about 0.63 square miles) in the Town of Vashon (see Figure 5.9); of the 405 acres, approximately 180 acres remained undeveloped in 1980. Full development of the entire local service area would raise the population to an estimated three times the design capacity of the Vashon Sewer District treatment plant.

The Vashon Sewer District has been operating since 1955 and underwent major improvements in 1974 and 1975. In 1979, the district served an estimated 600 people. This figure was obtained by dividing the amount of wastewater reaching the treatment plant by the estimated amount of wastewater (in gallons) produced per day per connection (gpdpc); a value of 250 gpdpc is commonly used during dry months (Ames 1989, 1990, 1994). The number of connections can be converted to an equivalent number of people by using the average housing figure of 2.5 people per residence or per connection (Puget Sound Council of Governments 1988).

In 1986, the treatment plant reportedly had the capacity to serve the equivalent of 1,375 people. January 1994 estimates indicate that the Vashon Sewer District is serving the equivalent of about 1,000 people. This figure was obtained by dividing the average total daily inflow to the treatment plant of 100,000 gallons by a reasonable estimate of wastewater production (250 gpdpc) and converting the resulting figure of 400 connections to 1,000 people using 2.5 people per connection.

In actuality, the conversion from wastewater production to number of people served is not completely straightforward. The Vashon Sewer District serves the K-2 Ski Manufacturing plant, the Vashon Nursing Home, a laundromat, and a restaurant, which together produce approximately 60 percent of the wastewater reaching the treatment plant. In January 1994, the K-2 Ski Manufacturing plant produced over 30 percent of the effluent reaching the treatment plant; the Vashon Nursing Home, the laundromat, and the restaurant contributed 12.5 percent, 10 percent, and 7.5 percent, respectively (Ames 1994). If the contribution of these four facilities is excluded, the District can be said to serve an estimated 160 connections, or about 400 people. A number of the connections are small businesses and apartments, however, both of which typically account for 1.5 to 2.0 people per connection. If 1.5 to 2.0 people per connection is used, the estimated number of people the treatment plant services is 240 to 320. The actual number of connections is approximately 350 to 400, of which approximately 200 to 225 are residential and 150 to 175 are commercial (Ames 1994).

The amount of wastewater reaching the treatment plant during wet months is reportedly far in excess of the amount of water distributed by King County Water District No. 19. This observation prompted extensive testing of the sewer and storm water drainage systems, eventually leading to the conclusion that storm-related moisture infiltrates the sewer system through numerous leaking joints between sections of sewer pipe. This occurs most readily during winter when the water table is high. Conversely, it is possible that wastewater may leak from the pipes and infiltrate the surrounding soil during dry seasons when the water table is low (Ames 1989). Since the Town of Vashon and the Vashon Sewer District are located in a low recharge area, the potential effects from the leaks are minimal.

The Vashon Sewer District is upgrading the sewer and storm water drainage system. Since 1989, all manholes in the local service area have been sealed, recessed manholes have been raised, and 500 of the 4,000 total feet of sewage/storm-drain pipe have been replaced. The Vashon Sewer District plans to replace the next 500 feet of pipe in the near future. A noticeable drop in wastewater during the rainy season confirms that the improvements to the sewage/storm-drainage system are working (Ames 1994).

6.5.2 On-Site Sewage Systems (Septic Systems)

On-site wastewater treatment and disposal, primarily in the form of septic systems, is recognized in the Vashon Community Plan (King County 1986) as a permanent means of wastewater treatment and disposal outside the Vashon Sewer District local service area. Since the local sewer service area covers less than one square mile of the Vashon-Maury Island Ground Water Management Area, the majority of the Vashon-Maury Island Ground Water Management Area population relies on septic systems for wastewater treatment and disposal. Although septic systems and cesspools are the most frequently reported sources of ground water contamination (Freeze and Cherry 1979), modern systems generally filter solid residue out of wastewater, then the filtered wastewater is subjected to a biological dinitrification or ion exchange process so that it may act as a beneficial source of ground water recharge. Septic system failures reported to the Seattle-King County Health Department from 1987 to 1988 are shown in Figure 5.9.

6.6 Storm Water Systems

Past and present storm water management practices have often caused ground water quality and quantity problems. Ground water quality may be impacted if aquifer recharge of storm water containing contaminants occurs. Also, ground water quantity problems result from the diversion of precipitation into storm water drains that discharge to surface water instead of recharging the aquifer under natural conditions.

Storm water management facilities can be designed to maximize infiltration into the ground, thereby increasing recharge to aquifers. However, an obvious concern is potential contamination of ground water by pollutants carried in storm water. In the past, storm water management emphasized flood control and was not particularly concerned with water quality. More recently, concern has shifted to storm water quality and its impact on receiving waters, including ground water. Storm water management practices use the best technology available at the time for source control and treatment facilities. Retention basins, infiltration facilities, biofilters and coalescing plate oil/water separators are commonly used to control storm water flow and improve water quality. Storm water should be monitored to ensure that ground water quality is not impacted.

Many natural storm water drainage systems in the Vashon-Maury Island Ground Water Management Area contribute to the flow of storm water runoff into Puget Sound (Morgan 1991). In addition, several constructed storm water systems direct runoff on the Island. The systems serving the Town of Vashon and the communities of Burton, Sandy Shores, Gold Beach, Dockton, and North Vashon are described in this section.

Two systems operate to collect and remove storm water in the Town of Vashon, one along Main Street and one for the remainder of the town. Storm water on Main Street is captured in storm drains and travels enclosed to the eastern end of Southwest 171st Street, where it empties into a canyon and flows to the Sound. Storm water captured elsewhere in the town travels through the storm-drain system via 100th Avenue Southwest and Southwest 176th Street to Cedarhurst Canyon, where it emerges and flows into Colvos Passage in Puget Sound (Morgan 1989).

Three systems regulate storm water flow in the Burton area. One system runs south from Vashon Island Highway to about Southwest 238th Street, where it flows into Quartermaster Harbor. Another system consists of three storm water catch basins that run south along the Vashon Island Highway from the intersection of Southwest 240th Street to Quartermaster Harbor. The third system begins at Inspiration Point, with collector systems on Southwest 240th Street and 115th Avenue Southwest, and discharges into Quartermaster Harbor (Morgan 1991).

In the Sandy Shores area, storm water flows from the upper Sandy Shores area to 94th Avenue Southwest to Southwest 275th Street, then into Puget Sound. At Gold Beach, storm water flows into a collector system at the top of 75th Avenue Southwest, then southeast down Gold Beach Drive into Puget Sound. In Dockton, storm water is collected at Vashon Island Highway and flows west down a county easement (261st Street), then east on Dockton Road Southwest where it crosses to the north at Dockton Park and flows into Quartermaster Harbor. At the north end of Vashon, near Cunliffe Road Southwest, storm water flows north on Vashon Island Highway Southwest into Puget Sound. On 103rd Avenue Southwest, twelve catch basins run north from Southwest 116th Street to the ferry dock.

7.0 GROUND WATER POLICIES

The following section summarizes ground water policies relevant to the Vashon-Maury Island Ground Water Management Area. Ground water policies for Washington state are presented first, followed by specific policies for King County and the Island.

7.1 Washington State

In October 1990, the state adopted Chapter 173-200 WAC, Water Quality Standards for Ground Waters of the State of Washington, that established statewide ground water quality goals, defined criteria to measure water quality, and complied with the Water Pollution Control Act of Washington (Chapter 90.48 RCW). The standards were developed by the Ecology Water Quality Program with the assistance of a 20-person citizens advisory committee and an internal Ecology work group. The Water Pollution Control Act grants Ecology the authority to develop the standards.

The standards protect all ground waters of the state using the most stringent criteria that exist. An enforcement capability is established by instituting minimum standards for ground water quality against which changes in water quality can be measured; the goal of the standards is "no net increase" in ground water contamination. The point of compliance with the standards is "everywhere in the ground water below the site." Ecology is the enforcement agency.

The standards require new businesses to maintain the existing ground water quality within the boundaries of their sites (Stern, no date). No addition of contaminants to the ground water is permitted, even if the ground water is already contaminated. Similarly, existing businesses are not allowed to degrade the ground water at all, even if the ground water is already contaminated. If existing ground water quality is better than the quality of discharge water that can be produced using "all known and reasonable methods of prevention, control, and treatment", the discharger must improve the technology rather than be allowed to degrade the ground water by using existing technology. A business that can document that it is causing no net increase in contaminants to the aquifer will be able to operate over a contaminated aquifer without incrimination, provided the operators adhere to the Ecology Best Management Practices.

The standards allow Ecology to establish Special Protection Areas, which are areas of beneficial use that require a level of ground water protection beyond that offered by the standards. For example, the level of cadmium permitted under the standards would probably be too high for fisheries, according to a spokesperson for Ecology (Stern no date). A Special Protection Area could be proposed by Ecology or a local entity, which would submit data to indicate why the area is special (an area that has federal sole-source aquifer status, for example). The final declaration of Special Protection Area status would come from Ecology. No specific actions are dictated by a Special Protection Area designation. When Ecology issues permits for Special Protection Areas, however, consideration unique qualities of the Special Protection Area would be required as part of the permitting process. The permits could be more restrictive in response to the specific vulnerabilities and needs of the areas. Special Protection Area designation could also provide local entities with an additional tool for restricting certain land-use activities.

7.2 King County

The two major King County plans guiding the Island water management decisions are the 1994 King County Comprehensive Plan and the 1986 Vashon Community Plan (King County 1986). Both plans are described below.

7.2.1 King County Comprehensive Plan

The King County Comprehensive Plan was revised and adopted by the Metropolitan King County Council on November 18, 1994 to comply with the Growth Management Act and the King County county-side planning policies. The policies that relate specifically to ground water are listed in the land use section 5.1.3.1.

The King County Comprehensive Plan establishes policies for ground water management throughout King County, including the Island. Generally, the Comprehensive Plan calls for the protection and enhancement of water quality through land-use and development activities that preserve the amenity and ecological functions of water features. The plan includes general policies on water quality and more specific policies concerning drainage systems, rivers, streams, water bodies, wetlands, floodplains, and aquifers. Protection and preservation of existing systems is encouraged, taking precedence over new development.

The King County Comprehensive Plan states that public watersheds should be managed primarily for the protection of drinking water, but should allow for multiple uses, including recreation, as long as such uses do not jeopardize the drinking water quality standards. According to the plan, forestry is a favored and permitted land use in rural areas and should not be construed as a public nuisance when carried on in a reasonable manner and in accordance with applicable public regulations, even though it may impact nearby rural residences.

7.2.2 Vashon Community Plan and Area Zoning

The 1986 Vashon Community Plan and Area Zoning (King County 1986) designates all of the Island as a water service area and establishes protection of the aquifer as being of primary importance to the Island. The 1986 Vashon Community Plan advocates continued use of Island water resources as the sole water supply, thus emphasizing the requirement that land uses and development densities be planned so that demands on the Island ground water resources do not exceed the resources' capacity to provide adequate supplies without deterioration of quality or quantity. In March 1992, at the request of the Ground Water Advisory Committee, the Seattle-King County Health Department and J. Dolstad of the Island applied to the U. S. Environmental Protection Agency for Vashon to be designated as a sole-source aquifer. On July 17, 1994, the U. S. Environmental Protection Agency designated the Vashon aquifer as a sole-source aquifer.

The 1986 Vashon Community Plan supports continued research and monitoring as well as efficient use of domestic water supplies and water systems. As specified by the 1986 Vashon Community Plan, intensive development should be served by a public water district or by an existing Group A water system. In addition, public water systems will not be permitted to expand if it is determined that expansion will decrease the level of service, including water quality, to current users. Similarly, the 1986 Vashon Community Plan states that proposals for development that involve extension of water service to new users will be reviewed with particular attention to ensure that service to current users will not be reduced below minimum state and county standards. Specifically, the policies from the 1986 Vashon Community Plan pertaining to ground water are as follows:

- V-3;
- V-44 through V-50 (special recommendations 1-3);
- V-52 through V-63 (special recommendations 1-5);
- Island-wide P-suffix condition; and
- High recharge area P-suffix conditions.

A letter "P" following a zoning classification, i.e., a P-suffix on the Island zoning map, indicates that site plan approval is required for development to proceed at that site; it may be necessary for the developer to meet special conditions designed to protect the public interest in developing the site. Zoning codes for sites in high recharge areas typically include the P-suffix. To protect infiltration to the Island aquifers, new residential, commercial, and industrial development planned for high recharge areas must comply with zoning regulations that establish the maximum coverage of infiltration surfaces and the relative amount of runoff permitted. Similarly, sites that have been determined to be of historic interest carry zoning codes that typically include a P-suffix; site plan approval of these sites requires review by the King County Historic Preservation Officer.

8.0 HYDROGEOLOGY

This section summarizes existing hydrogeologic data including a description of the Island geology; the Island water resources; past ground water levels (Carr 1983) and current (1989 through 1992) ground water levels; surface water, spring, and ground water quality; physical susceptibility areas; and the water budget for the Island. Stream flow, spring flow, and rainfall data collected from 1989 through 1992 are also presented.

8.1 Geology

The most detailed geologic information specific to the Vashon-Maury Island Ground Water Management Area is based on the work of geologist Derek B. Booth, formerly with King County Department of Natural Resources, Surface Water Management Division and now with University of Washington Civil Engineering Department (Booth 1991). The following paragraphs summarize pertinent aspects of Booth's report and map (see Figures 8.1 and 8.2). Booth's geologic interpretations are then compared with those presented earlier by Carr. The results of drilling deep Exploration Boring VT-1 are then discussed and compared with other deep wells located on the Island and Kitsap Peninsula.

8.1.1 Booth's Stratigraphy

The Island is composed entirely of sediments deposited during interglacial episodes. These sediments provide a discontinuous record of the multiple glaciations affecting the Puget Lowland. Sediment layers are probably not continuous across the Island, but most likely interfinger with each other, resulting in sediment sequences that change abruptly from place to place. During cold periods, glacier ice deposited both till and outwash sands and gravels.

Glacial till is material deposited either directly by the ice at its base or as melt-out debris at the ice surface near the glacial terminus. Till consists of all types of material, from clay particles to boulders (diamictons). Outwash forms in front of the ice sheet as it advances and retreats. Outwash deposits consist of rounded sands and gravels deposited by streams running off the ice front. Glacial till is generally much less permeable than glacial outwash. Therefore, most significant ground water supplies found on the island occur in outwash deposits rather than till.

Multiple ice-sheet glaciations and intervening nonglacial intervals have resulted in a complex sequence of deposits that underlie the Island to a depth of more than -400 feet mean sea level. Correlating deposits from the Island to the mainland has proven difficult.

The stratigraphic names for the most recent (Vashon stade) glacial deposits on the Island are as follows (Booth 1991) (see Figures 8.1 and 8.2):

- Qvr, recessional outwash: mainly stratified sand and gravel that mantle the upper till surface.
- Qvi, ice contact deposits: similar in texture to Qvr, but with collapse features and rare till lenses suggesting deposition on or near stagnant ice.
- Qvt, till: mainly compact diamictons, typically 40 to 60 feet thick having low permeability.
- Qva, advance outwash: commonly medium- and fine-grained sand, with some sandy gravel. Thickness of this unit varies from being absent (0 feet) to greater than 200 feet. The shallowest water-bearing zone on the Island is probably composed of permeable Qva material.

The elevation of the base of the Vashon stade deposits (the Qva unit) has been described by Booth (1991) and has been slightly modified to include data from two wells (VT-1 and Heights No. 3) which were drilled after map construction (see Figure 8.3).

Vashon stade deposits are underlain by the interglacial Olympia beds (Qob), which are generally composed of sand and silt with local layers of gravel, massive silt, and clayey silt. Because the Olympia beds are less permeable than the advance outwash, the elevation of their upper surface is of considerable hydrogeologic importance in how these beds control the occurrence and movement of ground water. A widely exposed lake (lacustrine) deposit of clay and silt (Qcs) is closely associated with the Olympia beds and may be a basal layer of the beds rather than a separate unit; elsewhere, the Olympia beds directly underlie the advance outwash (Qva). Several older Pleistocene till and interglacial sequences underlie the Olympia beds.

Booth (1991) provides detailed descriptions of the complex sequence of deposits that have led to the creation of the Island; the stratigraphic column in Figure 8.2 shows the relationship of geologic units in time. In general, Vashon stade units are found above mean sea level; older deposits are found near and below mean sea level. Vashon stade till and recessional (glacier receding) deposits occur over much of the surface of Vashon Island, whereas the surface exposures on Maury Island are predominantly Vashon stade till and advance outwash. The geologic map and accompanying cross sections of the Island illustrate the lateral variations in the thickness and the areally and vertically discontinuous nature of most units.

In comparison to Booth's work, Carr provides a rather simple classification of the Island geologic units, as discussed below. Booth's equivalent geologic units are given in parentheses. Unit I consists principally of till (Qvt), but also contains recessional outwash (Qvr). Unit II includes advance outwash sand and gravel (Qva) and is referred to as the Principal Aquifer. Carr notes that Unit II is characterized by its complexity and heterogeneity resulting in varying permeability and water yields to wells installed in different beds. Unit III comprises all pre-Vashon stade deposits, including silty layers that are presumably the Olympia beds (Qob). Carr also indicates Unit III contains a sandy layer (the Deep Aquifer) located at depths of -100 to -300 feet mean sea level.

Geological cross sections of the Island were constructed by Carr (1983) and Booth (1991) on the basis of surface exposures of geologic units and information obtained from well logs. The five cross sections constructed by Carr (see Figure 8.4) depict the subsurface of the Island. One cross section (A-A!) runs north-south, one cross section is laid out in a northwest-southwest direction (B-B!), and three cross sections run mostly southwest-northwest (C-C! D-D!, E-E!). Refer to Booth's *Geologic Map of Vashon and Maury Islands, King County Washington* (1991) for the cross sections constructed by Booth.

The northwest-southwest cross sections constructed by both Booth and Carr have similar geologic interpretations. The Unit I layer is directly underlain by Unit III in some areas; therefore, the most permeable aquifer unit is missing. Southwest-northwest cross sections (by Carr) show a thick Unit I layer that thins to the south on Vashon and Maury Islands. The thickness of Unit I is highly variable, presumably reflects the variable distribution of materials directly deposited by ice. Both Booth and Carr depict the Unit I layer (Qvr and Qvt) as thicker in valleys and thinner at high elevations on the north-south cross sections.

Booth's and Carr's interpretations of Unit II (Qva) thickness are generally similar, although Carr suggests that Unit II may be thicker. Unit II is shown to be thickest near or at the present Island margins, which may suggest the former location of meltwater rivers flowing from the ice on either side of the Island. Unit III is shown as the basal (lowermost) layer in all the cross sections; the thickness of the Unit III layer has not been determined (see Figure 8.4).

Comparison of the geologic maps prepared by Booth and Carr shows they are similar, although the nomenclature varies. Booth's map, for example, was defined on the basis of stratigraphic units; on the other hand, Carr separates the Island into Units I, II, and III. Booth's units are converted here to Units I, II and III for comparison with the Carr geologic map. Booth's map is different from Carr's in the following areas: Unit II extends into north-central Maury Island (around Mileta Creek); some coastal areas have been reclassified from Unit II to landslide or mass wasting areas, Unit III is not as prominent near the shorelines, and Unit III is not present near Upper Judd Creek. The greater detail offered by Booth reflects his more intensive study of the Island.

8.1.2 Deep Exploratory Boring

Geraghty & Miller drilled an exploration boring (VT-1) on Vashon Island to further define the subsurface geology and to further evaluate the resource potential and quality of the deeper hydrostratigraphic zones underlying the Vashon stade deposits. The following sections describe the stratigraphic information obtained from the boring installation to further understand the subsurface hydrogeology of the Island. A more thorough discussion of the hydrostratigraphic (relationships of water-bearing zones of the geologic units) information derived from VT-1 is presented in Section 8.3.4, Ground Water.

Exploratory Boring VT-1 was installed on the south side of Burton Acres Park on Vashon Island, Washington (see Figures 8.5 and 8.6). The boring was drilled to a total depth of approximately 500 feet below land surface. Stratigraphic units encountered in the borehole for VT-1 consisted of primarily of fine-grained sand, silt, and clay with occasional interbeds of silty to sandy gravel. Fine-grained deposits occurred from approximately zero to two feet below land surface and from approximately 40 to 485 feet below land surface and generally consisted of grey to light-grey, interbedded silt and clay with fine-grained sand. A trace of peat fragments was encountered at a depth of approximately 38 feet below land surface. More coarsely grained sands and gravel were encountered at depths of approximately two to 40 feet below land surface and generally consisted of grey-to-brown well-graded sand and gravel. Interbedded sands, silts, and gravels were encountered from approximately 485 to 500 feet below land surface.

Ground water was initially encountered during drilling at approximately 45 feet below land surface. A water-bearing zone consisting of fine-grained sand was also encountered from approximately 380 to 445 feet below land surface (approximate elevation of -330 to -395 feet mean sea level). An additional water-bearing zone of interbedded sand, silt, and silty gravel was encountered at approximately 485 to 500 feet below land surface. After drilling was terminated at 500 feet below land surface, the static water level recorded in the borehole on January 29, 1992 was 88.25 feet below land surface (approximate elevation of 38 feet mean sea level).

The stratigraphy encountered in the borehole for VT-1 was compared with the stratigraphy penetrated by other deep production wells on the Island (the KIRO Well on Maury Island and the Coho Well on Vashon Island) and a deep production well on the Kitsap Peninsula (Gig Harbor Production Well No. 5). The KIRO and the Coho wells were selected for comparison with VT-1 because of their depths and their location in south central Vashon and northern Maury Islands; limited data is available from wells completed in deep producing zones. A geologic cross section was prepared using these wells to compare hydrostratigraphic relationships of the deep aquifer zones on the Island with the deep aquifer on the Kitsap Peninsula (see Figures 8.5 and 8.6). (Geraghty and Miller 1992a)

The following discussion focuses on stratigraphic comparisons between VT-1 and other deep wells. The discussion is intended primarily to compare geologic units penetrated by the boreholes; correlations between hydrostratigraphic zones and ground water recharge is provided in Section 8.3.4, Water Resources.

Stratigraphic nomenclature from Booth (1991) is applied to the surficial Vashon stade units of the cross section. Also depicted on the cross section are approximate elevations of the producing zones in the wells and the approximate elevation of the bottom of Colvos Passage of the Puget Sound.

The stratigraphy shown on the cross section suggests that there may be some stratigraphic correlation between the VT-1, Coho, and KIRO wells. Similar Vashon stade and pre-Vashon stade deposits (primarily interbedded fine-grained sand, silt, and clay with occasional interbeds of silty to sandy gravel) were reported for the VT-1, Coho, and KIRO wells, although the elevations of the correlative units vary. The first 50 feet encountered in the VT-1 well were most likely advance outwash (Qva) deposits. The interbedded fine- and coarse-grained materials encountered from 50 to 485 feet below land surface may be equivalent to the Kitsap clay (a pre-Vashon age nonglacial deposits, as Olympia beds [Qob]). The wide variety of geologic deposits and complex stratigraphic relationships between deposits precludes correlation of the units reported for VT-1 with the units reported for Gig Harbor Well No. 5 on the Kitsap Peninsula (Booth 1992).

8.2 Water Resources

Water resources of the Vashon-Maury Island Ground Water Management Area include ground water (aquifers), springs, and surface water and their associated drainage basins. Much of the data regarding water resources on the Island available prior to this investigation has been summarized by Carr. The following sections provide an overview of the Island water resources.

8.2.1 Ground Water

Ground water provides the primary water supply for the Island. Two aquifers (shallow and deep) have been identified (Carr 1983). Carr shows the shallow, or "Principal Aquifer" exists in the advanced outwash (Qva) of the Vashon deposits (Unit II of Carr 1983). Carr reported that most of the Island wells are completed in this aquifer. Carr shows the Deep Aquifer as being in a sandy layer of Unit III that underlies the Vashon deposits. The only publicly owned water supply well on the Island, Water District No. 19, Well No. 2, is probably completed in this deep zone. Several Island wells have also penetrated this aquifer. This simple two aquifer system was refined during this study and is described further in Section 8.3.4, Ground Water.

8.2.2 Spring Water

Springs are abundant on the Island and represent natural ground water discharge. Springs serve as water supplies for some private residences and private purveyors; one spring is tapped by Water District No. 19 (Horton Dennis 1989). Seattle-King County Health Department generally does not consider springs to be reliable sources of potable water because they are susceptible to contamination.

8.2.3 Surface Water

Eight major drainage basins have been identified on the Island (see Figure 8.7); these include Beall, Fisher, Green Valley, Judd, Mileta, Needle (Shinglemill), Paradise Cove, and Tahlequah creeks. Judd and Needle (Shinglemill) creeks have the largest drainage areas (3,149 and 1,996 acres, respectively) and stream discharges on Vashon Island. Judd and Needle creeks occupy the central and northern interior regions of Vashon Island, respectively. The largest drainage basin on Maury Island, identified as the Mileta Creek basin, covers 1,546 acres. Although other drainage basins on the Island are smaller, the associated streams have measurable flow during dry months.

Surface water supply sources include Beall and Ellis creeks, located on the east side of Vashon Island. Flow from these creeks augments the water supply for Water District No. 19, operator of Well No. 2. About eight small ponds and lakes dot the upper plateaus of Vashon Island; none are known to be used as sources of drinking water.

8.3 Data Collection and Analysis

A Data Collection and Analysis Plan was developed and implemented as part of the Vashon-Maury Island Ground Water Management Plan (Geraghty & Miller 1990). The objectives of this task were to increase the understanding of the Island water resources in regard to quantity and quality, and to identify additional information required for effective management and protection of these resources based on Carr's 1983 findings and recommendations. To accomplish these objectives, Seattle-King County Health Department collected rainfall, stream flow, ground water, and surface water data between 1988 and 1993. These data are necessary to determine the volume of water infiltrating the aquifers, the volume of water leaving the Island through various processes, the effects of climatic changes on ground water and surface water systems, and the quality of the water utilized for public supply.

The data analyzed in the Data Collection and Analysis Plan included the 3-plus-year period from 1988 to 1992. The following sections summarize the data collection and analysis activities and compare the results from these activities with the preliminary assessment of the Island water resources provided by Carr.

8.3.1 Rainfall

Island volunteers collected data at nine rain gauge stations from December 1988 through January 1992 (see Table 8.1). Seven rain gauge stations were located on Vashon Island and two on Maury Island (see Figures 8.8 and 8.9). Station locations were selected to determine trends in rainfall across the Island, to maximize coverage of the Island, and to sample as many drainage basins as feasible, and still provide accessibility for volunteers who monitored the gauges. Rainfall data for Sea-Tac Airport, which is located approximately five miles east of the Island, were obtained from the Desert Research

Institute in Reno, Nevada to compare rainfall on the mainland with that of the Island. All precipitation data were tabulated by the Seattle-King County Health Department.

8.3.1.1 Methodology

Hydrographs were prepared for each rain gauge station by summing the daily rainfall data. Total rainfall for each station was then calculated by summing the monthly rainfall values (see Table 8.2) to compare trends across the Island and with the mainland east of the Island. To evaluate spatial trends in total rainfall, isohyetal (total rainfall) maps were prepared for 1989, 1990, and 1991 (see Figures 8.10, 8.11, and 8.12). A map combining the 1989, 1990, and 1991 total observed rainfall was constructed to evaluate average spatial rainfall distribution over the entire observation period (see Figure 8.13).

8.3.1.2 Results

The annual rainfall hydrographs for different years indicate similar patterns of rainfall variations at the Island stations. Based on these similarities, estimates of total monthly rainfall were made where feasible for some of the stations which lacked data for only one or two months (July 1990 and July 1991 for RG-1, February 1989 for RG-5, and July 1990 and April 1991 for RG-7).

The monthly rainfall for the stations monitored on the Island ranged from zero to approximately 15 inches (see Table 8.2). Rainfall data indicate that the Island received the most rainfall between November and April. The heaviest rainfall fell in March and November 1989, January and November 1990, and April and November 1991. The driest months were August and September, with September generally drier than August. These rainfall trends are consistent with rainfall data collected at Sea-Tac Airport and the rainfall trends reported by Carr.

The annual rainfall for the Island ranged from approximately 40 inches per year (RG-7, 1991) to approximately 62 inches per year (RG-3, 1990). The heaviest precipitation at all stations was recorded in 1990. The 1989 rainfall data were not included in the comparison of annual rainfall trends because four of the stations (RG-1, RG-2, RG-3, and RG-4) lacked data for at least two months.

The trends in total rainfall in the period 1989 through 1991 were compared to the rainfall trends for the 1974 through 1982 period reported by Carr (see Figure 8.14). Rain Gauge RG-7, located on the southern tip of Vashon Island and referred to as the Krimmel rain gauge in Carr's 1983 report, was used for this comparison. Rainfall reported at RG-7 in 1989 was lower than the average rainfall reported between 1974 and 1982; rainfall at RG-7 in 1990 was higher than the 1974 through 1982 period; and RG-7 in both 1991, and during the 1974 through 1982 period received approximately the same rainfall.

The spatial distribution of the total rainfall generally varied erratically across the Island. The isohyetal map for 1989 (see Figure 8.10), which does not include rainfall during

January and February for all stations shows the highest amount of rainfall occurred in the central portion of Vashon Island. In 1989, the least rainfall occurred in north and west central Vashon Island and south Maury Island. The rainfall distribution in 1990 (see Figure 8.11) showed the high rainfall areas were the north and south ends of Vashon Island, while the low rainfall areas were south Maury Island and west-central Vashon Island. Southwest and west-central Vashon Island received the least rainfall in 1991, while northwest Vashon Island and east Maury Island received the most (see Figure 8.12). The relationship between the variable rainfall trends and Island topography (a suspected cause of spatial rainfall variations) is not clearly defined. Precipitation at Sea-Tac Airport was consistently lower than on the Island.

The distribution of annual rainfall across the Island from 1989 to 1991 is inconsistent with the simple trend reported by Carr of decreasing rainfall from west to east for the period October 1981 to September 1982. Differences in data collection techniques may account for some variance in the rainfall distribution between the recent data and the Carr data. The recent isohyetal map, for example, was constructed using three years of data while Carr's isohyetal map was based on only one year of data. Thus, variations in total rainfall (as shown on Figures 8.10 through 8.12) could not be accounted for in the Carr map. In addition, the nine rain gauges in this study are distributed throughout the Island, while the seven rain gauges used by Carr are located near each other. Carr's configuration leaves a gap in the north end of Vashon Island and west of Burton. A third factor, wind, can affect the rates of precipitation on the Island. When wind directions vary from year to year, the rainfall distribution also changes. The rainfall distribution in any given year is partly a function of the dominant winds for that year. Carr states that data collected in his report may contain inaccuracies in precipitation data from using different types of rain gauges and possible errors in measurement; no continuous recording instruments for precipitation were documented by Carr.

8.3.1.3 Limitations

Generally, rainfall data were collected at each station daily; however, the data contain time gaps varying from days to months and may not be indicative of cumulative readings. Rainfall data from Stations RG-8 and RG-4 were collected very sporadically after December 1989 and April 1991, respectively. Therefore, annual rainfall was not calculated for these stations after these respective years (see Table 8.2). In addition, rainfall data was not collected from Stations RG-1 through RG-4 until March 1989. Seattle-King County Health Department will use automatic data loggers to eliminate future gaps in rainfall data collection.

8.3.2 Surface Water

From July 1989 through April 1992, Island volunteers and others collected stream gauge data at nine stream gauge sites located across the Island (see Table 8.3). The stream gauge sites were selected to be representative of the major surface drainage basins on the Island (see Figures 8.8 and 8.15) (URS 1992b). Other criteria used for selecting the gauge sites included the size of the drainage basin, whether or not the stream is perennial (flowed during all seasons), if the stream gauge site is located in a basin with monitoring wells, and accessibility for monitoring personnel. The gauge site locations were also selected to be near the mouths of the streams so maximum runoffs from each drainage area could be recorded. All drainage basins were not be represented; however, all drainage basins with year-round stream flow were monitored.

8.3.2.1 Methodology

The data were collected to provide additional information about stream flow on the Island and to assess the relationship of stream flow to rainfall and ground water elevations. Staff gauges were used to record stream stage data (stream height above an arbitrary datum) from seven streams. Staff gauge readings were converted to stream flow data by comparing recorded gauge heights with the stream discharge rating curves developed by URS Consultants (URS 1992a).

Stream flow data for Beall and Mileta Creeks were obtained using 90-degree v-notch weirs. Stream gauge data were collected at each site by volunteers and others who read the staff gauges and v-notch weirs on an intermittent basis; Seattle-King County Health Department tabulated the stream gauge data.

Five streams were initially involved in the data collection effort that began in 1989: Tahlequah, Judd, Needle (Shinglemill), Beall, and Mileta creeks. In 1991, as part of the Surface Water Management Study (EcoChem/Geraghty & Miller 1991) additional gauge stations were installed on Upper Judd, Fisher, Green Valley, and Paradise Cove creeks. The gauge station on Paradise Cove Creek was removed later in 1991 at the request of the property owners.

Stream flow rating curves were developed for each staff gauge by collecting stream rating parameters (stream velocities at selected stream cross sections [stages]) during low-flow summer months and high-flow winter months. The resultant rating curves can be used to calculate stream flow during normal stream conditions. Although attempts were made to determine both maximum and minimum stream rating parameters, the peak flow parameters for several of the gauging stations could not be obtained because of the lag time (up to five hours) between storm rain events and the stream response. The stream monitoring team could not predict the lag time between the storm event and stream response. Stream levels were recorded as soon as possible after storm events. As a result, the peak flows for several of the streams (Fisher Creek, Green Valley Creek, Judd Creek, Upper Judd Creek and Needle Creek) cannot be determined because the staff gauge readings exceeded the rating curves.

Stream flow trends were evaluated by preparing hydrographs for each stream either by graphing actual stream stage data or calculated flow for stations equipped with v-notch weirs. Stream discharge rating curves were developed by URS Consultants (1992a) for each staff gauge to convert recorded stream stages to stream flow. A recorded gauge height of 0.4 feet for Fisher Creek, for example, converts to a flow rate of approximately 0.2 cubic feet per second (cfs) based on the stream discharge rating curve. Two stream discharge-rating curves were developed for Tahlequah and Judd creeks because of subsequent adjustments of the staff gauges.

Trends in stream base flow, i.e., flow resulting from ground water discharge as compared to flow resulting from surface runoff, were based primarily on the flow data collected during the drier summer months. Base flow was estimated using stream stage heights to calculate flow for the creeks which had more or less continuous data for one or more summers (Beall, Fisher, Tahlequah, Judd, Upper Judd, Green Valley, Mileta, and Needle [Shinglemill] creeks). Base flow data could not be determined for Paradise Cove Creek because insufficient data were collected for the summer months.

8.3.2.2 Results

Trends in stream stage and stream flow data for the eight monitored creeks are presented in this section. Judd Creek has two monitoring sites, Judd Creek, and Upper Judd Creek. An evaluation of the general trends in the stream flow data is discussed first, followed by evaluations of the data collected for each creek.

Stream gauge data tend to correlate with rainfall amounts (see Figures 8.16 and 8.17). The hydrographs for each gauge station show that, predictably, stream flow was highest during the wetter winter months and lowest during the drier summer months. These trends indicate that surface runoff is the dominant source of peak stream flow.

A comparison of rainfall and stream gauge trends indicates overland flow appears to be the dominant component of stream runoff during high rainfall events because the rate of precipitation exceeds the rate of soil infiltration. The stream-level rise occurs after rainfall events, although timing of the rise (lag time) in individual streams varies (see Figure 8.16 and 8.17). Similar lag times between rainfall and stream flow data were reported by Carr.

The maximum values of stream stage levels (see Table 8.4) were recorded at Upper Judd (3.29 feet) and Needle (Shinglemill) creeks (2.40 feet). Minimum values were recorded at Fisher and Needle (Shinglemill) creeks; both creeks were reported as "dry" for periods during the summer months. Trends in stream flow data for each gauge station are described in the following subsections.

Beall Creek

Stream gauge data for Beall Creek were collected using a v-notch weir from September 1989 through March 1992. The stream flow during the period ranged from approximately 0.01 cubic feet per second to 4.28 cubic feet per second. The average flow during the period ranged from approximately 0.5 cubic feet per second to 1.5 cubic feet per second. The base flow during the period ranged from approximately 0.3 cubic feet per second to one cubic feet per second (70.5 to 235 mgpy).

Mileta Creek

Stream gauge data for Mileta Creek were collected using a v-notch weir from July 1989 through March 1992. The flow during the period ranged from zero to approximately 91 cubic feet per second. An average flow cannot be determined from the available data because data gaps exist between November 28, 1990 and May 9, 1991. The base flow during the period of record ranged from zero cubic feet per second to approximately two cubic feet per second (470 mgpy).

Fisher Creek

Stream gauge data for Fisher Creek were collected using a staff gauge from January 1991 through April 1992. In December 1991, an additional staff gauge was relocated to the opposite side of the creek downstream at the request of the property owner. The data collected at this station after the gauge installation is referred to as Gauge 2. Since the relocated staff gauge was set to the same level as Gauge 1, and the stream bed profile is the same for this location, the stream rating curve applies to data collected at Gauge 1 and Gauge 2.

The minimum stream level recorded for Gauge 1 was 0.6 cubic feet per second. The average stream flow rate was approximately 2.75 cubic feet per second. Base flow for Fisher Creek during 1991 was approximately one cubic feet per second (235 mgpy). The maximum flow for the period cannot be determined from the available data because peak flows exceeded the range of the discharge rating curve.

Green Valley Creek

Stream gauge data for Green Valley Creek were collected sporadically from January 1991 through April 1992 using a staff gauge. Base flow during 1991 was approximately 0.44 cubic feet per second (103 mgpy). The minimum stream flow rate was 0.44 cubic feet per second. The average stream flow rate was 0.57 cubic feet per second. The maximum flow for the period cannot be determined from the available data because peak flows exceeded the range of the discharge rating curve.

Paradise Cove Creek

Stream gauge data for Paradise Cove Creek were collected using a staff gauge from January 1991 through July 1991. The base, minimum, average, and maximum flow rates for the stream cannot be determined with accuracy because the data are randomly distributed and were collected for only a 6-month period. The minimum, maximum, and average stream flow rates for the 6-month period were, however, 0.12 cubic feet per second, 0.45 cubic feet per second, and 0.23 cubic feet per second, respectively.

Tahlequah Creek

Stream gauge data for Tahlequah Creek were collected using a staff gauge from July 1989 through April 1992. Base flow for the period was approximately 0.5 cubic feet per second (116 mgpy). The minimum stream flow rate was 0.3 cubic feet per second (using the April 20, 1990 to July 20, 1990 stream discharge rating curve). The average stream flow rate was 0.87 cubic feet per second (using the April 20 to July 20, 1990 rating curve). The maximum flow for the period cannot be determined from the available data because peak flows exceeded the range of the discharge rating curve.

Judd Creek

Stream gauge data for Judd Creek were collected using a staff gauge from July 1989 through April 1992. The base flow for the 1990 period was approximately two cubic feet per second (472 mgpy). The minimum, average, and maximum stream flow cannot be accurately determined because the staff gauge was washed out on three separate occasions (December 5, 1989; January 9, 1990; and November 23, 1990). The average and minimum stream flow values between January 17, 1990 and November 21, 1990, however, have been estimated from the available data to be approximately six to seven cubic feet per second and 2.25 cubic feet per second, respectively. The average stream flow value for 1990 is probably higher than estimated because stream level data was not collected during the high rainfall months of April and December. The maximum flow for the period cannot be determined from the available data because peak flows exceeded the range of the discharge rating curve.

Upper Judd Creek

Stream gauge data for Upper Judd Creek were collected using a staff gauge from January 1991 through January 1992. The observed base flow during 1991 was approximately 1.5 to two cubic feet per second (353 to 472 mgpy). The minimum stream flow rate was 1.5 cubic feet per second. The average stream flow rate was approximately eight to nine cubic feet per second. The maximum flow for the period cannot be determined from the available data because peak flows exceeded the range of the discharge rating curve.

Based on the average flows recorded for Upper Judd Creek and Judd Creek, it appears that the upper portion of Judd Creek has more flow than the lower portion. However, the average flow data collected at these two stations are not directly comparable. The data collected from Upper Judd Creek was not collected during the same time interval as most of the data for Judd Creek (January 1991 through January 1992 versus July 1989 through November 1990, respectively). In addition, the data collected at Upper Judd Creek contains many more peak flow events than Judd Creek, which skewed the average flow to higher values. Based on these limitations, it may be more appropriate to compare base flows for the two stations, which are approximately the same.

Needle (Shinglemill) Creek

Stream gauge data for Needle (Shinglemill) Creek were collected using a staff gauge from July 1989 through March 1991. The base flow ranged from approximately 1.5 to 2.5 cubic feet per second (353 to 590 mgpy) during 1989 and 1990. The minimum stream flow rate was 1.4 cubic feet per second. The average stream flow rate was three to four cubic feet per second. The maximum flow for the period cannot be determined from the available data because peak flows exceeded the range of the discharge rating curve.

8.3.2.3 Limitations

Conclusions based on stream data have several limitations. First, the interpretation and application of the data are restricted because of difficulties encountered in maintaining continuous stream gauge records without automatic recording instruments. (Staff gauges and weirs were selected as the instruments of measurement in an effort to provide adequate stream flow data within the economical constraints of the project budget.) As a result, the reliability of stream gauge data in determining stream flow rates and preparing Island water-budget calculations is less than optimal. The difficulties encountered are listed below, followed by an explanation.

- Storm damage to the staff gauges or weir structures.
- Streambed erosion and redeposition during storm events.
- Ungauged over-bank stream flow during storm events.
- Logistical problems associated with access to gauges/weirs during monitoring of actual storm events.
- Data gaps in daily stream gauge readings.

The staff gauges located on Judd and Needle (Shinglemill) Creeks were washed out during winter storm events in 1989 and 1990, but were repaired shortly after each event. A storm event in winter 1991 almost completely buried the Needle Creek staff gauge with sediment, rendering it useless. The weirs on both Mileta and Beall Creeks were washed out during a large storm event in January 1989. The washed-out weirs were replaced with more rigid structures that withstood storms during the following winter. Even after the Beall Creek weir was replaced, however, large storm events created stream flow events that overflowed the weir and eroded the banks around the structure. In addition, periodic maintenance activities involving flushing accumulated sand at the Water District No. 19 facility located upstream of the Beall Creek weir caused sand to accumulate in the weir structure.

The stream beds at all of the staff gauge sites were altered during winter storm events. The forces created by the higher flow rates tended to scour the stream bed in some locations and deposit sediments in others. In any case, original monitoring conditions were altered. URS tried to compensate for the variable stream beds by dredging out weirs and performing basic maintenance for gauges (Titus 1994).

The staff gauge readings were collected erratically and often with large gaps of time between observations that varied from months to years. The discontinuous nature of data collection is attributed to such factors as storm events damaging the weirs and gauges, and loss of interest by some of the volunteers. Peak stream flows were often not recorded because of the difficulties volunteer stream observers encountered in being on-site at the proper time after a storm event and in reading the peak flow measurement on the stream gauge in the dark. On the whole, the data collected are within reason for similar-type streams in the area and may be used as a "ballpark" estimate of actual conditions on the Island.

To compensate for these limitations in future data, it is recommended that automatic stream flow recorders be installed at the streams in which the staff gauges were not washed out. Crest gauges should be installed at the remainder of the streams to determine peak flow measurements. Periodic (monthly) stream bed profiles should be constructed for all streams.

8.3.3 Springs

The methodology, results, and limitations of the flow rate data collected by Seattle-King County Health Department from springs are discussed in the following subsections. A summary of the methodology is presented first, followed by a discussion of the results of the data analysis and limitations of the data set.

Six springs on the Island were selected for monitoring of flow rates. The selected springs were identified as North Vashon, Ober Beach, Klahanie (Atlas Water), Magnolia Beach, Morningside, and Manzanita (Jensen) springs. The J. Scott Spring was originally selected as a monitoring point, but, after access was denied following the first monitoring event, the North Vashon Spring was chosen. Data from the J. Scott Spring are not addressed in this chapter.

The springs were selected to provided information on ground water conditions in the drainage basins where ground water elevation in the shallow aquifer were being monitored in wells. Criteria used to select the springs included frequency of flow and access.

8.3.3.1 Methodology

Spring flow data were collected by Seattle-King County Health Department on a monthly basis (with several exceptions) from the spring 1990 through fall 1993. Data collection was discontinued at Ober Beach, Magnolia Beach and Morningside springs because on intermittent water flow and/or the absence of a satisfactory outlet to measure flow. Flow rates were determined by measuring the volume of water (in gallons) flowing into a container placed near the spring outlet over either 1- or 5-minute intervals. Flow rate data are interpreted below.

8.3.3.2 Results

Spring flow rates ranged from 0.04 to 5 gpm. Flow rates were generally highest in summer 1990 and lowest in winter 1992. Flow rates at North Vashon Water Company Spring ranged from 0.13 to 5 gpm. Highest flows were measured in June 1990 and 1991, while lowest flows were recorded in December 1992 and June 1993. Ranges of 0.05 to 1.33 gpm were recorded at the Atlas Water Company Spring; highest and lowest rates were measured in March 1992 and September 1992, respectively. The flow rates measured at Jensen Spring ranged from 0.04 to 1.50 gpm; the highest flows were recorded in June and July 1990 while the lowest were in December 1992.

No flow rate measurements could be obtained from Magnolia Beach and Morningside springs, but the one flow rate measured in March 1990 at Ober Beach indicated a flow rate of 1.25 gpm.

Although several springs were monitored in 1982, only data from Spring 24, located near Vashon Heights, was presented in Carr. Flow rates ranged from approximately eight gpm (in August 1982) to approximately 12 gpm (in March 1982 and November 1982). The flow rates recorded at Spring 24 were higher than the flow rates measured at any of the springs monitored during this study. No springs near Spring 24 were monitored recently.

8.3.3.3 Limitations

The collection methodology, variety of spring outlets, and the intermittent nature of some spring flows contributed to data inaccuracies. The equipment used to measure spring flow, for example, consisted of a bucket or graduated cylinder and a timer. If more sophisticated equipment were used in the future, greater accuracy might be achieved. The type of equipment used by Carr is unknown. In addition, the size of the spring outlets varied among the springs selected for monitoring, variances in flow rate can result from varying friction losses in different diameter pipes. Also, springs may discharge from more than one area; the flow monitored at each point may be only a fraction of the total flow being discharged from the spring.

Only Springs S-1 (North Vashon Water), S-3 (Atlas Water), and S-6 (Jensen) are currently being monitored for flow because of the intermittent nature of the flow at other springs (Shallow 1993). Flow rates discussed in this section are useful in comparing flow rates among the springs selected for monitoring, although the flow rates for individual springs may be imprecise.

8.3.4 Ground Water

The methodologies, results, and limitations of the ground water investigation conducted by Island volunteers are discussed in the following sections. Ground water-level data were collected by Seattle-King County Health Department staff to aid in assessing rainfall/recharge relationships, long-term trends in water levels (i.e., potential depletion of the ground water resource), and changes in ground water flow directions seasonally and over time. A summary of the methodologies is presented first, followed by a discussion of the results of the data analysis. Finally, trends in the recent ground water-level data are compared with conclusions reported by Carr.

Twenty-five wells on the Island were selected for monitoring ground water levels from 1989 to 1991 (see Table 8.5a). The selected wells are labeled W-1 through W-21 (see Figure 8.18). At locations where two wells existed (W-2, W-9, W-10, and W-16), the wells were distinguished by adding A and B to the well label (e.g., W-2A and W-2B).

The monitoring wells were selected to evaluate vertical and lateral variations of ground water conditions in the shallow aquifer across the Island. Criteria used to select the wells included even spatial distribution across the Island, well depths, approximate depth of the screened interval, access to the well, and homeowner availability. Part of the well selection criteria included reviewing available well logs, including logs provided by Carr, to help determine where the well was screened. Wells completed at varying depths in the shallow aquifer were selected to evaluate vertical variations in ground water conditions. Finally, only those wells where the owner gave permission for access were selected. Unfortunately, in many cases, wells that met the optimum criteria for selection had to be neglected because either no access was granted or no access portal hole existed.

8.3.4.1 Methodology

Water-level data were collected by Seattle-King County Health Department from the selected wells on a monthly basis from the summer or fall of 1989 through the spring of 1992; measurements were discontinued in Wells W-7, W-9B, and W-20 in October 1991, December 1989, and May 1991, respectively. Measurements in Wells W-7 and W-9B were discontinued because of the difficulty of accessing the well (i.e., portions of the well probe were lost) and W-20 because of the difficulty of access to the well casing on the property. The elevation of the top of the casing for each well (the measuring point for recording water levels) was estimated relative to mean sea level by Seattle-King County Health Department and Geraghty & Miller personnel using a hand-held altimeter and the appropriate 7.5-minute U. S. Geological Survey topographic map. All elevations were recorded in one day.

The water-level data and well completion depths were analyzed to determine the hydrostratigraphic units for the Island. Water-table elevation maps for the shallow aquifer were constructed to determine ground water flow directions and gradients. Hydrographs were prepared for each well to evaluate long-term trends in water levels.

The water-level elevations were compared with rainfall measurements at the nearest rain gauge.

8.3.4.2 Results

The following section describes the hydrostratigraphy of the Island, aquifer characteristics of hydrostratigraphic units, and trends in water levels.

Hydrostratigraphy

Water-level elevations in wells were analyzed to determine whether more than two hydrostratigraphic zones existed on the Island. Hydrostratigraphic zones are defined as water-bearing portions of major geologic sequences that have similar hydraulic heads (water-level elevations). Hydrostratigraphic zones should not be confused with geologic units because they often cross geologic boundaries. This is especially true in areas like Vashon Island where the hydrostratigraphic zones occur in complex geologic sequences that either change abruptly or grade laterally into one another over short distances. Carr did not address the possibility of multiple water-bearing zones, but rather attempted to show that a two-aquifer system occurred in two distinct geologic units. Data presented in the report suggest that the actual situation is more complex.

Two criteria (ground water elevations and well screen depths) were used to define the hydrostratigraphic zones. Four hydrostratigraphic zones were identified based on grouping wells with common hydraulic heads (see Figures 8.19 through 8.21). Zone 1 (the shallowest zone) is closest to ground surface. The average hydraulic head measurements in the wells associated with this zone are approximately 255 feet above mean sea level, as defined by Wells W-6, W-13, W-14, W-15, W-16A and B, W-19, and W-20. Infiltration into this hydrostratigraphic zone is probably the most efficient of all four zones because of its proximity to recharge areas (where water for the aquifer is replenished by rainfall). The potential for aquifer contamination is also the greatest in Zone 1 because it is closest to the surface.

Zone 2 lies beneath Zone 1. Hydraulic head measurements for wells in Zone 2 average about 97 feet above mean sea level, and are based on heads in W-1, W-2A, W-2B, W-18, and W-21. Well W-11 may also be included in Zone 2 because of its hydraulic head, but is most likely in the next lower zone (Zone 3) based on the screen depth. The anomalously high head in Well W-11 suggests it was constructed in an area where ground water recovery can move vertically downward with little head loss in comparison to other wells completed to the same depth. Well Log W-11 shows that 264 feet of the 423-foot well is composed of sandy units.

Two additional hydrostratigraphic zones (Zone 3 and Zone 4) successively underlie Zone 2. Wells included in Zone 3 are W-3, W-4, W-5, W-7, W-9A, W-10A, W-10B, W-11, and W-17. The hydraulic heads (18 feet and 11 feet mean sea level, respectively) defining these two zones are less distinct than the two overlying zones; however, the screen depth of wells such as W-8 and W-12, which are more than 250 feet deeper than the wells included in Zone 3, indicate that these wells are completed in a distinct hydrostratigraphic zone (Zone 4).

Well W-12 in Zone 4 has a hydraulic head that is above the average hydraulic head in Zone 3. A possible explanation is that the water infiltrating through a topographically high recharge area travels through more permeable sediments to reach the well screen of W-12. Thus, most of the original head of the infiltrating water is preserved.

The four hydrostratigraphic zones are found throughout the Island (see Figure 8.19). Although the hydrostratigraphic zones are conceptually portrayed as laterally continuous entities, the aquifer configuration is more complex as a result of lateral changes in geology. In addition, at least two of the hydrostratigraphic zones are probably separated by low permeability layers such as the silt aquitard suggested by Carr. Vertical leakage through zones occurs allowing infiltration of water from the near-surface zones into successively deeper zones.

Additional deep zones may exist on the Island, but information on deep hydrostratigraphic zones is limited. In an effort to further understand the deeper zones, the results of the installation of VT-1 were compared with other nearby deep wells (the KIRO Well [Well W-8] and the Coho Well [Well W-12]; Figures 8.5 and 8.6). Although the standing water level in the VT-1 borehole (-38 feet mean sea level) was lower than the average hydraulic head in Hydrostratigraphic Zone 4 (11 feet mean sea level), similar total well depths (W-8 [-412 feet mean sea level], Well W-12 [-368 feet mean sea level], VT-1 [-450 feet mean sea level]), indicate that VT-1 was drilled into Hydrostratigraphic Zone 4.

The potential for recharge to the deep Island hydrostratigraphic zone (Zone 4) from off-Island sources (primarily to the west) was evaluated by comparing the depths of wells completed in Zone 4 with depths of the Puget Sound and the Gig Harbor Well No. 5 (see Figures 8.5 and 8.6). Since the Zone 4 occurs in VT-1 at an elevation (-450 feet mean sea level) below Colvos Passage (-114 to -414 feet mean sea level) and at similar elevations as hydrostratigraphic zones penetrated by the Gig Harbor well (approximately -475 feet mean sea level), Hydrostratigraphic Zone 4 may be interconnected to the deep hydrostratigraphic zones of the mainland. However, there is no data to suggest that the hydrostratigraphic units, if interconnected, can transmit enough water to recharge the deep Island hydrostratigraphic units. It is more likely that Island precipitation and infiltration is the primary source of recharge to the deeper Island hydrostratigraphic zones.

Aquifer Characteristics

Since no pumping or slug (aquifer) tests were performed for Exploratory Well VT-1, the aquifer hydraulic characteristics of Aquifer Zone 4 were estimated based on the grain-size distribution of the soil samples collected (Driscoll 1986). The grain-size distribution of the soil sample collected at a depth of 435 feet bls was used to calculate the hydraulic conductivity. This sample was collected from a zone that was characterized during drilling as very fine-grained to fine-grained sand. Other portions of this water-bearing zone were characterized as finer and coarser than this sample, so this sample may portray a relatively representative average composition.

The hydraulic conductivity and transmissivity of Zone 4 were calculated at approximately 10 to 15 feet per day and 600 to 900 square feet per day, respectively. (The estimated transmissivity is based on an aquifer thickness of 60 feet. The aquifer thickness was estimated from the boring log for Well VT-1.) The storage coefficient was estimated at 10^{-3} to 10^{-5}, based on typical values for a confined aquifer (Driscoll 1986).

Additional aquifer characteristics were determined from the results of a pumping test conducted in the Coho Well (Carr 1991). The Coho Well is suspected to be completed in a different hydrostratigraphic zone than VT-4, but the aquifer characteristics derived from the well are summarized below to provide a further understanding of the subsurface hydrogeology.

Based on the 24-hour pumping test conducted in the Coho Well, Carr (1991) reported the transmissivity of the hydrostratigraphic zone the well is completed in is 414 gpd/per foot and the storage coefficient is 10^{-4}. The transmissivity for the Coho Well is less than VT-1, which further supports that these two wells may be completed in different hydrostratigraphic zones.

Water Levels

Hydrographs of the monthly water-level data were prepared for each well to evaluate trends in water levels during the observation period. The following trends can determined:

- For Zones 1, 3, and 4, there is generally no correlation between hydrographs for wells completed in the same hydrostratigraphic zone; the hydrographs display a variety of patterns in water levels. Conversely, most of the hydrographs for Zone 2 wells show a common pattern of little or no variation in water levels.

- Wells W-6, W-13, W-14, W-15, W-16 A and B, W-19, and W-20, screened in hydrostratigraphic Zone 1, show seasonal water-table fluctuations [difference between high and low] of 0.6 to 17.61 feet (see Table 8.5b). (Water levels with probable measurement errors were not included in determining these fluctuation ranges).

- Wells W-1, W-2A and B, W-18, and W-21, screened in hydrostratigraphic Zone 2, generally show seasonal water-table fluctuations of less than two to three feet (see Table 8.5b).

- Wells W-3, W-4, W-5, W-7, W-9A, W-10A and B, and W-17 are screened in hydrostratigraphic Zone 3. Seasonal water-table fluctuations of 0.63 to 9.08 feet occurred in these wells (see Table 8.5b).

- Wells W-8 and W-12 are screened in hydrostratigraphic Zone 4. Seasonal water-table fluctuations ranged from 0.87 to 2.79 feet (see Table 8.5b).

- Seasonal fluctuations observed in the wells tend to correlate with rainfall (allowing for a lag period of from one to four months for the water to infiltrate the aquifer). Seasonal high water-table elevations tend to occur during the early summer months, reflecting high recharge during the preceding winter and early spring months. Seasonal low water-table elevations tend to occur during the fall months, following periods of low rainfall during the preceding summer and early fall months (see Figures 8.22 and 8.23).

- Many of the wells show very little seasonal fluctuations in water levels. These wells (W-2A, W-2B, W-3, W-11, W-14, W-15, W-18, W-19, and W-21) are completed in all four hydrostratigraphic zones. The lack of seasonal fluctuations in water levels indicates that the portions of the hydrostratigraphic units these wells are screened in are not directly recharged by precipitation but are in relative equilibrium with recharge through long-term infiltration.

- Wells W-1, W-2A and B, W-6, W-10A and B, W-13, W-15, W-16A and B, W-19, W-20, and W-21 show long-term trends of increasing water-level elevations of approximately 0.5 to two feet per year. Trends in increasing water-level elevations in these wells correlate to increasing rainfall trends. Most of these wells are screened in Hydrostratigraphic Zone 1.

- In general, the long-term trends in the hydrographs indicate that all hydrostratigraphic zones monitored by the selected wells are generally stable and have not been affected by ground water withdrawals, particularly in the four areas of high water use (Town of Vashon, Dockton, Burton, and Vashon Center), although more consumption information is needed from unmetered private wells to adequately determine if more water is withdrawn than is supplied through recharge.

Water-table contour maps (see Figures 8.24 and 8.25) were prepared for the near-surface aquifer using the water-level elevation map from Carr (see Figure 8.26) modified using water levels recorded for wells completed in Zone 1 in this chapter. (Locations of wells used by Carr are shown in Figure 8.27.) The water-table surface generally corresponds with the Island surface topography (i.e., in areas with high elevations, the water-table elevation is high, whereas the water-table elevation is low in areas with low elevations). Ground water flows from topographic highs toward the coastline in Hydrostratigraphic Zone 1. Water-level contour maps were not prepared for Hydrostratigraphic Zones 2, 3, or 4 due to insufficient water-level data available for these zones.

The horizontal ground water gradient depicted in Hydrostratigraphic Zone 1 is generally steeper on the west side of Vashon Island (from Well W-16 west to the shoreline, where the gradient was 0.095 in November 1989 and 0.105 in April 1991) than on the east side of Vashon Island (from Well W-6 east to the shoreline, where the gradient was 0.026 in November 1989 to 0.027 in April 1991) (see Figures 8.24 and 8.25). The horizontal ground water gradient is generally steeper in the spring than in the fall as a result of the higher water table caused by recharge from winter rains. The ground water flow directions and gradients are similar to the values presented by Carr.

Vertical ground water gradients were evaluated by comparing the hydraulic heads in four sets of paired monitoring wells (W-2A and W-B [Zone 2], W-9A and W-9B [Zone 3], W-10A and W-10B [Zone 3], W-16A and W-16B [Zone 1]) that are completed at different depths. A downward gradient was calculated for the November 1989 water levels in Well Sets W-2 (-0.65) and W-9 (-0.44). Conversely, an upward gradient was calculated in Well Sets W-10 (0.10) and W-16 (2.42). In April 1991, Well Set W-2 had a downward gradient of -0.69, while Well Set W-16 has an upward gradient of 3.13. At the same time, the vertical gradient in Well Set W-10 changed from an upward gradient to a downward gradient (-0.05). Measurements of water levels in Well Set W-9B were discontinued after November 1989, so no vertical gradient could be determined.

8.3.4.3 Limitations

The water-level data were limited by data gaps in monthly water-level collection, logistical problems in access to wells, possible well use, possible tidal influence at near-shore wells, and possible influence from withdrawals from public supply wells in the vicinity. Monitoring wells within ½ mile of major public supply wells that may be affected by the drawdown from the supply wells include: W-2A and W-2B, W-10A and W-10B, W-11, and W-13; monitoring wells within one mile of major public supply wells include additional Wells W-4, W-6, W-7, W-9A and W-9B, W-12, and W-21. It is unlikely that water levels in these latter wells are affected by supply wells because of the complexity of the hydrostratigraphic zones and distance of the wells from the supply wells.

Anomalous spikes of high and low water-table elevations appear on many of the graphs. Possible sources of the anomalous data included well pumping while readings were being taken and human error in recording accurate measurements.

Insufficient information is available to characterize the flow systems of Hydrostratigraphic Zones 2, 3, and 4. Therefore, water-level contour maps could not be produced for these zones.

8.3.5 Physical Susceptibility Areas

Several maps have been generated that rank areas according to either the ground water physical susceptibility to contamination or the amount of potential recharge to ground water. The following sections discuss the methodologies, results and limitations of physical susceptibility areas on the Island. The two maps of physical susceptibility are then compared to the recharge areas delineated by Carr. The locations of impervious surfaces with respect to physical susceptibility areas are also presented. In addition, an evaluation of the recharge areas of the deeper hydrostratigraphic zones is included.

Two maps of ground water susceptibility to contamination have been generated for the Vashon-Maury Island Ground Water Management Area. Geraghty & Miller, Inc. implemented the criteria in Derek Booth's 1994 paper on recharge potential (Booth 1994a) as guidance for the construction of a physical susceptibility map at the request of the Seattle-King County Health Department (see Figure 8.28a). In addition, a county-wide methodology was adopted to define and rank areas that are physically susceptible to ground water contamination.

Booth recommends that the following criteria be used in construction of a physical susceptibility map :

- Surface geology permeability potential (see Figure 8.29).
- Depth-to-water susceptibility potential (see Figure 8.30).
- Slope susceptibility potential (see Figure 8.31).

The county-wide map uses the following criteria in construction of a physical susceptibility map:

- Surficial geology
- Soil type (one quarter weight)
- Depth to ground water

The primary difference between the two susceptibility maps are that Booth considered slope in his assessment and the county-wide map does not. The general approach used to evaluate the susceptibility potential for each map is summarized below. Areas with geologic units not discussed in the Booth paper (1994a) were evaluated using criteria developed in the Redmond-Bear Creek Ground Water Management Plan which was the recommended standard prior to Booth's criteria.

8.3.5.1 Methodology

The methodology used in the construction of the depth-to-water susceptibility potential, slope susceptibility potential, and surface geology permeability potential maps for Booth's susceptibility map is discussed in the following sections. A comparison of Booth's methodology with the methodology used to develop the County-wide map of physical susceptibility to ground water contamination is also presented. Areas with high, medium, and low susceptibility potentials were designated on each of Booth's maps with respect to their effect on recharge to the hydrostratigraphic zones. The three maps were then combined to produce a composite physical susceptibility map using the criteria outlined in Tables 8.6a, 8.7a, 8.8a and 8.9a. The distribution of impermeable surfaces (paved areas and rooftops) were then overlain on the composite map.

Permeability of Surficial Geology

The permeability of the Island surficial geology was determined using Derek Booth's geologic map (see Figure 8.1) of Vashon Island (1991). The permeability of the surficial geology on the Island was first divided into outwash, till, and the geologic units defined in the Redmond-Bear Creek Ground Water Management Plan, then each unit was classified as either a high, medium or low potential for physical susceptibility. The geologic units considered for the Vashon-Maury Island Ground Water Management Area are listed in Table 8.6. If the geologic unit on the map of the Island (Booth 1991) was classified as "outwash", then the unit was considered as a high potential for susceptibility because water (rainfall) infiltrates quickly through the unit. But, if the geologic unit was classified as "till", then the unit was considered a low potential unit because of low infiltration of water through the unit. The remainder of geologic units (e.g., alluvium, landslide deposits, etc.) were divided by permeability criteria into low, medium and high susceptibility potential (see Table 8.6).

The geologic units (shown in Figure 8.1) and associated potentials were evaluated as follows are listed in Table 8.6a for the Booth Map and in Table 8.6b for the county-wide map. The primary difference in these two approaches is that Booth considers advance outwash deposits high in susceptibility while the county-wide map rates the same deposits as medium in susceptibility.

To evaluate the areal distribution across the Island, the resultant areas of surface geology permeability potentials from Booth's work are displayed in Figure 8.29. The high potential surface geology permeability areas are confined to the Judd, Tahlequah, Fisher, Needle (Shinglemill), and Mileta creek drainage basins in northwest, south, and southeast Vashon Island and northwest Maury Island. Additional areas of high potential susceptibility are found on the plateau between Spring Beach and Burton, northwest of Burton, on the plateau between the Town of Vashon and Cove, directly east of Cove, on the northeast coast of Vashon Island, on the southwest coast of Maury Island, and on the northern shore of Maury Island.

Depth-to-Water

The depth-to-water susceptibility potential of the Island for Booth's mapping process (see Figure 8.30) was determined by evaluating the average depth-to-water in geologic units (outwash, till, and geologic units presented in the Redmond-Bear Creek Ground Water Management Plan). Average depth to water was calculated from the available water level data from the wells monitored between 1989 and 1992.

For Booth's map, the average depth-to-water measurements within a geologic unit were used to determine if the relative susceptibility potential of the unit was high, medium, or low (see Table 8.5b). If the depth-to-water in a geologic unit classified as outwash was less than or equal to 25 feet, then the unit was considered as having a high potential for depth-to-water susceptibility. But, if the depth-to-water in a same geologic unit was greater than 25 feet, then the unit was considered as having a low potential. The criteria used in the determination of the depth-to-water susceptibilities for the other geologic units are shown in Table 8.7a.

Booth's resultant depth-to-water susceptibility potentials were then plotted (see Figure 8.30) to evaluate the aerial distributions across the Island. The depth-to-water susceptibility map shows high potential areas are located along the south, southeastern, and southwestern shorelines of Vashon Island; northwest of Burton; and the drainage basin of lower Judd Creek.

The susceptibility ratings for different depths-to-water in the county-wide mapping process were based only on depth and not on surficial geology. The susceptibility rating for the depth-to-water criteria used in the county-wide susceptibility map is presented in Table 8.7b.

Slope

The slope susceptibility potential of the Island (see Figure 8.31) was evaluated in Booth's mapping process by comparing the percent of slope in each of the geologic units (outwash, till, and Redmond-Bear Creek Ground Water Management Plan). Slope was not considered in the county-wide mapping of physical susceptibility. The slope gradient (vertical drop per horizontal feet) was calculated for multiple areas on the Island from the U. S. Geological Survey topographic quadrangle maps for the Island (U. S. Geological Survey 1968a and b; 1981a, b, and c) and converted to a percentage. The gradient of the slope upon which precipitation falls affects the amount of precipitation that recharges into the ground. More rain tends to run off a steep slope than off a level plain.

The slope susceptibility potential was determined for each geologic unit as either high, medium, or low, based on the percent slope (see Table 8.8a), with the exception of geologic units classified as outwash. These outwash units were considered as a high potential for slope susceptibility regardless of percent slope, per Booth's criteria (1994a). If the percent slope in a unit classified as till was less than or equal to 40 percent, then the unit was considered as having a medium potential. The slope susceptibilities for the other geologic units are shown in Table 8.8a.

The resultant slope susceptibility potentials were plotted (see Figure 8.31) to evaluate the aerial distribution across the Island. The high slope susceptibility potential areas are generally located in the same areas as the high permeability potentials of surficial geologic units (the Judd, Tahlequah, Fisher, Needle [Shinglemill]), and in the Mileta creek drainage basins in northwest, south, and southeast Vashon Island and northwest Maury Island; the plateau between Spring Beach and Burton; northwest of Burton; on the plateau between the Town of Vashon and Cove; directly east of Cove; on the northeast coast of Vashon Island; on the southwest coast of Maury Island; on the northern shore of Maury Island), along the eastern and northern Maury Island coast, and the southwestern and northwestern Vashon Island coastlines.

Physical Susceptibility

The physical susceptibility potential for Booth's map was determined by evaluating all three physical parameters (surficial permeability susceptibility, depth-to-water susceptibility, and slope susceptibility). The slope, depth-to-water, and surficial permeability susceptibility potential maps were overlain (see Figure 8.32) to create a composite map of intersecting areas of susceptibility potentials (see Figure 8.28a). Each intersecting area, therefore, contains a composite of combinations of low, medium, or high potentials from the three individual physical parameter maps. The three individual susceptibilities for each of intersecting area are then combined to assign a relative susceptibility potential for each area of low, medium, or high. For example, the high-medium-high intersecting area would result in a combined high potential area on the completed physical susceptibility map. All of the composite classifications for intersecting areas and the resultant physical susceptibility classifications are included in Table 8.9a. After a susceptibility potential was assigned for each intersecting area, the physical susceptibility map was created (see Figure 8.28a).

The impervious surface map was then overlain on Booth's physical susceptibility map (see Figure 8.28a) to depict the distribution of impervious surfaces with respect to physical susceptibility areas (see Figure 8.33). Impervious surfaces on the Island (rooftops and paved areas) were distinguished using satellite data provided by the Department of Development and Environmental Services in the King County Environmental Division (Creahan 1994).

The impervious surfaces were not used as a criterion in classifying the physical susceptibility of an area. Although an impervious surface will impede surface infiltration (amount of water for recharge), it will not reduce the physical susceptibility of the underlying geologic units to underground releases from underground storage tanks, septic systems, piping, etc. These potential sources of contamination tend to be concentrated in areas (towns) where the impervious surfaces are also concentrated.

The county-wide physical susceptibility map (see Figure 8.28b) that was created as a mapping requirement for recharge areas under the Growth Management Act was made using criteria specifying surficial geology, soils and depth to ground water. Each criteria was rated individually as high, moderate or low according to the protocols listed in Tables 8.6b, 8.7b and 8.8b. The three individual scores were combined to yield an overall rating of aquifer susceptibility. It should be noted that soils were assigned one-quarter of the weight assigned to surficial geology and depth to ground water because their occurrence is a result of the physical and chemical weathering processes of surficial geology. A full rating for soils would duplicate surficial geology in the mapping equation.

8.3.5.2 Results

In the physical susceptibility analysis, the largest areas which show the highest physical susceptibility are (1) Judd Creek drainage, (2) Fisher Creek drainage, (3) Tahlequah Creek drainage, (4) Ellis and Ellisport Creek drainage, (5) Mileta Creek drainage, (6) a portion of Green Valley Creek drainage, (7) on the plateau between Spring Beach and Burton, (8) northwest of Burton, (9) on the northern Burton peninsula, (10) on the plateau between the Town of Vashon and Cove, (11) directly east of Cove, (12) near the northeast and northwest coasts of Vashon Island, (13) near the southwest and southeast coasts of Maury Island, and (14) near the northern shore of Maury Island. Several smaller areas of high potential physical susceptibility are scattered around the Island. Both Booth's map and the county-wide map are in agreement as to the high physically susceptible areas mentioned above. Slight discrepancies between the two maps can be attributed to the ranking associated with slope potential, and Booth's method of ranking the depth-to-ground water (high, medium and low ranking are dependent on both depth-to-water and the surficial geology).

Vegetation is beneficial to ground water. Vegetation decreases the velocity of runoff as water is diverted around stems and roots. This benefits recharge because slowing the runoff velocity increases the amount time for infiltration into the ground (Seattle-King County Health Department 1994). Each variety of vegetation has its own beneficial effects on recharge. Some plants have larger leaves or absorb greater amounts of water, but after transpiration (escape of water to atmosphere) is taken into consideration, the resultant amount of water that infiltrates into the soil is the same (Dunne 1978). Vegetation distribution maps were not prepared because vegetation distribution can change rapidly with land use practices (such as farming or logging), and vegetation is not one of the criteria recommended by Booth (1994a) for preparing physical susceptibility maps.

Impervious surfaces cover only a small percentage of the Island (see Figure 8.33). The impervious surfaces are concentrated in areas within the Town of Vashon and Vashon Center, coastal areas near Burton and Magnolia Beach, Sandy Shores and Gold Beach coastal areas, and miscellaneous areas scattered along the shoreline. Impervious surfaces (see Figure 8.33) near the Town of Vashon and Vashon Center cover low physical susceptibility areas; impervious surface areas near the shorelines often cover high to medium areas of physical susceptibility.

The Booth and county-wide physical susceptibility maps were compared to the recharge potential map by Carr (see Figure 8.34); in general, the Carr map was very different. The only localities of high physical susceptibility potential common to both the Carr map, and the Booth and county-wide maps are the area near the Maury Island golf course. This includes a portion of the plateau area between Burton and Paradise Cove, a portion of the Ellis and Ellisport Creek drainage, and a portion of Green Valley Creek drainage. Additional areas considered to have high recharge potential by Carr include central Maury Island, south-central and east-central Vashon Island, and the vicinity of the Town of Vashon. The total area of high recharge defined in this study is approximately 7,000 acres; Carr reported approximately 6,000 acres of high recharge area.

The difference between the areas of recharge defined by Carr (see Figure 8.34) and the areas of physical susceptibility (see Figures 8.28a and 8.28b) results from different methodologies and criteria used in development of the maps. The criteria Carr used for the development of the recharge map are slope, subsurface permeability, soil permeability, and vegetation. The criteria used to develop the Booth physical susceptibility map (see Figure 8.28a) are depth-to-water susceptibility, slope susceptibility, and permeability of the surficial geologic susceptibility units. The county-wide map considers surficial geology, soils and depth to water. In addition, Booth's (1991) geologic map of Vashon Island and Booth's (1994a) criteria for physical susceptibility map construction were not available when the Carr recharge map was constructed. The difference in distribution of surficial geologic units also may have contributed to the variances between maps. The different criteria and methodologies used to construct the maps resulted primarily in differing locations of high potential recharge areas.

Carr (1983) also used two additional methods to evaluate potential recharge areas: water levels (elevation and amplitude of fluctuation), and time delay (water level response). A close agreement between these two methods and the physical characteristics method was concluded by Carr.

Carr concluded that areas with the highest water-table elevations (primarily along west central Vashon Island) were areas of high recharge. This conclusion was based on the stated assumption that "under uniform conditions, areas with the highest water-table elevations will coincide with recharge areas." Uniform conditions would assume geologic homogeneity, among other factors. However, because the conditions at the Island are characterized by heterogeneity (primarily based on the detailed geologic mapping by Booth [1991]), the relationship between water-table elevation and recharge potential is complex and not easily interpreted. High water-table elevations may reflect high Island topography rather than strictly high recharge.

Carr (1983) also concluded that areas with the greatest fluctuations in water levels (primarily west-central Vashon Island) coincide with the locus of recharge. This assumption is also based on assumed uniform conditions. A comparison with Carr's conclusion should not be made based on water-level fluctuations in the wells monitored in this study, because the water-level fluctuations discussed in Section 8.3.4.2 did not show a clear correlation with respect to well location in potential recharge areas. As discussed in Section 8.3.4.2, interpretations of water levels in the wells are complicated by complexity and heterogeneity of the hydrostratigraphic units.

A comparison of the areas of physical susceptibility (see Figure 8.28a) and the potential point sources of contamination (see Figure 5.1c) was conducted to evaluate potential sources of contamination in high physical susceptibility areas. The results indicate the following potential contamination sources are located in areas of high physical susceptibility:

- Two underground storage tanks located in an area west of Point Beals.
- Two septic system failures in an area east of Cove.
- Middle section of Vashon Landfill on the plateau between Cove and the Town of Vashon.
- Two septic system failures on the edges of Ellis and Ellisport Creek drainage areas.
- Four septic system failures in Judd Creek drainage area.
- Two septic system failures on the edge of an area northwest of Burton.
- Two septic system failures on the plateau between Burton and Paradise Cove.
- Four septic system failures on areas of Maury Island.
- Golf course in Mileta Creek drainage area.
- Quarrying on the east coast Maury Island.

Potential sources of contamination were not compared to potential recharge areas in the report by Carr.

8.3.5.3 Limitations

The maps of areas physically susceptible to ground water contamination are intended to be used as a guide for development planning. It is useful for delineating general areas that may have high potential recharge; however, to determine the actual potential recharge of a specific area, more site-specific data may be needed, as is outlined in Section 9.0.

Insufficient information (deep well logs and aquifer characteristics) is available on the deeper hydrostratigraphic zones to conclusively determine the recharge areas for these zones. Recharge of deeper hydrostratigraphic zones is most likely derived from overlying hydrostratigraphic zones by leakage through the less permeable layers separating the zones, as discussed in Section 8.4.4.2.

8.4 Water Quantity and Water Budget

A water budget for the Island was prepared to provide a general understanding of the components of ground water recharge and natural discharge, and an estimate of the amount of water available for human consumption. The amount of water available for consumption is proportional to the amount of water that infiltrates (is absorbed by) the ground surface; water availability is affected by land use, population growth, and water use.

The total water budget for the Island was prepared by Mr. Ed McGavock (formerly with the U. S. Geological Survey, 1962 to 1993, as Assistant District Chief of the Water Resources Division). The water budget was calculated using data collected on the Island from 1989 to 1992 supplemented by publications of precipitation and stream flow data for the Island (U. S. Geological Survey 1985) and off-Island, near Gig Harbor (Drost 1982). The published data were used to provide a long-term database essential for providing the most accurate water-budget calculations. For purposes of preparing a water balance, a long period of precipitation data is suggested by the U. S. Geological Survey. In this instance, Vashon has only four years of continuous data, so the water balance was prepared using Gig Harbor data (which is the closest data station) and comparing the results with the actual Vashon data to adjust the calculations appropriately.

A water budget is an interpretation of the balance between the inflow of water (rainfall) and outflow of water (evapotranspiration, surface runoff, base flow, and subsurface flow) on the Island. Rainfall accounts for the total water entering the recharge areas on the Island. Rainfall measurements were obtained from Wauna Station in Gig Harbor (Drost 1982) and at Judd Creek (U. S. Geological Survey 1985) to provide long-term monitoring data. Evapotranspiration (water evaporated by soil and transpired by plants) data were obtained from Gig Harbor estimates (Drost 1982). Surface runoff is the amount of water that doesn't infiltrate into the ground, but discharges directly to Puget Sound. Surface runoff data from Gig Harbor (Drost 1982), augmented by data collected on the Island between 1989 and 1992, were used to provide long-term estimates of runoff from the Island. Base flow (or dry-weather flow [Dunne 1978]) is the amount of ground water that seeps into a stream. Estimates of base flow, calculated from base flow data available from Gig Harbor (Drost 1982), were augmented by the data collected between 1989 and 1992 on the Island. The subsurface outflow is the discharge of ground water into Puget Sound. The subsurface outflow is resultant of the components above and is used to determine the amount of ground water available for consumption. The estimated amounts for each parameter as calculated by E. McGavock are summarized in Table 8.9b.

Based on the water budget, the total ground water available for the Island is 4.26 bgpy or 12,895 acre-feet per year (AFY). Only a fraction of this water is capturable by wells and available for consumption. If too much water is withdrawn, the effects will be seen at the surface as a lower volume of stream flow (base flow is depleted), lower water table, and increased potential for seawater intrusion. Available water in this context is that which occurs in or on the Island without regard to the technical or economic feasibility of capturing the water.

The water budget by Carr (1983) estimated the water available from the Principal Aquifer as 578 mgpy (932 AFY). Carr's definition of available water is that which occurs in or on the island but may not be technically or economically feasible to use based on criteria established in the 1983 report (Carr 1983, page 10-6, Table 6-2). This water supply was estimated to support a population of 10,905 to 13,197. Carr did not account for water availability from surface water or deeper water-bearing zones; the methods used to calculate the water availability were not documented in the Carr report.

Population growth results in an increase in the number of residential and commercial buildings, roads, and parking lots sealing over ground water recharge areas, and an increased demand for water. Ground water withdrawals from the aquifer combined with covering over of recharge areas can lead to a diminished ground water supply for drinking water purposes. Because ground water and surface water are interconnected, surface water features such as lake levels and base flow of creeks are impacted by diminished ground water levels.

With demands for more ground water, agencies and purveyors must plan for methods to protect this valuable finite resource. In new developments, certain areas must either be left in their natural state, or provided with vegetation that induces recharge. Storm water facilities must be constructed to promote recharge of ground water provided that the storm water is first adequately treated so as not to contaminate ground water. The state is also currently investigating ways to treat and reuse wastewater. To conserve water, low-use water fixtures need to be installed in residential and commercial buildings and the public needs to be educated in water-conservation habits.

8.5 Water Quality

The following section describes the surface, spring, and ground water quality of the Island. The surface water system investigation by Seattle-King County Health Department includes data from freshwater and marine water, freshwater and marine water sediments, and marine shellfish. Additional studies of marine water and shellfish were conducted by the Washington State Department of Health, King County Department of Natural Resources, Water Pollution Control Division (formerly Metro), Seattle-King County Health Department, Puget Sound Water Quality Authority, and Quartermaster Harbor Yacht Club and Quartermaster Marine Association. Spring and ground water quality data were collected from private and public water-supply wells and springs across the Island. The water quality for each system -- surface, spring, and ground -- is discussed in separate sections below. All laboratory analyses were conducted by AmTest Inc. of Redmond, Washington, which is a state-certified laboratory. The spring and ground water data were validated by EcoChem, Inc. of Seattle, Washington. The surface water data was validated by Seattle-King County Health Department. In an effort to give a context for evaluation of water quality data, the term "trend" is used. When possible, any change in water quality at a particular location was said to establish a trend. The data set consisted of three sampling rounds. In many cases, the changes were not statistically significant, but were intended to be used in conjunction with the trigger mechanisms for indicator parameters so that a baseline might be established. The trigger mechanisms are described in Section 9.3.2.

8.5.1 Surface Water Quality

Samples of freshwater, marine water, freshwater sediment, marine water sediment, and marine shellfish were collected by Seattle-King County Health Department personnel from the following eight streams (see Figure 8.35):

- Beall Creek
- Fisher Creek
- Green Valley Creek
- Judd Creek
- Mileta Creek
- Paradise Cove Creek
- Needle (Shinglemill) Creek
- Tahlequah Creek

Upper Judd Creek was not specifically designated as one of the creeks from which water quality samples were collected. Samples were collected adjacent to the weir or staff gauge at each of the eight creeks. Samples were not collected at the Upper Judd Creek gauge location.

The following subsections summarize the surface water sampling methodology used by Seattle-King County Health Department, field and laboratory results, and limitations on use of the data. In addition, the results for the marine water and shellfish samples collected near Vashon and analyzed by Metro, the Washington State Department of Health, Puget Sound Water Quality Authority, and Quartermaster Harbor Yacht Club and Quartermaster Marine Association are briefly summarized.

8.5.1.1 Methodology

The methodology used by Seattle-King County Health Department in sample collection is discussed in detail in the surface water sample collection work plan (EcoChem/Geraghty & Miller 1991). The following section summarizes the sample collection activities conducted in 1991 and 1992.

Freshwater samples were collected adjacent to the staff gauge, in the middle of the creek (see Figure 8.35). Marine water samples were collected at three sampling sites 20 feet apart, at a water depth of three feet at the mouth of each creek (Shallow 1993). Freshwater sediment samples were collected above the high marine water tide and downstream from the freshwater collection site. Marine water sediment samples were collected in the middle of the shellfish collection area. Marine shellfish samples were collected in the vicinity of the marine water and marine sediment samples. No marine shellfish community could be located in Green Valley Creek, and, therefore, no shellfish samples were collected.

Freshwater samples were collected monthly from August 1991 through September 1992. Samples of marine water, marine water sediment, and marine shellfish were collected in August and November 1991 and April, July, and August 1992. Freshwater sediment samples were collected in August and September 1991 from Judd, Mileta, and Needle (Shinglemill) creeks. All samples were analyzed for the following bacteriological, metal, and inorganic parameters:

Bacteriological	Metal	Inorganic
Fecal coliforms	Calcium	Chloride
Total coliforms	Iron	Nitrate/nitrite
	Manganese	Sulfate
	Magnesium	
	Potassium	
	Sodium	
	Silica	
	Zinc	
	Silver	
	Selenium	
	Mercury	
	Barium	
	Copper	
	Cadmium	
	Lead	
	Chromium	
	Arsenic	

In addition, freshwater samples from Judd Creek and freshwater sediment samples from Judd and Mileta Creeks were analyzed for volatile organic compounds and/or pesticides and polychlorinated biphenyls in August and September 1991. Samples from creek basins where historical land-use information indicated volatile organic compounds, pesticides, or polychlorinated biphenyls might be present were analyzed for those constituents (Seattle-King County Health Department 1993b).

To evaluate the sampling results, analytical data for water samples were compared to Washington State water quality criteria (Chapter 173-201A WAC) for Class AA streams and marine water. At the time of this study, surface water standards were limited or not adopted by the state until after these sampling events were completed (Seattle-King County Health Department 1993b). The following water quality parameters were evaluated against the current Washington State water quality criteria:

Freshwater	Marine Water
Fecal coliforms	Total coliforms
Arsenic	Fecal coliforms
Chloride	Arsenic
Chromium	Cadmium
Mercury	Chromium
Selenium	Copper
Temperature	Lead
pH	Mercury
Aldrin	Selenium
Heptachlor	Silver
Toxaphene	Zinc
polychlorinated biphenyls	

Regulatory surface water quality standards are expressed as not-to-exceed, geometric mean, chronic, and acute values. The regulatory criteria for total coliforms and fecal coliforms (bacteria) consist of a geometric mean value not to be exceeded and a maximum value which no more than 10 percent of the samples may exceed. Geometric mean values were calculated with the sampling results for each season - fall (September, October, November), winter (December, January, February), spring (March, April, May), and summer (June, July, August) - to determine if concentrations vary seasonally. Analytical results from different years were combined together by season prior to computation of the geometric mean. Samples collected from different areas at the same creek were used in the geometric mean calculation (with the exception of laboratory duplicates). Since no marine water samples were collected during December, January, and February, the geometric mean results and 10-percent maximum results are not available for winter. (Marine water samples were collected concurrently with marine sediment and marine shellfish samples; since low tides during the winter months occurred during early morning hours, no sampling was conducted.)

Chronic and acute regulatory levels were established for metals (zinc, silver, selenium, mercury, copper, cadmium, lead, chromium, arsenic), chloride, PCP, polychlorinated biphenyls, and pesticides sample results. Chronic values are levels that may result in injury or death to an organism as a result of repeated or constant exposure over an extended period. Acute values are levels which may result in injury or death to an organism as a result of short-term exposure. The regulatory criterion for pH is a range of values not to be exceeded. Other regulatory criteria for the remaining constituents are expressed as not-to-exceed values.

To provide an additional indicator of quality for freshwater samples, analytical results for total dissolved solids, lead, and nitrate were compared to Federal Drinking Water Standards. This comparison was for purposes of general evaluation only, as Federal Drinking Water Standards do not necessarily apply to water in these streams.

According to Seattle-King County Health Department, no standards exist for freshwater or marine water sediments. Results of sediment sampling, therefore, were evaluated only for relative differences among the streams. Additionally, no standards exist for recreational harvested marine shellfish, according to Seattle-King County Health Department. Shellfish sampling results were, therefore, compared to U. S. Food and Drug Administration standards for marine shellfish in commercial growing areas. Of the parameters analyzed, a U. S. Food and Drug Administration standard exists only for fecal coliforms. According to Seattle-King County Health Department, the standard is a not-to-exceed value. Shellfish sampling results were compared to U. S. Food and Drug Administration standards for purposes of general evaluation only; these standards do not necessarily apply to the marine shellfish areas sampled.

8.5.1.2 Results

An evaluation of the data collected for each stream is provided below, followed by a discussion of limitations of the sampling data. The sample results exceeding regulatory limits and the highest levels recorded for sediment samples with respect to the other surface water areas sampled are summarized in Tables 8.9c and 8.10. Apparent trends in constituent levels are listed for each environment, if applicable.

Beall Creek

Freshwater, marine water, marine water sediment, and marine shellfish samples were collected for analysis from Beall Creek. The results are presented below.

Freshwater (Beall Creek)

Concentrations of fecal coliforms, selenium, arsenic, and chloride did not exceed the Washington State criteria for freshwater. Chromium and mercury were not detected. Temperature and pH values measured in the field were within Washington State criteria, with the exception of pH values as discussed below in Section 8.5.1.4, Surface Water Quality Data Limitations. Total dissolved solids, lead, and nitrate levels were all below Federal Drinking Water Standards. No increasing or decreasing trends in constituent levels were apparent in the freshwater results.

Marine Water (Beall Creek)

Concentrations of total coliforms, fecal coliforms, arsenic, and chromium did not exceed the Washington State criteria for marine water. Cadmium, mercury, selenium, and silver were not detected. Concentrations of lead exceeded the chronic standard in one sample

(August 1991), copper levels exceeded the acute standard in three samples (all collected in July 1992), and zinc exceeded the acute standard in one sample (August 1991). No increasing or decreasing trends were apparent from the marine water results.

Marine Water Sediment (Beall Creek)

Concentrations of constituents in marine water sediment samples were generally similar to those measured in the other streams sampled. An increasing trend in mercury and a decrease in lead levels were noted in the marine water sediments.

Marine Shellfish (Beall Creek)

Concentrations of fecal coliforms in marine shellfish exceeded the U. S. Food and Drug Administration standard in three of the ten samples analyzed (all from July 1992). A decreasing trend in arsenic levels and a possible decreasing trend in chromium were observed in the marine shellfish data.

Fisher Creek

Freshwater, marine water, marine water sediment, and marine shellfish samples were collected for analysis from Fisher Creek. The results are presented below.

Freshwater (Fisher Creek)

Concentrations of arsenic, chloride, and selenium did not exceed the Washington State criteria for freshwater. Chromium and mercury were not detected. Concentrations of fecal coliforms during the fall and summer monitoring periods exceeded the geometric mean limit. More than 10 percent of the fecal coliforms samples exceeded the maximum limit in summer, fall, and winter. No increasing or decreasing trends could be determined.

Temperature and pH values measured in the field were within Washington State criteria, with the exception of pH values as discussed below in Section 8.5.1.4, Surface Water Quality Data Limitations. Concentrations of total dissolved solids, lead, and nitrate were below the Federal Drinking Water Standards. Selenium levels decreased over time; a slight increasing trend could be interpreted from the fecal coliform results. Trends could not be determined in zinc results due to prolific laboratory blank contamination.

Marine Water (Fisher Creek)

Concentrations of arsenic, chromium, and zinc did not exceed the Washington State criteria for marine water. Cadmium, copper, mercury, selenium, and silver were not detected. Lead exceeded the Washington State chronic standard once (August 1991). Concentrations of fecal and total coliforms exceeded the geometric mean limit during the fall monitoring period; fecal coliform concentrations exceeded the 10 percent maximum limit during the fall. No increasing or decreasing trends were noted in the marine water results.

Marine Water Sediment (Fisher Creek)

Concentrations of constituents in marine water sediment samples were generally similar to those measured in the other streams sampled. Zinc concentrations increased slightly over time in marine water sediments.

Marine Shellfish (Fisher Creek)

Concentrations of fecal coliforms in marine shellfish exceeded the U. S. Food and Drug Administration standard in four of the twelve samples analyzed (April, July, and August 1992). Zinc concentrations decreased slightly over time.

Green Valley Creek

Freshwater, marine water, and marine water sediment samples were collected for analysis from Green Valley Creek. The results are presented below.

Freshwater (Green Valley Creek)

Concentrations of arsenic, chloride, chromium, and selenium were below Washington State criteria for freshwater. Mercury was not detected. Concentrations of fecal coliforms did not exceed the geometric mean limit, but more than 10 percent of the samples exceeded the maximum limit for fecal coliforms in spring and summer. Temperature and pH values measured in the field were within Washington State criteria, with the exception of pH values as discussed below in Section 8.5.1.4, Surface Water Quality Data Limitations. Lead and nitrate were below Federal Drinking Water Standards, but total dissolved solids exceeded the Federal Drinking Water Standard in one sample (August 1991). Selenium results showed an increasing trend.

Marine Water (Green Valley Creek)

Concentrations of total coliforms, fecal coliforms, arsenic, selenium, and zinc did not exceed Washington State criteria for marine water. Lead exceeded the Washington State chronic standard in one sample (April 1992). Cadmium, chromium, copper, mercury, and silver were not detected. Chlorine and fecal coliform levels rose slightly over time.

Marine Water Sediment (Green Valley Creek)

Concentrations of constituents in marine water sediment samples were generally similar to those measured in the other streams sampled. Chromium and nitrate concentrations showed increasing trends. Arsenic and fecal coliform levels showed decreasing trends.

Marine Shellfish (Green Valley Creek)

No shellfish samples were collected.

Judd Creek

Freshwater, marine water, freshwater sediment, marine water sediment, and marine shellfish samples were collected for analysis from Judd Creek. Two freshwater samples and two freshwater sediment samples were collected for analysis for volatile organic compounds, pesticides, and polychlorinated biphenyls; however, one freshwater sample was inadvertently analyzed for semivolatiles instead of pesticides and polychlorinated biphenyls. The laboratory analytical results for samples collected from Judd Creek are presented below.

Freshwater (Judd Creek)

Concentrations of arsenic, chloride, chromium, and selenium did not exceed the Washington State criteria for freshwater. Mercury was detected in one sample (September 1991) at a concentration exceeding the chronic limit. Fecal coliform values during all seasons exceeded the geometric mean value and more than 10 percent of the samples exceeded the maximum standard value in all four seasons. Temperature and pH values measured in the field were within Washington State criteria, with the exception of pH values as discussed in Section 8.5.1.4, Surface Water Quality Data Limitations.

Volatile organic compound analysis detected methylene chloride in two freshwater samples and acetone in one freshwater sample, in August and September 1991, respectively; these compounds were also detected in the trip blank and laboratory quality control blank for the September 1991 sampling event. Data validation of the methylene chloride and acetone samples resulted in a nondetect status for the samples. No pesticides or polychlorinated biphenyls were detected. No semivolatile compounds were detected in the one freshwater sample analyzed. Total dissolved solids, lead, and nitrate levels were below Federal Drinking Water Standards. No increasing or decreasing trends were apparent in the freshwater results.

Marine Water (Judd Creek)

Concentrations of arsenic, chromium, selenium, and zinc did not exceed the Washington State criteria for marine water. Cadmium, mercury, and silver were not detected. Concentrations of copper exceeded the acute limit in two samples (both from August 1991). Lead exceeded the chronic limit in two samples (August 1991 and April 1992). Total coliform and fecal coliform levels exceeded the geometric mean, and more than 10 percent of the samples collected in the fall exceeded the maximum limit. No increasing or decreasing trends were observed in the marine water results.

Freshwater and Marine Water Sediments (Judd Creek)

The highest chromium level detected in any of the freshwater sediment samples was detected in a sample collected at Judd Creek (43 micrograms per gram [μg/g]); chromium results for freshwater sediment samples ranged from 23 μg/g to 43 μg/g. Concentrations of other constituents in freshwater sediment samples were generally similar to those measured in the other streams sampled.

Acetone, methylene chloride, and 1,1,1-trichloroethane were detected in the freshwater sediment samples collected in August and September 1991; acetone and methylene chloride were also detected in the trip blank and laboratory quality control blank in September 1991. No pesticides or polychlorinated biphenyls were detected in the two freshwater sediment samples analyzed.

The highest chromium (110 μg/g) and lead levels (19 μg/g) detected in any of the marine water sediment samples were detected in samples collected at Judd Creek. Chromium results in marine water sediment samples from all creeks ranged from 11 μg/g to 110 μg/g; lead results in all marine water sediment samples ranged from less than 0.1 μg/g to 19 μg/g. Arsenic levels in Judd Creek were also slightly higher than in the other streams sampled. The level of total coliforms was significantly higher than levels detected in the other marine sediment samples. Other constituent concentrations in marine water sediment samples from Judd Creek were generally similar to those measured in the other streams sampled. No increasing or decreasing trends were noted in sediment results.

Marine Shellfish (Judd Creek)

Fecal coliform concentrations in marine shellfish exceeded the U. S. Food and Drug Administration standard in one of the eight samples analyzed (July 1992). Chromium levels decreased slightly over time; fecal coliform concentrations may be decreasing slightly.

Mileta Creek

Freshwater, marine water, freshwater sediment, marine water sediment, and marine shellfish samples were collected for analysis from Mileta Creek. One freshwater sediment sample was collected and submitted for analysis for pesticides and polychlorinated biphenyls. The results are presented below.

Freshwater (Mileta Creek)

Arsenic, chloride, and selenium concentrations did not exceed Washington State criteria for freshwater. Mercury was not detected. Chromium concentrations exceeded the chronic limit in three samples (August 1991 and June and August 1992). Fecal coliform concentrations exceeded the geometric mean limit in summer. More than 10 percent of the samples exceeded the maximum limit in summer and fall. Temperature and pH values measured in the field were within Washington State criteria, with the exception of pH values as discussed below in Section 8.5.1.4, Surface Water Quality Data Limitations. Total dissolved solids, lead, and nitrate levels were at or below Federal Drinking Water Standards. No increasing or decreasing trends were observed in the freshwater results.

Marine Water (Mileta Creek)

Concentrations of total coliforms, fecal coliforms, arsenic, chromium, selenium, and zinc did not exceed Washington State criteria for marine water. Cadmium and mercury were not detected. Copper and silver exceeded the acute levels in two and one samples, respectively (all from August 1991). Lead exceeded the chronic level in two samples (August 1991 and July 1992). Slightly increasing levels of fecal and total coliforms and marginally decreasing levels of copper were detected.

Freshwater and Marine Water Sediments (Mileta Creek)

The highest total coliform concentration (54,000 organisms per 100 milligrams [org/100 mg]) of any of the freshwater sediment samples was measured at Mileta Creek. Other freshwater sediment constituent concentrations in the Mileta Creek samples were generally similar to those measured in the other streams sampled. No pesticides or polychlorinated biphenyls were detected in the freshwater sediment sample analyzed for these constituents.

The highest fecal coliform concentration of any of the marine sediment samples was measured at Mileta Creek (August 1991), and the level of total coliforms was significantly higher than levels detected in the other marine sediment samples. Other constituent concentrations were generally similar to those measured in the other streams sampled. Fecal coliform levels decreased over time, but zinc levels increased slightly.

Marine Shellfish (Mileta Creek)

Fecal coliform concentrations in marine shellfish did not exceed the U. S. Food and Drug Administration standard. Fecal and total coliform levels showed decreasing trends while arsenic and mercury concentrations showed slightly decreasing trends.

<u>Paradise Cove Creek</u>

Freshwater, marine water, marine water sediment, and marine shellfish samples were collected for analysis from Paradise Cove Creek. The results are presented below.

Freshwater (Paradise Cove Creek)

Arsenic and chloride concentrations did not exceed Washington State criteria for freshwater. Chromium, mercury, and selenium were not detected. Fecal coliform concentrations exceeded the geometric mean limit and are 10 percent of the maximum limit in summer. Temperature and pH values measured in the field were within Washington State criteria, with the exception of pH values as discussed below in Section 8.5.1.4, Surface Water Quality Data Limitations. Total dissolved solids, lead, and nitrate levels were below Federal Drinking Water Standards. No increasing or decreasing trends were noted in the freshwater results.

Marine Water (Paradise Cove Creek)

Total coliforms, arsenic, chromium, selenium, and zinc concentrations did not exceed Washington State criteria for marine water. Cadmium, copper, mercury, and silver were not detected. Lead exceeded the chronic limit in one sample (November 1991). Fecal coliform samples exceeded the geometric mean limit in winter. No increasing or decreasing trends were apparent in marine water results.

Marine Water Sediment (Paradise Cove Creek)

The highest zinc concentration in any marine water sediment sample was detected in a sample collected at Paradise Cove Creek (November 1991). Other constituent concentrations were generally similar to those measured in the other streams sampled. Mercury levels decreased over time.

Marine Shellfish (Paradise Cove Creek)

Fecal coliform concentrations in marine shellfish exceeded the U. S. Food and Drug Administration standard in four of the eleven samples analyzed (August 1991 and August 1992). Mercury and copper levels decreased slightly over time.

<u>Needle (Shinglemill) Creek</u>

Freshwater, marine water, freshwater sediment, marine water sediment, and marine shellfish samples were collected for analysis from Needle (Shinglemill) Creek. The results are presented below.

Freshwater (Needle/Shinglemill Creek)

Concentrations of arsenic, chloride, and selenium were below Washington State criteria for freshwater. Chromium and mercury were not detected. Concentrations of fecal coliforms exceeded the geometric mean limit in winter, and more than 10 percent of the samples exceeded the maximum limit in summer and winter. Temperature and pH values measured in the field were within Washington State criteria, with the exception of pH values as discussed below in Section 8.5.1.4, Surface Water Quality Data Limitations. Total dissolved solids, lead, and nitrate concentrations were below Federal Drinking Water Standards. No increasing or decreasing trends were detected.

Marine Water (Needle/Shinglemill Creek)

Concentrations of total coliforms, fecal coliforms, arsenic, chromium, selenium, and zinc did not exceed Washington State criteria for marine water. Cadmium, mercury, and silver were not detected. Copper concentrations in three samples (all from July 1992) exceeded the acute limit and lead concentrations in three samples (August 1991, April 1992, and August 1992) exceeded the chronic limit. Arsenic levels increased slightly over time.

Freshwater and Marine Water Sediments (Needle/Shinglemill Creek)

All constituent concentrations in freshwater sediment samples and all constituent concentration but mercury in marine water sediment samples were generally similar to those measured in the other streams sampled. The highest mercury concentration measured in any of the marine water sediment samples was measured in a sample collected at Needle (Shinglemill) Creek (0.567 μg/g). The mercury concentrations in marine water sediment samples at Needle Creek ranged from less than 0.007 μg/g to 0.567 μg/g. Potentially decreasing levels were observed in chromium and lead results for marine water sediments.

Marine Shellfish (Needle/Shinglemill Creek)

Fecal coliforms were detected in the one marine shellfish sample collected, although the detected concentration was below the U. S. Food and Drug Administration standard. No shellfish were found in subsequent sampling events.

Tahlequah Creek

Freshwater, marine water, marine water sediment, and marine shellfish samples were collected from Tahlequah Creek for analysis. The results are presented below.

Freshwater (Tahlequah Creek)

Concentrations of arsenic, chloride, and selenium were below Washington State criteria for freshwater. Chromium and mercury were not detected. Concentrations of fecal coliforms exceeded the geometric mean and 10 percent of the samples collected in summer exceeded the maximum limit value. Temperature and pH values measured in the field were within Washington State criteria, with the exception of pH values as discussed below in Section 8.5.1.4, Surface Water Quality Data Limitations. Total dissolved solids, lead, and nitrate concentrations were below Federal Drinking Water Standards. Selenium levels increased slightly, while chloride levels slowly decreased.

Marine Water (Tahlequah Creek)

Total coliforms, arsenic, chromium, selenium, and zinc concentrations did not exceed Washington State criteria for marine water. Cadmium, mercury, and silver were not detected. Lead exceeded the chronic level once (April 1992). Copper exceeded the acute level once (August 1991). Concentrations of fecal coliforms exceeded the geometric mean limit in winter, spring, and summer; more than 10 percent of all the samples collected in summer exceeded the maximum limit value. Arsenic levels decreased slightly, while selenium levels slightly increased. Total coliform levels may be slightly increasing.

Marine Water Sediment (Tahlequah Creek)

The highest total coliform concentration (5,400 org/100 ml) detected in any of the marine water sediment samples was measured in Tahlequah Creek (July 1992). Other constituent concentrations were generally similar to those measured in the other streams sampled. Mercury levels decreased over time; selenium concentrations might be slightly increasing.

Marine Shellfish (Tahlequah Creek)

Fecal coliform concentrations in marine shellfish exceeded the U. S. Food and Drug Administration standard in five of the six samples analyzed (August and November 1991, and July and August 1992). Silver levels increased slightly over time.

8.5.1.3 Summary of Results

The surface water quality data is summarized below. Freshwater, freshwater sediment, marine water, marine water sediment, and marine shellfish data are discussed first, followed by a discussion of the associations between the sampling results and the different environmental areas sampled.

Fecal coliforms were present above regulatory levels in samples from seven of the eight freshwater streams; Beall Creek was the exception. These high values may be caused by non-point sources such as septic system discharges and animal wastes from hobby farms and wildlife. Mercury concentrations in Judd Creek exceeded the chronic level once, and chromium levels in Judd and Mileta creeks exceeded Washington freshwater standards for streams once.

A variety of metals were detected above Washington marine water standards in marine water samples collected by Seattle-King County Health Department. Lead was the most predominant metal, having been detected in at least one sampling event for all marine water samples. Copper was present above regulatory standards at least once in Beall, Judd, Mileta, Needle (Shinglemill), and Tahlequah Creeks. Zinc and silver were detected above regulatory standards at least once in Beall and Mileta Creeks, respectively.

Tahlequah and Judd Creeks exceeded regulatory levels for fecal coliforms; total coliform levels in Judd Creek exceeded regulatory standards.

No regulatory standards have been established for freshwater sediments. On a relative basis, however, similar constituent levels were detected in all of the freshwater sediment samples with the exception of the elevated chromium levels (the highest detected) detected in freshwater sediment samples collected from Judd Creek. Total coliform levels were highest in Mileta Creek for freshwater sediment samples. Concentrations of the remainder of the constituents detected in freshwater sediment samples from the other creeks were within similar ranges of values.

No regulatory standards have been established for marine water sediments. On a relative basis, however, constituent levels of marine water sediment samples were similar to each other, with the following exceptions. High chromium (the highest detected) lead, and arsenic levels were detected in samples collected from Judd Creek. Total coliform levels in the marine water sediment samples were highest in Tahlequah Creek, although high levels were also recorded in Mileta Creek. Fecal coliform levels were highest in Mileta Creek. Zinc and mercury levels were highest in Paradise Cove and Needle (Shinglemill) creeks, respectively.

Fecal coliform levels exceeded U. S. Food and Drug Administration standards or the marine shellfish samples collected by Seattle-King County Health Department from Beall, Fisher, Judd, Paradise Cove, and Tahlequah creeks. Neither total or fecal coliforms exceeded U. S. Food and Drug Administration standards in the samples collected from Green Valley, Mileta, or Needle creeks.

With the exception of coliforms, associations of high levels of contaminants were not observed between freshwater, freshwater sediment, marine water, marine water sediment, and marine shellfish. Contaminants detected in one sampling media were not detected in the others. Therefore, specific potential contaminant sources or specific contaminant transport pathways could not be identified. Conversely, coliforms (total or fecal) were most often detected in more than one sampling media.

Trends in constituent levels for freshwater and marine water, marine water and freshwater sediments, and shellfish are listed below.

Freshwater

- Decreasing selenium levels in Fisher Creek and chloride levels in Tahlequah Creek.
- Increasing selenium levels in Green Valley and Tahlequah creeks and fecal coliform levels in Fisher Creek.

Freshwater Sediments

There were no trends detected for freshwater sediments.

Marine Water

- Decreasing arsenic levels in Tahlequah Creek and copper levels in Mileta Creek.
- Increasing fecal coliform levels in Green Valley, Tahlequah, and Mileta creeks, arsenic levels in Needle Creek, selenium levels in Tahlequah Creek, and chloride levels in Green Valley Creek.

Marine Water Sediments

- Decreasing fecal coliforms levels in Green Valley and Mileta creeks, mercury levels in Paradise Cove and Tahlequah Creeks, chromium levels in Needle Creek, arsenic levels in Green Valley Creek, and lead levels in Beall and Needle creeks.
- Increasing levels of mercury in Beall Creek, of chromium in Green Valley Creek, of zinc in Fisher and Mileta creeks, of selenium in Tahlequah Creek, and of nitrate in Green Valley Creek.

Shellfish

- Decreasing levels of total coliforms in Mileta Creek, of fecal coliforms in Judd and Mileta Creeks, of chromium in Beall and Judd Creeks, of arsenic in Beall Creek, and of copper in Paradise Cove Creek.
- Increasing levels of mercury and arsenic in Mileta Creek and of silver in Tahlequah Creek.

Many of the increasing or decreasing trends listed above were only marginally detectable. Chloride, nitrate (as nitrogen), iron, arsenic, cadmium, and manganese were tested in various streams in 1982 (Carr 1983). All levels were below current maximum contaminant levels with the exception of iron.

8.5.1.4 Limitations

The surface water quality data presented above should be used with caution. These data were analyzed by the laboratory prior to the implementation of a number of regulatory guidelines for water quality. Therefore, detection limits for mercury in freshwater and marine water samples were above the chronic regulatory limits. Similarly, the detection limit for silver in marine water samples was above the acute regulatory limit. In addition, pH values reported for many of the streams were unnaturally low (below three standard units) for surface water. Although the pH instrument was calibrated daily, lower pH levels were recorded during latter data collection due to an instrument malfunction.

Ground water quality trends are based on three sampling events over a 2-year period. Trends could be more accurately established if additional sampling was conducted.

8.5.1.5 Other Marine Water Studies

Previously conducted marine water quality and shellfish studies include the Washington State Department of Health Shellfish Program, and the marine water and shellfish monitoring studies performed by the King County Department of Natural Resources, Water Pollution Control Division (formerly Metro) and Seattle-King County Health Department. Shellfish sampling programs have also been completed by the Quartermaster Harbor Yacht Club and Quartermaster Marine Association, and the University of Washington Fisheries Research Institute. The results of these studies are summarized below.

Washington State Department of Health

The Washington State Department of Health evaluated fecal coliform levels in marine water at eight locations in Quartermaster Harbor near the Burton Peninsula in July 1988, January 1990, February 1991, and May 1991. Fecal coliform results ranged from 1.8 organisms per 100 milliliters (org/100 ml) to 79.0 org/100 ml. Concentrations of fecal coliforms did not exceed the geometric mean limit, but more than 10 percent of the samples exceeded the maximum limit at one sampling location (PEI/Barrett 1992).

King County Department of Natural Resources, Water Pollution Control Division (formerly Metro)

Marine water quality studies have been conducted for National Pollutant Discharge Elimination System monitoring by Ecology, and later the King County Department of Natural Resources, Water Pollution Control Division (formerly Metro), throughout Puget Sound since 1988 (King County 1993b). Two stations, Tramp Harbor and Luena Beach, were monitored on the Island during summer months (May to September) between 1990 and 1992. Marine water and shellfish (close to shore) were analyzed for fecal coliforms.

Marine water samples were collected by the King County Water Pollution Control Division (formerly Metro) from 1988 to 1992 at two stations on Maury Island (the Tramp Harbor pier and the Luena public beach on SW 232nd) and analyzed for fecal coliforms (King County 1993b). The results from the marine water sample collected from Luena Beach (see Table 8.10) in June 1990 were below the instrument detection limit (not given in report); further samples were not collected. Marine water samples collected from Tramp Harbor between 1990 and 1992 ranged from 5 to 3,300 org/100 ml. Concentrations of fecal coliforms exceeded the geometric mean limit during the summer; more than 10 percent of the summer 1991 samples exceeded the maximum value limit.

Fecal coliform levels in the Water Pollution Control Division (formerly Metro) data conform to Seattle-King County Health Department data with the exception of the 3,300 org/100 ml result in August 1991.

Fecal coliform levels in marine shellfish collected from Tramp Harbor (see Table 8.10) ranged from 20 org/100 mg to 17,000 org/100 mg. Concentrations of fecal coliforms in marine shellfish exceeded the U. S. Food and Drug Administration standard in September 1990, and May, July, and September 1992. The Seattle-King County Health Department levels of fecal coliforms correspond to the Water Pollution Control Division levels. No trends in fecal coliform levels in marine water and marine shellfish were apparent.

Seattle-King County Health Department

The Seattle-King County Health Department conducted the Shellfish Sampling Programs Summary as part of the on-site sanitary survey between March and September 1990 to analyze shellfish for fecal coliforms and paralytic shellfish poisoning. Shellfish and marine water samples were collected by Seattle-King County Health Department from six beaches (not given) for paralytic shellfish poisoning analyses. Paralytic shellfish poisoning levels "have not been shown to be indicative of pollution" (PEI/Barrett 1992). Fecal coliform and total coliform levels were evaluated from shellfish samples collected by Seattle-King County Health Department during April to October 1990 from Burton Acres, Quartermaster Harbor Marina, Bunker Trail/Point Vashon, Cove, and Kingsbury. Shellfish levels of fecal coliforms ranged from 40 organisms per 100 grams (org/100 g) to 1,700 org/100 g; five samples (Quartermaster Harbor Marina, Bunker Trail/Point Vashon, Cove, and Kingsbury) out of eight exceeded the U. S. Food and Drug Administration standard. The highest levels of fecal coliforms were found at Quartermaster Harbor Marina and Cove. Total coliform sample results from Quartermaster Marina and Bunker Trail/Point Vashon were 340 org/100 g and 4,800 org/100 g, respectively; no U. S. Food and Drug Administration standard has been established for total coliform levels in shellfish (PEI/Barrett 1992).

The geometric mean for fecal coliform levels in marine water ranged from 3 org/100 ml to 252 org/100 ml. The geometric mean limit was exceeded in samples collected at Quartermaster Harbor (in both events sampled, April and May 1990), at Bunker Trail (in one of three sampling events, May 1990), and at Kingsbury (in the only sampling event, June 1990). Insufficient data were presented to evaluate if 10 percent of the samples exceeded the maximum limit (PEI/Barrett 1992).

Storm-drain outlets and streams were tested for fecal coliforms as part of the sanitary survey conducted during 1989 and 1990. The eight areas sampled included: three locations in Bunker Trail (the culvert under the ferry dock, Casa del Sol drainage, and a residence 700 feet east of the ferry dock); two places in Beulah Park (Beulah Creek at 135th Avenue SW, Beulah Creek at Cove); and three areas in Burton (street outfall at the Marina, Judd Creek, and Quartermaster Yacht Club). Fecal coliform levels in freshwater from eight areas ranged from 90 org/100 ml to 380,000 org/100 ml. The geometric mean limit was exceeded at all stations at least once. More than 10 percent of the samples at all stations exceeded the maximum limit at least once.

Marine water and marine water sediment samples were collected at Bunker Trail, Cove, Spring Beach, Burton, and analyzed for fecal coliforms in 1989 and 1990 as part of the sanitary survey conducted by Seattle-King County Health Department (Gomez 1989). Fecal coliform levels in marine water and marine water sediments ranged from two to 800 org/100 ml and from less than 100 to more than 160,000 org/100 mg, respectively. It cannot be determined from the available data whether regulatory levels for marine water were exceeded (PEI/Barrett 1992); no standards have been established for marine water sediment samples.

Quartermaster Yacht Club and Quartermaster Marine Association

The Quartermaster Yacht Club and Quartermaster Marine Association investigated marine water quality and shellfish in Quartermaster Harbor. Marine water samples were collected in September 1982, February 1983, and September 1983 at various depths from seven locations in Quartermaster Harbor, and analyzed for total coliforms, fecal coliforms, and oil and grease. Total coliform levels in marine water ranged from below the detection limit (less than 3 org/100 ml) to 1,100 org/100 ml. Total coliform levels in samples collected at the marina, yacht club, mid-channel off Manzanita, Judd Creek, and 91st Avenue SW exceeded the geometric mean limit. More than 10 percent of the samples collected from these locations exceeded the maximum limit value. Total coliform levels in marine water samples collected at Dockton County Park and Dockton did not exceed regulatory levels (PEI/Barrett 1992). Fecal coliform levels in marine water ranged from less than 3 org/100 ml to 460 org/100 ml. Fecal coliform levels in samples collected at the marina, yacht club, Judd Creek, and 91st Avenue SW exceeded the geometric mean limit. More than 10 percent of the samples collected from these locations exceeded the maximum limit value. Oil and grease results ranged from less than 1.0 mg/L to 7 mg/L; no standards have been established for oil and grease in marine water (PEI/Barrett 1992).

In 1983, shellfish samples were collected by the Quartermaster Harbor Yacht Club and Quartermaster Marine Association from eight sampling locations and analyzed for total and fecal coliforms; arsenic, lead, cadmium, mercury, copper, and zinc. The constituent ranges of the shellfish samples as listed below:

Total coliforms	130 to ≥ 24,000 org/100 g
Fecal coliforms	45 to 5,400 org/100 g
Arsenic	0.412 to 2.90 μg/g
Lead	0.036 to 3.12 μg/g
Cadmium	0.294 to 0.809 μg/g
Mercury	Not detected

Copper	4.9 to 69.2 μg/g
Zinc	54.4 to 84.1 μg/g

Fecal coliform levels in two of the 17 samples exceeded the U. S. Food and Drug Administration standard. No standards have been established for total coliforms and metals in shellfish.

Puget Sound Water Quality Authority

The Puget Sound Water Quality Authority has coordinated the Puget Ambient Monitoring Program from 1989 to present in areas throughout Puget Sound. One location (Quartermaster Harbor near Burton) has been monitored in the study. Marine water samples are collected monthly for one year every three years; samples were last collected between October 1991 and September 1992 and will be collected again in October 1994. The samples are analyzed for concentrations of nutrients (nitrate/nitrite, ammonia, orthophosphate, chlorophyll), fecal coliforms, dissolved oxygen, salinity, temperature, pH, and turbidity.

Fecal coliform levels in the marine water samples ranged from below detection limits to 3 org/100 ml; no regulatory standards were exceeded. Nitrate levels ranged from 0.01 mg/L to 0.449 mg/L which are below the 10 mg/L regulatory limit (Prescott 1994).

8.5.2 Spring Water Quality

Samples of spring water were collected by Seattle-King County Health Department personnel from the following six spring locations (see Figure 8.35):

- North Vashon
- Ober Beach
- Klahanie
- Magnolia Beach
- Morningside
- Manzanita (Jensen)

The lower Judd Creek spring was sampled in October 1989; sampling was then discontinued at the owner's request. The North Vashon spring was sampled in place of the lower Judd Creek spring after the first sampling event. The Lower Judd Creek data are not included in the results discussed in Section 8.5.2.2.

The following sections summarize the methodology, results, and limitations of the spring water quality investigation. Included in the results subsection is a summary of the Carr spring water quality results.

8.5.2.1 Methodology

Spring water samples were collected using a method similar to the method of surface water collection discussed in the surface water sample collection work plan (EcoChem/Geraghty & Miller 1991). Spring water samples were collected in October 1989, April 1990, and October 1990 and analyzed in a laboratory for total and fecal coliforms, metals (zinc, mercury, copper, lead, chromium, arsenic, iron, and manganese), nitrate (as nitrogen), nitrite (as nitrogen), sulfate, fluoride, and total dissolved solids (see Table 8.11). Spring sampling locations (see Figure 8.35) were selected from areas where contamination sources were suspected and where ground water data are sparse since springs represent a natural discharge of ground water.

8.5.2.2 Results

To assess the sampling results, analytical data for water samples were compared to Washington State water quality criteria (Chapter 173-201A-030 WAC) for Class AA streams (discussed in Section 8.5.1, Surface Water Quality). Chloride, nitrate, total dissolved solids, zinc, copper, lead, chromium, arsenic, sulfate, and fluoride values were all below Washington State regulatory standards, although one laboratory duplicate for nitrate exceeded these limits. The highest level of nitrate (4.4 mg/L [S-4], or 11 mg/L in the S-4 duplicate) was detected in the samples from Magnolia Beach (see Table 8.11), collected from the southeastern edge of Vashon Island on Quartermaster Harbor in November 1989. The highest level of total dissolved solids (290 mg/L) was detected in the duplicate sample (S-2) at Ober Beach (see Table 8.11), collected from the northwestern Vashon Island shoreline in October 1990. The highest level of chloride was detected in a sample collected at North Vashon in April 1990 (see Table 8.11).

During one or more sampling events, samples collected from at least one spring equaled or exceeded current water quality levels for iron, manganese, and mercury. Regulatory levels for iron were exceeded once during the October 1990 sampling event in both Morningside and Jensen Springs at 0.46 mg/L and 2.3 mg/L, respectively. Increasing iron levels were detected from the data at Morningside Spring. Manganese exceeding regulatory levels was detected in the Atlas Water, Magnolia Beach, and Jensen Springs (0.082 mg/L, 0.05 mg/L [0.63 mg/L in the laboratory duplicate], and 0.241 mg/L, respectively). Neither iron nor manganese levels in the springs are considered a health hazard. Mercury levels exceeding regulatory limits were detected once each at North Vashon Water and Morningside Springs in October 1990 at levels of 0.0022 mg/L and 0.002 mg/L, respectively.

Total and fecal coliforms were present in at least two springs during each sampling event. Total coliforms were not detected in the Atlas Water Spring. However, total coliforms were detected above regulatory limits once in North Vashon Water, Magnolia Beach, and Jensen Springs; twice in the Ober Beach Spring; and in all three sampling events at Morningside Spring. Fecal coliforms levels in the springs have not exceeded Washington

State water quality criteria, with the exception of fecal coliform levels in two samples collected at Morningside Spring that exceeded regulatory limits. Analytical results for Ober Beach and Morningside Spring indicate increasing levels of total coliforms at both springs. Increasing levels of fecal coliforms were also detected at Morningside Spring. Total and fecal coliform levels decreased at Magnolia Beach. Total and fecal coliform levels were "too numerous to count" at Morningside Spring.

The water quality of the springs tested on the Island is generally within regulatory compliance levels with the exception of coliforms. Total coliform levels above regulatory limits were detected at least once in five of the seven springs. Fecal coliform levels above regulatory limits were detected in one spring.

Spring water quality trends for the other constituents analyzed could be classified as increasing, decreasing, or no trend established. Increasing levels were detected in the following constituents: mercury (S-1, S-2), copper (S-1, S-5, S-6), total dissolved solids (S-3, S-5), lead (S-4, S-5, S-6), arsenic (S-1, S-3, S-5), sulfate (S-4), nitrate (S-2), iron (S-3, S-5, S-6), and manganese (S-3, S-5, S-6). Decreasing levels were found in the following constituents: total dissolved solids (S-1, S-4), zinc (S-4, S-5), copper (S-3), lead (S-3), chromium (S-3, S-6), arsenic (S-4), chloride (all springs), sulfate (S-2, S-3), nitrate (S-5, S-6), iron (S-4), and manganese (S-2, S-4).

Spring and surface water samples (undifferentiated) were collected in 1982 by Carr (1983) and analyzed for specific conductance, chloride, nitrate as nitrogen, iron, total hardness, alkalinity, arsenic, cadmium, and manganese. Iron levels exceeding regulatory limits were detected at three springs (S-2, S-21, S-22). The analytical results for all other parameters did not exceed current or past federal or state drinking water standards. The analytical results for nitrate (as nitrogen) ranged from below the detection limit to 3.0 mg/L at "Judd-Above Land" (Spring 12?); chloride valued ranged from 3 to 15 mg/L at Springs 15, 17, and 19. Historical total dissolved solids levels (1966 to 1982) ranged from 90.8 to 124.4 mg/L, which were below regulatory standards; nitrate levels ranged from trace to 7.08 mg/L. Samples were not analyzed for chloride during this period. The sampling location names are not displayed in Carr.

8.5.2.3 Limitations

The spring data collected by Seattle-King County Health Department for this chapter has several limitations for comparisons with spring data collected by Carr. These limitations are listed below.

- Different laboratory methods were used to analyze the Carr samples and the Seattle-King County Health Department samples. Some of the data results from Carr were derived from Hach test kits, which produce less reliable results than of an analytical laboratory. Differences in the analytical methods used for each sample were not discussed in the Carr report.

- Detection limits for the analytes tested by an analytical laboratory may have been different for the Carr data and the Seattle-King County Health Department data. Detection limits for Hach kits are generally higher than those of an analytical laboratory.

- Regulatory limits for ground water have changed. More stringent levels are currently in effect. (Spring data use regulatory limits imposed for ground water.)

- Sample collection methods may have varied between the Carr study and Seattle-King County Health Department study.

- Samples may have been collected from different sample locations at the same spring in both the Carr study and the Seattle-King County Health Department study.

- Since data from only three sampling events were available, trend analyses may be inaccurate.

Spring water samples could not be collected at all sampling locations during every sampling event because of the intermittent nature of the spring flow.

8.5.3 Ground Water Quality

Ground water quality data were collected to identify trends in ground water quality over time and to assess the potential impacts to ground water from land- and ground water use. The following sections discuss the methodologies and results of the water quality sampling. In addition, the results are compared to ground water quality trends reported by Carr. A discussion of the data limitations concludes the ground water quality section.

8.5.3.1 Methodology

A discussion of the criteria for selecting the monitoring wells to be sampled is provided below, followed by a discussion on the specific water quality parameters that were assessed and how the data was evaluated.

Ground water quality data were collected by Seattle-King County Health Department and the consultants from 21 of the 24 selected monitoring wells (see Table 8.5a). Criteria used to select wells for monitoring included availability of well logs, areal distribution of wells, screened interval, representative of geology in the area, representation of major surface water drainage areas, and well owner permission for access.

Water quality data were collected during three sampling events: October/ November 1989, April 1990, and October 1990. At sites which contained two wells (W-2, W-9, W-10, and W-16), only one well was selected for water quality monitoring (see Table 8.5a). For consistency, the same selected wells were sampled for each sampling event with the exception of Well W-9B, which was sampled only during the first round of sampling in 1989. The second- and third-round samples were collected from Well W-9A because of difficulties encountered in sampling Well W-9B. Ground water samples were collected and submitted for laboratory analysis for standard drinking water parameters including coliform bacteria, alkalinity, total dissolved solids, and hardness.

Specific water quality parameters evaluated to assess land- and ground water use impacts include chloride (as an indicator of seawater intrusion), nitrate (as an indicator of septic system and/or agricultural contamination), and total dissolved solids (as a general indicator of land-use impact). The laboratory results for concentrations of chloride, nitrate, and total dissolved solids were tabulated (see Tables 8.12, 8.13, and 8.14) to evaluate trends in these specific parameters. The areal distribution for chloride, nitrate, and total dissolved solids is presented in Figure 8.36. In addition, the water quality data were compared with current Safe Drinking Water Act maximum contaminant levels (see Table 8.15).

8.5.3.2 Results

The laboratory results for samples collected from 21 Island wells between 1989 and 1991 indicate that chloride and nitrate concentrations were consistently low (chloride less than 10 mg/L and nitrate less than 3.5 mg/L; Tables 8.12 and 8.13, respectively) with the exception of Wells W-3, W-8, and W-10B which exceeded 10 mg/L of chloride once. Both chloride and nitrate levels were lower than the 1982 results presented in Carr. These concentrations were relatively constant with the exception of Wells W-9A and W-10B, which had a slight increasing levels of chloride. Total dissolved solids levels were generally low (less than 400 mg/L), but increased over time in ground water Wells W-1, W-2A, W-9B, W-10B, W-14, and W-21 (see Table 8.14). The total dissolved solids levels in the other monitoring wells were either relatively constant or showed decreasing trends. The levels of total dissolved solids for this study were similar to those reported in Carr. The levels of chloride, nitrate, and total dissolved solids suggest minimal (if any) impact from land or ground water use.

The low levels of chloride indicate none of the monitoring wells have been impacted by seawater intrusion. Chloride was detected in eight monitoring wells (Willamette West, Point Robinson U. S. Coast Guard, Chobot, Sandy Beach Community, Mallman, and Stevens) in the Carr report at levels above 10 mg/L. Based on these results, Carr reported that seawater may be intruding on the north end of Vashon Island and on the east coast of Maury Island. One private well north of Glen Acres was classified by the King County Water Review Board as intruded by seawater (Shallow 1994). Monitoring Well W-3, which contained concentrations of chloride in excess of 10 mg/L of chloride once between 1989 and 1990, are located near two of the monitoring wells with chloride levels greater than 10 mg/L reported by Carr; Monitoring Well W-3 is located near the Glen Acres well declared to be intruded by seawater, although it is unknown of the two wells are screened within the same hydrostratigraphic zone. For comparison, between 1989 and 1991 chloride levels in the freshwater environment on the Island ranged from less than one mg/L to 220 mg/L; chloride levels in the marine water samples ranged from 73 mg/L (near the mouth of a freshwater stream) to 18,000 mg/L.

Nitrate was used as a water quality indicator because it evidences a potential health hazard. The absence of geologic nitrate sources on the Island implies that elevated nitrate levels, if detected, result from other sources, such as drainfields, drainfield effluent, fertilizer, animal wastes, and decaying vegetation. The only well on the Island with a nitrate (as nitrogen) level in excess of the maximum contaminant level of 10 mg/L is located at the Coast Guard station at Point Robinson (Carr 1983); however, the Coast Guard well was reportedly installed near the previous site of a horse corral. Nitrate (as nitrogen) concentrations in other wells sampled by Carr ranged from below the laboratory detection limit to 5.3 mg/L. Nitrate levels were below 3.5 mg/L in the 21 wells sampled in 1989 and 1990. Nitrate (as nitrogen) monitoring will be especially important in the future as new drainfields are constructed in the severe public health hazard or health caution areas on the Island (PEI/Barrett 1992).

Comparison of the ground water quality data with Safe Drinking Water Act maximum contaminant levels indicates lead was detected above the Safe Drinking Water Act maximum contaminant level in samples collected from Wells W-13 and W-15 during one or more of the three sampling events (see Tables 8.15 and 8.16); lead was detected above the current Safe Drinking Water Act maximum contaminant level in one well in 1981 (Carr 1983). An increasing trend of lead was noted in Well W-8, and possibly in Wells W-9A, W-17, and W-19. Iron and manganese are present in many of the wells, as they were in 1982 (Carr 1983), but the presence of these constituents is not considered a health hazard.

In addition, total coliforms were detected once above Safe Drinking Water Act maximum contaminant levels in ground water samples collected in 1989 and 1990 from Wells W-1, W-2, W-8, W-15, and W-20. Total coliform may be increasing over time in Wells W-1, W-8, and W-20. Total and fecal coliform analyses were not performed during the 1982 water quality study (Carr 1983). The remainder of the parameters tested for ground water quality were either not detected or detected below Safe Drinking Water Act maximum levels. Mercury was detected above current Safe Drinking Water Act maximum contaminant levels once in 1980 (Carr 1983); however, this well was not monitored during the study period covered by this chapter.

Although below the Safe Drinking Water Act maximum contaminant levels, levels of mercury, zinc, and arsenic may be increasing in the following wells, based on the 1989 and 1990 data:

Mercury: W-2A, W-4, W-6, W-7, W-9A, W-14, W-15, W-16A, W-17, W-19, W-20, W-21

Zinc: W-4, W-10B, W-17, W-20

Arsenic: W-3, W-4, W-8, W-10A, W-20, W-21

No other trends were detected from ground water results.

Water quality data submitted to the Washington State Department of Health by major water purveyors on the Island were also evaluated to determine potential increasing or decreasing trends in constituents. Samples were analyzed for metals, fluoride, nitrate, chloride, turbidity, conductivity, hardness, and color. Most water quality parameters were not detected; only conductivity and nitrate levels were detected, at but the values were below Safe Drinking Water Act maximum contaminant levels. Increasing nitrate levels were detected at Burton Water Company, Gold Beach Water Association, and possibly at Maury Mutual Water Company. Potentially increasing conductivity levels were reported for all purveyors except Maury Mutual Water Company and Westside Water Association. Since water samples were collected from various distribution points in the water system, but not directly from wells, it is uncertain if the results are representative of water in the well or the distribution system piping.

8.5.3.3 Limitations

The ground water data collected by Seattle-King County Health Department in 1989 and 1990 may have several limitations for comparisons to data collected by Carr and the Washington State Department of Health. These limitations are as follows:

- Different laboratory methods may have been used to analyze the Carr data and the Seattle-King County Health Department data. Some of the data results from Carr were derived from Hach test kits, which are less reliable than an analytical laboratory. Differentiation between the analytical methods used for each sample were not discussed in the report by Carr.
- Detection limits for the analytes tested may have been different for the Carr study and the Seattle-King County Health Department study. Detection limits for Hach kits are generally higher than those of an analytical laboratory.
- Regulatory limits for ground water have changed. More stringent levels are currently in effect.
- Sample collection methods may have varied between the Carr study and Seattle-King County Health Department data. Carr states that sample results show influence of salt spray, but does not elaborate on whether the well may have elevated chloride levels because of spray on the well or salt spray on the sample during collection.

- Since data from only three sampling events were available, trend analyses may be inaccurate.

Since samples for the Washington State Department of Health were collected from the water supply/distribution system and collection areas, water quality may not be representative of the water quality in the hydrostratigraphic zone. The potential for contamination within the distribution system should be considered while assessing trends in water quality. Therefore, the Washington State Department of Health data should be used with caution.

9.0 CONCLUSIONS AND RECOMMENDATIONS

The Vashon-Maury Island Ground Water Management Plan is the culmination of over ten years worth of study, investigation, and data collection. The conclusions and recommendations presented here form the basis for a substantial resource management effort that encompasses regulatory requirements, land-use planning guidelines, public education, and public policy discussions. This chapter includes all the information provided by Carr as well as additional information collected and evaluated by Seattle-King County Health Department, Vashon Island volunteers and Geraghty & Miller from 1988 through the spring of 1994. In addition, where possible, the data compiled and collected by Geraghty & Miller was compared to historical information or current data from other sources including water purveyors. (Geraghty & Miller 1992b)

The information of primary interest for the water resource protection efforts is the water budget prepared by the former U. S. Geological Survey hydrologist, Mr. Ed McGavock, in accordance with standard procedures and taking into account the local conditions of the Island. When compared to the water budget prepared by Carr, McGavock's water budget suggests that there may be substantially more water on the Island than previously calculated. This difference is accounted for in several areas.

First, the scientific methodology has progressed in the last 10 years. The calculations used by Carr represented the state-of-the-art knowledge and methodologies available at the time. The calculations used by McGavock represent a refinement of the initial calculations and methods.

Secondly, the water budgets differ because the fundamental data including precipitation and infiltration have changed from the initial calculations. The precipitation used by McGavock covered a 40-year period of record for Gig Harbor, verified by the precipitation data gathered over a 4-year period on the Island. The primary difference in data are the precipitation numbers. McGavock used 46.5 inches of precipitation while Carr used 40 inches. Both values are within the range of the average value derived from the 40-year record. However, McGavock's higher value was developed considering the actual precipitation data for the study period. McGavock also identified that the margin of error for the high precipitation value could be in the range of 35 percent. Carr used precipitation data from one year, and that year may have been non-representative of a typical water year for the island.

Finally, the initial representation of the Island hydrogeology has been refined using the data collected. The hydrogeology suggests that Carr's Principal Aquifer was appropriate given the data used to define that representation. However, the current understanding of the hydrogeology is that the Principal Aquifer is actually interconnected to several water-bearing zones, resulting in additional water from those other zones. A schematic representation of this concept is presented in Figure 9.1. However, the theoretical amount of water on the Island does not suggest that a higher population figure can be supported. It simply demonstrates that the base amount of water varies over time and that a statistically based number representing the expected amount of water available is dependent upon the factors described in the calculations. Both water budgets should be taken together to form a set of boundaries for water resource management policy development.

Section 9.0 briefly summarizes the background information, states the circumstances of the data analysis portion of this Area Characterization and presents the conclusions that can be drawn from these data. In addition, this section identifies data gaps and makes recommendations for filling those gaps based on the information presented in previous investigations of the Vashon-Maury Island Ground Water Management Area plus the conclusions derived from the most recent data in this chapter. The summary section is presented first, followed by the conclusions of the data analysis, and lastly, the future data needs and recommendations is discussed.

9.1 Summary of Background Information

The Ground Water Advisory Committee and Seattle-King County Health Department have developed a series of position papers related to specific land uses on the Island. Those papers were prepared using current land-use information, information on potential development, and records regarding the condition of specific properties relative to environmental characteristics. The conclusions extract the details about environmental characteristics as well as summarize the actions being taken to monitor the activities and/or reduce the risk of ground water contamination. The recommendations from those position papers are identified in Section 9.3.

9.1.1 Land Use

Sites and/or practices of particular interest to the Ground Water Advisory Committee relative to their effects on the environment were the Vashon Landfill, the former NIKE missile site, on-site sewage systems, biosolids application or disposal locations, underground storage tanks, agricultural spraying, road maintenance spraying, sand and gravel pits, hazardous materials management, and the ASARCO smelter Superfund site. Their potential effects on ground water quality were reviewed and evaluated. The potential for contamination at each area is discussed in the following sections.

Vashon Landfill

The Vashon Landfill is regulated under the Resource Conservation and Recovery Act Subtitle D. To continue operating, the landfill operators must monitor the ground water and the landfill for generation of leachate and methane gases. Additionally, the landfill was required to meet minimum standards for construction and operation. The King County Solid Waste Division and the Seattle-King County Health Department are monitoring water quality in and around the Vashon Landfill. Water quality standards for total coliforms, arsenic, vinyl chloride, methylene chloride, 1,1,1-trichloroethane, chemical oxygen demand, chromium, endrin, and lindane have been exceeded during one or more sampling events. The old landfill was capped, and a leachate collection system was installed. Recent King County Solid Waste Division monitoring results at the landfill have indicated dramatic improvements in overall water quality indicators. Vinyl chloride and its associated landfill gas require additional measures for cleanup; recommendations to control the lateral and vertical extent of the landfill gas have been received and authorized for implementation. The King County Solid Waste Division believes that it is unlikely that the landfill presents a significant risk to public water supplies. However, the Ground Water Advisory Committee and the Seattle-King County Health Department should evaluate ground water quality data collected in and around the landfill.

Former NIKE Missile Launch Site

The former NIKE missile launch site was investigated for potential toxic and hazardous waste contamination in 1988 and 1992 under the U. S. Department of Defense investigation program, the Defense Environmental Restoration Program. Chlorobenzene, ethylbenzene, total xylenes, trichloroethene, diesel 6, diesel 2, and/or gasoline were detected in the surficial soils near the Paint and Fuel Storage Area at concentrations of concern to the environment and human health. The U. S. Army Corps of Engineers will mitigate the Paint and Fuel Storage Area by removing the contaminated top soil in the area and replace it with clean soil. Ground water quality on-site did not contain volatile organic compounds, polychlorinated biphenyls, petroleum hydrocarbons or trace metals at concentrations that present a concern for human health and the environment.

Biosolids

Pursuant to the federal Clean Water Act, the application of biosolids for beneficial reuse (i.e., land application) is regulated to reduce the risk of contamination to ground water. The Vashon Sewage Treatment facility produces about 10 tons of biosolids annually, which is currently transported off the Island for further treatment and/or disposal at an approved facility. Ground water monitoring is not required because presently the biosolids are transported off the Island. This facility needs to be monitored, and if biosolids are disposed on the Island, the disposal site(s) need to be evaluated for impacts to ground water quality.

Underground Storage Tanks

Underground storage tanks are regulated under the Resource Conservation and Recovery Act for purposes of eliminating leakage into the ground water. Ecology regulates underground storage tanks pursuant to Model Toxics Control Act. There are currently 3,700 leaking underground storage tanks reported to Ecology. There are 28 commercial and approximately 700 residential underground storage tanks reported to exist on the Island. Seven incidents of leaks in commercial underground storage tanks have been confirmed. Six of these sites have been cleaned up to the Ecology requirements; one site is currently under remedial action. Residential underground storage tanks are not monitored for leaks although they are subject to the same cleanup requirements as commercial underground storage tanks.

Agriculture/Roadside Spraying

The Federal Insecticide, Fungicide, Rodenticide Act (FIFRA) is the primary mechanism for managing the environmental effects of the application of chemicals for agricultural and roadside maintenance purposes. FIFRA generally requires that all chemicals be used in accordance with the labels on the products. Vegetation along the roadside is commonly sprayed with herbicides. Pesticides are only applied to the tansy ragwort weed, which is deadly to livestock. Other than the compounds found at the Vashon landfill, no pesticides and herbicides occurrences have been reported on the Island.

Feedlots are minimally regulated under the federal Clean Water Act. The feedlot owners and operators are required to minimize the runoff from contained facilities. For individual and private ranching operations, no controls are in place at the federal level. Animal wastes are high in nitrates, but the potential for contamination of the ground water is not significant as long as there are no concentrated feeding operations. An investigation of the effects of ranching on the Island or ground water has not been conducted.

Sand and Gravel

The sand and gravel operations on the Island are not monitored for ground water quality. However, the Clean Water Act has general primary and secondary standards that require any facility to receive a National Pollutant Discharge Elimination System permit for discharge to waters of the state. In addition, there is a general prohibition against discharges that are toxic, or that produce high turbidity, sheens, pH less than 6.0 or higher than 9.0 standard units, and low dissolved oxygen. A general National Pollutant Discharge Elimination System permit for sand and gravel operations will be required in the future; surface water discharge from these facilities will be required to meet state water quality standards.

Hazardous Materials

Hazardous wastes and the generation and management thereof are regulated under the Resource Conservation and Recovery Act and the state Dangerous Waste regulations. Generators of hazardous wastes are required to report the amount of wastes generated annually to the U. S. Environmental Protection Agency and Ecology. The data summarized below are based on the records in the state or the U. S. Environmental Protection Agency files. The information is current as of April 1994. The only way that hazardous materials are brought to the Island is via the Washington State Ferry Service. Four active hazardous waste generators have been identified on the Island by the U. S. Environmental Protection Agency/Ecology. The Local Hazardous Waste Management Program in King County personnel at King County Department of Natural Resources, Water Pollution Control Division and Seattle-King County Health Department have inspected eight small quantity generator businesses as a result of complaints or requests; these sites are reinspected one month after observation of spillage to determine if the site has been satisfactorily cleaned up. There are no other records to indicate that the generators identified have improperly disposed of wastes on the Island. Data collected by Ecology (large quantity hazardous waste generators), and by the Local Hazardous Waste Management Program (Seattle-King County Health Department and King County Department of Natural Resources, Water Pollution Control Division (small quantity hazardous waste generators)) should be shared with Seattle-King County Health Department for (1) entry into the database, (2) evaluation of ground water quality at these sites, and (3) mapping the location of these generators.

ASARCO Smelter

In 1984, the Washington State Department of Health (with Seattle-King County Health Department and Tacoma-Pierce County Health Department) conducted a study of unprotected drinking water sources to determine if arsenic, cadmium, and lead were present. The Washington State Department of Health concluded that these constituents were not present at significant levels in the 20 wells, 11 springs, and two surface water sources that were monitored on the Island.

9.1.2 Water Applications

9.1.2.1 Projected Water Demand

Based on the water consumption figures provided by the seven main purveyors (Group A) the average per person consumption rates were revised from the 120 gpd estimated by Carr to 103 gpd. Projection for average water demands by the year 2000 are estimated at 417 mgpy while the maximum demand is projected at 729 mgpy.

9.1.2.2 Water Use

Comparisons of the permitted water withdrawal quantities with actual water withdrawal quantities indicate two (Heights Water Association and Water District No. 19) of six (Burton Water Company, Dockton Water Association, Heights Water Association, MMC, Water District No. 19, and Westside Water Association) purveyors surveyed have exceeded maximum permitted quantities for instantaneous withdrawal. Three (Dockton Water Association, Heights Water Association, and Water District No. 19) of the four (Dockton Water Association, Heights Water Association, MMC, and Water District No. 19) purveyors surveyed have exceeded the permitted maximum annual withdrawal quantities.

The exact number of private wells on the Island is unknown. However, Seattle-King County Health Department obtained copies from Ecology of 280 well logs for public supply and private wells on the Island. Many of the older wells on the Island may not be included in the Ecology files. However, there are new procedures for well tagging with identification tags and data entry into the Seattle-King County Health Department database when new wells are drilled. This will assist in defining the number of wells currently in use on the Island.

9.1.2.3 Wastewater Disposal

Vashon Sewer District

In 1986, the Vashon Sewer District had the capacity to serve the equivalent of 1,375 people. The Vashon Sewer District serviced the equivalent of 1,000 people (connections to businesses are included in this figure) in January 1994. When a wastewater treatment system reaches 85 percent of the hydraulic capacity and organic loading capacity, the federal Clean Water Act requires that the facility begin planning for expansion and/or upgrades to meet projected demands or that it stop adding sewer connections. If the sewer system is significantly affected by inflow/infiltration from storm water, then the system must modify the sewer collection system to eliminate those flows. Storm water, including ground water, infiltrates the sewer system through leaky pipe joints during wet times of the year. Conversely, wastewater may infiltrate and transport potential contaminants into the subsurface during dryer times of the year. The Vashon Sewer District has been making noticeable improvements to the sewage and storm water drainage system.

9.2 Physical Properties Characterization

Data concerning rainfall, surface water, spring water, ground water, exploratory well, physical susceptibility areas, and water budget for the Vashon-Maury Island Ground Water Management Area were collected from late 1989 through early 1992 to further refine the understanding of the Island water resources. Physical susceptibility areas and a water budget were evaluated to update the characterization of the Island. Based on the latest data collection efforts and Area Characterization, the following conclusions can be drawn.

Geology

Vashon Island is composed of a complexly layered sequence of glacial and interglacial sediments to a depth of over 400 feet below land surface. These sediments either change abruptly or grade laterally into one another over short distances. Correlation of units from one area to another has proven difficult. The most significant ground water supplies occur in the more permeable glacial outwash deposit, though less permeable deposits also provide useable quantities of water. A detailed geologic map of the Island produced by Booth (1991) reclassifies the surficial geology nomenclature presented by Carr to nomenclature used for Vashon stade deposits.

9.2.1 Rainfall

Nine rain gauge stations were monitored between 1989 and 1992. The following rainfall trends for the Island are derived from the rainfall data collected.

- Similar seasonal trends in rainfall fluctuations occur across the Island. The Island receives the most rainfall between November and April and the least between August and September.
- The annual rainfall for the Island ranged from approximately 40 to 62 inches per year.
- The spatial distribution of the total rainfall generally varied erratically across the Island; however, the highest amount of rainfall generally falls in the central portion of Island. Total rainfall accumulations at Sea-Tac Airport on the mainland east of the Island are consistently lower than on the Island.
- The distribution of annual rainfall across the Island from 1989 to 1991 is inconsistent with the simple trend reported by Carr of decreasing rainfall from west to east for the period October 1981 to September 1982. The trend appears to show greater rainfall in the central to west central area of the Island where the elevations are higher than at the low-lying areas.

9.2.2 Surface Water

Eight creeks were monitored during the observation period to determine trends in stream flow and the quality of surface water on the Island. Stream flow data were collected by Seattle-King County Health Department and Island volunteers using staff gauges and weirs. The streams were monitored because the surface water is an expression of some amount of baseflow derived from recharge to the ground water. In other words, the streams are hydraulically connected to the ground water and thus would be the most observable expression of the ground water recharge. Water quality was evaluated from laboratory analysis of samples of freshwater, marine water, freshwater sediments, marine water sediments, and marine shellfish. The water quality data were compared to regulatory standards where those numbers existed. Regulatory levels for the sake of comparison were the Clean Water Act chronic freshwater or marine shellfish water quality standards. The comparisons were summarized qualitatively below with the specific data included in the appropriate section of the text. The following conclusions are drawn from these data collection and analysis efforts:

- The stream flow data collected by the Seattle-King County Health Department and Island volunteers using staff gauges and weirs are generally useful to calculate stream flow during normal steam conditions. Stream base flows ranged from approximately 0.3 cubic feet per second (Beall Creek) to two cubic feet per second (Judd, Upper Judd, and Needle Creeks). Average stream flows ranged from approximately 0.5 (Beall and Green Valley Creeks) to nine cubic feet per second (Upper Judd Creek).
- Data collection to support the development of maximum stream flows was minimal for most of the streams primarily due to the unpredictability of storm events and stream response time. The storm events resulted in stream bed erosion around and high maintenance of the weirs and staff gauges. These methods were selected as a economical alternative to permanent and automatic stream gauges.
- Predictably, stream flow tends to correlate with rainfall. Stream flow is highest during the wetter winter months and lowest during the drier summer months.
- With some exceptions (primarily coliforms), the quality of surface water environment on the Island is generally within regulatory standards.
- Fecal coliforms were present above regulatory levels within samples from seven of the eight freshwater streams; Beall Creek was the exception. These high values may be caused by non-point sources such as septic tank system discharges and animal wastes from hobby farms and wildlife. Mercury levels were exceeded once in Judd Creek, and chromium levels in Judd and Mileta Creeks exceeded Washington freshwater standards for streams once.
- A variety of metals were detected above Washington marine water standards in marine water samples collected by Seattle-King County Health Department. Lead was the most predominant metal, having been detected in at least one sampling event for all marine water samples. Copper was present above regulatory standards at least once in Beall, Judd, Mileta, Needle (Shinglemill), and Tahlequah Creeks. Zinc and silver were detected above regulatory standards at least once in Beall and Mileta Creeks, respectively. Tahlequah and Judd Creeks exceeded regulatory levels for fecal coliforms; total coliform levels exceeded regulatory standards in Judd Creek.
- No regulatory standards have been established for freshwater or marine water sediments. On a relative basis, however, constituent levels in samples collected from each medium were generally similar to each other.

- Fecal coliform levels exceeded U. S. Food and Drug Administration standards for the marine shellfish samples collected by Seattle-King County Health Department from the mouths of Beall, Fisher, Judd, Paradise Cove, and Tahlequah Creeks. Neither total nor fecal coliforms exceeded U. S. Food and Drug Administration standards in the samples collected from Green Valley, Mileta, or Needle Creeks.
- Trends in constituent levels, although often below regulatory standards, include increasing levels of selenium in freshwater samples collected from Green Valley and Tahlequah Creeks and fecal coliform levels in Fisher Creek. Fecal coliform levels appeared to increase in marine water samples collected near the mouths of Green Valley, Tahlequah, and Mileta Creeks, arsenic levels in Needle Creek, selenium levels in Tahlequah Creek, and chloride levels in Green Valley Creek. Mercury levels appeared to increase in marine water sediments collected near the mouths of Beall Creek, of chromium in Green Valley Creek, of zinc in Fisher and Mileta Creeks, of selenium in Tahlequah Creek, and of nitrate in Green Valley Creek. Mercury and arsenic appeared to increase in shellfish samples collected near the mouths of Mileta Creek and of silver in Tahlequah Creek.
- With the exception of coliforms, associations of high levels of contaminants were not observed between freshwater, freshwater sediment, marine water, marine water sediment, and marine shellfish. Contaminants detected in one sampling media were not detected in the others. Therefore, specific potential contaminant sources or specific contaminant transport pathways could not be identified. Conversely, coliforms (total or fecal) were most often detected in more than one sampling media.
- Other sampling programs conducted by the Washington State Department of Health, King County Department of Natural Resources, Water Pollution Control Division, and the Seattle-King County Health Department detected fecal coliforms exceeding regulatory levels in marine water samples from Tramp Harbor, Quartermaster Harbor, Bunker Trail, and Kingsbury. Fecal coliforms exceeding regulatory levels were detected in marine shellfish samples collected from Tramp Harbor, Quartermaster Harbor, Bunker Trail/Point Vashon, Cove, and Kingsbury. According to the data collected during this study and the Sewage Facilities Plan (PEI/Barrett 1992), the most likely source of the contaminants in these locations is failing septic systems.

9.2.3 Spring Water

Six springs were monitored between 1989 and 1992. Two of these springs, Atlas and Ober Beach, are used for public water supplies. Flow rates were estimated from field data. Water quality was again compared to water quality standards where those numbers existed. The following conclusions were drawn from this data collection effort.

- Spring flow rates ranged from 0.04 to 5 gallons per minute. Flow rates were generally highest in summer 1990 and lowest in winter 1992.

- During one or more sampling events, samples collected from at least one spring equaled or exceeded current water quality standards for iron, manganese, and mercury. Neither iron nor manganese levels in the springs are considered a health hazard. Mercury levels exceeded the regulatory limit at North Vashon Water and Morningside Springs in October 1990.
- The water quality of the springs tested on the Island is generally within regulatory compliance levels with the exception of coliforms. Total coliforms above regulatory levels were detected at least once in North Vashon Water, Magnolia Beach, and Jensen Springs; and twice in the Ober Beach Spring. Fecal coliforms above regulatory limits were only detected in Morningside Spring.
- Increasing levels were detected in the following constituents: mercury (S-1, S-2), copper (S-1, S-5, S-6), total dissolved solids (S-3, S-5), lead (S-4, S-5, S-6), arsenic (S-1, S-3, S-5), sulfate (S-4), nitrate (S-2), iron (S-3, S-5, S-6), and manganese (S-3, S-5, S-6). These trends were established using only three sampling events.

9.2.4 Ground Water

Twenty-four wells were monitored between 1989 and 1992 for water-level elevations based on recommendations by Carr; water quality samples were collected from 21 of the 24 wells. Trends in water levels, ground water quality, and aquifer characteristics were derived from the data collected and are presented below.

Hydrostratigraphy

- The complex stratigraphy on the Island results in ground water occurring in hydrostratigraphic zones (water-bearing portions of major geologic sequences that have similar hydraulic heads) rather than distinct geologic units. Hydrostratigraphic zones should not be confused with geologic units because they often cross geologic boundaries. For example, two adjacent geologic units may consist of a coarse-grained channel deposit with a fine-grained overbank deposit. However, since ground water will cross the boundary, the water-bearing zone is within the two units combined.
- Based on an evaluation of water-table elevations recorded in the wells and well screen depths, four hydrostratigraphic zones have been recognized on the Island. In descending order from ground surface, Zone 1 wells have an average hydraulic head of 255 feet above mean sea level; Zones 2, 3, and 4 have average hydraulic heads of 97, 18, and 11 feet above mean sea level, respectively. Zones 3 and 4 are also differentiated by the mid-screen depth of the well. Wells in Zone 4 have mid-screen depths over 250 feet deeper than those in Zone 3. Figures 8.19 through 8.21 are schematic diagrams showing the approximate locations of the zones penetrated by wells in the monitoring program.

- Although the hydrostratigraphic zones are conceptually portrayed as laterally continuous entities, the aquifer configuration is more complex as a result of lateral changes in geology. In addition, at least two of the hydrostratigraphic zones are probably separated by low permeability layers such as the silt aquitard suggested by Carr. Vertical leakage through zones occurs allowing infiltration of water from the near-surface zones into successively deeper zones.

- The results of the installation of Exploratory Boring VT-1 indicate the boring was drilled into Hydrostratigraphic Zone 4. The complex hydrostratigraphic relationships between these units precludes correlation of the results of VT-1 with the hydrostratigraphic units reported for Gig Harbor Well No. 5 on the Kitsap Peninsula.

- There are no data to suggest that the hydrostratigraphic units located off the Island, if interconnected with Island hydrostratigraphic units, transmit enough water to recharge the deep Island hydrostratigraphic units. It is more likely that Island precipitation and infiltration is the primary source of recharge to the deeper Island hydrostratigraphic zones.

Water Levels

- Depth to ground water varies across the Island. In general, the deepest depths to ground water are associated with the central axis of Vashon Island, while the shallowest depths to ground water occur near the coastlines in the approximate middle of Vashon Island.

- Ground water is mounded on the Island and flows from the higher topographic areas toward the coastlines. The mounding occurs in several localized areas generally in the west central higher elevation areas.

- Observed water levels in wells across the Island fluctuated (rise and fall) seasonally between approximately one and 15 feet, with the greatest fluctuation occurring in Zone 1. Specifically, wells in Hydrostratigraphic Zone 1 fluctuated seasonally 0.36 to 14.92 feet. Wells in Zones 2, 3, and 4 fluctuated seasonally 0.29 to 6.12, 0.12 to 10.05, and 1.13 to 3.32 feet, respectively. Seasonal fluctuations observed in the wells tend to correlate with rainfall (allowing for a lag period of from one to four months for the water to infiltrate the aquifer).

- The water-bearing zones monitored by the selected wells generally showed a stable or a slight rise in the water level during this study and, therefore, do not have appear to have been affected by ground water withdrawals. This general rise in water level corresponds to the rainfall recorded.

Water Quality

The ground water quality conclusions are based on a review of indicator parameters. These parameters are those which would typically be associated with several of the land-use practices discussed in the previous section of the conclusions and are those most frequently found in regulatory water quality data bases. From these data, general assessments about water quality can be deduced, serving as the baseline for a long-term monitoring program. It should be noted that the data collected from 1989 through 1990 only represent three sampling events and identified trends are subject to a margin of error.

- The concentrations of chloride, nitrate, and total dissolved solids are within the normal ranges expected to represent minimal impact on ground water from land use. Chloride and total dissolved solids are naturally occurring but higher levels would be indicative of concentrated development when viewed in conjunction with the zoning and land-use components. Total dissolved solid levels were generally low (less than 400 mg/L), but increased with time for ground water samples. Nitrates are indicative of waste from animals or humans and generally an increase signifies a point source of waste such as failed septic tanks, leaky sewer pipes, infiltration from a surface water discharge of wastewater, or uncontrolled concentrated animal wastes.
- There is no evidence of seawater intrusion in the wells monitored during this study period on the Island. King County Water System Review Board found one of the monitoring wells north of Glen Acres to be affected by seawater intrusion. Another of the wells had a slightly higher chloride concentration once between 1989 and 1990. However, the majority of wells monitored during the study were located in the interior of the Island, not near the shoreline where the potential for intrusion is greatest. These wells were selected based on accessibility and availability for monitoring during the study.
- Lead concentrations exceeded the Safe Drinking Water Act maximum contaminant level in ground water sampled from Wells W-13 and W-15. Lead concentrations apparently increased in Well W-8 and possibly in Wells W-9A, W-17, and W-19.
- Total coliforms were detected above the Safe Drinking Water Act maximum contaminant level once in Wells W-1, W-2, W-8, W-15, and W-20. Increasing levels of total coliform in the three sampling events was associated with Wells W-1, W-8, and W-20.
- Although below the Safe Drinking Water Act maximum contaminant levels, potentially increasing levels of mercury were associated with Wells W-2A, W-4, W-6, W-7, W-9A, W-14, W-15, W-16A, W-17, W-19, W-20, and W-21. Zinc concentrations may be increasing in Wells W-4, W-10B, W-17, and W-20. Increasing amounts of arsenic may be associated with Wells W-3, W-4, W-8, W-10A, W-20, and W-21.
- Water quality data submitted to the Washington State Department of Health by major water purveyors on the Island indicate nitrate levels were detected but at various concentrations below Safe Drinking Water Act maximum contaminant levels. Increasing nitrate levels were detected at Burton Water Company, Gold Beach Water Association, and possibly at Maury Mutual Water Company. Potentially increasing

conductivity levels were found in data from all purveyors except Maury Mutual Water Company and Westside Water Association.

9.2.5 Physical Susceptibility Areas

Booth's physical susceptibility map for the Island is a composite of the areas shown to be susceptible to contamination based on slope, depth to water, and surface geology.

- The areas showing the highest potential recharge and which are over five acres in areal extent (see Figure 8.28a) are:

  (1) Judd Creek drainage,
  (2) Fisher Creek drainage,
  (3) Tahlequah Creek drainage,
  (4) Ellis and Ellisport Creek drainage,
  (5) Mileta Creek drainage,
  (6) a portion of Green Valley Creek drainage,
  (7) on the plateau between Spring Beach and Burton,
  (8) northwest of Burton,
  (9) on the northern Burton peninsula,
  (10) on the plateau between the Town of Vashon and Cove,
  (11) directly east of Cove,
  (12) near the northeast and northwest coasts of Vashon Island,
  (13) near the southwest and southeast coasts of Maury Island, and
  (14) near the northern shore of Maury Island.

- Most of the physically susceptible areas are co-terminus with low-density, single-family residential land-use areas. A portion of the physically susceptible areas are located in high-density, single-family residential and manufacturing land-use areas.
- A comparison of the areas of physical susceptibility and the potential point sources of contamination indicate several potential contamination sources are located in the most physically susceptible areas. Most of these sources are underground storage tanks or septic systems.

9.2.6 Water Budget

The estimated water budget for the Island is 4.26 bgpy or 12,895 AFY. This amount is higher than that calculated in 1983 (Carr 1983), primarily due to the precipitation value used. With the variation in rainfall amounts ranging from 40 inches per year to 60 inches per year, both water budgets generally identify that a significant amount of both runoff and recharge occurs on the Island.

9.3 Recommendations and Future Information Needs

The objective of the Ground Water Management Plan was to develop an understanding of the Island water resources, both from a quality and a quantity perspective, and prepare a comprehensive plan to protect those resources in the future. The framework for the plan is to enhance the Island abilities to monitor and manage the resource and provide a basis for the development of public policies to protect the ground water. The Island water resources are an important part of many policy decisions.

In an effort to ensure that the resource is protected, the Ground Water Advisory Committee developed recommendations for policies on various land-use and planning issues, and monitoring/data collection for comparison against the information presented in this chapter. The Ground Water Advisory Committee looked at the local community needs and put those needs in context with the federal, state and local rules that apply to the protection of water. Those rules are complex and require substantial enforcement from the agencies to ensure compliance.

The regulatory framework is founded on the many federal environmental statutes. Paramount among those are the Clean Water Act, which sets standards for water quality and establishes a permitting system to limit discharges to waters of the state; the Resource Conservation and Recovery Act, which establishes a "cradle-to-grave" tracking system for the generation of hazardous wastes, sets standards of operations for all generators of hazardous waste, establishes a permit system for the treatment, storage and disposal of hazardous wastes; Federal Insecticide, Fungicide and Rodenticide Act, which requires chemical manufacturers to make specific instructions for application of pesticides and herbicides and establishes and federal licensing system for commercial applicators of agrichemicals; the Safe Drinking Water Act, which sets standards for the quality of water delivered by public water supply systems and allows the designation of sole-source aquifers; and the Coastal Zone Management Act which requires that coastal zones be protected against degradation. Each of the federal laws has a specific purpose and none of them are comprehensive in their coverage. The Clean Water Act is the closest to having universal applicability and includes wetlands, sediments and non-point sources among the other issues covered.

The state has the responsibility to determine which, if any, of these federal laws to enforce; any left unclaimed by the state are automatically enforced by the federal agencies, generally the U. S. Environmental Protection Agency. The state has authority to enforce the equivalent of the Clean Water Act and the Resource Conservation and Recovery Act (Washington Dangerous Waste Act), as well as the all-encompassing Model Toxics Control Act, which requires cleanup of environmental contamination regardless of the source. The Washington State Water Quality Standards for Ground Water are applicable to all ground water in the state. The state also administers the water rights through a water rights permits system in an effort to allocate the State resources and to reduce the risk of "mining" of the resource.

Additionally, the State Growth Management Act requires local jurisdictions to define service area boundaries for future growth; SEPA and a variety of other programs are aimed at reducing the risk to human health and the environment from unregulated discharges. At the local level, the Island has the most opportunity to control impacts to the environment and to strike the balance between development and environmental management through the land-use planning and zoning processes. The focus of these recommendations is on the activities that can be implemented locally to positively affect the outcome of these decisions. Some of the actions require a combined effort among federal, state, and local agencies, while others are the responsibility of only one group. The recommendations in this section are prioritized and listed according to the Ground Water Advisory Committee objectives which are as follows:

(1) Define policies that are preventive in nature relative to activities that have the potential to impair the ground water quality.

(2) Identify parameters that are generally indicative of contamination for specific sources and identify concentrations of those parameters that would trigger additional action towards resource protection.

(3) Establish feasible and cost-effective measures to observe and monitor long-term trends in the water quantity on the Island.

The following sections summarize recommendations to further the understanding of water resources on the Island based on the results of this investigation.

9.3.1 Policies

The Ground Water Advisory Committee reviewed a series of policy papers on a variety of topics ranging from a general non-degradation policy to a specific policy pertaining to application of pesticides and fertilizers. Summaries of these policy papers are included in Chapter 2 of the Vashon-Maury Island Ground Water Management Plan. However, where the policies addressed specific ground water management practices, the policies are summarized and included in this section of recommendations. The policies included in this document also address issues that require some governmental agency implementation.

(1) Data Management

It is important to recognize that the Island resources must be managed comprehensively and with regard to all significant environmental and resources issues. A major component of resource management is data collection and data management. In order for the Island resources to be defined and thus protected, a comprehensive data management system should be instituted. In addition to using a database system, Seattle-King County Health Department should investigate and purchase a relational geographic information system that will allow for the display of data in a variety of formats.

All of the data which has been collected to date, as well as the data which are suggested for collection as part of these specific recommendations, should be used to provide historical and current information in an easy-to-retrieve method. The Seattle-King County Health Department already uses a database for well, surface water, stream, and precipitation data. This database should be evaluated to ensure that the future data manipulation and systems are compatible with the existing system.

Specific database management evaluation criteria are:

- Number of data points for the ultimate size of the database;
- Size and type of computer hardware and software needed to meet the data input needs;
- Number of data fields required for each geographic location (i.e., water levels, sediment, water quality parameters, field measurements, well construction data, lithography, date and time of data collection, etc.); and
- Type of presentation capabilities required.

The data management system is the most significant cost item in the recommendations. The two-step process is first, to develop the database system and second, to enter and maintain the database. Costs for the first phase range from $50,000 to $100,000 and depend upon the amount of custom programming required to meet the user's data needs. The second phase is an ongoing cost but can be much lower on an annual basis because it is labor intensive and can be taught to co-op students or summer interns relatively easily. The annual database maintenance and data entry costs again depend upon how much data are collected each year but probably could be approximately $5,000 per year. Funding options should be developed by Seattle-King County Health Department in conjunction with the Ground Water Advisory Committee and may include Community Development Block Grants, cooperative agreements with the U. S. Geological Survey, Clean Water grants from Department of Ecology, and Pollution Prevention grants from the U. S. Environmental Protection Agency.

(2) Water Conservation Policies

Several specific recommendations derived through this study included a focus on voluntary water conservation measures including use of water-conserving fixtures. The zoning classifications with P-suffixes already require the use of water-conserving plumbing fixtures and flow restriction devices for new development on Vashon Island. (King County 1988b) Additional incentives for retrofitting existing development should be considered. In many of the arid or semi-arid regions of the country, the water purveyors have provided financial incentives to homeowners to replace aging, high water-use fixtures with the low water-usage fixtures through a rebate program. Assuming two toilet replacements per residence, 4,517 housing units (according to the 1990 census figures) and $80 rebate per fixture, this cost would be approximately $725,000. The resultant water savings could be up to 50 percent over the amounts used in 1980.

In addition to water-conserving fixtures, the installation of water meters at individual residences would be an appropriate measure to provide data relative to water usage and ultimately, water availability. However, the cost of installing and purchasing meters would be prohibitive if proposed for each individual residence (on the order of $9,000,000 for the Island). Therefore, it would be more appropriate and cost-effective to establish a demonstration program using houses on wells and on public water systems and extrapolate the results Island-wide. Meters, in conjunction with well construction information or public water system treatment volumes, would provide a substantial record of water quantity. The information might then be used to construct a more thorough database of information on a localized basis. This would be critical information for future development and zoning decisions.

Finally, as a water conservation measure, the water purveyors should be required to monitor water usage system-wide with emphasis placed on meeting the terms and conditions of the water rights permits issued by the state.

(3) Monitoring and Ground Water Quality Protection

As new development occurs in the high physical susceptibility areas, the zoning and planning programs already in place could be enhanced by adding provision to increase monitoring based on types and locations of proposed developments. For example, where high-density development is proposed, monitoring requirements for background and indicator parameters (i.e., nitrates, total dissolved solids, chlorides and pH) should be included in the building permit. Baseline data to define the water quality of the system prior to development should include definition of the resource, discussion of potential impacts, and monitoring program designed to measure the impacts. Additionally, the zoning ordinances for use of Best Management Practices for management of storm water runoff and sensitive areas protection during construction should be carefully reviewed and made site-specific to provide the optimal amount of protection for the habitat, wildlife, and water resources.

(4) General Zoning

The following policies should be considered to protect the quality and quantity of the aquifer.

- Create a local Aquifer Protection Area for Vashon-Maury Island per RCW 36.36.

- Develop land-use policies that are protective of aquifer sensitive areas identified in Section 8.3.5.2.
- Require a hydrogeologic site evaluation as part of the environmental assessment for new or revised projects having the potential for ground water contamination.
- Protect identified high physical susceptibility areas.
- Require 5-year tightness tests for residential underground storage tanks or require permits for underground storage tanks which require a tightness test for renewal.
- Propose land-use restrictions prohibiting on-site storage of potential contaminants at junkyards.

(5) Public Awareness

Maintain a high level of public awareness by implementing a system through which data are collated and retained in a usable manner.

- The results of the continuing data collection efforts can be conveyed to the public on a regular basis to preserve high levels of public awareness and "grass-roots" responsibility for the Island water resources.
    - Educate homeowners on the proper disposal of potential hazardous wastes (motor oils, paints, etc.,).
    - Explain the effects of disposing common household hazardous wastes down the drain.
- Promote public hearings on proposed development, applications for building permits, and future land use.

9.3.2 Water Quality

Goals: Establish monitoring programs and practices to manage and protect the quality of Island water resources.

(1) Levels for water quality parameters which would trigger implementation of protection policies are defined for the following water quality parameters:

    - nitrates (5 mg/L and a statistical evaluation as described in the following paragraph).
    - chlorides (125 mg/L and a statistical evaluation as described in the following paragraph).

- total dissolved solids (250 mg/L and a statistical evaluation as described in the following paragraph).

For these parameters, the trigger is one of two occurrences, either:

(a) An absolute increase in the concentration, where the increase is more than 10 percent of the trigger level, or

(b) A steady increase in the concentration where that increase occurs over several sampling rounds and the slope of the concentration versus time graphical representation of the data shows that a continuation of the increase will result in exceeding the standard in an unacceptable time frame.

Trigger levels for other significant pollutants may include:

- For any substance that is carcinogenic, mutagenic or teratogenic, and has not previously been detected in Vashon ground water: any detectable level that is confirmed by repeated (at least two samples at least two weeks apart) monitoring.
- For any substance that is carcinogenic, mutagenic or teratogenic and has previously been detected at background levels: 10 percent of Washington State ground water limit.
- For any primary pollutant - any pollutant that poses a potential risk to public health - that has not previously been detected in Vashon ground water: any detectable level that is confirmed by repeated (at least two samples at least two weeks apart) monitoring.
- For any primary pollutant (except fecal coliform) that has previously been detected at background levels: 20 percent of Washington State ground water limit.
- For any secondary pollutant - any pollutant that is primarily of aesthetic concern - not the probable result of seawater intrusion: 50 percent of Washington State ground water limit.
- For any secondary pollutant that is the probable result of seawater intrusion: 10 percent of Washington State ground water limit.
- For fecal coliform, the trigger is any detection that is not corrected by disinfection procedures.

(2) Construction balances for each of the major hydrostratigraphic zones to determine the geochemical "signature" of each zone. The water within separate hydrostratigraphic zones often has a distinct signature defined by the distribution of ion concentrations. These signatures should be developed and monitored as indicators of contamination as follows:

- Sample wells identified in this study as completed in each of the hydrostratigraphic zones and analyze for major anions and cations.

- Construct a Stiff diagram by plotting the concentrations of detected anions and cations. The shape of the diagram will define the signature for the zone.

- Changes in the ion distribution should be used as indicators of contamination (such as sea water intrusion) and could be used to aid in establishing trigger mechanisms.

(3) Establish a monitoring well network and continue implementation of the ground water quality monitoring program. The well network established for this study may be augmented by additional wells. Selection of additional wells should be based on the following:

- Location within high physical susceptibility areas and near coastal areas (to monitor specifically for seawater intrusion).
- Completed in the shallowest hydrostratigraphic zone (Zone 1) since this zone is most susceptible to contamination and can serve as an "early warning" to deeper zones.
- Spatial distribution within areas to be monitored.
- Accessibility to monitoring personnel.

The selected wells should continue to be monitored for the water quality parameters monitored in this study to build on the established data base and confirm observed trends in concentrations. Specifically, additional sampling should be conducted for wells in which increasing levels of contaminants (such as lead) were identified in this study. Wells near the shoreline should be closely monitored for indications of overpumping and associated seawater intrusion.

As part of the monitoring program, a control area should be established for closely monitoring water quality and extrapolating the results to other areas of the Island. The control area should be established based on the following criteria:

- Location within high physical susceptibility area.
- Availability of sufficient monitoring points to monitor the shallowest hydrostratigraphic zone across the control area.
- Knowledge of land-use activities within the control area to establish cause and effect relationships.

(4) Continue to monitor water quality at the mouths of the major streams as an indicator of impacts from land use within the drainage basin. Streams monitored in this study should continue to be monitored since they represent the major drainage basins on the Island and have established access points. The streams should continue to be monitored for the water quality parameters monitored in this study to build on the established data base and confirm observed trends in concentrations. Specifically, continue to monitor the creeks identified in Section 8.5.1.2 as having increasing trends in constituent concentrations. Continue to monitor contaminants in shellfish in areas identified in Section 8.5.1.2 as above regulatory levels. Conduct a non-point source survey of the major streams.

(5) Invite the Center for Urban Water Resources Management at the University of Washington or the King County Water and Land Resources Division to present state-of-the-art ideas on quantity and quality controls for storm water runoff that might be applicable to a rural environment like Vashon Island.

(6) Continue to monitor the water quality of selected wells for potential impacts by point and non-point sources of contamination to provide long-term trends in constituent levels. Specifically, continue to monitor the wells identified in Section 8.5.3.2 (including the wells associated with the water purveyors) as having constituents above regulatory levels or increasing trends in concentrations of constituents.

9.3.3 Water Quantity

Goals: Establish programs and practices to monitor, define, manage and protect the quantity of Island water resources.

(1) Monitor Island precipitation levels to determine long-term tends specific to the Island. The monitoring should be conducted as follows:

- Install automatic rain gauge recorders at the locations monitored during this study. These locations are representative of the major Island collection basins. The data collected will build on the data base established during this study.
- Establish schedule, funding, and personnel to download recorders and to collect periodic manual readings for cross-referencing the automatic recorders.

(2) Monitor water levels in the monitoring well network to determine long-term trends in water levels of the hydrostratigraphic zones. The long-term trends will aid in determining if ground water overdrafts are occurring, or the effects of drought periods on ground water levels. The well network established for this

study should be augmented by additional wells. Selection of additional wells should be based on the following:

- Location within high and low physical susceptibility areas. Wells in high physical susceptibility areas will be more sensitive to the effects of ground water recharge, wells in low physical susceptibility areas will be more sensitive to ground water overdrafts.
- Completed in the shallowest hydrostratigraphic zone (Zone 1) since this zone is most susceptible to recharge and overdrafts.
- Spatial distribution within areas to be monitored.
- Accessibility to monitoring personnel.

The wells should continue to be monitored on either a monthly or quarterly basis. Pumping conditions (on or off and for how long) should be noted at the time of water level recording. Within high use areas, flow gradient with and without pumping influences should be evaluated. Continued monitoring of the wells monitored in this study will build on the established data base and observed trends in water levels.

As part of the monitoring program, a control area should be established for closely monitoring water quantity and extrapolating the results to other areas of the Island. The following monitoring activities should be conducted within the control area:

- Install and monitor automatic rain gauges to record precipitation (the amount of water coming into the control area).
- Install and monitor automatic stream gauges to record stream runoff (the amount of surface water leaving the control area through direct runoff and the amount of ground water leaving the control area through stream baseflow).
- Monitor water levels in selected monitoring wells to determine the effects of recharge and/or ground water withdrawals.

The control area should be established based on the following criteria:

- Location within high physical susceptibility area.
- Availability of sufficient monitoring wells to monitor the shallowest hydrostratigraphic zone across the control area.
- Knowledge/control of land-use activities (such as logging, ground water withdrawal rates) within the control area to establish cause and effect relationships.

(3) Reactivate the U. S. Geological Survey stream gauging station located on Judd Creek to establish long-term trends in stream flow and response to seasonal variations in precipitation.

9.3.4 Site-Specific Recommendations

Land Use/Water Quality

Land use and water quality are inextricably linked. The long-term goal of the Ground Water Advisory Committee is to define the current land use, to review the policies used to make land-use decisions and to implement the recommendations identified in the various position papers prepared throughout the project. In addition to those specific recommendations, the following recommendations are expected to assist in refining the understanding of the land use and to suggest improved management where current facilities exist.

(1) Vashon Landfill

- Vashon Landfill should continue to be monitored for vinyl chloride. However, due to budget constraints, the Seattle-King County Health Department is no longer sampling off-site. Additional sampling will be based on need, as determined by the Seattle-King County Health Department. The King County Solid Waste Division installed eight additional monitoring wells in 1994. Four wells were installed to monitor deep ground water. The other four wells were installed to monitor the shallow ground water zones. The wells were located both upgradient and downgradient from the landfill.
- Landfill cleanup should include a system to handle vinyl chloride gas. The King County Solid Waste Division has requested and received budget authority to implement the recommendations to control the lateral and vertical extent of landfill gas as close to the edge of the refuse boundary as possible.
- Document users of creek near Vashon Landfill to which spring water recharges.
- Suggest closure of existing landfill, development of additional landfill and/or transfer capacity to another location.
- Provide a location, capacity for a transfer service and different types of recycling services.
- Provide a location and capacity of landfill leachate pretreatment and storage facilities.
- Provide a location and capacity of storm water facilities for the landfill.
- Provide a location, capacity and nature of a landfill composting operation.

- Increase the capacity of the landfill leachate collection system to capture waters from a major rainfall.
- Establish a collection site for hazardous materials at the county landfill site on the Island.
- Monitor the water quality data of wells at and around the Vashon landfill collected by the King County Solid Waste Division and Seattle-King County Health Department in the vicinity of the landfill to determine if the shallow and deep aquifers are interconnected, or connected to water producing zones for public supply.

(2) NIKE Battery Site

- Conduct soil cleanup at the NIKE site. Planned remedial actions by the U. S. Army Corps of Engineers for the former Paint and Fuel Storage Area include removing five feet of contaminated top soil, then another five feet of clean soil, from the site of the former Paint and Fuel Storage Area. Clean soil will replace the soil removed. Seattle-King County Health Department/Ground Water Advisory Committee should monitor the progress.
- Confirm that ground water has not been impacted at NIKE site by installing and monitoring a monitoring well in the area of former Paint and Fuel Storage Area.

(3) On-Site Sewage Systems

- Conduct long-term monitoring for nitrate trends on ground water quality from on-site systems due to age, soils, lack of maintenance and materials used.

(4) Biosolids

- When application is made for utilizing biosolids, the permitting/lead agency, will forward a copy of the approved application to the Management Committee.

(5) Agriculture

- Conduct spot checking and long-term monitoring to Island ranches for nitrate, especially at sites located in high recharge areas.

(6) Sand and Gravel

- Monitor all sand and gravel operations for impacts on ground water quality.

(7) Hazardous Materials

- Train a response team (Vashon fire department) for hazardous substance cleanup for potential hazardous substance spills during transportation.
- Track which hazardous products are transported to the Island (manufacturing and grocery stores).
- Investigate junkyards reported to have stored polychlorinated biphenyl transformers for hazardous substances they may contribute to the ground water.
- Input data into Seattle-King County Health Department database concerning large and small quantity hazardous waste generators for impacts on ground water quality, and map the locations of the generators.

Area Characterization

References

Vashon-Maury Island
Ground Water Management Plan

December 1998

10.0 REFERENCES

Ames, R. 1989. Vashon Sewer District. Telephone conversations with J. A. Smith, Geraghty & Miller, Inc., August 29 and September 6, 1989.

__________. 1990. Vashon Sewer District. Telephone conversation with J. A. Smith, Geraghty & Miller, Inc., June 28, 1990.

__________. 1993. Vashon Sewer District. Personal communication with Seattle-King County Health Department, November 1993.

__________. 1994. Vashon Sewer District. Telephone conversation with M. D. Mierisch, Geraghty & Miller, Inc., January 25, 1994.

Baird, M. 1989. Washington State Ferry System, Safety Officer. Telephone conversation with J. A. Smith, Geraghty & Miller, Inc., November 3, 1989.

Baxter, T. 1994. Maury Mutual Water Company. Telephone conversation with M. D. Mierisch, Geraghty & Miller, Inc., January 20, 1994.

Beck, R. W., and Associates/Sweet, Edwards & Associates. 1984. *Ground Water Geology/Quality Investigations for the King County Rural Landfills*, December 1984.

Becker, Jay. 1989. The Vashon-Maury Island Beachcomber, Editor. Telephone conversation with J. A. Smith, Geraghty & Miller, Inc., November 2, 1989.

Booth, D. B. 1991. *Geologic Map of Vashon and Maury Islands, King County, Washington, with text to accompany map MF2161*. U. S. Department of the Interior, U. S. Geological Survey, Map Distribution Center, Denver, Colorado.

__________. 1992. King County. Personal communication to L. E. Roberts, Geraghty & Miller, Inc., August 13, 1992.

__________. 1994a. *Recharge Potential and Criteria for Identifying Susceptibility Areas*. January 20, 1994.

Bredouw, P. 1994. Planning consultant. Telephone conversation with M. D. Mierisch, Geraghty & Miller, Inc., January 21, 1994.

Bromenshenk, J. 1989. University of Montana. Telephone conversation with J. A. Smith, Geraghty & Miller, Inc., November 8, 1989.

Capehart, B. 1993. King County Parks, Planning and Resources, Community Planning Division. Personal communication with Seattle-King County Health Department, November 1993.

__________. 1994. King County Parks, Planning and Resources, Community Planning Division. Telephone conversation with M. D. Mierisch, Geraghty & Miller, Inc., January 18, 1994.

Card, A. 1989. Washington Department of Natural Resources. Personal communication to Geraghty & Miller, Inc., November 6, 1989.

Carr, J. R./Associates. 1983. *Vashon/Maury Island Water Resources Study, Seattle, Washington*, December 1, 1983.

Carr/Associates. 1991. *Production Well 1, Construction and Testing Report, Coho Community Association*, Seattle, Washington.

CH2M Hill, Inc. *Draft Monitoring Well Construction and Hydrogeologic Report for Vashon Island Landfill, 1995*. Prepared for King County Solid Waste Division.

Clemans, G. 1993. Seattle-King County Health Department. Internal communication within Seattle-King County Health Department, October 28, 1993.

__________. 1994. Seattle-King County Health Department. Telephone conversation with M. D. Mierisch, Geraghty & Miller, Inc.

Coville, G. 1993. Seattle-King County Health Department. Personal communication with Seattle-King County Health Department, 1993.

Creahan, K. 1994. King County Environmental Division. Telephone conversation with M. D. Mierisch, Geraghty & Miller, Inc., January 25, 1994.

DeLorme Mapping Company. 1988. *Washington Atlas & Gazetteer*. Freeport, Maine.

Dolstad, D. 1994. Westside Water Association. Telephone conversation with M. D. Mierisch, Geraghty & Miller, Inc., January 20, 1994.

Driscoll, F. G. 1986. *Groundwater and Wells, 2nd ed.* Johnson Filtration Systems, St. Paul, Minnesota.

Drost, B. W. 1982. *Water Resources of the Gig Harbor Peninsula and Adjacent Areas, Washington: U. S. Geological Survey Water-Resources Investigations Open File Report 81-1021*.

Dunne. 1978. *Water in Environmental Planning*, Freeman and Company Publishing.

Easter, B. 1989. King County Department of Natural Resources, Spray Technician. Telephone conversation with J. A. Smith, Geraghty & Miller, Inc., November 7, 1989.

EcoChem, Inc. and Geraghty & Miller, Inc. 1990. *Vashon/Maury Island Ground-Water Management Plan: Data Collection and Analysis Plan, Phase I, King County, Washington, March 1990.*

__________. 1991. *Vashon/Maury: Water and Community Program Surface-Water Data Collection, Analysis, and Quality Assurance Project Plan, King County, Washington, May 20, 1991.*

Fitzpatrick, R. 1994. Heights Water Association. Telephone conversation with M. D. Mierisch, Geraghty & Miller, Inc., January 20, 1994.

Freeze, R. A., and J. A. Cherry. 1979. *Groundwater.* Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 604 pp.

Geraghty & Miller, Inc. 1990. *Vashon-Maury Island Ground-Water Management Program, Land-Use Background Data, King County, Washington, August 10, 1990.*

__________. 1991. *Hydrogeology Background Data and Water Use in the Vashon Island Ground-Water Management Area, King County, Washington, January 15, 1991.*

__________. 1992a. *Exploratory Water Well Installation, Vashon Island Ground-Water Management Program, Burton Acres Park, Vashon Island, Washington, Project No. WA02801, August 4, 1992.*

__________. 1992b. *Vashon-Maury Island Ground-Water Management Plan Data Analysis Report, Project No. WA028.01, King County, Washington, August 31, 1992.*

Gomez, A. 1989. Seattle-King County Health Department. Telephone conversation with J. A. Smith, Geraghty & Miller, Inc., November 3, 1989.

Gregory. 1994. Williams Heating Oil Company. Telephone conversation with M. D. Mierisch, Geraghty & Miller, Inc., March 7, 1994.

Hall, Seldon. 1994. Washington State Department of Health. Telephone conversation with M. D. Mierisch, March 3, 1994.

Harding Lawson Associates. 1991. Letter report to John Komorita, Senior Engineer, King County Solid Waste Division, Seattle, Washington, August 8, 1991.

Harper-Owes/Golder Associates, Inc. 1986. *Technical Memorandum, Vashon Landfill Leachate Control, Task IB: Geotechnical and Water Quality Investigations, Washington*, (draft), August 1986.

Harper-Owes Associates. 1988. Letter report to Kevin Kiernan, King County Department of Natural Resources, Solid Waste Division, Seattle, Washington.

Hickock, D. 1993. Seattle-King County Health Department. Internal communication within Seattle-King County Health Department, November 1993.

Horton Dennis & Associates, Inc., with CH2M Hill. 1989. *Vashon Coordinated Water System Plan, Regional Supplement* (draft), December 1989.

__________. 1990. *Vashon Coordinated Water System Plan, Regional Supplement* (final).

Jones, L. 1989. King County Agricultural Preservation Program. Telephone conversation with J. A. Smith, Geraghty & Miller, Inc., November 6, 1989.

Jurgensen, S. 1993. King County Solid Waste Division. Letter to Paul Shallow, Seattle-King County Health Department, November 17, 1993.

Kiernan, K. 1996 King County Solid Waste Division. Personal communication with Paul Shallow, King County Department of Natural Resources, 1996.

King County. 1986. *Vashon Community Plan and Area Zoning*, October 31, 1986. Department of Parks, Planning, and Resources; Planning Division; King County, Washington.

__________. 1988a. *1988 Annual Growth Databook, June 1988.* Department of Parks, Planning & Resources, Seattle, Washington.

__________. 1988b. Zoning - Title 21. Department of Parks, Planning, and Resources; Building & Land Development Division; Bellevue, Washington.

__________. 1988c. Rural Landfills, Periodic Groundwater Checklist. Department of Public Works, Division of Solid Waste, Seattle, Washington.

__________. 1989a. *1989 Annual Growth Databook.* Department of Parks, Planning & Resources, Seattle, Washington.

__________. 1990. *Sensitive Areas Map Folio*, December 1990. Department of Parks, Planning, and Resources; Planning and Community Development Division; King County, Washington.

__________. 1991. *King County Annual Growth Databook 1991*, King County Washington. Department of Parks, Planning, and Resources; Planning Division; King County, Washington.

__________. 1992. *King County Annual Growth Databook 1992*, King County Washington, August 1992. Department of Parks, Planning, and Resources; Planning Division; King County, Washington.

__________. 1993a. *King County Annual Growth Databook 1993*, King County Washington, 1993. Department of Parks, Planning, and Resources; Planning Division; King County, Washington.

__________. 1993b. *Water Quality Status Report for Marine Waters, King County Area, 1990 to 1992.* King County Department of Natural Resources, Water Pollution Control Division, King County, Washington, Publication No. 171, December 1993.

King County Board of Health 1987. *Rules and Regulations #3, On-Site Sewage Disposal Systems, Effective April 1, 1987.* Seattle, Washington.

King County Council. 1985. *King County Comprehensive Plan*, Seattle, Washington, April 15, 1985.

King County Solid Waste Division. 1993. Memorandum to P. Shallow, Seattle-King County Health Department. November 17, 1993.

Knowlton, D. 1993. Washington State Department of Ecology. Personal communication with Seattle-King County Health Department, October 28, 1993.

Koler, J. 1989. King County Historic Preservation Officer. Telephone conversation with J. A. Smith, Geraghty & Miller, Inc., November 3, 1989.

Lewis, W. J., S. S. D. Foster, and B. S. Drasar. 1980. *The Risk of Groundwater Pollution & On-Site Sanitation in Developing Countries, A Literature Review*: Duebendorf, Switzerland.

Maas, J. A. 1993. U. S. Army Corps of Engineers, Seattle District. Personal communication to M. Mierisch, Geraghty & Miller, Inc., April 8 and 15, 1993.

Mann, L. 1993. U. S. Army Corps of Engineers. Personal communication with Seattle-King County Health Department, November 1, 1993.

Misko. 1993. Washington State Department of Ecology. Personal communication to Seattle-King County Health Department, November 15, 1993.

Moran, Dan. 1993. Seattle-King County Health Department. Personal communication within Seattle-King County Health Department, September 20, 1993.

Morgan, C. 1989. King County Department of Natural Resources, Roads Division, Vashon Island, Washington. Personal communication to J. A. Smith, Geraghty & Miller, Inc., September 6, 1989.

__________. 1991. King County Department of Natural Resources, Roads Division, Vashon Island, Washington. Personal communication to Geraghty & Miller, Inc.

Murphy. 1989. Williams Heating Oil Company, Vashon, Washington. Personal communication to J. A. Smith, Geraghty & Miller, Inc.

Newman, B. 1989. Washington State Department of Ecology, Northwest Division. Telephone conversation with J. A. Smith, Geraghty & Miller, Inc., August 24, 1989.

__________. 1994. Washington State Department of Ecology, Northwest Division. Telephone conversation with M. D. Mierisch, Geraghty & Miller, Inc., January 24, 1994.

Newman, G. 1989. King County Department of Natural Resources, Roads Division. Telephone conversation with J. A. Smith, Geraghty & Miller, Inc., November 3, 1989.

PEI/Barrett Consulting Group, with Washington State Department of Ecology and Seattle-King County Health Department. 1992. *Sewage Facilities Plan for the Severe Public Health Hazard Areas, Vashon Island, Washington* (draft), September 1992.

Prescott, C. 1994. Puget Sound Water Quality Authority. Telephone conversation with M. D. Mierisch, Geraghty & Miller, Inc., February 24, 1994.

Puget Sound Council of Governments (PSCOG). 1988. *Population and Employment Forecasts, King County, Washington.*

Puget Sound Regional Council. 1993. Telephone conversation with J. T. Alberts, Geraghty & Miller, Inc., April 1, 1993.

Puget Sound Water Quality Authority. 1988. *1989 Puget Sound Water Quality Management Plan, June 15, 1988* (draft). Seattle, Washington.

Quesinberry, B. 1994. Water District No. 19. Telephone conversation with M. D. Mierisch, Geraghty & Miller, Inc., January 20, 1994.

Reid, C. 1993. Department of Agriculture. Personal communication with Seattle-King County Health Department, October 28, 1993.

Safioles, S. 1993. Department of Ecology. Personal communication with Seattle-King County Health Department, October 12, 1993.

Seattle-King County Health Department. no date. *Water System Report Form for the Ground-Water Program* (Vashon), Seattle, Washington.

__________. 1990. Environmental Health Division. Letter with comments on draft Land-Use Background Data report to Geraghty & Miller, Inc.

__________. 1993a. Environmental Health Division. Facsimile memorandum to M. Mierisch, Geraghty & Miller, Inc., March 30,1993.

__________. 1993b. Environmental Health Division. Letter with comments on draft Updated Characterization report to Geraghty & Miller, Inc.

__________. 1994. Environmental Health Division. Facsimile memorandum to M. D. Mierisch, Geraghty & Miller, Inc., March 3,1994.

Seattle-King County Health Department, with the Washington State Department of Health (formerly Department of Social and Health Services) and the Tacoma-Pierce County Health Department. 1984. *Vashon/NE Tacoma Drinking Water Survey, Seattle, Washington.*

Shallow, Paul. 1989. Seattle-King County Health Department, Environmental Health Division. Memorandum to B. A. Carpenter, Geraghty & Miller, Inc., March 9, 1989.

__________. 1993. Seattle-King County Health Department, Environmental Health Division. Facsimile memorandum to L. E. Roberts, Geraghty & Miller, Inc., February 12, 1993.

__________. 1994. Seattle-King County Health Department, Environmental Health Division. Telephone conversation with M. D. Mierisch, Geraghty & Miller, Inc., January 19, 1994.

Shapiro and Associates, Inc. and Applied Geotechnology Inc. 1992. *Site Inspection Follow-up Study, Former NIKE Battery S-61, Vashon Island, Washington, June 1992.*

Shapiro and Associates, Inc. and Science Applications International Corporation. 1988. *Executive summary and site maps from Confirmation Study of Former NIKE Battery S-61 for Potential Toxic and Hazardous Waste Contamination, Vashon Island, Washington, Contract No. DACA67-86-D-0099, Work Order No. 3, September 1988.*

Shuman, R. 1994. King County Department of Natural Resources, Water Pollution Control Division. Telephone conversation with M. D. Mierisch, Geraghty & Miller, Inc., January 26, 1994.

Stern. no date. Washington State Department of Ecology. Personal communication to Geraghty & Miller, Inc.

Thrasher, K. 1993. King County Department of Natural Resources, Water Pollution Control Division. Personal communication to M. Mierisch, Geraghty & Miller, Inc., April 2 and 5, 1993.

Titus, Bruce. 1994. URS Consultants. Telephone conversation with L. E. Roberts, Geraghty & Miller, Inc., March 22, 1994.

Todd, M. 1994. Dockton Water Association. Personal communication with M. D. Mierisch, Geraghty & Miller, Inc., January 20, 1994.

URS Consultants. 1992a. Letter Report, Vashon Island Ground Water Management and Surface Water Management Program, Stream Flow Observations, Vashon Island, Washington, June 26, 1992.

__________. 1992b. Location Descriptions of the Ground and Surface Water Management Program Staff Gauges and Weirs, August 11, 1992.

U. S. Environmental Protection Agency. 1987. Survey of Pesticides Used in Selected Areas Having Vulnerable Groundwaters in Washington State, August 1986, rev. July 1987. Pesticides Section, Region 10, Seattle, Washington.

__________. 1989b. *Comprehensive Environmental Response, Compensation, and Liability Listing (CERCLIS)*, March 31, 1989. Region 10, Seattle, Washington.

U. S. Geological Survey. 1968a. *Duwamish Head Topographic Map, 7.5 minute quadrangle*. U. S. Department of the Interior, Survey and Mapping Branch, Denver, Colorado.

__________. 1968b. *Vashon Topographic Map, 7.5 minute quadrangle*. U. S. Department of the Interior, Survey and Mapping Branch, Denver, Colorado.

__________. 1973. *Des Moines Topographic Map, 7.5 minute quadrangle*. U. S. Department of the Interior, Survey and Mapping Branch, Denver, Colorado.

__________. 1981a. *Gig Harbor Topographic Map, 7.5 minute quadrangle*. U. S. Department of the Interior, Survey and Mapping Branch, Denver, Colorado.

__________. 1981b. *Olalla Topographic Map, 7.5 minute quadrangle*. U. S. Department of the Interior, Survey and Mapping Branch, Denver, Colorado.

__________. 1981c. *Tacoma North Topographic Map, 7.5 minute quadrangle*. U. S. Department of the Interior, Survey and Mapping Branch, Denver, Colorado.

__________. 1985.

University of Washington. 1987. *Ruston/Vashon Arsenic Exposure Pathways Study, March 31, 1987*. School of Public Health and Community Medicine, Seattle, Washington.

Washington State Department of Ecology. 1988a. *Seawater Intrusion -- What Does It Mean To Us?,* October 1988.

__________. 1988b. *Sites by County, Hazardous Waste Investigations and Cleanup Program* (draft site list), December 22, 1988. Olympia, Washington.

__________. 1989. *List of State Hazardous Waste Investigations and Cleanup, September 12, 1989*. Olympia, Washington.

__________. 1990. *Listing of Underground Storage Tanks Reported in Washington State, March 27, 1989*. Olympia, Washington.

Washington State Department of Ecology and the U. S. Environmental Protection Agency. 1993. *Hazardous/Dangerous Waste Notifiers Listing*. November 15, 1993.

Area Characterization

Glossary

Vashon-Maury Island
Ground Water Management Plan

December 1998

Glossary

ACUTE VALUE. Level which may result in injury or death to an organism as a result of short-term exposure.

ADVANCE OUTWASH. Outwash deposited during a time interval marked by the advance or general expansion of a glacier. See OUTWASH.

AEROBIC. Life or processes that require, or are not destroyed by, the presence of oxygen. For example, soil microorganisms which will degrade sewage effluent from septic systems need oxygen to function.

AFY. acre-feet per year.

ALLUVIAL. Pertaining to or composed of alluvium or deposited by a stream or running water.

ALLUVIUM. A general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during comparatively recent geologic time by a stream or other body of running water as a sorted or semi-sorted sediment in the bed of the stream or on its floodplain or delta, or as a cone or fan at the base of a mountain slope.

ANOMALOUS. An adjective to describe a departure from the expected or normal.

AQUIFER. A soil or geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield economical quantities of water to wells and springs. See CONFINED AQUIFER, UNCONFINED AQUIFER.

AQUIFER SENSITIVE. Localities where rainfall replenishes an aquifer most efficiently.

AQUIFER SYSTEM. A body of permeable and relatively impermeable materials that functions regionally as a water-yielding unit. It comprises two or more permeable units separate at least locally by confining units that impede groundwater movement but do not greatly affect the regional hydraulic continuity of the system. The permeable materials can include both saturated and unsaturated sections.

AQUIFER TEST. A test involving the withdrawal of measured quantities of water from or addition of water to a well, and the measurement of resulting changes in head in the aquifer both during and after the period of discharge or addition, e.g., a bailer or pump test. (These are withdrawal tests).

AQUITARD. A geologic formation, group of formations, or part of a formation with low permeability through which only limited water flows or moves to or from an adjacent aquifer.

AREA OF INFLUENCE. Area surrounding a pumping well within which the water table or potentiometric surface has been changed due to the well's pumping or recharge.

AREAL. An adjective indicating spatial distribution and horizontal extent.

ARSENIC. A native metallic element which, in sufficient concentrations, can be hazardous to human health. Arsenic can also accumulate in the tissues of aquatic organisms, though the nervous system of the organism is unaffected. Consumption of the organism, such as fish or shellfish, can cause acute illness in humans and other mammals.

ARTESIAN. An adjective referring to ground water confined under hydrostatic pressure, e.g., the hydrostatic pressure of ground water is generally due to the weight of water at higher levels in the zone of saturation.

ARTESIAN WELL. A well deriving its water from a confined aquifer in which the hydraulic water level stands above the ground surface; synonymous with flowing artesian well.

ATTENUATION. The general process of reducing the amount and concentration of contaminants in water. Includes physical, chemical and biological processes as well as dilution.

AUTO FACILITIES. Facilities which provide services to on-road motorized vehicles usually handling quantities of petroleum products, such as gasoline, diesel fuel, oil, antifreeze, etc.

BASAL LAYER. The geologic or hydrogeologic layer situated at and forming the base of the structure.

BASALT. A general term for dark-colored iron- and magnesium-rich igneous rocks. It is the principal rock type making up the ocean floor and is easily seen in exposed cliffs in Eastern Washington.

BASE FLOW. That part of stream discharge not attributable to direct runoff from precipitation or snowmelt, usually sustained by ground water discharge.

BEDROCK. A general term for the rock, usually solid, that underlies soil or other unconsolidated material.

BENTONITE. A colloidal clay, largely made up of the mineral sodium montmorillonite, [a hydrated aluminum silicate] used in sealing the annular space to create a surface or sanitary seal.

BEST MANAGEMENT PRACTICE. A method, activity, maintenance procedure, or other management practice for reducing the amount of pollution entering a water body. The term originated from the rules and regulations developed pursuant to Section 208 of the federal Clean Water Act (40 Codified Federal Register 130).

BGPY. billion gallons per year

BIOLOGICAL OXYGEN DEMAND. A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. The greater the biological oxygen demand, the greater the degree of pollution. A major objective of conventional wastewater treatment is to reduce the biological oxygen demand so that the oxygen content of the water body will not be significantly reduced. Although biological oxygen demand is not a specific compound, it is defined as a conventional pollutant under the federal Clean Water Act.

BLS. below land surface

CADMIUM. A heavy metal element that accumulates in the environment and is toxic to human health.

CAPILLARY ACTION. The movement of water within the interstices of a porous medium due to the forces of adhesion, cohesion, and surface tension acting in a liquid that is in contact with a solid.

CAPILLARY FRINGE. The zone at the bottom of the vadose zone where ground water is drawn upward by capillary force.

CARBONATE. A sediment formed by the organic of inorganic precipitation from aqueous solution of carbonates of calcium, magnesium, or iron.

CATCH BASIN. A reservoir or basin into which surface water may drain, used to collect and retain material.

CENTENNIAL CLEAN WATER FUND, also known as the Water Quality Account. In 1986 legislation was passed creating the Water Quality Account in the Washington State treasury (RCW 70.146). The purpose of the account is to provide financing of water pollution control facilities and activities. The account receives revenue from a tax on tobacco products. Ecology, in adopting rules for administration of the account, has named it the Centennial Clean Water Fund.

CFS. cubic feet per second

CHEMICAL OXYGEN DEMAND. The amount of oxygen required for the oxidation of the organic matter in a water sample or a water body.

CHLORIDE. A compound of chlorine with one other positive element or radical; an indicator parameter for seawater contamination of ground water.

CHRONIC VALUE. Level that may result in injury or death to an organism as a result of repeated or constant exposure over an extended period.

CLAY. A term used in the U.S. and by the International Society of Soil Science for a rock or mineral particle in the soil, having a diameter less than 0.002 millimeters (2 microns).

CLEAN WATER ACT. Basic federal legislation regulating surface water quality.

COALESCING. Uniting as a whole.

COLIFORM BACTERIA. Bacteria (*E. coli*) associated with human and warm-blooded animal waste.

COLLAPSE FEATURE. Any geologic structure resulting from the removal of support and consequent collapse by the force of gravity.

CONE OF DEPRESSION. A depression in the groundwater table or potentiometric surface that has the shape of an inverted cone and develops around a well from which water is being withdrawn. It defines the area of influence of a well.

CONFINED AQUIFER. A formation in which the groundwater is isolated from the atmosphere at the point of discharge by impermeable geologic formations; confined groundwater is generally subject to pressure greater than atmospheric. See AQUIFER.

CONFINING BED. A geologic unit with low permeability (hydraulic conductivity) which restricts movement of water into or out of the aquifer. See also aquiclude, aquitard.

CONTAMINATION. The degradation of natural water quality as a result of anthropogenic activities.

COMMERCIAL. Of or relating to the exchange or buying and selling of commodities on a large scale and involving transportation from place to place.

CONTACT LAYER. The point of contact between two types of deposits, e.g., between two types or ages of rocks, between two fluids, etc.

CONTAMINANT. Any physical, chemical, biological, or radiological substance or matter not naturally occurring in the environment or present in amounts that can, in sufficient concentration, adversely affect human health or the environment.

CONVENTIONAL INORGANIC CONTAMINANT. Statutorily listed inorganic contaminants, i.e., those substances of mineral origin, not of carbon-based structure.

CONVENTIONAL ORGANIC CONTAMINANT. Statutorily listed organic contaminants, i.e., those animal or plant-produced substances containing mainly carbon, hydrogen, and oxygen.

CROSS SECTION. A schematic representation of geologic layers as seen in a side view.

DATUM. Any numerical or geometric quantity or value that serves as a base or reference for other quantities or values; any fixed or assumed position or element (such as a point, line, or surface) in relation to which others are determined.

DEEP SEDIMENTS. Sediments extending to a depth greater than that typical of sediments in the vicinity.

DEMOGRAPHIC. Of or relating to the dynamic balance of a population, especially with regard to density and capacity for expansion or decline.

DEPTH TO WATER. The vertical distance from a specified datum to the top of a body of water.

DIAMICTON. A general term for unsorted, unstratified, and unconsolidated drift consisting of a heterogeneous mixture of clay, silt, and sand ranging widely in size and shape.

DISCHARGE. Ground water that flows out of an aquifer into an adjacent aquifer or to the surface into a spring or river.

DISCHARGE AREA. An area in which there are upward components of hydraulic head in the aquifer. In the discharge area ground water flows toward the surface, and may escape as a spring, seep, or base flow, or by evaporation and transpiration.

DISPERSION. The spreading and mixing of chemical constituents in groundwater caused by diffusion and mixing due to microscopic variations in velocities within and between pores.

DISSOLVED OXYGEN. The amount of oxygen, in parts per million by weight, dissolved in water. It is a critical factor for fish and other aquatic life, and for self-purification of a surface water body after inflow of oxygen-consuming pollutants.

DRAINAGE BASIN. The land area from which surface runoff drains into a stream channel or system of channels, or to a lake, reservoir, or other body of water.

DRAWDOWN. The distance between the static water level and the top surface of the cone of depression during pumping of a well.

DRILLER'S LOG. See WELL LOG.

DRINKING WATER STANDARDS. Federal or state water quality regulations that limit the contaminant levels of certain compounds for drinking water.

DRUMLINOID. A rock or drift deposit whose form approaches, but does not fully attain, the shape of a low, smoothly rounded, elongate oval hill, mound, or ridge of compact glacial till or other kinds of drift built under the margin of the ice and shaped by its flow. It usually has a blunt nose pointing in the direction from which the ice approached, and a gentler slope tapering in the other direction.

DYNAMIC EQUILIBRIUM. A condition of which the amount of recharge to an aquifer equals the amount of natural discharge.

EFFLUENT. Liquid waste discharged from a manufacturing or treatment process, in its natural state or partially or completely treated, that discharges into the environment.

ENVIRONMENTAL REVIEW. An assessment conducted by an organization for its own use to appraise the aggregate effect of social and physical activities that influence a community or ecosystem.

EROSION. The general process or group of processes whereby the materials of the Earth's crust are moved from one place to another by running water (including rainfall), waves and currents, glacier ice, or wind.

EVAPOTRANSPIRATION. Loss of water from a land area through transpiration of plants and evaporation from the soil.

FECAL COLIFORM. Those coliform bacteria found in the intestinal tracts of mammals. The presence of high numbers in a water body is considered the standard indicator parameter for drainfield effluent contamination and can indicate the recent release of untreated wastewater and/or the presence of animal feces. These microorganisms may also indicate the presence of pathogens that are harmful to humans.

High numbers of fecal coliform bacteria, therefore, limit beneficial uses such as swimming and shellfish harvesting.

FLOODPLAIN. The surface or strip of relatively smooth land adjacent to a river channel, constructed by the present river and covered with water when the river overflows its banks. It is built of alluvium carried by the river during floods and deposited in the sluggish water beyond the influence of the swiftest current.

FLOW LINES. On a hydraulic gradient diagram, the lines indicating the direction followed by groundwater toward points of discharge. Flow lines are perpendicular to equipotential lines.

FLOW RATE. The volume of flow per time (e.g., gallons per minute).

FLOWING ARTESIAN WELLS. Wells which tap confined aquifers which flow at ground surface without the necessity of pumping.

FUNCTIONAL PLANS. A plan designed or developed chiefly from the point of view of use.

GEOLOGY. The study of the planet Earth, the materials of which it is made, the processes that act on these materials, the products formed, and the history of the planet and it life forms since its origin, especially as recorded in rocks.

GEOLOGIC MAP. A map showing the aerial distribution of geologic units and the altitude or structure of those units.

GEOMETRIC MEAN. The n^{th} root of the product of n numbers. Used particularly for evaluation of a few values that are very high or very low relative to the other values (skewed).

GLACIAL. Of or relating to the presence and activities of ice or glaciers. Pertaining to distinctive features and materials produced by or derived from glaciers and ice sheets.

GLACIAL DRIFT. A general term for unconsolidated sediment transported by glaciers and deposited directly on land or in the sea.

GLACIOFLUVIAL. Pertaining to the meltwater streams flowing from melting glacier ice and especially to the deposits and land forms produced by such streams.

GLACIOLACUSTRINE. Deposits created in lake environments from glacial silts and clays.

GPD. gallons per day

GPDPC. gallons per day per connection

GPM. gallons per minute

GRAVEL. An unconsolidated, natural accumulation of rounded rock fragments resulting from erosion, consisting predominantly of particles larger than sand (diameter greater than 1 millimeter, or 1/2 inch), such as boulders, cobbles, pebbles, granules, or any combination of these fragments.

GROUND WATER. All water that is located below the ground surface; more specifically, subsurface water below the water table.

GROUND WATER DIVIDE. A ridge in the water table, or potentiometric surface, from which ground water moves away at right angles in both directions.

GROUND WATER MODEL. A simplified conceptual or mathematical image of a ground water system, describing the feature essential to the purpose for which the model was developed and including various assumptions pertinent to the system. Mathematical ground water models can include numerical and analytical models.

GROUND WATER TABLE. The surface between the zone of saturation and the zone of aeration; the surface of an unconfined aquifer.

HARDNESS. A property of water causing formation of an insoluble residue when the water is used with soap. It is primarily caused by calcium and magnesium ions.

HAZARDOUS SUBSTANCE. Generally, any material that poses a threat to human health and/or the environment. Typical hazardous substances are toxic, corrosive, ignitable, explosive, or chemically reactive. Also, any substance designated by the Environmental Protection Agency to be reported is a designated quantity of the substance is spilled in the waters of the United States or if otherwise emitted to the environment.

HAZARDOUS WASTE. Federally regulated man-made waste that is ignitable, corrosive, reactive, toxic, or listed as hazardous waste. Washington state law regulates additional wastes and identifies two categories: dangerous waste and extremely hazardous waste.

HOBBY FARM. A farm operated not for profit.

HYDRAULIC CONDUCTIVITY. The rate of flow of water in gallons per day through a cross section of one square foot under a unit hydraulic gradient, at the prevailing temperature or adjusted for a temperature of 60°F. Expressed in units of gallons per day per foot (gpd/ft).

HYDRAULIC CONNECTION. The condition in which two water-bearing layers or bodies may freely transmit water between them.

HYDRAULIC HEAD. The height of the free surface of a body of water above a given subsurface point.

HYDROGEOLOGY. The science that deals with subsurface waters and with related geologic aspects of surface waters. It is often used interchangeably with geohydrology.

HYDROGEOLOGIC. Those factors that deal with subsurface waters and related geologic aspects of surface water.

HYDROGRAPH. A graph showing stage, flow, velocity, or other characteristics of water with respect to time. A stream hydrograph commonly shows rate of flow; a ground water hydrograph commonly shows water level or hydraulic head.

HYDROLOGIC CYCLE. The cyclical movement of water from the oceans to atmosphere to the land and back to the oceans.

HYDROSPHERE. All waters of the Earth, as distinguished from the rocks (lithosphere), living things (biosphere), and the air (atmosphere).

HYDROSTRATIGRAPHY. The assemblage of layers of aquifers and aquitards.

IGNEOUS. A type of rock solidified from molten material.

IMPERMEABLE. An adjective used to describe rock, soils, or sediments that impede the flow of water.

INDUSTRIAL. Of or relating to engaging in systematic labor for some useful purpose or the creation of something of value, especially a manufacturing activity.

INFILTRATION. The downward movement of rain water or surface water into soil, or the penetration of water from the soil into sewer or other pipes through defective joints, connections, or manhole walls.

INFILTRATION FACILITY. A facility constructed for the purpose of intercepting ground water and providing a perennial water supply to a man-made water source.

INTERBED. A bed, typically thin, of one kind of rock material occurring between or alternating with beds of another kind.

INTERCONNECTED. Mutually joined or related, such as having internal connections between the parts or elements.

INTERGLACIAL. Pertaining to or formed during the time interval between two successive glacial stages. The term implies both the melting of ice sheets to about their present level, and the maintenance of a warm climate for a sufficient length of time to permit certain vegetational changes to occur.

INTERTIDAL. Pertaining to the ocean environment exposed between low tide and during high tide. The alternate wetting and drying of this area makes the intertidal zone a transition between land and water and creates special environmental conditions and habitats.

KING COUNTY COMPREHENSIVE PLAN. The county's long-range, county-wide, comprehensive land use plan was published in 1985 and updated on November 18, 1994. It establishes policies for ground water management throughout King County, including Vashon-Maury Island.

LAND USE. The way land is developed and used (e.g., agriculture, residences, industries, etc.). Certain types of pollution problems are often associated with particular land-use practices.

LACUSTRINE. Referring to a lake environment.

LAMINATED. The layering or thin bedding in sedimentary rocks.

LANDFILL. A general term indicating a land disposal site for refuse and/or dirt from excavations.

LEACHATE. The liquid that has percolated through solid waste and dissolved soluble components.

LEAD. A heavy metal that is hazardous to human health if breathed or swallowed. It can accumulate in organic and inorganic substances and in sufficient concentrations can cause acute illness in humans and other mammals.

LEAD AGENCY. The agency which acts or serves as the leader.

LENS. A geologic deposit bounded by converging surfaces, at least one of which is curved, thick in the middle and thinning out toward the edges, resembling a convex lens. Also a laterally disappearing stratum (layer).

MAGAZINE. A room in which powder or other explosives are kept in a military installation.

MANTLE. A general term for an outer covering of material.

MASS WASTING AREA. A general term for an area in which the dislodgement and downslope transport of soil and rock material occur under the direct application of gravitational body stresses. In contrast to other erosion processes, the debris removed by mass wasting is not carried within, on, or under another medium and includes slow displacement, such as creep, and rapid movements, such as rock slides.

MAXIMUM CONTAMINANT LEVEL. The maximum permissible level of a contaminant in water that is delivered to the users of a public water system, as required by the Safe Drinking Water Act regulations.

MEAN. Same as average; the sum of a list of values divided by the number of items on the list.

METALS. A class of elements characterized as malleable, lustrous, and good conductors of heat and electricity. Metals, often found in rocks and minerals, are naturally released to the environment by erosion as well as generated by human activities. Certain metals, such as mercury, lead, nickel, zinc, and cadmium, are of environmental concern because they are released to the environment in excessive amounts by human activity. They are generally toxic to life at certain concentrations. Since metals are elements, they do not break down in the environment over time and can be incorporated into plant and animal tissue.

METAMORPHIC. A rock that has been physically and/or chemically changed from an original texture and/or composition, usually by very high temperatures or pressures below the earth's surface.

MG/L. milligrams per liter

MGPD. million gallons per day

MGPY. million gallons per year

MILLIGRAMS PER LITER (mg/L). Milligrams per liter; a unit of concentration in water equivalent to a part per million or 0.0001 percent.

MICROORGANISMS. Microscopic organisms such as any of the bacteria, protozoans, or viruses.

MIGRATION. A broad term applied to the movement of organisms and chemical constituents from one place to another over long periods of time.

MITIGATE. To take measures to reduce the adverse impacts to the environment.

MODEL TOXICS CONTROL ACT. Law passed by the citizens of Washington state requiring cleanup of hazardous waste sites (Chapter 70.105D RCW), which became effective in March 1989. The Model Toxics Control Act is implemented through the Model Toxics Control Act Cleanup Regulation (Chapter 173-340 WAC).

MONITOR. To systematically and repeatedly measure conditions to track changes. For example, dissolved oxygen in a bay might be monitored over a period of several years to identify trends in concentration.

MONITORING WELL. A well drilled for the purpose of systematically and repeatedly collecting ground water samples for physical, chemical, or biological analysis to determine the amounts, types, and distribution of contaminants in the ground water beneath the site.

NITRATE. A compound containing nitrogen commonly associated with domestic and agricultural waste. Nitrates in water can cause severe illness in infants and cows.

NON-POINT SOURCE. A dispersed and uncontrolled source of pollutants, such as storm water runoff, that cannot be defined as a discrete point. Non-point sources (e.g., agriculture, forestry, urban, mining, construction, dams and channels, and land disposal) may contribute pathogens, suspended solids, and toxicants. While individual sources may be insignificant, the cumulative effects of nonpoint source pollution or contamination can be significant.

ORG/100 G. organisms per 100 grams

ORG/100 MG. organisms per 100 milligrams

ORG/100 ML. organisms per 100 milliliters

OUTFALL. The place where an effluent is discharged into receiving waters.

OUTWASH. Stratified sand and gravel removed or washed out from a glacier by meltwater streams and deposited in front of or beyond the end moraine or the margin of an active glacier. The coarser material is deposited nearer to the ice.

OUTWASH PLAIN. A broad, gently sloping sheet of outwash.

PARALYTIC SHELLFISH POISONING. An illness, sometimes fatal to humans and other mammals, caused by a neurotoxin produced by a type of plankton called Gonyaulax. During certain times of the year and at certain locations, these organisms proliferate in "blooms" (sometimes called red tides) and can be concentrated by clams, mussels, and other bivalves. The nervous system of shellfish is unaffected. Consumption of the shellfish can cause acute illness in humans and other mammals.

PARAMETER. Any of a set of physical properties whose values determine the characteristics or behavior of a system. For example, height, weight, sex, and hair color are all parameters that can be determined for humans. Water quality parameters include temperature, pH, salinity, dissolved oxygen concentration, and many others.

PARCEL. A tract or plot of land.

PATHOGENIC. Capable of causing disease.

PEAT. A non-compacted deposit of organic material commonly developed from bogs or swamps.

PERCHED ZONE. An area of unconfined ground water separated from an underlying main body of ground water by an unsaturated zone.

PERCOLATE. The act of water seeping or filtering through soil without a defined channel.

PERENNIAL STREAM. A stream or reach of a stream that flows continuously through the year and whose upper surface generally stands lower than the water table in the region adjoining the stream.

PERMEABILITY. The property or capacity of a porous rock, sediment, or soil for transmitting a fluid; it is a measure of the relative ease of fluid flow under unequal pressure.

PESTICIDE. A general term used to describe chemical substances used to destroy or control pest organisms. Pesticides include herbicides, insecticides, algicides, fungicides, and others. Many of these substances are manufactured and are not naturally found in the environment. Others, such as pyrethrum, are natural toxins which are extracted from plants or animals.

PETROLEUM PRODUCT. A substance produced by the distillation and removal of impurities from petroleum, a naturally occurring complex liquid hydrocarbon. The process yields a range of combustible fuels, petrochemicals, and lubricants in gaseous, solid, and liquid forms.

pH. A measure of the degree of alkalinity or acidity of a solution on a scale of 0 to 14, with a pH of 7.0 indicating neutral. A pH lower than 7.0 indicates an acidic condition and a higher pH indicates an alkaline or basic condition. The pH of water influences many of the types of chemical reactions that will occur in it. For instance, a slight decrease in pH may greatly increased the toxicity of substances such as cyanides, sulfides, and most metals. A slight increase may greatly increase the toxicity of pollutants such as ammonia. Originally stood for "potential of hydrogen".

PHENOLIC COMPOUNDS. Organic compounds that are by-products of petroleum refining, tanning, and textile, dye, and resin manufacturing. Low concentrations cause taste and odor problems in water; higher concentrations can kill aquatic life and humans.

PLAT. A diagram drawn to scale, showing boundaries and subdivisions of a tract of land as determined by survey, together with all essential data required for accurate identification and description of the various units shown and including one or more certificates indicating due approval.

PLUME. A contaminated portion of an aquifer extending from the original contaminant source.

POINT SOURCE. A stationery location or fixed source of pollutants. Also, any single identifiable source of pollution. For example, the discharge pipe of a sewage treatment plant or a factory is a point source.

POLICY MAKER. The person or agency which generates a policy.

POLLUTANT. A substance introduced into the environment that adversely alters the physical, chemical, or biological properties of the environment.

POLLUTION. The presence of a substance whose nature, location, or quantity produces undesirable environmental effects.

POLYCHLORINATED BIPHENYLS. A group of manufactured chemicals including about 70 different but closely related compounds made up of carbon, hydrogen, and chlorine. If released to the environment, they persist for long periods of time and can biomagnify in food chains because they have no natural usage in the food web. Polychlorinated biphenyls are suspected of causing cancer in humans. Polychlorinated biphenyls are an example of an organic toxicant.

POROSITY. The percentage of the bulk volume of a rock or soil that is occupied by interstices, whether isolated or connected.

POTABILITY. Ability to be used as drinking water.

POTENTIAL RECHARGE. The maximum amount of water available under natural climatic conditions for absorption and addition to the zone of saturation in the subsurface.

POTENTIOMETRIC SURFACE. The surface to which water will rise in an aquifer under hydrostatic pressure.

PARTS PER MILLION (ppm). A unit of concentration equivalent to 0.0001 percent.

PRIMARY TREATMENT. A wastewater treatment method that uses settling, skimming, and (usually) chlorination to remove solids, floating materials, and pathogens from wastewater. Primary treatment typically removes about 30 percent of biological oxygen demand and less than half of the metals and toxic organic substances.

PRIORITY POLLUTANT. A substance listed by the Environmental Protection Agency under the federal Clean Water Act as toxic and having priority for regulatory controls. The list currently includes 13 metals, 2 inorganic compounds, and 111 natural and artificial organic compounds. The list of priority pollutants includes some substances that are not of immediate concern in Puget Sound, and it does not include all known harmful compounds.

PRIVATE WELL. A well that provides drinking water for consumption by a particular person or group.

PUBLIC WELL. A well that provides drinking water for consumption by all members of a community.

PUGET SOUND WATER QUALITY AUTHORITY. The state agency charged with the development and oversight of the Puget Sound Water Quality Management Plan (Chapter 90.70 RCW).

PUBLIC WATER SYSTEM. Any water supply system intended or used for human consumption or other domestic uses, including source, treatment, storage, transmission, and distribution facilities where water is furnished to any community or group of individuals, or is made available to the public for human consumption or domestic use, but excluding all water supply systems serving one single family residence.

RECESSIONAL OUTWASH. Outwash deposited during a time interval marked by the backward displacement or general decrease in the volume of a glacier. See OUTWASH.

RECHARGE. The addition of water to the zone of saturation; also, the amount of water added.

RECHARGE AREA. Area in which water reaches the zone of saturation by surface infiltration.

RED TIDE. See Paralytic Shellfish Poisoning.

REGULATION. An authoritative rule or order having the force of law issued by an executive authority of a government.

REGULATORY AGENCY. An administrative division of federal, state, or local government which controls or directs according to established regulations. A regulatory agency usually does not have the authority to determine policy.

RESIDENTIAL. Restricted to or occupied by dwellings used for living.

RESOURCE CONSERVATION AND RECOVERY ACT. The federal law that classifies and regulates solid and hazardous waste.

REVISED CODE OF WASHINGTON (RCW). The compilation of the laws of the state of Washington published by the Statute Law Committee.

REZONE. To alter the zoning of.

RCW. Revised Code of Washington

RUNOFF. That part of precipitation flowing overland to surface streams.

SALINITY. The total quantity of dissolved salts in water, measured by weight in parts per thousand. Salinity is usually computed from some other factor, such as the amount of chloride.

SAND. A rock fragment smaller than a granule and larger than a coarse silt grain, having a diameter in the range of 1/16 to 2 millimeters.

SANDSTONE. A sedimentary rock composed of abundant rounded or angular fragments of sand set in a fine-grained matrix (silt or clay) and more or less firmly united by a cementing material.

SANDY GRAVEL. An unconsolidated sediment containing more particles of gravel size than of sand size, more than 10 percent sand, and less than 10 percent of all other finer sizes.

SCREEN. A metal or plastic slotted tube used to maintain the well opening in unconsolidated aquifer formations and to admit water being pumped from the aquifer.

SEAWATER INTRUSION. The entry of seawater into a fresh water aquifer.

SECONDARY TREATMENT. A wastewater treatment method that usually involves the addition of biological treatment to the settling, skimming, and disinfection provided by primary treatment. Secondary treatment may remove up to 90 percent of the biological oxygen demand and significantly more metals and toxic organics than primary treatment.

SEDIMENT. Material suspended in or settling to the bottom of a liquid, such as the sand and mud that make up much of the shorelines and bottom of Puget Sound.

SEDIMENTARY ROCKS. Rocks resulting from the consolidation of loose sediment that has accumulated in layers.

SEEP. A place where ground water discharges naturally onto the land surface in quantities insufficient to form a stream of flowing water. See also, SPRING.

SEQUENCE. A succession of geologic events, processes, or rocks, arranged in chronologic order to show their relative position and age with respect to geologic history as a whole.

SHALE. A fine-grained sedimentary rock, formed by the consolidation of clay, silt, or mud. It is characterized by finely laminated structure and will not fall apart on wetting.

SHELLFISH. An aquatic organism, such as a mollusk (clam or snail) or crustacean (crab or shrimp), having a shell or shell-like exoskeleton.

SILT. A rock fragment or particle smaller than a very fine sand grain and larger than coarse clay, having a diameter in the range of 1/256 to 1/16 millimeters.

SLOPE. The inclined surface of any part of the Earth's surface, as a hillslope.

SLUDGE. Semisolid residue resulting from the treatment of wastewater. Some of the contaminants (especially toxic metals) that were in the wastewater may remain in the sludge after treatment. Treated wastewater may be discharged into water, but sludge must be disposed of elsewhere. Sludge is usually at least partially dried before disposal and, if relatively uncontaminated, may be added to soil to increase plant growth.

SOLE SOURCE AQUIFER. The source of ground water providing at least 50 percent of the water for human use in any one area. Areas with a sole source aquifer have no other readily available source of ground water; any contamination to the aquifer could contaminate the entire water supply.

SPECIAL PROTECTION AREAS. Areas of beneficial uses that require a level of ground water protection beyond that offered by the normal state standards.

SPECIFIC CONDUCTANCE. Electrical conductance of a body of unit length and unit cross section at a specified temperature, expressed as micromhos per centimeter at 20°C; an indicator of the presence of charged ions in solution.

SPRING. A place where ground water discharges naturally onto the land surface in quantities sufficient to form a stream of flowing water. See also, SEEP.

STAFF GAUGE. A graduated scale or gauge on a staff, wall, pier, or other vertical surface, used in measuring water-surface height.

STATIC WATER LEVEL. That water level of a well that is not being affected by withdrawal of ground water.

STORAGE COEFFICIENT. The volume of water released from storage per unit-volume of porous medium per unit change in head.

STORM WATER. Water from rainfall and snowmelt that flows overland to surface streams.

STRATIGRAPHIC. Pertaining to the composition and position of layers of rock or sediment.

STRATIGRAPHY. The arrangement of strata, especially as to geographic position and chronologic order of sequence. It is concerned not only with the original succession and age relationships of rock strata, but also with their form, distribution, lithologic composition, fossil content, geophysical and geochemical properties, and interpretation in terms of environment or mode of origin and geologic history.

STREAM BASE FLOW. See Base Flow.

STREAM DISCHARGE RATING CURVE. A graphic illustration of the relationship between gauge height and volume of flowing water, expressed as volume per unit of time.

STREAM FLOW. A type of channel flow, applied to that part of surface runoff traveling in a stream whether or not it is affected by diversion or regulation.

STREAM STAGE DATA. Stream height, as measured above an arbitrary datum.

SUPERFUND. The federal program operated that funds and carries out the Environmental Protection Agency solid waste emergency and long-term removal remedial activities. These activities include establishing the National Priority List, investigating sites for inclusion on the list, determining their priority level on the list, and conducting and/or supervising the ultimately determined cleanup and other remedial actions. Superfund is operated under the legislative authority of Comprehensive Environmental Response, Compensation, and Liability Act and Superfund Amendments and Reauthorization Act of 1986.

SURFACE DRAINAGE BASIN. A depressed area with no surface outlet which provides for the removal of unwanted water from the surface of the ground.

SURFACE WATER. All waters on the surface of the Earth, including fresh and salt water, ice and snow.

SURFICIAL. Pertaining to or occurring on a surface, especially the surface of the Earth.

TERTIARY. A period of earth's history estimated to have occurred between 65 and 2 million years ago.

TILL. Predominantly unsorted and unstratified drift, generally unconsolidated, deposited directly by and underneath a glacier without subsequent reworking by meltwater, and consisting of a heterogeneous mixture of clay, silt, sand, gravel, and boulders ranging widely in size and shape.

TOPOGRAPHY. The general configuration of a land surface or any part of the Earth's surface, including its relief and the position of its natural and man-made features.

TOPOGRAPHIC. Pertaining to the general configuration of a land surface.

TOTAL COLIFORMS. See COLIFORM BACTERIA.

TOTAL DISSOLVED SOLIDS. A term that expresses the quantity of dissolved organic and inorganic material in a sample of water. Excessive amounts make water unfit to drink or use in industrial processes.

TOTAL SUSPENDED SOLIDS. Particles, both mineral (clay and sand) and organic (algae and small pieces of decomposed plant and animal material), that are suspended in water.

TOXIC. Poisonous, carcinogenic, or otherwise directly harmful to living organisms.

TOXIC WASTE. Any unwanted material left over from a manufacturing process or refuse from places of human or animal habitation that are harmful to living organisms.

TRANSMISSIVITY. The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. Transmissivity values are given in gallons per minutes through a vertical section of an aquifer one foot wide and extending the full saturated height of an aquifer under a hydraulic gradient of 1 in the English Engineering system; in the International System, transmissivity is given in cubic meters per day through a vertical section of an aquifer one meter wide and extending the full saturated height of an aquifer under a hydraulic gradient of 1.

TRANSPIRATION. The process by which water absorbed by plants, usually through the roots, is evaporated into the atmosphere from the plant surface.

TURBULENT FLOW. Water flow in which the flow lines are confused and heterogeneously mixed. It is typical of flow in surface water bodies.

µg/g. micrograms per gram

UNCONFINED AQUIFER. An aquifer where the water table is exposed to the atmosphere through openings in the overlying materials.

UNSATURATED ZONE. The subsurface zone containing both water and air. The lower part of the unsaturated zone (capillary fringe) does not actually contain air, but is saturated with water held by suction at less than atmospheric pressure.

U.S. ENVIRONMENTAL PROTECTION AGENCY. The federal agency which administers many federal environmental laws. Environmental Protection Agency Region 10, which includes Vashon-Maury Island, is headquartered in Seattle.

V-NOTCH WEIR. A device placed across a stream and used to measure the discharge. The v-notch weir structure used by King County in this study is 2 feet high by 8 feet long. The v-notch located in the center of the weir has a vertical depth of 12 inches to the center of the v on the weir crest plate. A small access door is mounted on one side of the v-notch for the removal of sediment and small debris. After the weir was placed across the stream bed, sandbags were placed along the front edges and sides of the weir to offset erosion and structural stability problems. A staff gauge was mounted on the upstream side of the weir near the stream bank. The zero graduation mark was aligned with the lowest point of the v-notch crest plate.

VADOSE ZONE. The zone containing water under pressure less than that of the atmosphere, including soil water, intermediate vadose water, and capillary water. This zone is limited above by the land surface and below by the surface of the zone of saturation, that is, the water table.

VASHON COMMUNITY PLAN AND AREA ZONING. The document containing detailed land use, capital improvement, and zoning plans published in 1986. The plan designates all of Vashon-Maury Island as a water service area and establishes protection of the aquifer as being of primary importance to the Island.

VASHON STADE. A substage of the Fraser glaciation glacial stage.

VINYL CHLORIDE. A chemical compound, used in producing some plastics, that is believed to be carcinogenic.

VISCOSITY. The property of a substance to offer internal resistance to flow. Specifically, the ratio of the shear stress to the rate of shear strain.

VOLATILE ORGANIC COMPOUND. Any organic compound which participates in atmospheric photochemical reactions except for those organic compounds designated by the Environmental Protection Agency Administrator as having negligible photochemical reactivity.

WASHINGTON ADMINISTRATIVE CODE (WAC). The compilation of all state regulations adopted by state agencies through the rule-making process. For example, Chapter 173-201 WAC contains water quality standards.

WASHINGTON DEPARTMENT OF ECOLOGY (ECOLOGY). The state agency charged with developing, implementing, and enforcing many environmental protection laws and policies, including the state Water Pollution Control Act and the Model Toxics Control Act. Ecology is the preferred term for referring to the Department of Ecology, as the abbreviation DOE might be confused with the federal Department of Energy.

Ecology's authority to develop water quality standards is granted by the Water Pollution Control Act.

WATER ELEVATION. The vertical distance from a datum to the water surface in relation to mean sea level.

WATER FLOW. The movement of water and the moving water itself; also, the rate of movement.

WATER LEVEL. The vertical distance from a datum to the water table.

WATER PURVEYOR. A person or group that supplies water as a matter of business.

GROUP A. A community (residential) or noncommunity (school/business/industry) water system with 15 or more connections or serving an average of 25 people. Group A public water supply systems are regulated by the Washington State Department of Health.

GROUP B. A public water system which is not a Group A water system. Group B public water supply systems are regulated by the SKCHD and presently consist of two to nine connections.

WATER QUALITY STANDARDS FOR GROUND WATERS OF THE STATE OF WASHINGTON. Regulation adopted by the State of Washington in October 1990 (Chapter 173-200 WAC) that establishes statewide ground water quality goals, defines criteria to measure water quality, and complies with the Water Pollution Control Act of Washington (Chapter 90.48 RCW).

WATERSHED. The geographic region within which water drains into a particular river, stream, or other body of water. A watershed includes hills, lowlands, and the body of water into which the land drains.

WATER TABLE. The surface between the vadose zone and the groundwater; the surface of a body of unconfined ground water where the pressure is equal to that of the atmosphere.

WEATHERING. The destructive process(es) by which the atmosphere and surface water chemically change the character of a rock.

WELLHEAD. The immediate area around the top of a well. Contamination of the aquifer may occur from surface water if the wellhead is not sealed to prevent flow down the well casing.

WELL LOG. A record of the geologic and aquifer conditions encountered by a driller during drilling of a water supply well. The State of Washington requires that a log be completed for each well.

WELL POINT. A screening device, equipped with a point on one end that is meant to be driven into the ground.

WETLANDS. An area that is regularly saturated by surface or ground water. Wetlands include tidal flats, shallow subtidal areas, swamps, marshes, wet meadows, bogs, and similar areas. Wetlands as defined by the Shoreline Management Act include all land within 200 feet of the ordinary high water mark, floodways, and floodplain areas.

ZONE OF CONTRIBUTION. The area surrounding a pumping well that encompasses all areas or features that supply ground water recharge to the well.

ZONE OF INFLUENCE. The area surrounding a pumping well within which the water table or potentiometric surfaces have been changed due to ground water withdrawal.

ZONING. To designate by ordinance areas of land reserved and regulated for different land uses

SOURCES

- Glossary of Environmental Terms and Acronym List, U.S. Environmental Protection Agency, August 1988.
- Groundwater Wells, Driscoll, F. Johnson Division, 1986.
- Groundwater Resource Protection, King County Planning Division/State of Washington/ Department of Ecology.
- Redmond-Bear Creek Ground Water Management Program Draft Hydrogeologic Characterization Report by EMCON Northwest, Inc., November 1992.
- Northern Thurston County Ground Water Management Plan, February, 1992.

Table 4.1 Summary of Precipitation and Temperature at the Vashon Island, Washington Weather Station, 1931 to 1954

Month	Temperature (F)								Precipitation Totals (Inches)								Mean number of days					Month
	Means			Extremes								Snow, Sleet						Maximum		Minimum		
	Daily max. -1	Daily min. -2	Mthly -3	Record highest	Year	Record lowest	Year	Mean degree days**	Mean	Daily max. -1	Year	Mean	Max. mthly -4	Year	Daily max. -1	Year	Precip. .10 inch or more	Above 90 degrees	Below 32 degrees	Below 32 degrees	Below 0 degrees	Month
(a)	24	24	24	24		24		24	24	24		24	24		24		24	24	24	24	24	
JAN	43.5	33.3	38.4	66	1935	8	1943	825	6.74	3.24	1935	4.6	19.5	1935	14	1943	12	0	2	12	0	JAN
FEB	47.6	35	41.3	68	1941+	11	1950+	665	5.58	3.9	1951	1.3	8	1936	4	1949+	11	0	1	9	0	FEB
MAR	52.5	36.6	44.6	74	1934	25	1936	630	4.56	2.63	1950	0.8	11.3	1951	5.3	1951	11	0	0	6	0	MAR
APR	59.5	40.3	49.9	82	1940+	25	1935	455	2.75	1.85	1937	T	T	1954+	T	1954+	7	0	0	2	0	APR
MAY	65.5	44.2	54.9	88	1953	29	1954	315	1.94	1.33	1941						6	0	0	*	0	MAY
JUN	70.5	48.3	59.4	95	1942	36	1944	170	1.69	1.2	1931						5	*	0	0	0	JUN
JUL	75.2	50.7	63	96	1942	40	1939	80	0.82	1.09	1934						3	*	0	0	0	JUL
AUG	74.1	51.7	62.9	95	1952+	42	1935	80	0.95	1.06	1936						3	*	0	0	0	AUG
SEP	68.4	49.3	58.9	91	1944	35	1934+	185	2.21	2.02	1953						5	*	0	0	0	SEP
OCT	59.3	44.7	52	81	1934	21	1935	405	4.52	2.14	1934						9	0	*	*	0	OCT
NOV	50.7	39.6	45.2	70	1949	19	1935	595	6.61	2.16	1942	0.4	7.5	1946	6	1946	12	0	0	4	0	NOV
DEC	46	36.5	41.3	64	1939	13	1941	735	8.16	3.22	1937	0.3	7.7	1948	3	1948	14	0	*	8	0	DEC
Year	59.4	42.5	51	96	JUL 1942	8	JAN 1943	5140	46.53	3.9	FEB 1951	7.9	19.5	JAN 1935	14	JAN 1943	98	*	3	41	0	Year

(a)	Average length of records, years	-1	Daily maximum
+	Also on earlier dates, months, or years	-2	Daily minimum
T	Trace, an amount too small to measure	-3	Monthly
*	Less than one half	-4	Maximum monthly
**	Base 65 degrees F	(F)	Degrees Fahrenheit

Source: J.R. Carr/Associates 1983 from the U.S. Department of Commerce, Weather Bureau in Cooperation with the Washington State Department of Commerce and Economic Development, Climatography of the United States 20-45.

Table 5.1. Population and Housing Estimates, 1970-1990

Demographic	1970	1980	1990	Percent Change 1970-1980	Percent Change 1980-1990
Total Population	6,516	7,377	9,309	13%	26%
Average Household Size	3.05	2.53	2.5	-17%	-1%
Total Households	2,123	2,894	3,703	36%	28%
Single-Family Households	2,027	2,594	3,488	28%	34%
Multi-Family Households	53	300	215	466%	-28%

Source: Puget Sound Council of Governments 1988, Puget Sound Regional Council 1993

Table 5.2. Population and Housing Estimates, 1980-1992

Demographic	1980	1990	1992	Percent Change 1980-90	Percent Change 1990-92
Population					
Unincorporated Area	7,400	9,300	9,900	25.7%	6.5%
Population per square mile	200	250	266	25.0%	6.4%
Households					
Total	2,890	3,800	4,100	31.5%	7.9%
Household Size	2.53	2.43	2.41	-4.0%	-0.8%
Housing Units					
Total	3,110	4,500	4,800	44.7%	6.7%
Single-Family Households	2,650	4,000	4,300	51%	7.5%
Mobile Homes	150	200	200	33.3%	0.0%
Multi-Family Households	300	300	300	0.0%	0.0%

Source: King County Annual Growth Databook 1993

Table 5.3. Population Estimates and Forecasts for Vashon-Maury Island Ground Water Management Area, 1980 - 2020

	1980	1990	2000	2010	2020
TOTAL POPULATION	7,377	9,309	11,095	12,148	13,458
Average Household Size	2.53	2.52	2.39	2.25	2.16
TOTAL HOUSEHOLDS	2,894	3,703	4,641	5,393	6,228
Single Family Households	2,593	3,488	4,407	5,115	5,846
Multi-Family Households	301	215	234	278	382
Lower-Income Households	675	773	896	978	1,073
Lower-Mid. Income Households	691	830	1,008	1,138	1,258
Upper-Mid. Income Households	790	1,044	1,308	1,494	1,698
Upper-Income Households	738	1,056	1,429	1,784	2,200
TOTAL EMPLOYMENT	1,322	1,656	2,022	2,409	2,699
Manufacturing	316	334	372	440	447
Whol/Tran/Comm/Util	191	286	365	415	443
Retail Trade	325	393	468	357	609
Services	222	374	540	709	853
Govt./Education	268	269	277	308	347
TOTAL LAND (AREA)	23,418	23,659	23,659	23,659	23,659
Residential	933	1,194	1,489	1,720	1,968
Employment	303	439	527	612	691
Vacant Developable	15,428	14,854	14,396	14,022	13,634
Balance	6,754	7,172	7,247	7,305	7,366

Source: Puget Sound Regional Council, April 1992.

Note: 1980 total land (acres) based on 1980 census. The 1990 total land acres based on the 1990 census.

Table 5-3. Population Estimates and Forecasts for Vashon-Maury Island Ground Water Management Area, 1980 - 2020 (continued)

FAZ: Forecast and Analysis Zone -- the basic geographic unit for the data forecasts, composed of Vashon and Maury Islands.

Total Population: the total number of persons residing within the FAZ.

Total Households: the total number of occupied housing units within the FAZ, and the sum of the four household income groups.

Single-Family Households: the number of households occupying 1-unit detached or 1-unit attached units, or a mobile home/trailer, as defined by the 1980 U.S. Census.

Multi-Family Households: the number of households in structures containing 2 or more units, as defined by the 1980 U.S. Census.

Lower-Income Households: the number of households in the FAZ with incomes in the lowest income quartile of all households in the region (the income levels that contain the lowest 25 percent of the region's households).

Lower-Middle Income Households: the number of households in the FAZ with incomes in the second income quartile of all households in the region.

Upper-Middle Income Households: the number of households in the FAZ with incomes in the third income quartile of all households in the region.

Upper-Income Households: the number of households in the FAZ with incomes in the highest income quartile of all households in the region.

Total Employment: the total number of jobs located in the FAZ, including part-time, self-employed, proprietors, and military, as well as wage and salary workers, in all industry sectors except resources (agriculture, forestry, fishing, and mining) and construction. (The latter sectors are estimated for the county totals).

Manufacturing: the number of jobs in SIC 19-39 plus the Puget Sound Naval Shipyard (PSNS) in Kitsap County.

Whol/Tran/Comm/Util: the number of jobs in wholesale trade, transportation services, communication, and utilities; SIC 40-42, 44-51.

Government/Education: the number of jobs in SIC 43, 82, 92-97 and government enterprises classified elsewhere (except PSNS).

Total Land: the total land area in acres in the FAZ.

Residential Land: the total acreage in residential land uses in the FAZ -- net residential land, not including streets, parks, etc.

Employment Land: the total acreage in land uses associated with the jobs estimated or forecasted for the FAZ -- net employment land, not including streets, etc.

Vacant Developable Land: the total acreage of land in the FAZ which is physically developable according to standards and policies currently applicable by local governments.

Balance: the remainder of land area in the FAZ that is not contained in the residential, employment, or vacant-developable land categories, particularly, physically unbuildable land, streets, parks, and similar land uses.

Table 5.4a. Population Estimates and Forecasts, 1970-2010

Demographic	Incorporated	Unincorporated	Total
1970	0	6,500	6,500
1980	0	7,400	7,400
1990	0	9,300	9,300
2000	0	11,100	11,100
2010	0	11,500	11,500

Source: King County Annual Growth Databook 1992/1993.

Table 5.4b. Growth Estimates of Communities in King County

Community Planning Area	1980 Pop.	1990 Pop.	1992 Pop.	2000 Pop. Forecast	2010 Pop. Forecast	Percent Diff. 1980-1992
Bear Creek	12,250		22,600	33,100	37,600	84.5
East King County	400		800	900	900	100.0
East Sammamish	12,100		35,200	46,300	52,200	190.9
Eastside *	144,750	163,800	NA	186,800	193,200	13.2
Enumclaw	10,600		13,000	14,800	15,000	22.6
Federal Way *	68,600	98,600	NA	125,900	145,300	43.7
Green River *	54,200	70,600	NA	84,200	95,100	30.3
Highline *	124,100	133,800	NA	143,400	152,200	7.8
Newcastle *	65,050	80,000	NA	93,800	98,400	23.0
Northshore	58,550		71,200	73,900	182,000	21.6
Shoreline	58,500		62,000	64,700	67,800	6.0
Snoqualmie	15,150		22,900	30,200	31,400	51.2
Soos Creek	71,050		101,400	119,400	134,700	42.7
Tahoma/Raven Heights	24,400		38,800	45,100	47,100	59.0
Unincorporated King County	503,250		540,800	589,600	640,400	7.5
Vashon	7,400		9,900	11,100	11,500	33.8
Community Average	76,897	34,175	57,413	103,950	119,050	46.1

Source: King County Annual Growth Databook, 1993.

Note: All population figures are for unincorporated areas within the community planning area unless noted. 1992 population estimates only given for unincorporated areas.

* Communities where more population was located in incorporated areas have incorporated populations listed, but, 1990 population figures are provided instead of 1992 figures. Similarly, percent growth of the community was compared between 1980 and 1990 estimates, instead of between 1980 and 1992

Table 5.5. Residential Permits and Units, 1980-1992

Year	Single-Family Permits	Single-Family Units	Multi-Family Permits	Multi-Family Units	Total Permits	Total Units
1980	76	76	0	0	76	76
1981	79	79	0	0	79	79
1982	48	48	0	0	48	48
1983	56	56	1	11	57	67
1984	41	41	0	0	41	41
1985	41	41	0	0	41	41
1986	47	47	1	18	48	65
1987	78	78	0	0	78	78
1988	84	84	0	0	84	84
1989	90	90	0	0	90	90
1990	159	159	2	12	161	171
1991	125	127	0	0	125	127
1992	91	91	2	36	93	127

Source: King County Annual Growth Databook 1993

Table 5.6. Selected New Industrial and Commercial Permits, 1980-1990

Year	Industrial Permits	Value ($)	Office, Bank, Professional Permits	Value ($)	Store and Restaurant Permits	Value ($)	Total Permits	Total Value ($)
1980	0	$0	1	$10,000	1	$160,000	2	$170,000
1981	2	$49,100	1	$95,500	1	$90,000	4	$234,600
1982	0	$0	1	$20,000	0	$0	1	$200,000
1983	1	$50,000	0	$0	0	$0	1	$50,000
1984	0	$0	0	$0	1	$200,000	1	$200,000
1985	0	$0	1	$155,800	0	$0	1	$155,800
1986	2	$174,000	0	$0	0	$0	2	$174,000
1987	1	$413,200	1	$963,600	1	$67,200	3	$1,444,000
1988	0	$0	0	$0	0	$0	0	$0
1989	0	$0	0	$0	0	$0	0	$0
1990	0	$0	0	$0	1	$46,300	1	$46,300

Source: King County Annual Growth Report 1991.

Table 5.7. Solid Waste Generation, 1984-1991

Year	Population	Solid Waste Generation Rate (tons/person)	Solid Waste Generation Rate (tons/year)	Annual Landfill Volume Required (cy/year)
1984	7434	0.651	4840	16132
1985	7876	0.6937	5463	18211
1986	7976	0.7363	5873	19576
1991	9800	0.6956	6817	22723

(1) In-place density equals 600 pounds per cublic yard, 1 ton = 2000 lb

cy: Cubic yards

Source: Harper-Owes 1988.
SKCHD, 1993.
1992 Annual Growth Databook
Annual Report 1991 - King County Solid Waste Division

Table 5.8a. Summary of Results of Analyses Performed on Sludge Collected from the Vashon Sewer District on November 18, 1987

Tests Performed	Results	Units
Total Solids	1.6%	
Fecal Strep	>160,000	MPN per 100 mls
Fecal Coliform Count	>160,000	MPN per 100 mls
Total Coliform Count	>160,000	MPN per 100 mls
Total Kjeldahl Nitrogen as N	940.	ppm (mg/L)
Soluble Nitrate as N	0.3	ppm (mg/L)
Total Ammonia as N	3.0	ppm (mg/L)
Total Phosphate as P	240.	ppm (mg/L)
Sulfate	3.	ppm (mg/L)
Potassium	70.	ppm (mg/L)
Magnesium	64.	ppm (mg/L)
Iron (total)	100.	ppm (mg/L)
Manganese	7.	ppm (mg/L)
Barium	<0.8	ppm (mg/L)
Mercury	0.085	ppm (mg/L)
Selenium	< 0.02	ppm (mg/L)
Silver	7.	ppm (mg/L)
Hexavalent Chromium	< 0.05	ppm (mg/L)

MPN	Most probable number
mls	Milliliters
ppm	Parts per million
mg/L	Milligrams per liter
<	Less than
>	Greater than

Laboratory analysis performed by Laucks Testing Laboratories, Inc.

Table 5.8b. Summary of Results of Analyses Performed on Biosolids (sludge) Collected fromthe Vashon Sewer District on September 22, 1987

Tests Performed	Results	Units
Total Solids	1.3	%
Total Arsenic	2.7	ppm (mg/L)
Total Lead	54.0	ppm (mg/L)
Total Zinc	530.0	ppm (mg/L)
Total Nickel	17.0	ppm (mg/L)
Total Cadmium	3.3	ppm (mg/L)
Total Copper	88.0	ppm (mg/L)
Total Kjeldahl Nitrogen as N	49,000.0	ppm (mg/L)

ppm Parts per million
mg/L Milligrams per liter

Laboratory analyses were performed by Laucks Testing Laboratories, Inc.

Note: Currently biosolids (sludge) are disposed of off-Island.

Table 5.9. Underground Storage Tanks Reported to Ecology as of October 8, 1993

Site Name	Site Address	Site Number	Tank Code	Age (Years)	Gallons (x 1000)	Substance Stored
Alascom, Inc.	Vashon Earth Station	7283	1	10	1-5	Diesel fuel
Burton Shell	23919 Vashon Highway SW	11593	1	8	5-10	Removed 9/91
			2	8	5-10	Removed 9/91
			3	8	5-10	Removed 9/91
			4	20	NA	Removed 9/91
			5	20	NA	Removed 9/91
			6	29	0.5-1.0	Removed 9/91
			7	29	0.5-1.0	Removed 9/91
Camp Sealth	14414 SW Camp Sealth Rd.	101526	1	19	0.5-1	Unleaded gas
Engels Repair and Towing	22725 Dockton Rd SW	100811	1	15	NA	Leaded gas
			2	3	0.5-1.0	Unleaded gas
			3	27	0.5-1.0	Diesel fuel
GE American (Sea Stn)	8700 SW 159th Street	336	1	8	1-2	Diesel fuel
Island Automotive and Equipment	17803 Vashon Highway SW	11720	1	8	0.5-1	Diesel fuel
			2	15	0.5-1	Kerosene
			3	15	2-5	Leaded gas
			4	20	2-5	Leaded gas
			5	20	2-5	Unleaded gas
Kimm Co., Inc.	99 St SW & 178 St	11350	1	15	0.5-1.0	Leaded gas
			2	15	0.5-1.0	Diesel fuel
KING Radio Transmitter Facility	Lat 47 deg, 23' 40" Long 122 deg, 25' 31" Maury Island	99001	1	10	NA	Diesel fuel
			2	29	0.5-1.0	Removed 10/91
			3	11	0.5-1.0	Removed 10/91
KIRO-AM Transmitter	Route 3, Box 155	12509	3	29	1-5	1,2,4 Oil
K2 Corporation	19215 99th Ave SW	97630	1	18	>20	Permanently out of service
			2	18	>20	
			3	23	0.5-1	
Laidlaw Transit	9200 SW 204th	7191	1	32	1-5	Removed 11/91

Table 5.9. Underground Storage Tanks Reported to Ecology as of October 8, 1993 (continued)

Site Name	Site Address	Site Number	Tank Code	Age (Years)	Gallons (x 1000)	Substance Stored
Mom's Deli & Grocery	19124 Vashon Highway SW	101970	1	29	5-10	Diesel fuel
			2	29	10-20	Alcohol BL
			3	29	5-10	Alcohol BL
			4	29	10-20	Alcohol BL
			5	29	5-10	Alcohol BL
Quartermaster Harbor	23824 Vashon Highway SW	101791	1	29	0.5-1.0	Permanently
			2	29	0.5-1.0	out of
			3	29	0.5-1.0	service
Vashon	10015 SW 196th Street	6885	7431	25	1-5	Removed
Vashon High School	20120 Vashon Highway SW	100624	1	10	1-2	Diesel fuel
Vashon Island Facility	8700 SW 159th	7402	1	11	10-20	Removed 1/92
			2	33	0.5-1.0	Removed 6/90
			3	33	0.5-1.0	Removed 6/90
			4	1	5-10	Diesel fuel
Vashon Island Landfill	18850 130th Avenue SW	101126	1	6	1-2	Diesel fuel
Vashon Sand & Gravel	1/2 mile East of 75th Ave SW	4966	1	25	NA	Removed 11/89
			2	25	NA	Removed 11/89
Williams Heating,	99th Ave SW & SW 196th	11602	1	17	5-10	Kerosene
			2	17	5-10	Diesel fuel
			3	17	5-10	Diesel fuel
			4	17	5-10	Diesel fuel
			5	7	0.5-1	Unleaded gas
Williams Heating, Inc.	103rd SW 225th	11594	1	25	10-20	Removed NA
			3	25	10-20	Removed NA
			2	25	10-20	Removed NA

Source: Washington State Department of Ecology

NA = Not Applicable

Table 6.1. Projected Water Demand for the Vashon-Maury Island Ground Water Management Area (Puget Sound Regional Council)

	1980	1990	2000	2020
Population	7,377	9,309	11,095	12,148
Projected Demand (Mgpd)	0.885	1.117	1.331	1.458
Annual Demand (Mg)	323	408	486	532

Mgpd Million gallons per day
Mg Millions of gallons

Based on Puget Sound Regional Council 1992 Forecasts and Water Demand of 120 Gallons per Day per Person

---

Table 6.2. Projected Water Demand for the Vashon-Maury Island Ground Water Management Area (Annual Growth Databook)

	1980	1990	2000	2010*
Population	7,400	9,300	11,100	11,500
Projected Demand (Mgpd)	0.888	1.116	1.332	1.380
Annual Demand (Mg)	324	407	486	504

Mgpd Million gallons per day
Mg Millions of gallons

* Source 1993 King County Annual Growth Databook

Based on 1991 Annual Growth Datatbook Population Forecasts and Water Demand of 120 Gallons per Day per Person.

Table 6.3a. Water Rights of and Water Use by Major Water Purveyors in the Vashon Ground Water Management Area

Purveyor	Instantaneous Withdrawal rate (QI) (1) (2)	Annual Permitted Withdrawal Quantity (QA) (Acre-Feet) (2)	Annual Permitted Withdrawal Quantity (QA) (Gallons) (3)
Burton Water Company	200 G (4)	NA	NA
Dockton Water Association	0.16 C	25	8151175
Gold Beach Water System	NA	NA	NA
Heights Water Association	60.0 G, 85.0 G, 0.1 C, 0.15 C, 0.5 C	96, 95	31300512 30974465
Maury Mutual Water Company	0.334 C	100	32604700
Water District #19	250.0 G, 0.9 C	300	97814100
Westside Water Association	2.0 C, 0.5 C	1120	365172640

Source: Geraghty & Miller 1991.

C Cubic feet per second
G Gallons per minute
NA Not available
QI Instantaneous withdrawal
QA Annual withdrawal

1 Multiple sources are listed separately
2 Source: Ecology Listing of Recorded Water Rights, September 5, 1989
3 One acre-foot equals 326,047 gallons
4 Source: Bill Lasby with SKCHD, 1991.

Table 6.3a Consumption Ranges for Group A Purveyors

Name of Water System	Number of Connections	Peak Demand gpm (est)	Peak Demand gpd	Peak Demand cf mo	Peak Demand cfs (est)	Demand Time Period	Average Demand gpm (est)	Average Demand gpd	Average Demand cf mo	Average Demand cfs (est)	Pumpage Volume/Consumption in gpy (to) and AFY (bottom) 1989	1990	1991	1992	Average gpd/ connection	Maximum gpd/ connection
Burton Water Company	375	76.4	110,000	441,147	0.17	NP	42.3	60,959	244,472	0.09	NP	NP	23,000,000 71	July 91-July 92	163	293
Dockton Water Association	294	54.6	78,664	315,476	0.12	1992	34.3	49,400	198,115	0.08	23,363,200 72	24,521,900 75	24,999,300 77	25,986,000 80	168	268
Gold Beach Water System	147	NP	NP	NP	NP	1992	3.8	5,514	22,113	0.01	NP	NP	NP	2,012,536 6	38	NP
Heights Water Association	585	160.6 178.6 171.2 169.1	231,285 257,155 246,471 243,457	927,552 1,031,301 988,454 976,367	0.36 0.40 0.38 0.38	1989 1990 1991 1992	64.2 71.4 68.5 67.7	92,514 102,857 98,582 97,440	371,021 412,500 395,356 390,776	0.14 0.16 0.15 0.15	52,373,389 161	53,829,303 165	52,615,391 161	52,110,050 160	158	395
Maury Mutual Water Company	88	55.0 NP	79,200 NP	317,626 NP	0.12 NP	summer winter (2)	20.0 14.0	28,800 20,160	115,500 80,850	0.04 0.03	7,389,567 23	7,162,892 22	7,233,471 22	6,801,263 21	327	900
Water District #19 (5)	1,075	420.0	604,741 See attached	2,425,270	0.94	1989 to 1992	290.6	418,506 See attached	1,678,388	0.65	149,017,500 457	149,137,500 457	159,150,20 488	153,713,400 471	389	563
Westside Water Association	219	69.4	100,000	401,043	0.15	NP	41.7	60,000	240,626	0.09	NP	NP	NP	NP	274	457

A 30-day month was used in cf mo calculation.
1 cubic foot = 7.4805 gallons
1 acre-foot = 326,047 gallons

AFY Acre-feet per year
cfs Cubic feet per second
cf mo Cubic feet per month
est Estimated
gpd Gallons per day
gpm Gallons per minute
gpy Gallons per year
NP Not provided

(1) Values provided by purveyors in 1993
(2) Over 24 hours
(3) Lowest demand provided for Heights Water Association
(4) Average demand value provided by G. Garrison in 1/94
(5) Peak demand calculated by percentage increase in product figures for Plant 1

Table 6.3b. Consumption Ranges for Group A Purveyors Peak and Average Water Consumption (Gallons per Month)

Water District #19 Peak and Average Water Consumption (Gallons per Month)

Month	1989	1990	1991	1992
January	520,300 - 343,500	391,500 - 293,493	517,100 - 284,900	654,200 - 335,100
February	704,300 - 411,900	452,100 - 309,300	587,200 - 346,900	526,200 - 302,200
March	555,400 - 363,200	473,200 - 340,600	422,500 - 372,500	625,300 - 364,700
April	530,900 - 323,400	536,600 - 370,700	450,300 - 374,800	472,100 - 341,600
May	572,700 - 440,400	532,200 - 361,612	527,900 - 407,900	631,100 - 472,100
June	722,100 - 535,200	550,800 - 428,000	646,600 - 481,300	838,900 - 596,300
July	745,600 - 552,890	737,400 - 601,900	870,200 - 686,400	791,000 - 554,800
August	710,800 - 509,000	746,600 - 582,713	879,200 - 620,700	902,900 - 638,800
September	722,300 - 473,700	577,300 - 470,200	741,000 - 508,000	718,800 - 461,560
October	465,700 - 334,100	575,300 - 403,300	694,000 - 406,700	560,600 - 356,289
November	480,900 - 316,200	559,200 - 301,900	359,700 - 315,600	409,600 - 319,516
December	483,200 - 296,600	753,500 - 389,609	475,700 - 318,700	411,000 - 305,500

Total Water Consumption (Production)
(Gallons)

Year	Well	Plant 2 (Ellis Creek)	Total including Plant 1
1989	41189800	59688600	149017500
1990	44390300	71541000	149137500
1991	71809500	43044900	159150200
1992	66129500	41036400	153713400

Source: Water District 19 (1993)

Table 6.3c. Existing Small Water Systems (Group B)

Water Systems	Section-Township-Range (W.M.)	Connections/Notes
Alderosa Water System	NE1/4, NE1/4 11-22-02	2 Connections, Well Source, Wants to Expand
Armstrong-Scott Water System	16-22-3	Approved for 4 Connections, Not in Service Yet, Wants to Expand
Arrakis Water System	02-21-2	3 Connecttions, Well source
Atlas Water Corporation	04-22-03	3 Connections, Spring Source
Bachelor Water System	01-21-02	11 Connections, Spring Collection
Beulah Park Water System	26-23-02	18 Connections
Billings	18-23-03	4 Connections, Spring Source
Biloxi Community System	07-23-03	Group B, Spring Source
Both Water System	24-22-02	2 Connections
Bouich Water System	17-23-03	Well Site Only
Burton Baptist Assembly	20-22-03	22 Connections, Well Source
Calvary Full Gospel Church	SE1/4, SW1/4 12-22-02	2 Connections, Well Source
Camp Sealth	26-22-02	Group A
Clam Cove Water System	NE1/4, SW1/4 02-21-02	Approved for 9 Connections
Cooper-Ibsen Duntley Water System	35-22-02	Group B
Cove Beach Water System	26-23-02	22 Connections, Spring Source
Crecelius Water System	NE1/4, SE1/4 26-23-02	3 Connections
R.L. Davis Water System	31-23-03	3 Connections
Davis, Randy Water System	25-22-02	3 Connections
Deignan, M.	NW1/4, SE1/4 23-22-02	Group B
Dump Road Water System	36-23-02	2 Connections, Well Source
Edge City	35-23-02	3 Connections, Spring Source
Eighty-five Acres	01-22-02	12 Connections
Forest View Water System	SW1/4, NE1/4 32-23-03	4 Connections
Forever Yours Water System	SW1/4 11-22-02	2 Connections
Glen Acres Community System	20-23-3	8 Connections
Goetz Water System	SW1/4 35-22-02	?
Goforth Water System	29-23-03	6 Connections, Spring Source
Grady Water System	7-23-03	4 Connections, Spring Source
Green Water System	26-23-02	Group B, Spring Source
Hamilton Water System	20-22-03	Group B, 5 Connections
Hansen, A.	23-22-02	Group B
Harbor Heights Community System	25-22-02	Group B
Hartmann Water System	25-23-02	4 Connections, Spring Sourcee
Henrickson Water System	SE1/4 35-23-02	Group B
Heubner Water System		Approved for 2 Connections

Table 6.3c. Existing Small Water Systems (Group B) (continued)

Water Systems	Section-Township-Range (W.M.)	Connections/Notes
Highbank Water System	NE1/4, NW1/4 36-23-02	Group B
Hillcrest Water System	31-22-03	7 Connections, Well Source
Hillside Water System	20-23-03	Group B
Hollymere Water System	21-22-3	6 Connections, Well Source
Holmes, E.W.	21-23-03	6 Connections, Spring Source
Holmes-Glickenstein	18-23-03	2 Connections
Hoover	29-23-03	2 Connections, Surface Source
Ireland, R.	24-22-02	2 Connections, Surface Source
Island Spring Water	25-23-02	Approved for 9 Connections, Wants to Expand
Jensen, J.	31-21-02	3 Connections, Spring Source
Katica Water Supply	20-23-03	4 Connections
Khahanie Beach Water System	04-22-03	3 Connections presently. 12 when in full use.
Laver Water	35-23-02	4 Connections, 3 Springs
Luana Water Association	14-22-03	33 Connections, Well Source
MKR Water System	23-21-03	3 Connections
Madrona West	11-22-02	4 Connections
Magnolia Beach Addition Supply	24-22-02	8 Connections
Marine View Estates	NW1/4, NW1/4 23-22-03	25 Connections, Approved for 53 Connections
McIntyre Water System	NW1/4, SW1/4 01-21-02	18 Connections, 2 Wells, Approved for 30 Connections
McKinney Water System	14-22-03	2 Connections
McLeod Water System	20-23-03	3 Connections, Well Source
Miles	35-23-02	3 Connections
Miller	NW1/4, SW1/4 01-21-02	8 Connections, Well Source
Moore, J.	18-23-03	2 Connections
Morningside	17-23'03	4 Connections, Spring Source
Mountain View Water System	29-23-03	13 Connections
Mumford-Newson Water System	23-22-03	2 Connections
North Cedarhurst Mutual System	18-23-03	6 Connections
North Vashon Water Company	06-23-03	27 Connections, Spring and Intertie Source
Ober Beach	24-23-02	5 or 6 Connections, Spring Source
Opelsky	24-22-02	2 Connections
Paquette, R.	SE1/4, SE1/4 35-23-02	2 Connections
Paradise Cove Water	26-22-02	24 Connections, Spring Source

Table 6.3c. Existing Small Water Systems (Group B) (continued)

Water Systems	Section-Township-Range (W.M.)	Connections/Notes
Patience Water System	35-23-02	2 Connections
Penning-Alston Water System	01-21-02	3 Connections, Surface Water Source
Peretti	20-23-03	5 Connections, Well Source
Point Robinson Park Water System	23-22-03	Group B
Quartermaster Heights	NW1/4, SE1/4 24-22-02	13 Connections, Approved for 34 Connections
Redfield Water System	31-22-03	Group B
Risdal/Drescher	01-21-02	3 Connections
Salerno	NW1/4, SW1/4 25-23-02	3 Connections
Sanborn Mutual	18-22-03	Group B, Spring Source
Sandy Beach Water System	07-23-03	10 Connections
Sauer Water System	20-23-03	6 Connections
Scott, J.	NW1/4, NE1/4 18-22-03	3 Connections, 2 Springs
Scott, James C.	NW1/4, NW1/4 24-22-02	2 Connections
Sellers Water System	25-23-02	3 Connections
Shawnee Water System	SE1/4, NE1/4 24-22-02	15 Connections
Sky Ridge Water System	14-22-03	2 Connections
South Manzanita Beach Water System	31-22-03	5 Connections
Sunwater Beach	23-22-02	14 Connections
Sylvan Beach Water System	SE1/4, NW1/4 06-23-03	13 Connections
Tahlequah	02-21-02	Group B
Udall-Twing	01-21-02	2 Connections, Spring Source
Vashon Estates	21-22-03	12 Connections, Well Source
Vashon Sand and Gravel	21-22-03	Group A Serving Gravel Pit
Vashon Water and Road Association	23-22-02	9 Connections with Plans for 11 or 12
Vashon Water and Road South	NW1/4, SE1/4 23-22-03	5 Connections, 8 Shares
Wax Orchards	13-22-02	Group A, Spring System
Wesleyan Community Church	SW1/4, SE1/4 24-22-02	33 Connections
White Water System	NW1/4, NW1/4 23-22-02	1 Residential, 1 Irrigation Connection
Womish Inc.	01-21-02	15 Connections, 2 Wells

Table 6.4. Available Information Pertaining to Major Water Purveyors in the Vashon- Maury Island Ground Water Management Area

System	Number of Connect /Re's	Source (GPD) Req'd (1)	Source (GPD) Available	Minimum Storage Requirements (Gal) Standby (2)	Equalize (3)	Fire (4)	Total (5)	Available Storage	Storage Deficiency
Heights	571	456,800	396,000	251,811	31,303	360,000	391,300	330,000	- 61,303
Westside	219	175,200	158,400	175,200	18,945	360,000	378,945	253,000	- 125,945
Water District 19	1,075	860,000	828,000	233,275	22.575	360,000	382,575	1,725,000	+ 1,342,425
Burton	375	300,000	216,000	300,000	29,325	360,000	389,325	130,000	- 259,325
Maury Mutual	88	70,400	50,400	52,800	15,900	120,000	152,100	53,000	- 99,100
Dockton	294	235,200	345,000	58,000	7,320	360,000	367,320	381,000	+ 13,680
Gold Beach	147	117,600	360,000	69,237	-0- (6)	120,000	120,000	85,000	- 35,000

Source: Horton Dennis and Associates, Inc. 1989

RE Residential equivalent based on actual water used and an assumed average use rate.

* 1993 Number of connections supplied by seven largest Group A purveyors.

(1) Required source calculated based on Seattle-King County Health Department (SKCHD) requirement of 800 gallons per day per connection.

(2) Required standby storage is based on SKCHD requirement of 800 gallons per residential equivalent for single source systems with more than 99 connections. Standby storage requirement for single source systems with less than 100 connections (Maury Mutual) is based on SKCHD requirement of 600 gallons per residential equivalent. Reduction of standby storage requirement for multiple source systems is calculated according to the requirements and formula presented in the SKCHD "Sizing Guidelines for Public Water Supplies; Section VI.B."

(3) Equalizing storage is based on the formula put forth in the SKCHD "Sizing Guidelines for Public Water Supplies; Section VI.C."

(4) Fire flow storage requirements are calculated based on the general requirement of 1,000 gallons per minute (gpm) for a duration of 2 hours in residential areas (1,000 gpm x 2 hours = 120,000 gallons). For commercial areas, a general requirement of 3,000 gpm for a duration of 2 hours was used (360,000 gallons). Although some specific areas may be exempt from fire flow requirements, all purveyors are subject to fire flow storage requirements.

(5) Total required storage is based on Equalizing Storage plus the larger of Fire or Standby Storage.

(6) Equalizing Storage is a negative value and is therefore not reported, zero is used in place of the negative value.

Table 8.1. Rain Gage Stations and Data Collection Periods

Station Name	Location[1]	Available Data
RG-1	R3E/T22N/S22	March 1989 - January 1992
RG-2	R2E/T22N/S24	March 1989 - January 1992
RG-3	R2E/T23N/S25	March 1989 - January 1992
RG-4	R3E/T22N/S6	March 1989 - May 1991
RG-5	R2E/T22N/S31	December 1988 - January 1992
RG-6	R2E/T22N/S2	December 1988 - January 1992
RG-7	R2E/T21N/S2	December 1988 - January 1992
RG-8	R3E/T23N/S18	December 1988 - June 1990
RG-9	R3E/T23N/S29	December 1988 - December 1991
Sea-Tac Airport	R4E/T23N/S29	December 1988 - January 1992

1 Locations are given in U.S. Geological Survey (USGS) range (R), township (T), and section (S)

Table 8.2 Summary of Monthly Rainfall Data*

Date	Rain Gage No. 1 Monthly	Rain Gage No. 1 Yearly	Rain Gage No. 2 Monthly	Rain Gage No. 2 Yearly	Rain Gage No. 3 Monthly	Rain Gage No. 3 Yearly	Rain Gage No. 4 Monthly	Rain Gage No. 4 Yearly	Rain Gage No. 5 Monthly	Rain Gage No. 5 Yearly	Rain Gage No. 6 Monthly	Rain Gage No. 6 Yearly	Rain Gage No. 7 Monthly	Rain Gage No. 7 Yearly	Rain Gage No. 8 Monthly	Rain Gage No. 8 Yearly	Rain Gage No. 9 Monthly	Rain Gage No. 9 Yearly	Sea-Tac Rain Gage Monthly	Sea-Tac Rain Gage Yearly
Dec-88									3.95		3.55		4.44		3.82		4.61		3.48	
Jan-89									4.26		3.34		4.17		3.47		3.85		2.76	
Feb-89									2.8		3.29		3.38		3.61		3.72		3.42	
Mar-89	6.55		7.4		5.38		6.51		1.34		5.28		7.46		6.97		6.64		5.79	
Apr-89	3.63		3.32		2.95		3.42		1.03		2.93		3.15		3.23		3.42		2.8	
May-89	3.24		1.88		2.02		2.215		1.64		1.38		1.77		1.9		1.97		2.78	
Jun-89	1.2		1.2		1.34		1.05		1.13		0.94		1.19		1.12		0.9		1.14	
Jul-89	0.88		0.83		0.67		1		0.79		0.82		1.15		0.75		0.99		0.64	
Aug-89	0.89		0.63		0.64		0.86		0.39		0.55		0.47		1.14		0.83		0.89	
Sep-89	0.38		0.62		0.33		0.33		0.46		0.33		0.35		0.46		0.4		0.54	
Oct-89	3.83		3.75		4.14		3.985		3.645		3.74		3.96		3.85		3.99		2.96	
Nov-89	7.15		6.44		6.64		7.44		7.225		5.73		7.39		5.1		6.85		6.13	
Dec-89	5.4		5.63		5.5		5		5.6		6.53		5.17		2.59		5.27		4.79	
1989		32.91		30.6		29.61		31.61		30.51		33.82		39.59		34.21		38.83		34.69
Jan-90	10.39		12.02		13.99		12.2		11.27		11.48		11.75		10.43		10.9		9.41	
Feb-90	4.05		6.39		10.05		5.84		3.37		4.48		7.37		5.44		6.59		3.72	
Mar-90	3.06		3.59		3.65		3.49		2.65		3.12		3.54		4.38		3.15		2.58	
Apr-90	2.38		3.01		1.83		2.13		2		1.92		2.34		1.92		2.1		2.54	
May-90	1.72		1.6		1.65		1.9		1.64		1.42		1.64		1.76		1.79		1.98	
Jun-90	3.29		3.29		3.21		3.31		3.48		2.92		3.77		2.27		3.26		3.05	
Jul-90	2.12		0.81		0.63		0.87		0.67		0.32		2.33				0.84		0.56	
Aug-90	0.94		1.27		1.09		1.11		0.87		0.93		0.69				0.96		0.71	
Sep-90	0		0		0		0.04		0		0		0				0		0.05	
Oct-90	6.67		7.12		5.97		4.97		7.26		4.62		7.14		6.12		5.61		5.79	
Nov-90	12.72		14.32		15.15		14.78		11.6		12.6		12.62		11.46		14.62		10.71	
Dec-90	3.89		4.04		4.67		3.95		3.9		2.95		4.49				4.7		3.63	
1990		51.23		57.46		62.29		54.39		48.71		46.98		57.68		43.78		54.52		44.75
Jan-91	5.85		5.61		6.29		6.09		5.31		4.95		5.43				5.04		4.46	
Feb-91	5.79		6.33		8		5.93		6.05		6.5		6.15				6.12		4.69	
Mar-91	5.83		5.19		6.64		6.52		5.04		8.37		5.30				5.69		4.66	
Apr-91	7.6		8.1		6.88		8.83		7.95		7.49		3.63				7.65		6.53	
May-91	1.69		1.46		1.86		1.67		1.93		1.54		1.96				1.86		1.39	
Jun-91	2.35		1.43		1.34				1.53		1.01		1.69				1.45		1.29	
Jul-91	2.82		0.57		0.71				0.35		0.3		0.31				0.31		0.28	
Aug-91	3.26		3.22		3.07				3.15		2.83		3.23				2.92		2.17	
Sep-91	0		0		0.02				0.1		0		0.23				0.23		0	
Oct-91	2.04		1.99		3.36				2.21		1.78		2.2				2.04		1.31	
Nov-91	5.92		6.58		9.71				7.04		6.43		6.09				7.12		6.33	
Dec-91	4.15		4.57		4.51				4.52		4.12		4.00				4.35		3.31	
1991		47.32		45.07		52.41				45.18		41.32		40.22				44.98		35.42
Jan-92	8.34		9.88		14.42				7.43		9.67		9.2							

Data collected by Island volunteers.
*Blanks in data field indicate no data was collected.
iurem :hes.

Table 8.3 Stream Gage Stations and Data Collection Periods

Station Name	Location[1]	Drainage Area[2] (acres)	Available Data[3]
*Needle Creek	R3E/T23N/S18	1,996	7/20/89 - 3/17/91
Beal Creek	R3E/T23N/S24	211	9/17/89 - 3/11/92
Upper Judd Creek	R3E/T22N/S7	NA	1/10/91 - 1/30/92
Judd Creek	R3E/T22N/S18	3,149[4]	7/20/89 - 4/6/92
Green Valley Creek	R2E/T22N/S14	762	1/10/91 - 4/8/92
Mileta Creek	R3E/T22N/S21	700[5]	7/20/89 - 3/11/92
Fisher Creek	R2E/T22N/S24	1,549	1/28/91 - 4/5/92
Paradise Cove Creek	R2E/T22N/S23	200[5]	1/11/91 - 7/9/91
Tahlequah Creek	R2E/T21/S2	780	7/20/89 - 4/5/92

1 Locations are given in U.S. Geological Survey (USGS) range (R), township (T), and section (S)
2 Data source: Carr/Associates, 1983
3 Data collected are not continuous.
4 Total drainage area for Judd Creek
5 Estimated

* Needle Creek is also known as Shinglemill Creek.

Table 8.4 Summary of High/Low Stream Gage Readings

Month/Year	Beal Creek High	Beal Creek Low	Fisher Creek High	Fisher Creek Low	Green Valley Creek High	Green Valley Creek Low	Judd Creek High	Judd Creek Low	Needle Creek High	Needle Creek Low	Mileta Creek High	Mileta Creek Low	Paradise Cove Creek High	Paradise Cove Creek Low	Tahlequah Creek High	Tahlequah Creek Low	Upper Judd Creek High	Upper Judd Creek Low
Jul-89							0.91	0.88	0.43	0.42		0.13			0.44	0.42		
Aug-89									0.42	0.42	0.13	0.11						
Sep-89	0.64	0.41							0.42	0.42		0.15						
Oct-89	0.81	0.5					1.18	0.89	0.62	0.42		0.15						
Nov-89	0.68	0.5					1.5	0.97	0.88	0.57	1.6	1.5				0.73		
Dec-89	0.95	0.53					1.5	1	1.2	0.44					0.59	0.56		
Jan-90	0.77	0.67					2.1	1.28	2.4	0.48					0.72	0.53		
Feb-90	0.68	0.67					1.75	1.3	0.94	0.72	1.77	1.59			0.95	0.58		
Mar-90	0.78	0.52					1.76	1.21	0.72	0.6					0.62	0.48		
Apr-90	0.67	0.37							0.64	0.6		1			0.48	0.42		
May-90	0.68	0.47					2	1.13	0.64	0.6		0.9				0.4		
Jun-90	0.65	0.62					1.38	1.04	0.6	0.58	0.89	0.83				0.4		
Jul-90	0.67	0.3					1.28	1.02		0.58	0.81	0.79				0.43		
Aug-90	0.71	0.42					1.06	1.03	0.58	0.5	0.78	0.9				0.5		
Sep-90	0.59	0.51					1.08	1.04	0.8	0.58						0.6		
Oct-90	0.8	0.57					1.31	1.11	0.84	0.6								
Nov-90	0.96	0.62					1.67	1.18	0.62	0.6		0.56				0.54		
Dec-90																		
Jan-91	1.24	0.58	0.44	0.33	0.48	0.21				0.64			0.25	0.14		0.51	2.8	0.59
Feb-91	1	0.73	0.75	0.4	0.31	0.19		0.52	1.6	0.7			0.23	0.16		0.54	3.29	0.52
Mar-91	0.64	0.27	0.8	0.4	0.28	0.16		0.4		0.13			0.25	0.18		0.54	1	0.48
Apr-91			1.81	0.4									0.25	0.17		0.59	2.83	0.47
May-91	0.82	0.62	0.45	0.38								4.05					0.46	0.29
Jun-91	0.73	0.67	0.42	0.26													0.35	0.33
Jul-91	0.77	0.5	0.29	0.25		0.13		0.2						0.17		0.43	0.34	0.33
Aug-91	0.82	0.51		0.24				0.19				3.8				0.45	0.53	0.35
Sep-91	0.73	0.53	0.24	0.22				0.19				3.85				0.42		
Oct-91	0.78	0.49	0.51	0.2		0.2		0.21				4				0.47		
Nov-91	0.52	0.23	0.85	0.22		0.18		0.95								0.55	0.69	0.38
Dec-91		0.17	0.9	0.24		0.16		0.49				4.22				0.54	1.2	0.42
Jan-92		0.35		0.31				0.58				4.2				0.54	3.17	0.45
Feb-92		0.71		0.46				0.4				4.21				0.55		
Mar-92		0.76		0.29		0.14		0.34				4				0.48		
Apr-92				0.25		0.14		0.28								0.46		

*This table is meant only to be a summary of data. Data was intended to be collected daily. Data points for each day of each month were not always collected. If only one point was available, that one point was placed in the Low column.
Data collected by Island volunteers.
Measurement in feet.

Table 8.5a Summary of Well Construction Details, Ground Water Monitoring Sites and Data Collection Periods

Well Name	G&M ID	(1) Carr ID	Location (sec-twnshp-rng)	Ground Elevation (msl)	TD (ft.bls)	(2) TD (ft.msl)	Screen Interval (ft.bls)	(3) Screen Interval (ft.msl)	[Booth] Base of Vashon at Well (ft.msl)	(4) [Booth] Screen +/- Base of Vashon (ft.)	Range in Water Level Elevation	Monitored for Water Quality	Monitored for Water Levels	Available Water Level Data
Phillips	W-1	136	NENE-S8-T23N-R3E	200	97	103	89-94	106-111	~60	46 to 51	108 to 124	X	X	9/13/89 - 3/10/92
Heights #1	W-2a	140	NENE-S18-T23N-R3E	230	177	53	158-163 167-172	67-72 58-63	~50	8 to 22	84 to 86	X	X	8/9/89 - 3/10/92
Heights #2	W-2b	(new)	NENE-S18-T23N-R3E	200	150	50	139-148	52-61	~50	2 to 11	86 to 91		X	8/9/89 - 3/10/92
Glen Acres	W-3	143	NWNE-S20-T23N-R3E	150	142	8	NA	NA	~200	-192?	21 to 29	X	X	10/27/89 - 3/13/92
Rodrigues	W-4	(new)	NWNE-S29-T23N-R3E	190	305	-115	300-305	-110to-115	~160	-290 to -295	-109 to -7	X	X	9/13/89 - 3/13/92
Mountain View *	W-5	?	S29-T23N-R3E	190	320	-130	NA	NA	~150	-260?	-64 to 14		X	9/7/89 - 3/13/92
Davis	W-6	(new)	NWNW-S31-T23N-R3E	400	173	227	164-169	231-236	~300	-64 to -69	249 to 260	X	X	7/19/89 - 3/10/92
Toomey *	W-7	76?	S6-T22N-R3E	280	297	-17	NA	NA	~110	-127?	29 to 49	X	X	9/28/89 - 10/31/91
KIRO (Queen Cty Brd)	W-8	86	SENW-S16-T22N-R3E	50	462	-412	440-460?	-390to-410	~75	-465 to -485	5 to 7	X	X	8/9/89 - 3/13/92
White #1	W-9a	106	NWSW-S23-T22N-R3E	400	450	-50	420-449	-20to-49	~150	-170 to -199	3 to 11	X	X	8/9/89 - 3/13/92
White #2 *	W-9b	107?	S23-T22N-R3E	400	375	[25	NA	NA	~150	-125?	31 to 36	X	X	4/9/81 - 12/28/89
Gold Beach #1	W-10a	106	S28-T22N-R3E	85	117	-32	113-117	-28to-32	~-25?	-3 to -7	-8 to 5		X	8/9/89 - 3/13/92
Gold Beach #2	W10b	109	S28-T22N-R3E	85	118	-33	99-104 104-109	-14to-19 -19to-24	~-25?	1 to 11	-11 to 4	X	X	8/9/89 - 3/13/92

Table 8.5a Summary of Well Construction Details, Ground Water Monitoring Sites and Data Collection Periods

Well Name	G&M ID	(1) Carr ID	Location (sec-twnshp-rng)	Ground Elevation (msl)	TD (ft.bls)	(2) TD (ft.msl)	Screen Interval (ft.bls)	(3) Screen Interval (ft.msl)	[Booth] Base of Vashon at Well (ft.msl)	(4) [Booth] Screen +/- Base of Vashon (ft.)	Range in Water Level Elevation	Monitored for Water Quality	Monitored for Water Levels	Available Water Level Data
Sandy Shores (B&H)	W-11	116	NENW-S29-T22N-R3E	380	423	-63	396-417	-36to-57	~20	-56 to -77	65 to 117	X	X	9/13/89 - 3/13/92
Rueter	W-12	97	Lot2-S21-T22N-R3E	105	473	-368	468-473	-363to-368	~120	-483 to -488	-38 to 17	X	X	7/19/89 - 3/13/92
Foley	W-13	93?	SWNW-S16-T22N-R3E	250	85	165	75-80	170-175	~25	145 to 150	235 to 242	X	X	9/7/89 - 3/10/92
Motoyoshi	W-14	(new)	SENW-S35-T22N-R2E	390	183	207	NA	NA	~180	27?	213 to 226	X	X	7/21/89 - 3/10/92
Bowan	W-15	(new)	NENE-S35-T22N-R2E	380	188	192	183-188	192-197	~225	-28 to -33	219 to 221	X	X	10/4/89 - 3/10/92
Baker	W-16a	46	SESW-S14-T22N-R2E	285	67	218	NA	NA	~145	73?	257 to 276	X	X	7/19/89 - 3/10/92
Baker #2 *	W-16b	48	S14-T22N-R2E	290	62	228	NA	NA	~145	83?	233 to 248		X	7/19/89 - 3/10/92
Perla	W-17	(new)	SWNE-S11-T22N-R2E	200	220	-20	215-220	-15to-20	~170	-185 to -190	29 to 33	X	X	9/7/89 - 3/10/92
Hamilton	W-18	126	NWNE-S35-T23N-R2E	190	118	72	NA	NA	~125	-53	114 to 115	X	X	9/7/89 - 3/10/92
DeFrang	W-19	132	NWNW-S36-T23N-R2E	460	175	285	169-173	287-291	~250	37-41	307 to 337	X	X	7/19/89 - 3/10/92
Johnson *	W-20	120	S25-T23N-R2E	380	122	258	NA	NA	~310	-52?	281 to 288	X	X	7/19/89 - 5/23/91
Kuperberg	W-21	116?	NESW-S24-T23N-R2E	190	133	57	open	NA	~170	-113?	76 to 77	X	X	7/21/89 - 3/10/92

Well logs submitted to G&M by SKCHD on 9/14/93.
Note: Elevations were estimated by P.Shallow & A. Ripley.
(sec-twnshp-rng) - Section-Township-Range
Associated Well logs in Appendix D.
Booth 1991 - Base of Vashon map elevations used.

*	No well logs provided by SKCHD.
?	Unknown
~	Approximately
bls	Below land surface
ft	Feet
ft. msl	Feet above mean sea level
ID	Identification
msl	Mean sea level
NA	Not available

(1) Carr Well ID may be in error
(2) elevation - TD (ft.bls)
(3) elevation - screen interval (ft.bls)
(4) screen interval - base of Vashon (Booth)

Table 8.5b Vashon Water Level Elevations - High/Low Comparison

Water-Level Elevations

Well ID	Year	High Reading	High Month	Low Reading	Low Month	3 Year Maximum	3 Year Minimum	Total Change	Comments
W-1(2)	1989	121.13	Dec	116.71	Sep			4.42	Sep-Dec data collected
	1990	123.7	May	117.58	Aug			6.12	Dec 90 data missing, 112.57 probable error
	1991	123.95	May	121.5	Dec			2.45	Nov missing, 108.48 & 112.5 probable error
	1992			122.65					Mar data only
						123.7	116.71	6.99	
W-2a(2)	1989	84.42	Dec	83.95	Aug			0.47	Aug-Dec data collected, Sep 89 data missing
	1990	85.01	Nov	84.25	Jan			0.76	Dec 90 missing
	1991	86.31	Oct	84.75	Mar			1.56	Nov 91 missing
	1992			85.45					Mar data only
						86.31	83.95	2.36	
W-2b(2)	1989	88.67	Dec	87.87	Aug			0.8	Aug-Dec data collected
	1990	89.33	Jun	86.54	Jan			0.79	Dec 90 data missing
	1991	90.64	Oct	89.13	Feb			1.51	Nov 91 data missing
	1992			89.88					Mar data only
						90.64	87.87	2.77	
W-3(3)	1989	21.54	Dec	21.21	Nov			0.33	Oct-Dec data collected
	1990	22.11	Nov	20.95	Sep			1.16	Dec 90 data missing
	1991	22.03	Feb	21.29	Jun			0.74	Sep 91 data missing
	1992			29.43*					* probably in error, Mar data only
						22.11	20.95	1.16	
W-4(3)	1989	-6.79	Nov	-13.5	Sep			6.71	Sep-Dec data collected
	1990	-6.66	Jan	-11.2	Mar			4.54	Dec 90 data missing
	1991	-7.83	Nov	-14.04	Feb			6.21	Sep 91 data missing, actual low was -108.51 but probable error
	1992			-7.77					Mar data only
						-6.66	-14.04	7.38	
W-5(3)	1989	14.25	Dec	11.96	Oct			2.29	Sep-Dec data collected
	1990	13.5	Jan	11.23	Mar			2.27	Dec data missing
	1991	14.1	Jan	10.49	Mar			3.61	Oct data missing,several readings below 10.49 but probable error
	1992			12.75					Mar data only
						14.25	10.49	3.76	

Table 8.5b Vashon Water Level Elevations - High/Low Comparison

		Water-Level Elevations							
Well ID	Year	High Reading	High Month	Low Reading	Low Month	3 Year Maximum	3 Year Minimum	Total Change	Comments
W-6(1)	1989	254.77	Jul	249.13	Nov			5.64	Jul-Dec data collected, Aug & Sep data missing
	1990	256.09	May	249.87	Nov			6.22	Dec data missing
	1991	260.21	May	251.38	Jan			8.83	Nov data missing
	1992			253.75					Mar data only
						260.21	249.13	11.08	
W-7(3)	1989	48.58	Dec	46.46	Oct			2.12	Sep-Dec data collected, low value of 42.48 probable error
	1990	49.3	May	46.34	Mar			2.96	Dec data missing
	1991	48.16	May	47.08	Jun			1.08	Jan-Oct data collected, low values 42.06&29.42 probable error
						49.3	46.34	2.96	
W-8(4)	1989	6.46	Dec	5.59	Nov			0.87	Aug-Dec data collected, Sep data missing
	1990	7.29	Jan	4.77	Aug			2.52	Dec data missing
	1991	6.72	Mar	4.64	Oct			2.08	Sep data missing
	1992			6.96					Mar data only
						7.29	4.77	2.52	
W-9a(3)	1989	9.75	Nov	8.83	Oct			0.92	Aug-Nov data collected, Sep missing, low value 2.5 probable error
	1990	10.37	Apr	7.89	Aug			2.48	Feb-Nov data collected
	1991	10.9	Feb	9.55	May			1.35	Sep & Oct data missing
	1992			10.23					Mar data only
						10.37	7.89	2.48	
W-9b(5)	1989	36.21	Nov	35	Apr			1.21	Apr?-Dec data collected, missing May, Jun & Jul data 31.36 probable error
W-10a(3)	1989	-3.33	Nov	-7	Aug			3.67	Aug-Dec data collected, missing Sep data
	1990	0.85	Apr	-8.23	Sep			9.08	Dec data missing
	1991	4.74	May	-2.85	Nov			7.59	Sep data missing
	1992			2.31					Mar data only
						4.74	-8.23	12.97	
W-10b(3)	1989	-3.5	Dec	-5.35	Oct			1.85	Aug-Dec data collected, missing Sep data
	1990	-0.13	Apr	-5.55	Sep			5.42	Dec data missing, -11.11 value probable error
	1991	3.54	May	-3.19	Oct			6.73	Sep data missing, -6.51 probable error
	1992			1.33					Mar data only
						3.54	-6.51	10.05	

Table 8.5b Vashon Water Level Elevations - High/Low Comparison

Water-Level Elevations

Well ID	Year	High Reading	High Month	Low Reading	Low Month	3 Year Maximum	3 Year Minimum	Total Change	Comments
W-11(3)	1989	115	Oct	114.37	Oct			0.63	Sep-Dec data only, 65.08 value probable error
	1990	116.21	Nov	93.44	Jul			22.77	Dec data missing
	1991	116.6	Aug	109.23	Jul			7.37	Jun, Sep, & Dec data missing, 68.36 probable error
	1992			83.61*					Mar data only, * probable error
						116.6	93.44	23.16	
W-12(4)	1989	16.25	Dec	13.65	Jul			2.4	Jul-Dec data collected, Aug-Sep data missing
	1990	17.17	Jan	14.38	Oct			2.79	Dec data missing, -36.50 value probable error
	1991	16.02	Feb	14.31	May			1.71	Sep data missing, <14.31 probable error
	1992			16.76					Mar data only
						17.17	13.85	3.32	
W-13(1)	1989	236	Sep, Dec	235.4	Nov			0.6	Sep-Dec data collected
	1990	239.32	Mar	236.12	Oct			3.2	Dec data missing
	1991	242.38	Apr	238.05	Dec			4.33	Nov data missing
	1992			239.76					Mar data only
						242.38	235.4	6.98	
W-14(1)	1989	225.29	Dec	224.17	Nov			1.12	Jul-Dec data collected, Aug & Sep data missing
	1990	225.33	Jan	224.4	Feb			0.93	Dec data missing, 213.3 value probable error
	1991	226.33	Oct	224.08	Aug			2.25	Nov data missing
	1992			226.05					Mar data only
						226.33	224.08	2.25	
W-15(1)	1989	220.08	Dec	219.29	Nov			0.79	Oct-Dec data collected
	1990	220.46	Jan	219.16	Sep			1.3	Dec data missing
	1991	220.85	Oct	219.34	Jan			1.51	Nov data missing
	1992			220.67					Mar data only
						220.85	219.16	1.69	
W-16a(1)	1989	263.25	Jul	257.08	Dec			6.17	Jul-Dec data collected, Aug & Sep data missing
	1990	272.09	Mar	258.85	Oct			13.24	Dec data missing
	1991	277.77	Apr	260.16	Dec			17.61	Nov data missing
	1992			267.67					Mar data only
						277.77	257.08	20.69	

Table 8.5b Vashon Water Level Elevations - High/Low Comparison

Water-Level Elevations

Well ID	Year	High Reading	High Month	Low Reading	Low Month	3 Year Maximum	3 Year Minimum	Total Change	Comments
W-16b(1)	1989	236.52	Jul	233.19	Dec			3.33	Jul-Dec data collected, Aug & Sep data missing
	1990	239.26	May	233	Jan			6.26	Dec data missing
	1991	248.42	May	235.83	Jan			12.59	Nov data missing
	1992			233.08					Mar data only
						248.42	233	15.42	
W-17(3)	1989	30.17	Sep	28.71	Nov			1.46	Sep-Dec data collected
	1990	31.14	Apr	28.77	Oct			2.37	Dec data missing
	1991	32.54	May	29.31	Dec			3.23	Nov data missing
	1992			29.68					Mar data only
						32.54	28.71	3.83	
W-18(2)	1989	114.82	Nov	114.25	Nov			0.57	Sep-Dec data collected
	1990	115.25	Jan	114.22	Feb			1.03	Dec data missing
	1991	115.03	Jan	114.28	Dec			0.75	Nov data missing
				114.28					Mar data only
						115.25	114.22	1.03	
W-19(1)	1989	316.21	Dec	315.5	Nov			0.71	Jul-Dec data collected, Aug & Sep data missing, 336.95 value proba
	1990	316.6	Aug	315.74	Feb			0.86	Dec data missing, 306.82 & 307.55 probable error
	1991	318.06	Aug	316.34	Mar			1.72	Nov data missing, 308.40 & 307.88 probable error
	1992			317.11					Mar data only
						318.06	315.5	2.56	
W-20(1)	1989	282.63	Jul	280.67	Nov			1.96	Jul-Dec data collected, Aug & Sep data missing
	1990	284.01	May	281.29	Jan			2.72	Dec data missing
	1991	286.23	May	282.19	Feb			4.04	Jan-May data collected
						286.23	280.67	5.56	
W-21(2)	1989	76.67	Dec	75.5	Nov			1.17	Jul-Dec collected, Aug & Sep data missing
	1990	76.33	Nov	75.82	Feb			0.51	Dec data missing
	1991	77.34	Oct	76.12	Apr, Jun			1.22	Nov data missing
				76.82					Mar data only
						77.34	75.5	1.84	

All measurements are in feet mean sea level.

ID	Identification	(1)	Wells completed in Zone 1
WLs	Water-level elevations	(2)	Wells completed in Zone 2
		(3)	Wells completed in Zone 3
		(4)	Wells completed in Zone 4
		(5)	Not assigned to hydrostratigraphic zone due to insufficent data

Table 8.6 Susceptibility Potential of Surficial Geologic Units

Geologic Abbreviation	Geologic Unit Name	Age	Susceptibility Potential Classification
Qvr	Recessional-Outwash Deposits	Pleistocene	High
Qvi	Ice-Contact Deposits	Pleistocene	High
Qva	Advance-Outwash Deposits	Pleistocene	High
Qpfc	Coarse-Grained Pre-Fraser Facies	Pleistocene	High
Qvt	Till	Pleistocene	Low
Qvu	Vashon Drift (undivided)	Pleistocene	Low
Qpff	Fine-Grained Pre-Fraser Facies	Pleistocene	Low
Qdi	Intermediate Drift	Pleistocene	Low
Qti	Intermediate Till	Pleistocene	Low
Qdu	Pre-Fraser Drift	Pleistocene	Low
Qtu	Pre-Fraser Till	Pleistocene	Low
Qal	Alluvium	Holocene	High
Qob	Olympia Beds	Pleistocene	Medium
Qsgo	Older Sand and Gravel	Pleistocene	Medium
m	Modified Land	Holocene	Medium
Qb	Beach Deposits	Holocene	Medium
Qls	Landslide Deposits	Holocene	Medium
Qmw	Mass-Wastage Deposits	Holocene	Medium
Qpf	Pre-Fraser Deposits (undivided)	Pleistocene	Medium
Qpfm	Clay and Silt	Pleistocene	Medium
Qcs	Clay and Silt	Pleistocene	Medium
Qpof	Fine-Grained Pre-Olympia Beds	Pleistocene	Low
Qpom	Mixed Pre-Olympia Deposits	Pleistocene	Low
Qcso	Older Clay and Silt	Pleistocene	Low
Qw	Wetland Deposits	Holocene	Low
Qtb	Pre-Fraser Deposits (undivided)	Pleistocene	Low

Table 8.7 Susceptibility Potential for Depth-to-Water Criteria

Depth to Water (BLS)	Susceptibility Potential Classification
≤ 25 feet	High
> 25 feet	Medium
≤ 25 feet	Medium
> 25 feet	Low
< 25 feet	High
25 - 75	Medium
> 75 feet	Low

Table 8.8 Susceptibility Potential for Slope Criteria

Percent Slope	Susceptibility Potential Classification
Any	High
≤ 40	Medium
> 40	Low
< 40	High
40 - 80	Medium
> 80	Low

Table 8.9a Physical Susceptibility Rating Criteria

Composite Classifications	Resultant Physical Susceptibility Classification
HHH	High
HHM	High
HHL	Medium
HMM	Medium
HML	Medium
HLL	Medium
MMM	Medium
MML	Medium
MLL	Low
LLL	Low

H High
M Medium
L Low

Table 8.9b Water Budget Estimates

Water Budget Component	VASHON ISLAND AFY	VASHON ISLAND cfs	VASHON ISLAND gpm	VASHON ISLAND mgpy	MAURY ISLAND AFY	MAURY ISLAND cfs	MAURY ISLAND gpm	MAURY ISLAND mgpy	VASHON & MAURY ISLANDS AFY	VASHON & MAURY ISLANDS cfs	VASHON & MAURY ISLANDS gpm	VASHON & MAURY ISLANDS bgpy
Inflow												
Rainfall	73,750	102	45,700	24,020	17,380	24	10,800	5,676	91,130	126	56,500	29.696
Outflow												
Evapotranspiration	29,270	40.4	18,100	9,513	6,900	9.5	4,270	2,244	36,170	49.9	22,370	11.758
Surface Runoff	17,230	23.8	10,660	5,603	4,055	5.6	2,510	1,319	21,285	29.4	13,170	6.922
Base Flow	16,800	23.2	10,390	5,461	3,980	5.5	2,460	1,293	20,780	28.7	12,850	6.754
Subsurface Flow	10,450	14.6	6,550	3,443	2,445	3.4	1,560	820	12,895	18	8,110	4.263

Note: Water budget estimates calculated by E. McGavock. See Appendix N for further details.

AFY Acre-feet per year
bgpy billion gallons per year
cfs cubic feet per second
gpm gallons per minute
mgpy million gallons per year

Table 8.9c Summary of Surface Water Samples Exceeding Established Limits

Sample Medium	Beal Creek	Fisher Creek	Green Valley Creek	Judd Creek	Mileta Creek	Paradise Cove Creek	Needle (Shinglemill) Creek	Tahlequah Creek
Fresh Water	None	Fecal coliform[0,1]	Fecal coliform[1] TDS[2] (1) [8/91]	Mercury[4] (1) [9/91] Fecal coliform[0,1] Methylene chloride (2) [8/91[3],9/91[3]] Acetone[3] (1) [9/91]	Chromium (3) [8/91[4], 6/92[5],8/92[4]] Fecal coliform[1]	Fecal coliform[1]	Fecal coliform[1]	Fecal coliform[1]
Marine Water	Lead[4] (1) [8/91] Copper[5] (3) [7/92] Zinc[5] (1) [8/91]	Lead[4] (1) [8/91]	Lead[4] (1) [4/92]	Copper[5] (2) [8/91] Lead[4] (2) [8/91,4/92] Total coliform[1] Fecal coliform[1]	Copper[5] (2) [8/91] Silver[5] (1) [8/91] Lead[4] (2) [8/91,7/92]	Lead[4] (1) [11/91]	Copper[5] (3)[7/92] Lead[4] (3) [8/91, 4/92,8/92]	Lead[4] (1)[4/92] Copper[5] (1)[8/91] Fecal coliform[0,1]
Freshwater Sediment	NS	NS	NS	Chromium[7]	Total coliforms[7]	NS	None	NS
Marine-Water Sediment	None	None	None	Chromium[7] Lead[7] Arsenic[8] Total coliforms[8]	Fecal coliforms[7] Total coliforms[8]	Zinc[7]	Mercury[7]	Total coliform[7]
Marine Shellfish	Fecal coliform[6] (3)[7/92]	Fecal coliform[6] (4) [4/92, 7/92,8/92]	NS	Fecal coliform[6] (1) [7/92]	None	Fecal coliform[6] (4) [8/91,8/92]	None	Fecal coliform[6] (5) [8/91,11/91,7/92,8/92]

(1) Indicates number of samples in which constituent was detected.
[8/91] Indicates sample collection dates(s) for which constituent was detected.
None No sample exceeded standards established either by Washington State or for this study.
TDS Total dissolved solids
NS Not sampled
TCA 1,1,1-tetrachloroethane

[0] Geometric mean exceeds coliform criteria.
[1] More than 10% of values exceed maximum coliform level.
[2] Value exceeds federal maximum contaminant limit standards.
[3] Detected in field blanks. Sample less than 10 times maximum contaminant limit.
[4] Chronic
[5] Acute
[6] Exceeds Federal Drug Administration standards.
[7] Highest level with respect to other sediment samples (fresh or marine).
[8] Significantly higher level than other sediment samples (fresh or marine).

Note: Detection limits for mercury in freshwater and marine water above chronic limit. Detection limits for silver in marine water higher than acute limit. Fresh water pH values in December 1991 and January 1992 were very low and probably in error. No regulatory limits have been established for sediments.

Data collected by Seattle-King County Department of Public Health; summary analytical results in Appendix J.

Table 8.10 Metro Marine Water Quality/Shellfish Analytical Results

Date Sampled	Marine Water Fecal Coliforms (org/100 ml)		Marine Shellfish Fecal Coliform (org/100 mg)
	Tramp Harbor	Luena Beach	Tramp Harbor
6/90	----	BDL	
7/90	11	----	110
8/90	33	----	130
9/90	31	----	440***
5/91	----	----	40
6/91	----	----	90
7/91	BDL**	----	20
8/91	3300*/**	----	170
9/91	5**	----	130
5/92	11	----	490***
6/92	33	----	130
7/92	49*	----	17000***
8/92	17	----	20
9/92	17	----	330***

*	10% exceedance of maximum criteria (43/100 ml) per season.
**	Geometric mean exceeded regulatory level (14/100 ml).
***	Exceeds FDA MCL (230/100 g).
----	Not sampled.
MCL	Safe Drinking Water Act maximum contaminant level.
Org/100 ml	Organisms per 100 milliliters
Org/100 mg	Organisms per 100 milligrams
BDL	Below detection limit

Table 8.11 Summary of Spring Water Quality Data

Spring ID	Sample Date Oct-89	Apr-90	Oct-90
Chloride (mg/L)			
S-1 North Vashon	NS	9.5	4.8
S-2 Ober Beach	7.6	4.3	3.1
S-3 Atlas Water	NS	NS	NS
S-4 Magnolia Beach	19	5.8	NS
S-5 Morningside	18	4.0	3.1
S-6 Jensen	NS	NS	NS
Nitrate (mg/L)			
S-1 North Vashon	NS	2.5	2.5
S-2 Ober Beach	<0.2	1.2	1.4
S-3 Atlas Water	NS	NS	NS
S-4 Magnolia Beach	<0.5	4.4	NS
S-5 Morningside	<0.5	<0.2	<0.2
S-6 Jensen	NS	NS	NS
TDS (mg/L)			
S-1 North Vashon	NS	145	210
S-2 Ober Beach	148	140	280
S-3 Atlas Water	NS	NS	NS
S-4 Magnolia Beach	114	145	NS
S-5 Morningside	155	100	140
S-6 Jensen	NS	NS	NS

J Estimated value
mg/L Milligrams per liter
NS Not sampled
Data collected by Seattle-King County Department of Public Health.

Table 8.12 Ground Water Quality Data for Chloride

Well ID	Sample Date Oct-89 (mg/L)	Apr-90 (mg/L)	Oct-90 (mg/L)
W-1	5.6	2.8	<0.5
W-2A	5.4	2.8	2.3
W-3	14	6.4	2.9
W-4	6.9	3.5	2.9
W-6	4.5	2.3	2.3
W-7	5.2	2.6	3.4
W-8	13	8.1	4.0
W-9A	NS	4.0	4.7
W-9B	1.6	NS	NS
W-10B	1.6	8.4	19
W-11	7.7	4.1	3.5
W-12	6.7	3.2	3.1
W-13	5.1	2.9	2.9
W-14	5.2	2.9	1.5
W-15	5.7	3.3	2.7
W-16A	6.1	3.2	2.3
W-17	4.7	2.7	2.1
W-18	8.6	4.3	3.8
W-19	4.7	2.6	2.1
W-20	5.3	3.1	2.9
W-21	5.6	2.6	<0.5

mg/L Milligrams per liter
NS Not sampled
Data collected by Seattle-King County Department of Public Health.

Table 8.13 Summary of Water Quality Data for Nitrate

Well ID	Sample Date Oct-89 (mg/L)	Apr-90 (mg/L)	Oct-90 (mg/L)
W-1	<0.2	<0.2	<0.2
W-2A	1.3	<0.2	<0.2
W-3	<0.2	<0.2	<0.2
W-4	<0.2	<0.2	<0.2
W-6	1.1	<0.2	2.0
W-7	<0.2	<0.2	<0.2
W-8	<0.2	<0.2	2.2
W-9A	NS	<0.2	<0.2
W-9B	<0.2	NS	NS
W-10B	1.5	1.1	3.4
W-11	0.51	<0.2	<0.2
W-12	<0.2	<0.2	<0.2
W-13	<0.2	<0.2	<0.2
W-14	<0.2	<0.2	<0.2
W-15	<0.2	<0.2	<0.2
W-16A	2.1	1.4	1.7
W-17	0.47	<0.2	<0.2
W-18	<0.2	<0.2	<0.2
W-19	0.73	<0.2	<0.2
W-20	2.5	2.7	2.5
W-21	0.53	<0.2	<0.2

mg/L Milligrams per liter
NS Not sampled
Data collected by Seattle-King County Department of Public Health.

Table 8.14 Summary of Water Quality Data for Total Dissoved Solids

Well ID	Sample Date Oct-89 (mg/L)	Apr-90	Oct-90
W-1	178	180	230
W-2A	152	140	220
W-3	224	365	170 J
W-4	267	270	350 J
W-6	89	110	130
W-7	136	160	150 J
W-8	303	365	260 J
W-9A	NS	50	350 J
W-9B	108	NS	NS
W-10B	176	165	360 J
W-11	198	155	180 J
W-12	182	185	200 J
W-13	64	50 J	110 J
W-14	99	116 J	150
W-15	84	74 J	95
W-16A	103	80 J	120
W-17	111	80	100 J
W-18	223	245	210 J
W-19	94	110	110 J
W-20	94	55	120
W-21	137	115	210

J Estimated value
mg/L Milligrams per liter
NS Not sampled
Data collected by Seattle-King County Department of Public Health.

Table 8.15 Safe Drinking Water Act Maximum Contaminant Levels

Constituent	SDWA MCLs (mg/L)	Wells Exceeding Standards*
<u>WATER QUALITY PARAMETERS</u>		
Total Coliform	0 or 1	W-1, W-2, W-8, W-15, W-20
Fecal Coliform	0	
Total Dissolved Solids	500	
Total Hardness	NA	
Total Alkalinity	NA	
Carbonate	NA	
Bicarbonate	NA	
Hydroxide	NA	
Total Organic Halides	NA	
<u>INORGANICS</u>		
Arsenic	0.05	
Barium	1.0	
Cadmium	0.01	
Calcium	NA	
Chloride	250	
Chromium	0.05	
Copper	1.0	
Fluoride	2	
Iron	0.3	W-1, W-2, W-3, W-8, W-9, W-10a, W-11, W-13, W-19, W-20
Lead	0.05	W-13, W-15
Magnesium	NA	
Manganese	0.05	
Mercury	0.002	
Nitrate (as N)	10	
Nitrite (as N)	1	
Potassium	NA	
Selenium	0.01	
Silica	NA	
Silver	0.05	
Sodium	NA	
Sulfate	250	
Zinc	5.0	

mg/L Milligrams per liter
NA Not available
SDWA MCLs Safe Drinking Water Act maximum contaminant levels, 40 CFR 141, as per WAC 173-340-720 (2)(a)(ii)(A)
* Concentration in named well exceeded standards at least one time during the sampling period of October 1989 through October 1990.

Table 8.16 Water Quality Data in Wells Exceeding Safe Drinking Water Act Maximum Contaminant Level

Well ID	Sample Date Nov-89	Apr-90	Oct-90
LEAD (1)			
W-13 (mg/L)	0.063 *	0.073 *	0.004
W-15 (mg/L)	0.006	0.081 *	0.009
TOTAL COLIFORM (2)			
W-1 (MPN/100 ml)	<2	<1	9.0 (in dup) *
W-2 (MPN/100 ml)	2.0 *	<1	<1
W-3 (MPN/100 ml)	<2	<1	14.0 *
W-15 (MPN/100 ml)	<2	4.0 *	<1
W-20 (MPN/100 ml)	<2	<1	2.0 *
IRON (3)			
W-1 (mg/L)	.4 *	.57 *	.35 *
W-2 (mg/L)	.4 *	.13	.14
W-8 (mg/L)	.32 *	.34 *	.14
W-9 (mg/L)	1.5 *	.55 *	.06
W-10 (mg/L)	.38 *	.48 *	.76 *
W-11 (mg/L)	.22	.12	.33 *
W-13 (mg/L)	.52 *	.25	.23
W-14 (mg/L)	1.7 *	.56 *	.95 *
W-18 (mg/L)	10 *	8.8 *	11 *
W-19 (mg/L)	.42 *	.34 *	.42 *
W-21 (mg/L)	.22	.42 *	.32 *

mg/L	Milligrams per liter
MCL	Safe Drinking Water maximum contaminant level.
MPN/100 ml	Organisms per 100 milliliters
*	Exceeds the MCL
(1)	MCL for lead is 0.05 mg/L
(2)	MCL for total coliforms is 0 or 1 MPN/100 ml
(3)	MCL for iron is 0.3 mg/L

The detection limits for lead, total coliforms, and iron are 0.001 mg/L, 1 or 2 MPN/100 ml, and 0.01 mg/L, respectively.

Area Characterization

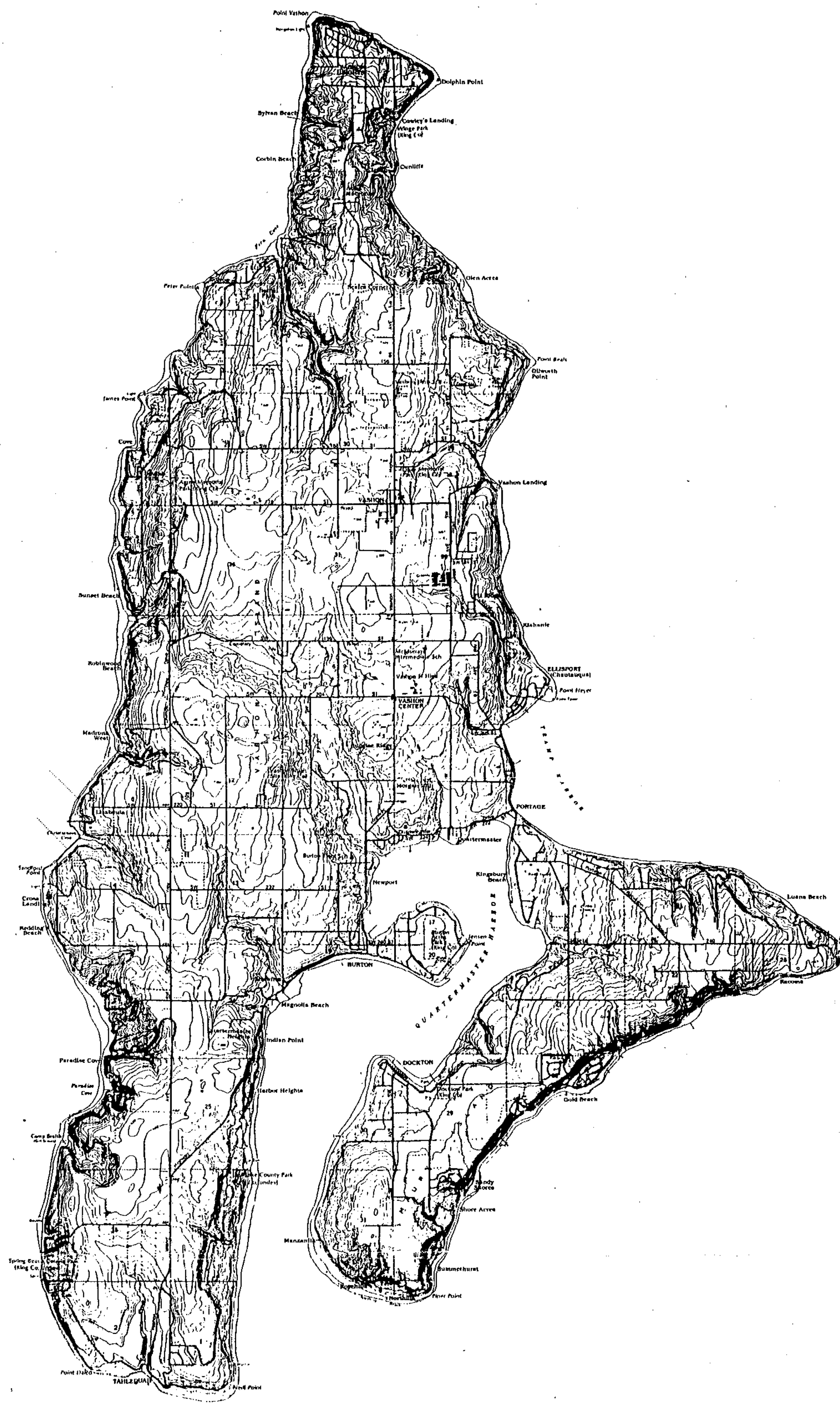
Figures

Vashon-Maury Island
Ground Water Management Plan

December 1998

DWG DATE: MAR 1993 | PRJCT NO.: WA028.02 | FILE NO.: | DRAWING: | CHECKED: | APPROVED: LER | DRAFTER: SAC

163135



N

0 1 2

Approximate Scale In Miles

SOURCE: Geraghty & Miller 1993.

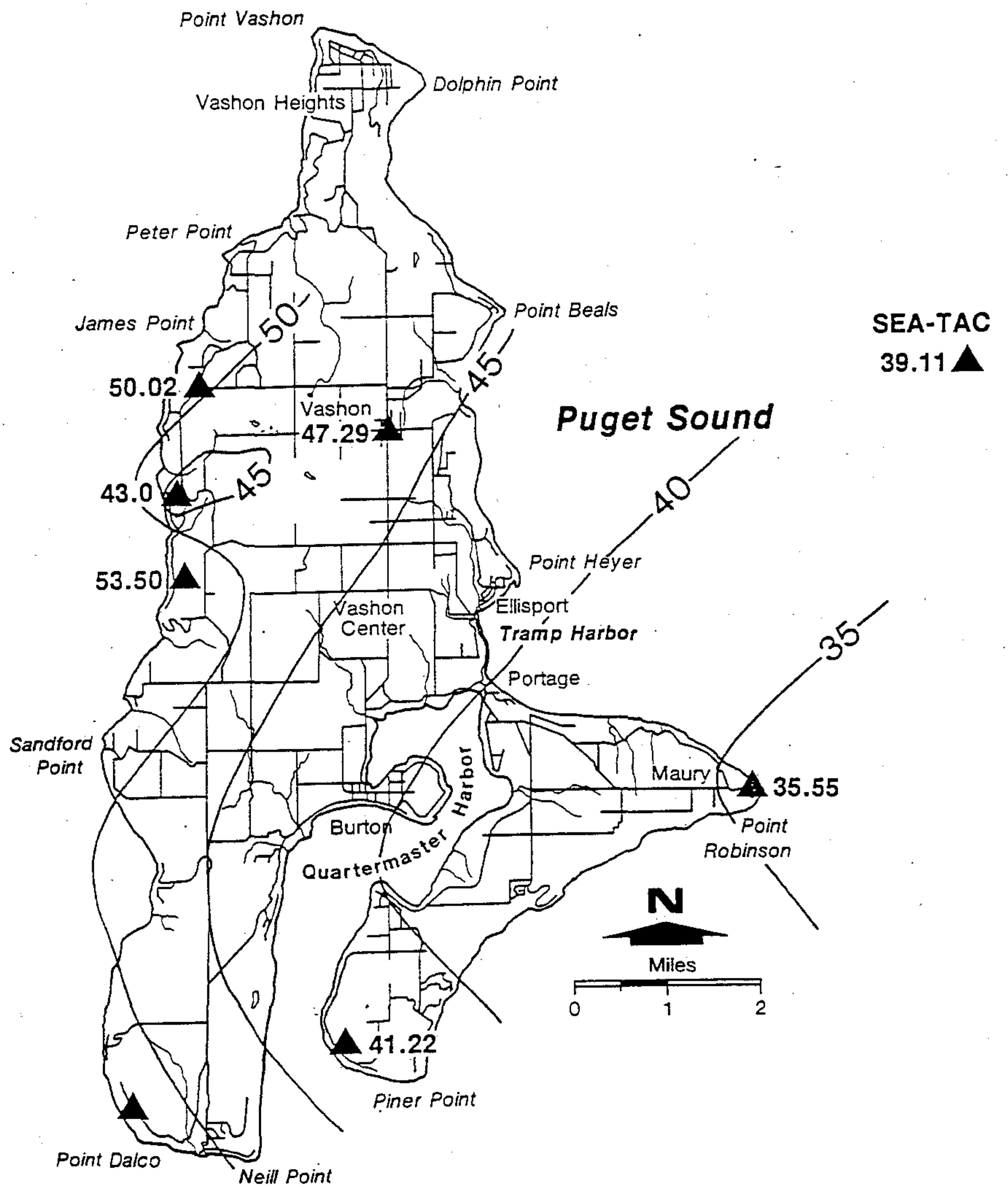
GERAGHTY & MILLER, INC.
Environmental Services

GROUND WATER MANAGEMENT AREA

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE **2.1**

156186



SOURCE: Carr 1983.

DRAFTER: SAC | APPROVED: LER | CHECKED: | DRAWING: | FILE NO.: | PRJCT NO.: WA028.02 | DWG DATE: MAR 1993

GERAGHTY & MILLER, INC.
Environmental Services

ISOHYETAL (TOTAL PRECIPITATION) MAP, 1981 - 1982

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE
4.1

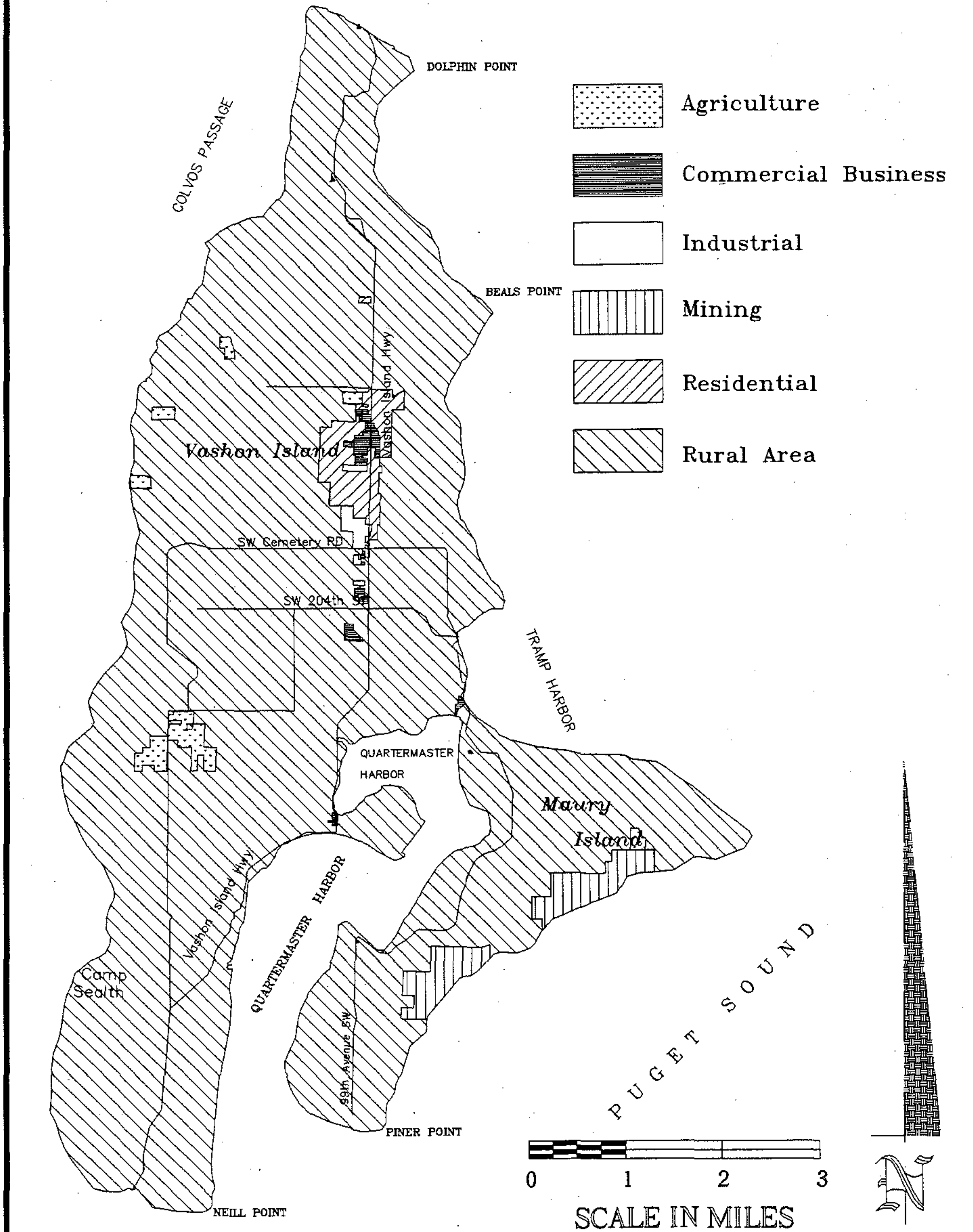


Figure 5.1.a. Existing Land Use

source: Surface Water Management, Geographical Information Systems
date: July 11, 1996

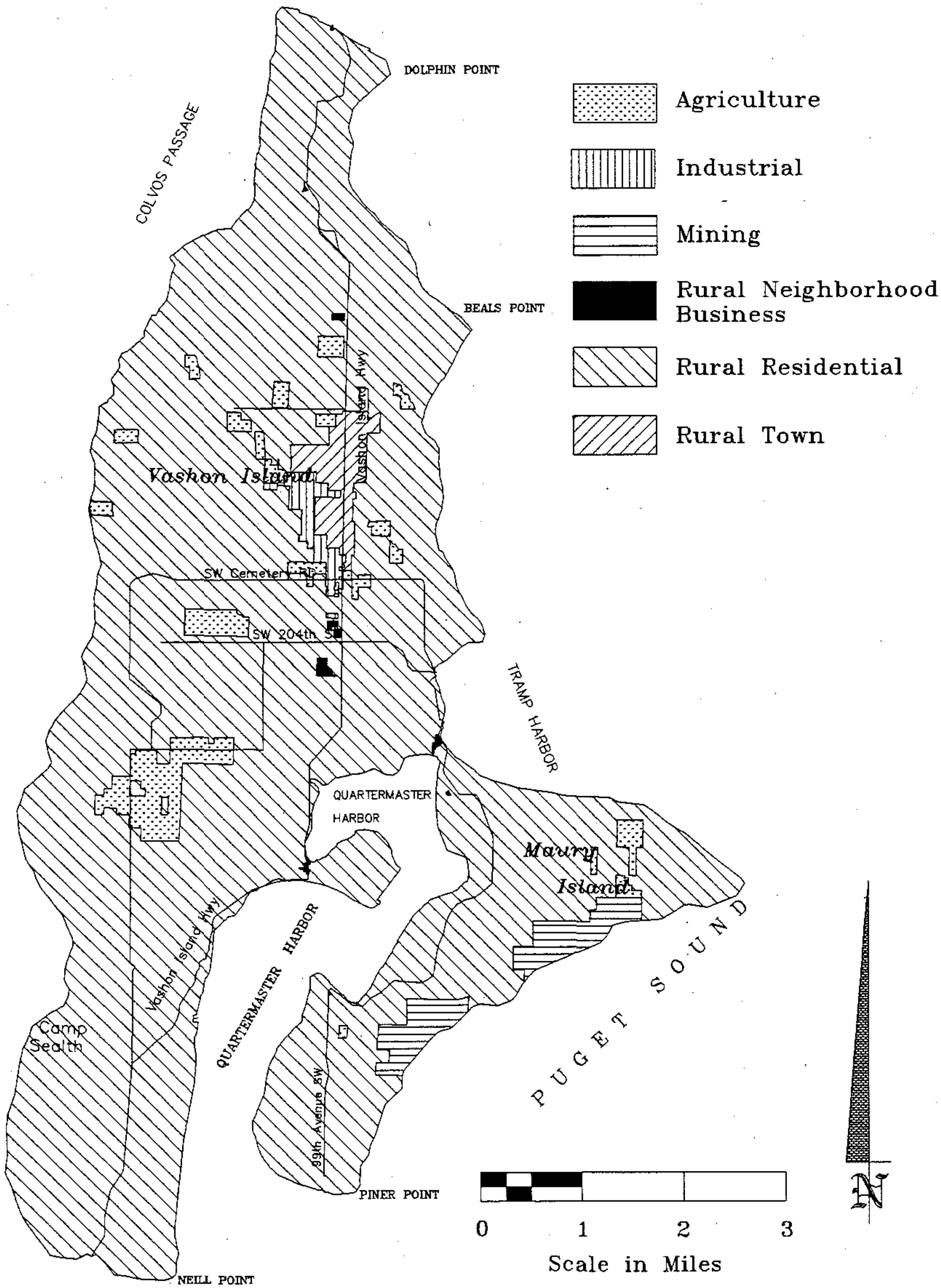
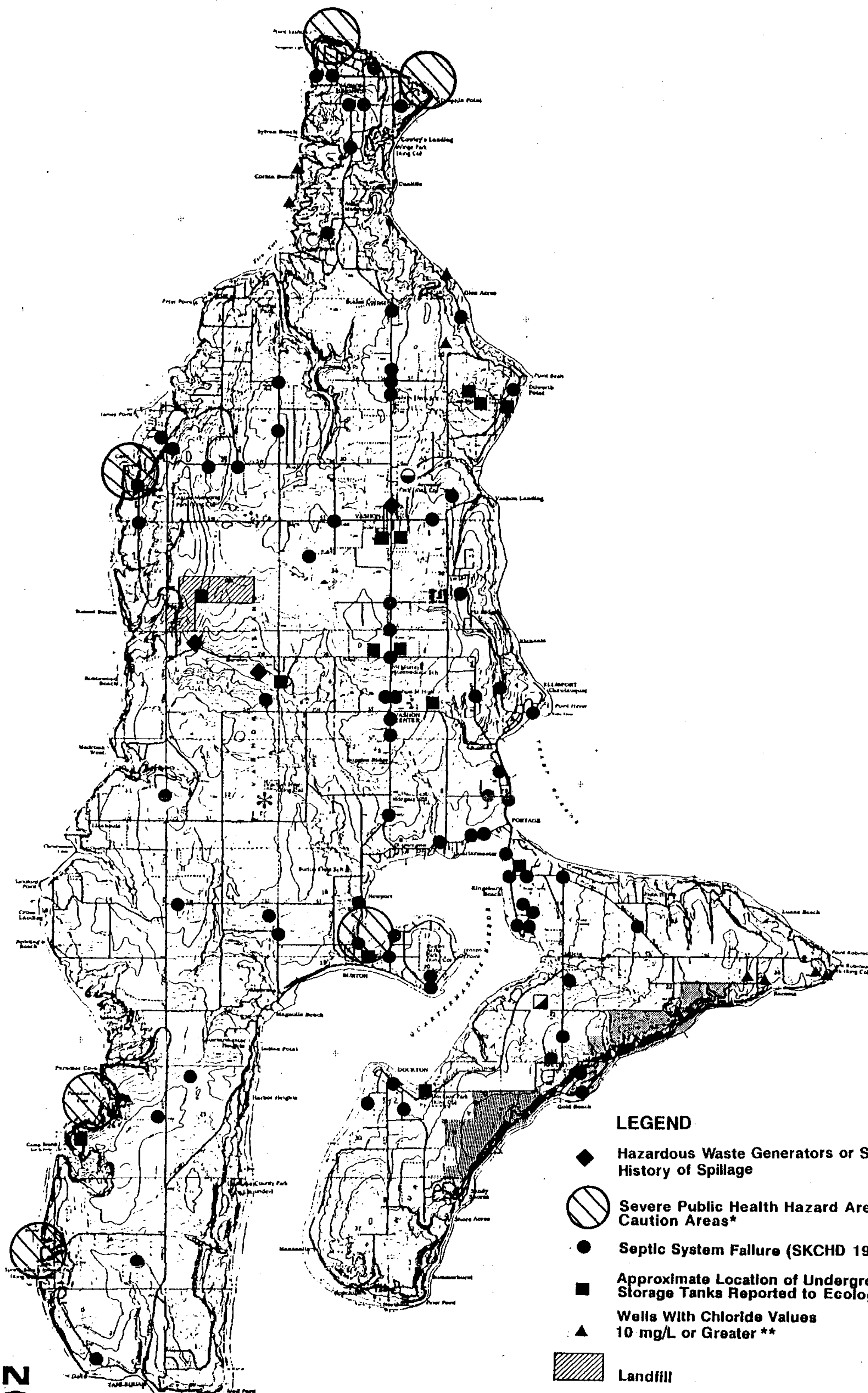


Figure 5.1.b. Future Land Use

source: Surface Water Management, Geographic Information System
date: July 11, 1996

DWG DATE: MAR 1994	PRJCT NO.:WA0028.008	FILE NO.:	DRAWING:	CHECKED:	APPROVED: LER	DRAFTER: SAC

163135



N

0 1 2

Approximate Scale in Miles

NOTE: Some potential point sources of contamination may not be shown.

* Health hazard and caution areas reported in PEI/Barrett 1992.

** Chloride values from data reported in Carr 1983.

MODIFIED FROM: Geraghty & Miller 1990.

LEGEND

- ◆ Hazardous Waste Generators or Sites With History of Spillage
- Severe Public Health Hazard Area/Health Caution Areas*
- ● Septic System Failure (SKCHD 1987)
- ■ Approximate Location of Underground Storage Tanks Reported to Ecology
- ▲ Wells With Chloride Values 10 mg/L or Greater **
- Landfill
- Quarrying
- * Former NIKE Missile Site
- Golf Course
- Vashon Sewage Treatment Plant

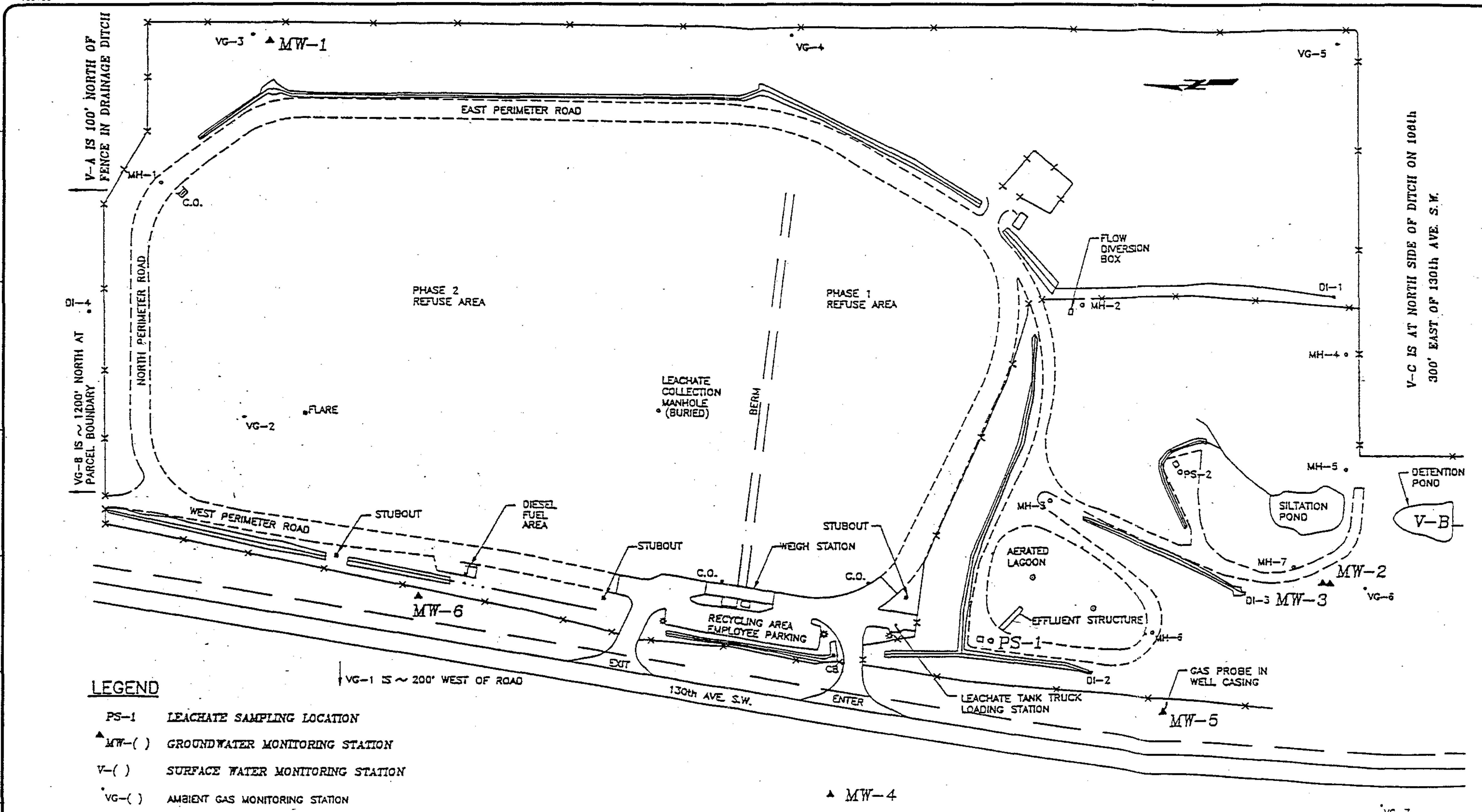
GERAGHTY & MILLER, INC.
Environmental Services

POTENTIAL POINT SOURCES OF CONTAMINATION

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE 5.1c

163135



SOURCE: Harding Lawson 1991.

GERAGHTY & MILLER, INC.
Environmental Services

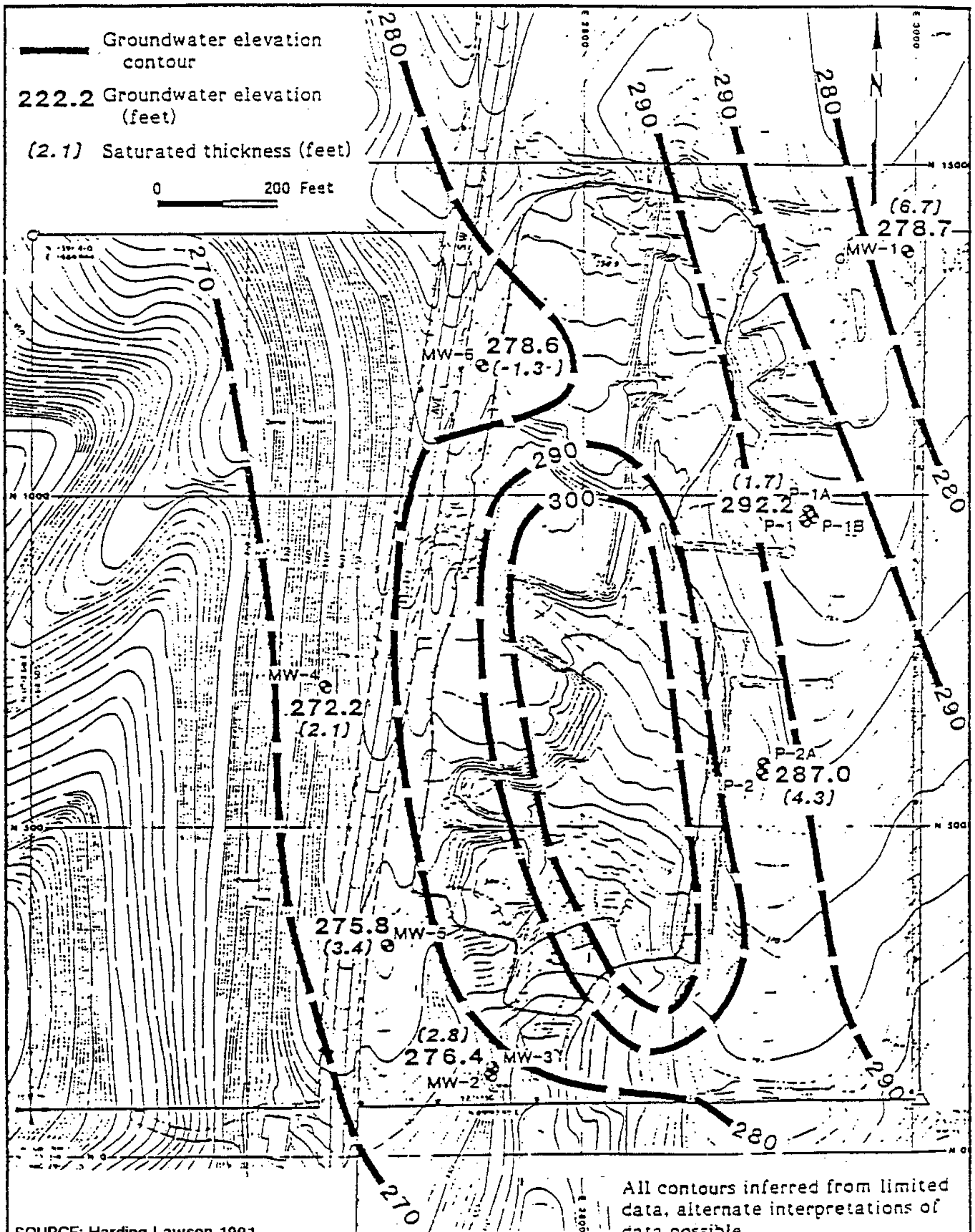
VASHON ISLAND LANDFILL SAMPLING LOCATIONS

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE 5.2

DWG DATE: MAR 1993 | PRJCT NO.: WA028.02 | FILE NO.: | DRAWING: | CHECKED: | APPROVED: LER | DRAFTER: SAC

156186



DRAFTER: SAC | APPROVED: LER | CHECKED: | DRAWING: | FILE NO.: | PRJCT NO.: WA028.02 | DWG DATE: MAR 1993

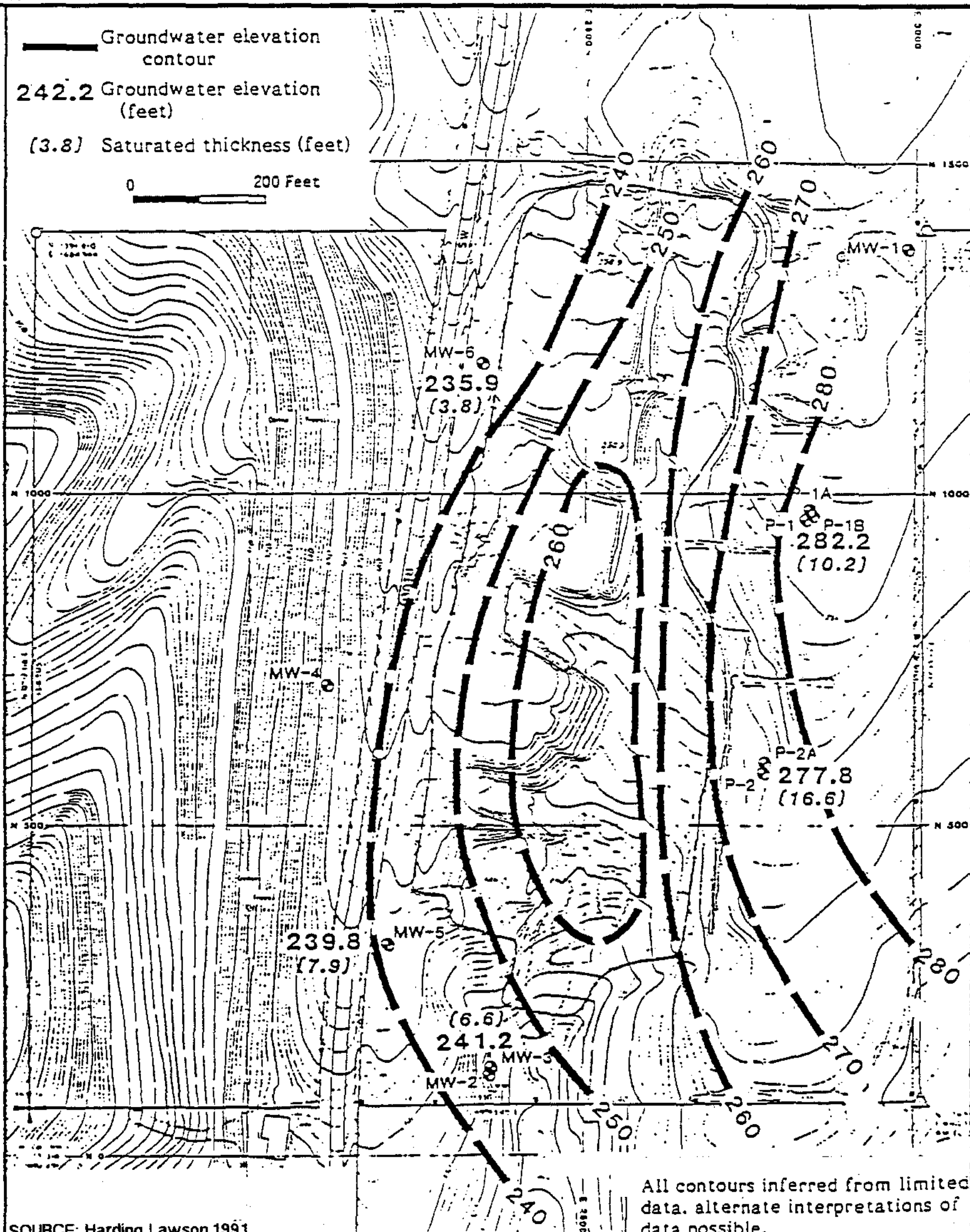
GERAGHTY & MILLER, INC.
Environmental Services

GROUND WATER ELEVATIONS OF UPPER GROUND WATER ZONE FOR VASHON LANDFILL

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE 5.3

156186



DRAFTER: SAC | APPROVED: LER | CHECKED: | DRAWING: | FILE NO.: | PRJCT NO.: WA028.02 | DWG DATE: MAR 1993

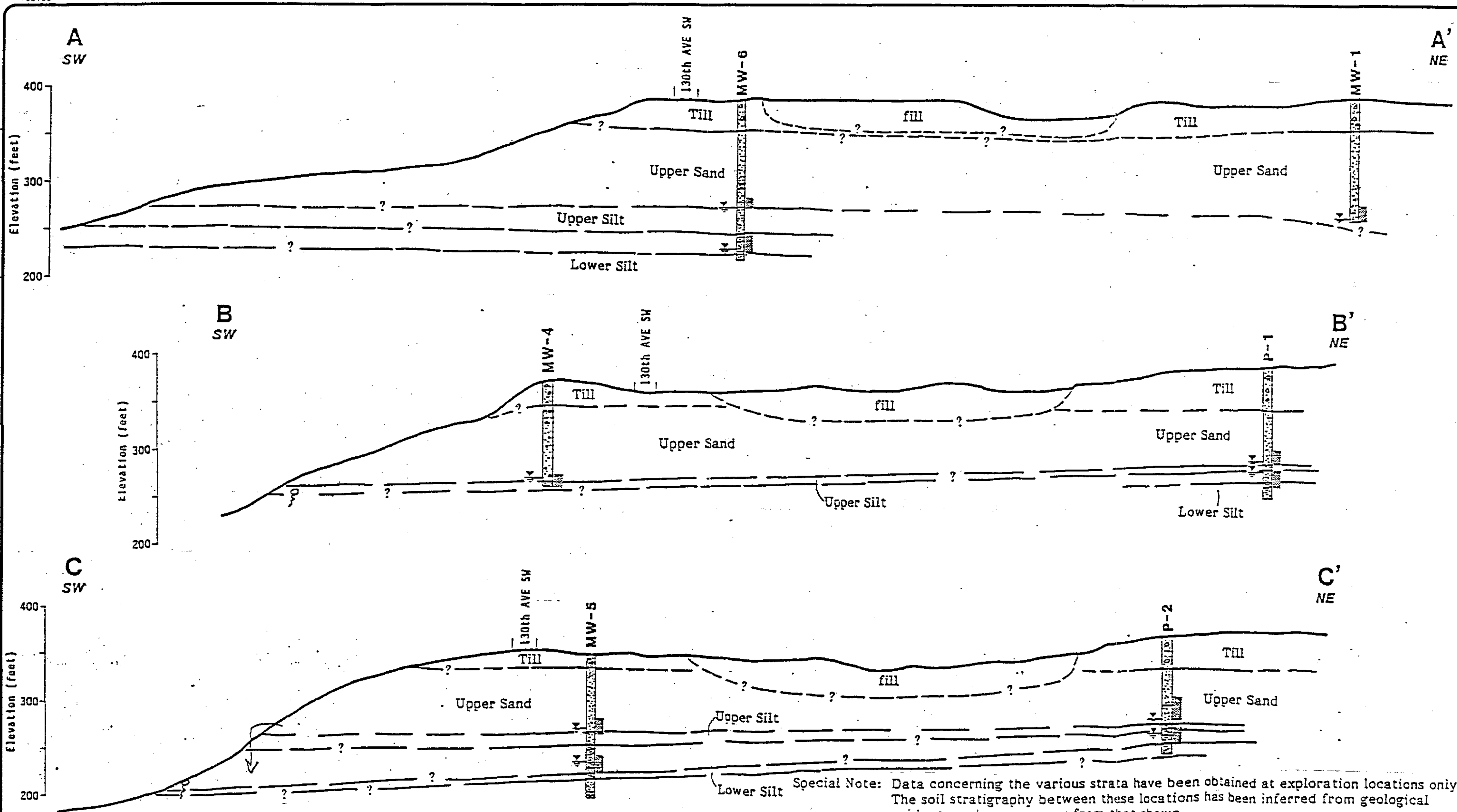
GERAGHTY & MILLER, INC.
Environmental Services

GROUND WATER ELEVATIONS OF LOWER GROUND WATER ZONE FOR VASHON LANDFILL

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE 5.4

163135



DRAFTER: SAC
APPROVED: LER
CHECKED:
DRAWING:
FILE NO:
PRJCT NO: WA028.02
DWG DATE: MAR 1993

Contact, dashed where inferred
Measured water level
Spring
Gravel Pack Interval

0 500 1000 Feet

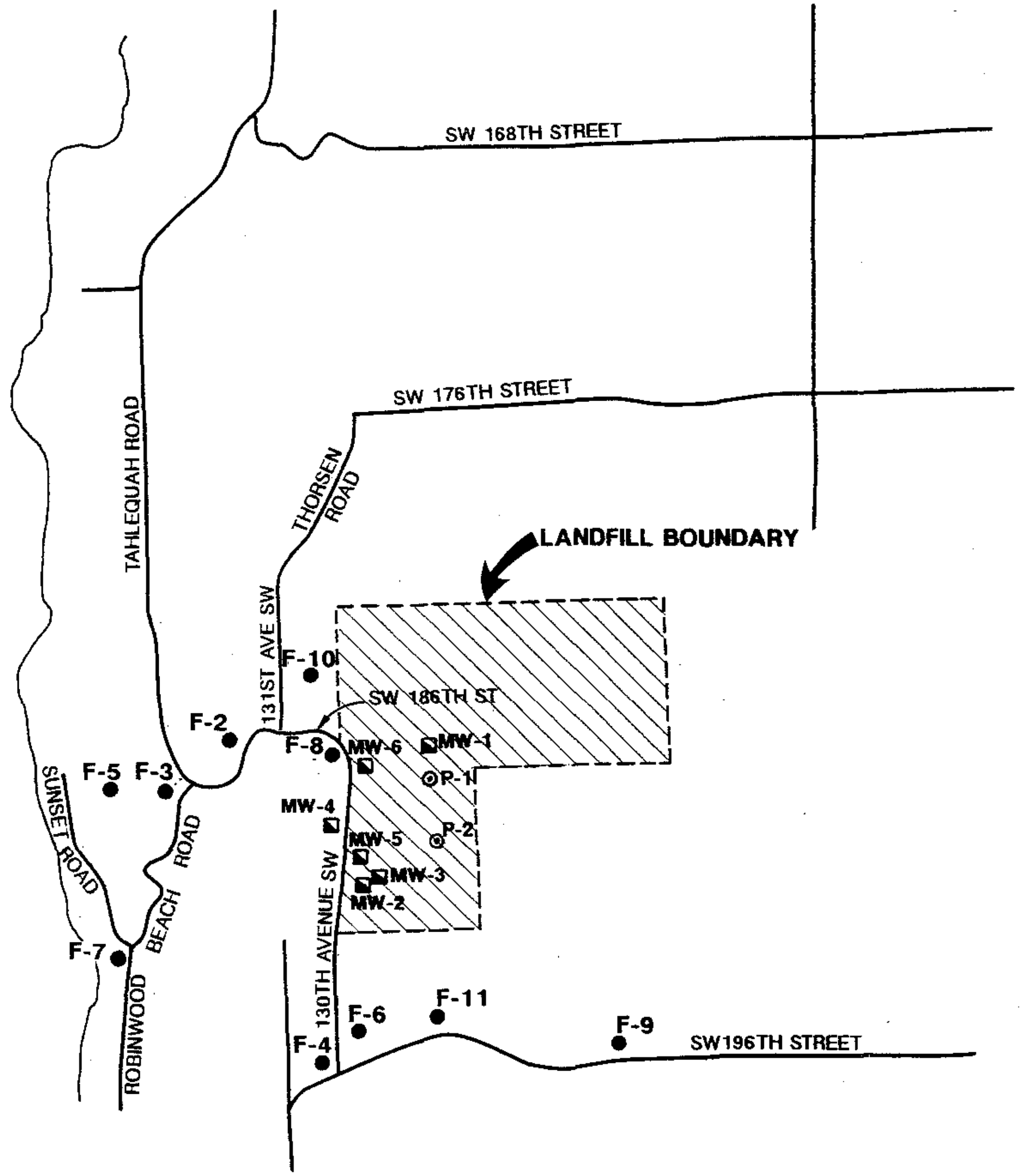
SOURCE: Harding Lawson 1991.

GERAGHTY & MILLER, INC.
Environmental Services

GEOLOGIC CROSS SECTIONS
VASHON LANDFILL
VASHON GROUND WATER MANAGEMENT PLAN

FIGURE
5.5

163135



LEGEND

F-2 ●	Sampling Location Outside Vashon Landfill
MW-1 ◪	Monitoring Well Inside Vashon Landfill
P-1 ⊙	Piezometer Inside Vashon Landfill

N

NO SCALE

SOURCE: SKCHD 1993.

GERAGHTY & MILLER, INC.
Environmental Services

SAMPLING LOCATIONS OUTSIDE OF VASHON LANDFILL

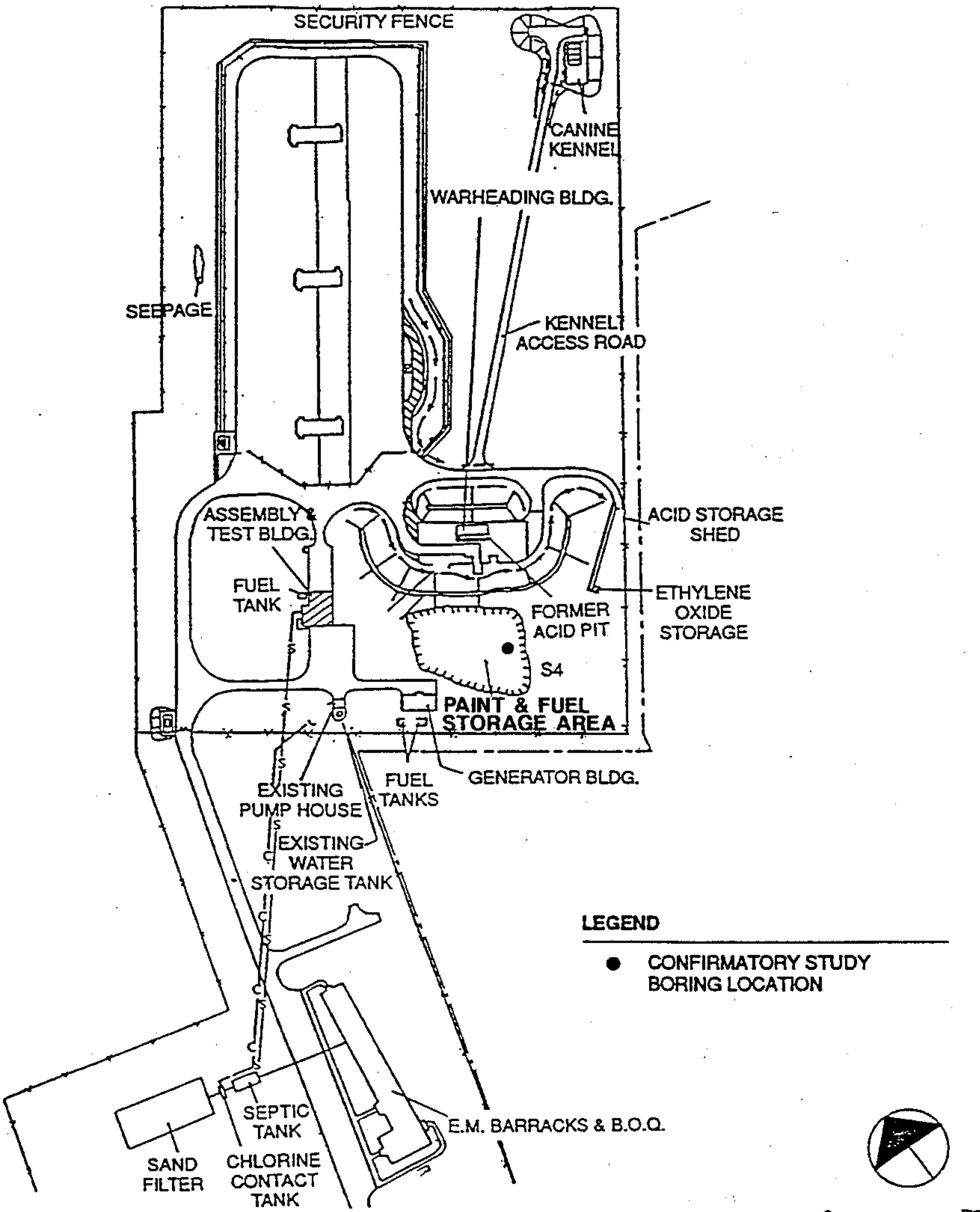
VASHON GROUND WATER MANAGEMENT PLAN

FIGURE

5.6

DWG DATE: APR 1993 | PRJCT NO.: WA028.02 | FILE NO.: | DRAWING: | CHECKED: | APPROVED: LER | DRAFTER: SAC

156186



SOURCE: SHAPIRO 1992

DRAFTER: SAC | APPROVED: LER | CHECKED: | DRAWING: | FILE NO.: | PRJCT NO.: WA028.02 | DWG DATE: MAR 1993

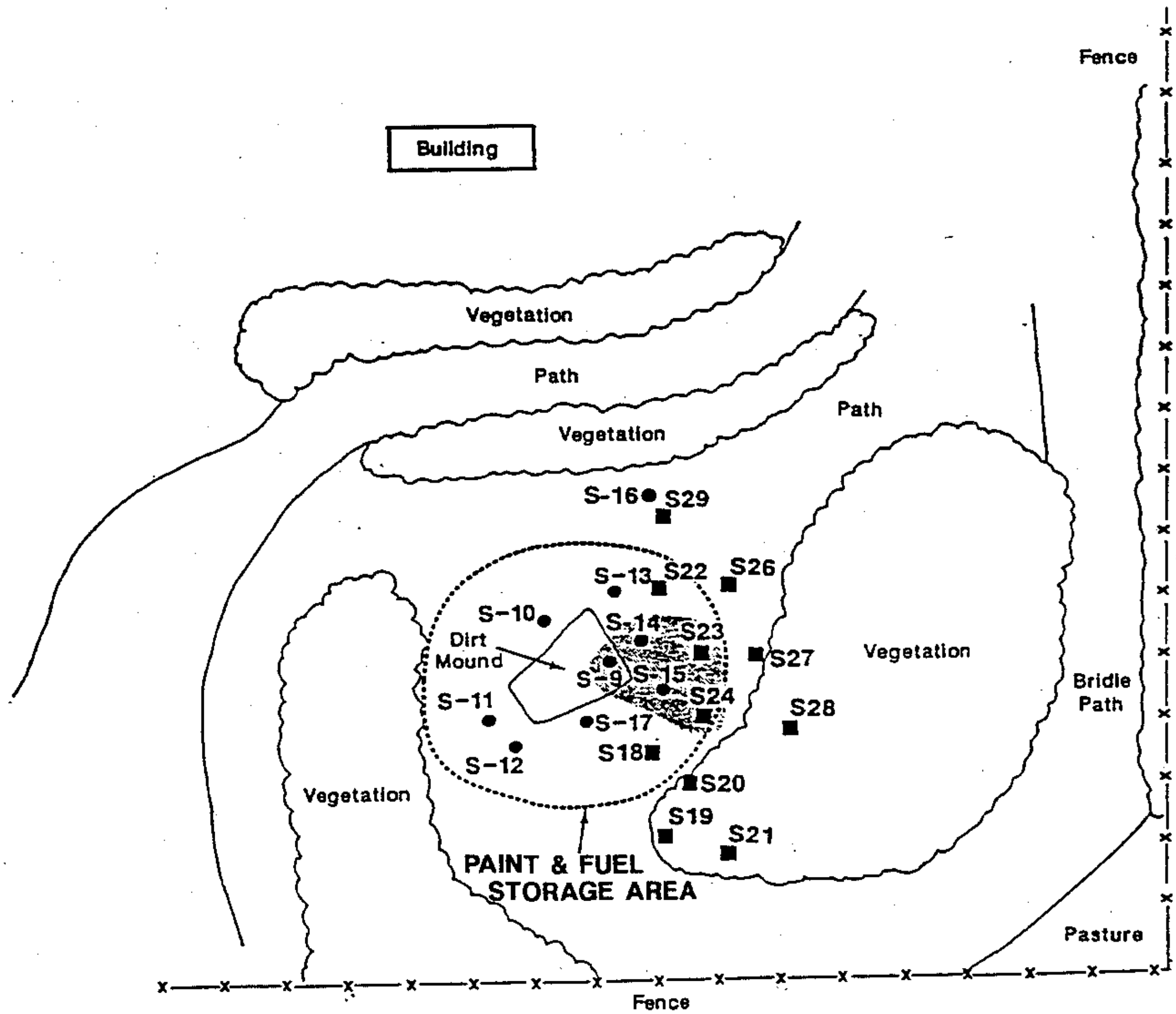
GERAGHTY & MILLER, INC.
Environmental Services

LAUNCH SITE MAP
FORMER NIKE MISSILE SITE
VASHON GROUND WATER MANAGEMENT PLAN

FIGURE
5.7

156186

DRAFTER: SAC | APPROVED: LER | CHECKED: | DRAWING: | FILE NO.: | PRJCT NO.: WA028.02 | DWG DATE: MAR 1993

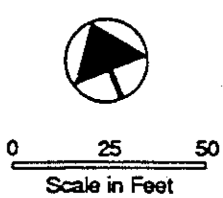


LEGEND

S-11 ● Soil Boring number & approximate location

S23 ■ USACE Test Pit number & approximate location

Approximate horizontal extent of soil contamination defined by the presence of volatile organic compounds and fuel hydrocarbons above their Method A cleanup levels. Vertical extent of these contaminants vary (see text). This area was estimated using field boring logs and chemical results.



SOURCE: SHAPIRO 1992

GERAGHTY & MILLER, INC.
Environmental Services

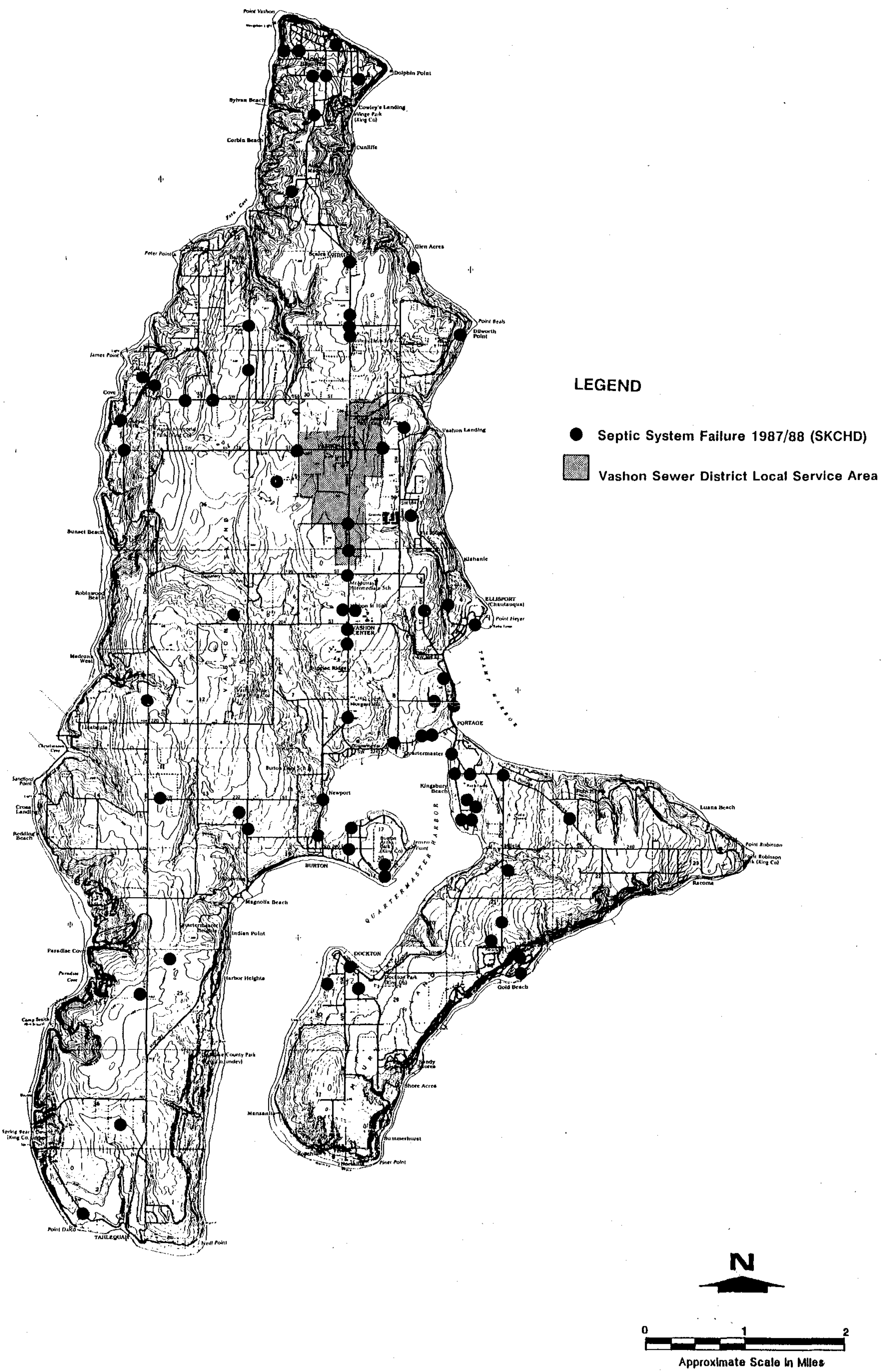
EXTENT OF SOIL CONTAMINATION
FORMER NIKE MISSILE SITE

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE 5.8

DWG DATE: MAR 1993	PRJCT NO.: WA028.02	FILE NO.:	DRAWING:	CHECKED:	APPROVED: LER	DRAFTER: SAC

163135



SOURCE: Geraghty & Miller 1991

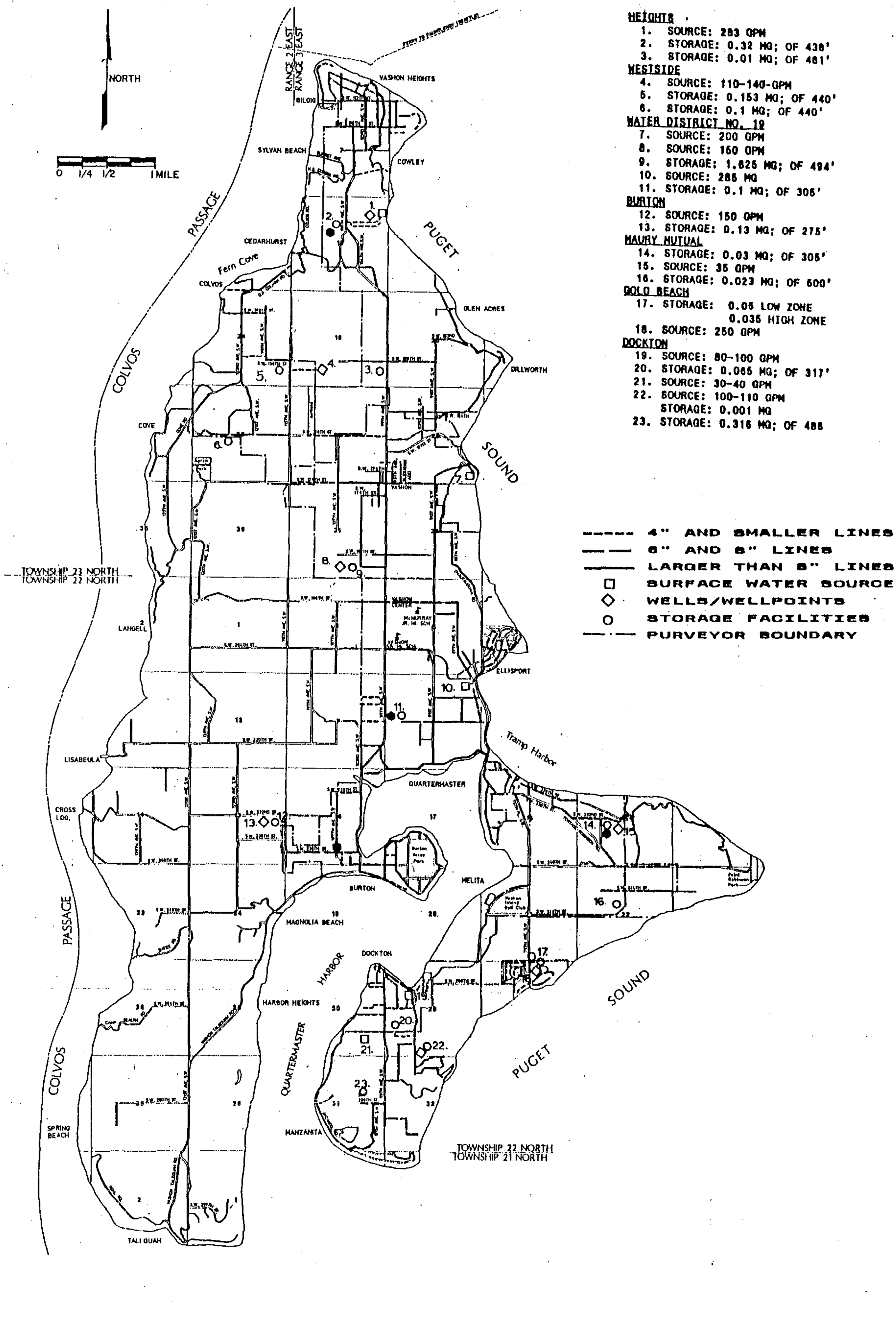
GERAGHTY & MILLER, INC.
Environmental Services

VASHON SEWER DISTRICT LOCAL SERVICE AREA AND SEPTIC SYSTEM FAILURES REPORTED TO SKCHD 1987/88

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE 5.9

DWG DATE: MAR 1993 | PRJCT NO.: WA028.02 | FILE NO.: | DRAWING: | CHECKED: | APPROVED: LER | DRAFTER: SAC



SOURCE: HORTON DENNIS 1989.

GERAGHTY & MILLER, INC.
Environmental Services

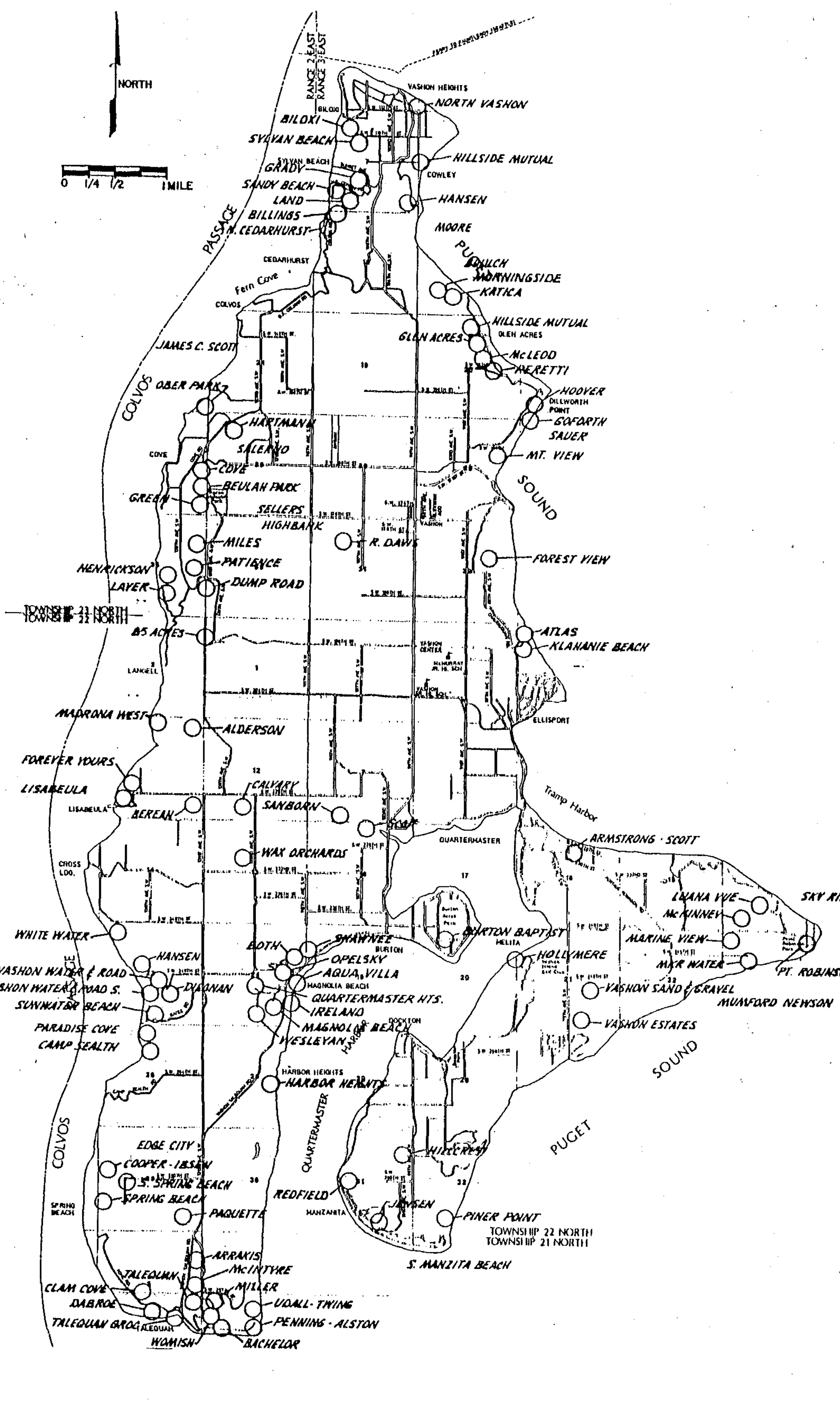
THE SEVEN MAJOR PURVEYORS' WATER SYSTEMS IN THE VASHON GROUND WATER MANAGEMENT AREA: SOURCES, AREAS OF DISTRIBUTION, AND STORAGE FACILITIES

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE 6.1

DWG DATE: MAR 1993 | PRJCT NO.: WA028.02 | FILE NO.: | DRAWING: | CHECKED: | APPROVED: LER | DRAFTER: SAC

163135



SOURCE: HORTON DENNIS 1989

GERAGHTY & MILLER, INC.
Environmental Services

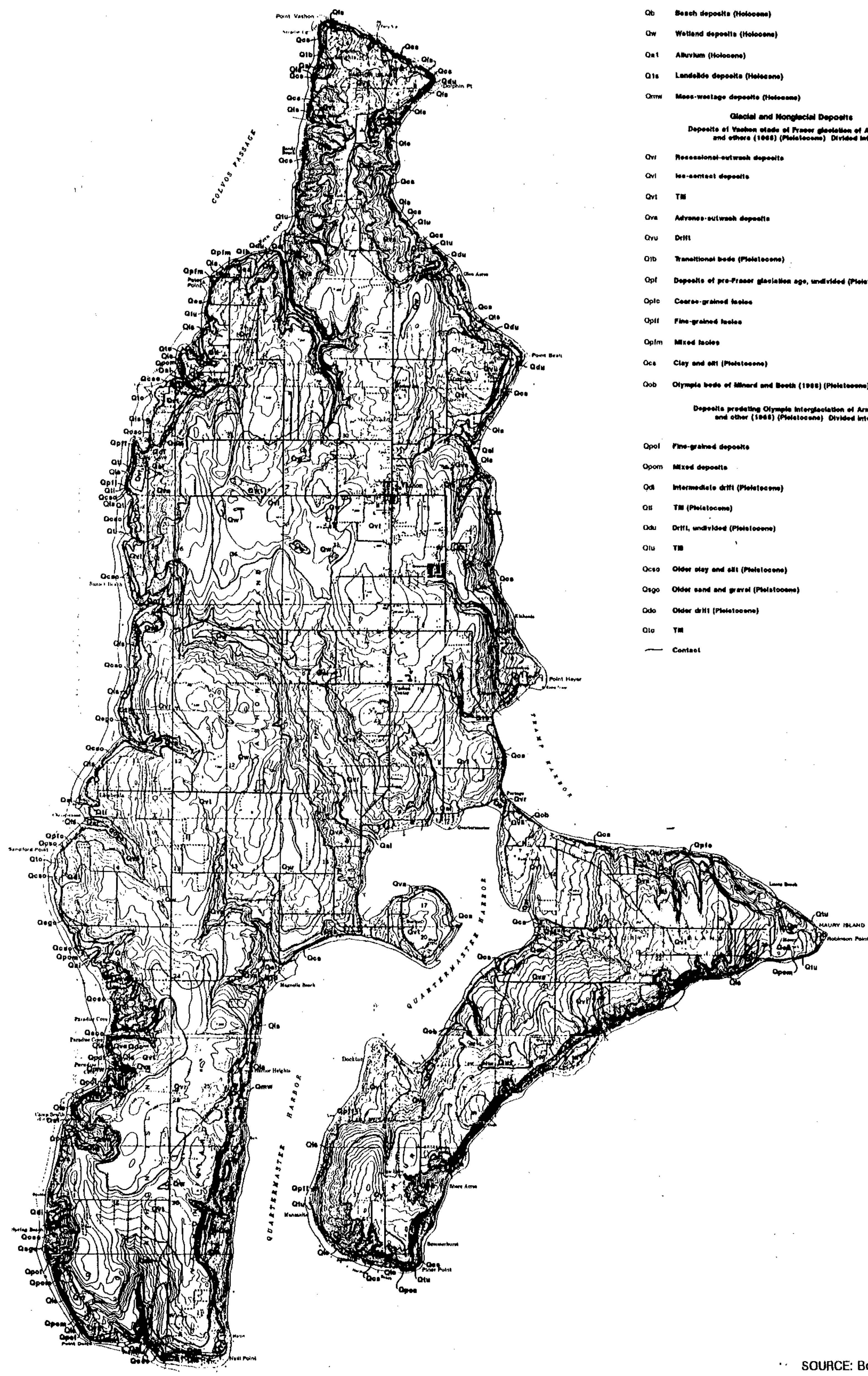
GROUP B WATER SYSTEMS IN THE VASHON GROUND WATER MANAGEMENT AREA: SOURCES, AREAS OF DISTRIBUTION, AND STORAGE FACILITIES

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE **6.2**

DWG DATE:	PRJCT NO.:	FILE NO.:	DRAWING:	CHECKED:	APPROVED:	DRAFTER:

163135



DESCRIPTION OF MAP UNITS

Posglacial Deposits

m	Modified land (Holocene)
Qb	Beach deposits (Holocene)
Qw	Wetland deposits (Holocene)
Qal	Alluvium (Holocene)
Qls	Landslide deposits (Holocene)
Qmw	Mass-wastage deposits (Holocene)

Glacial and Nonglacial Deposits

Deposits of Vashon stade of Fraser glaciation of Armstrong and others (1965) (Pleistocene) Divided into:

Qvr	Recessional-outwash deposits
Qvi	Ice-contact deposits
Qvt	Till
Qva	Advance-outwash deposits
Qvu	Drift
Qtb	Transitional beds (Pleistocene)
Qpf	Deposits of pre-Fraser glaciation age, undivided (Pleistocene)
Qpfc	Coarse-grained facies
Qpff	Fine-grained facies
Qpfm	Mixed facies
Qcs	Clay and silt (Pleistocene)
Qob	Olympia beds of Minard and Booth (1988) (Pleistocene)

Deposits predating Olympia interglaciation of Armstrong and other (1965) (Pleistocene) Divided into:

Qpof	Fine-grained deposits
Qpom	Mixed deposits
Qdi	Intermediate drift (Pleistocene)
Qti	Till (Pleistocene)
Qdu	Drift, undivided (Pleistocene)
Qtu	Till
Qcso	Older clay and silt (Pleistocene)
Qsgo	Older sand and gravel (Pleistocene)
Qdo	Older drift (Pleistocene)
Qto	Till
——	Contact

SOURCE: Booth 1991.

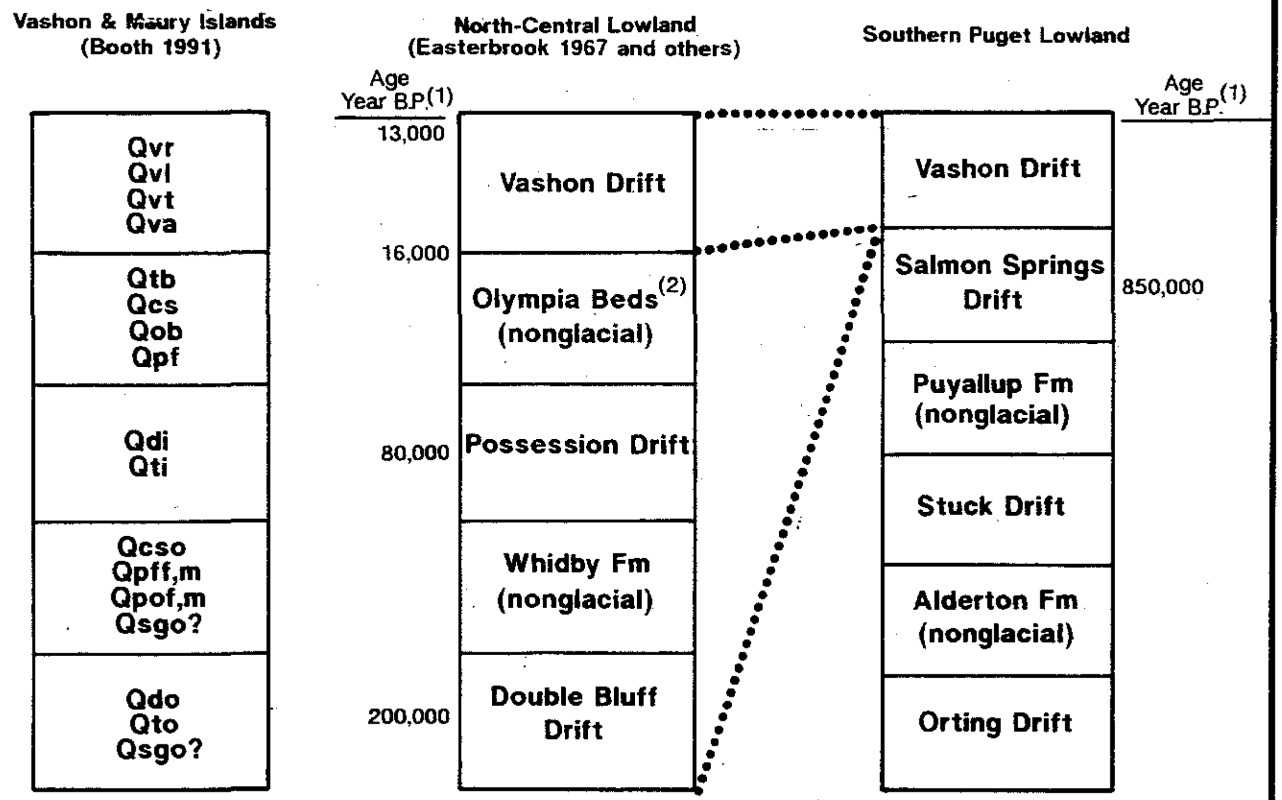
GERAGHTY & MILLER, INC.
Environmental Services

GEOLOGIC MAP OF VASHON ISLAND

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE 8.1

156186



DESCRIPTION OF GEOLOGIC UNITS[3]

Qvr	Recessional-Outwash Deposits
Qvi	Ice-Contact Despoits
Qvt	Till
Qva	Advance-Outwash Deposits
Qtb	Transitional Beds
Qcs	Clay and Silt
Qob	Olympia Beds
Qpf	Pre-Fraser Deposits
Qdi	Intermediate Drift
Qti	Intermediate Till
Qcso	Older Clay and Silt
Qsgo	Older Sand and Gravel
Qdo	Older Drift
Qto	Older Till

Year B.P. - Years before present

(1) All dates from Easterbrook (1986)

(2) Informally named Olympia Beds From Minard and Booth (1988)

(3) See Glossary for description of geologic units

DRAFTER: SAC | APPROVED: MM | CHECKED: | DRAWING: | FILE NO.: | PRJCT NO.: WA0028.00B | DWG DATE: FEB 1994

GERAGHTY & MILLER, INC. *Environmental Services*

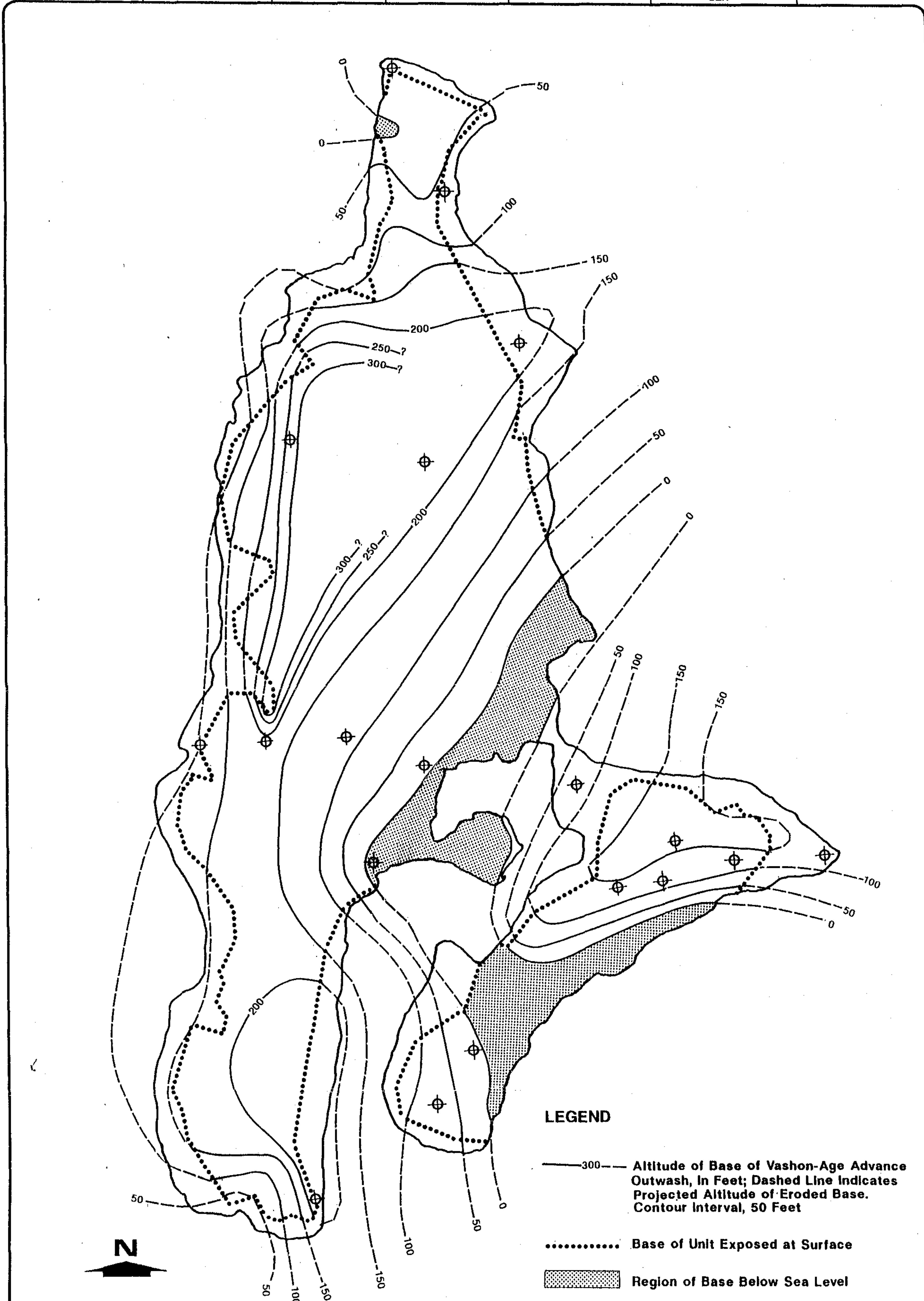
PUGET LOWLAND REGIONAL CORRELATIONS AND SPECULATIVE VASHON AND MAURY ISLAND CORRELATIONS

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE 8.2

Data current as of 1994

DWG DATE: MAR 1993 | PRJCT NO.: WA028.02 | FILE NO.: | DRAWING: | CHECKED: | APPROVED: LER | DRAFTER: SAC



Modified from: Booth, D.B.,1991, Geologic Map of Vashon and Maury Islands, King County, Washington. U.S. Geologic Survey Miscellaneous field studies Map MF-2161.

Map current as of 1991

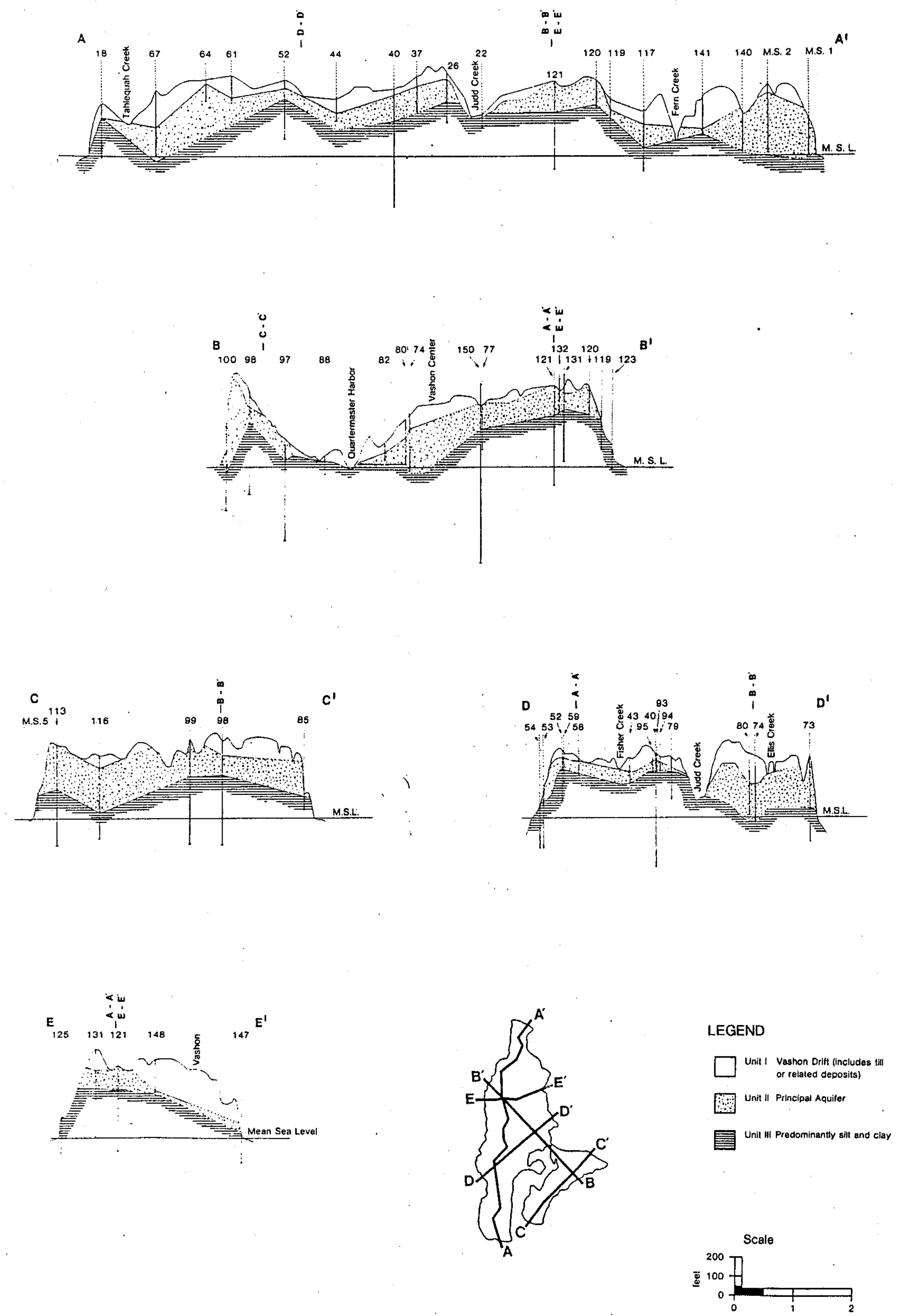
GERAGHTY & MILLER, INC.
Environmental Services

STRUCTURE CONTOUR MAP SHOWING ALTITUDE OF BASE OF VASHON AGE ADVANCE OUTWASH, IN FEET

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE 8.3

DWG DATE: MAR 1994	PRJCT NO.: WA0028.OOB	FILE NO.:	DRAWING:	CHECKED:	APPROVED: LER	DRAFTER: SAC



SOURCE: Carr 1983.

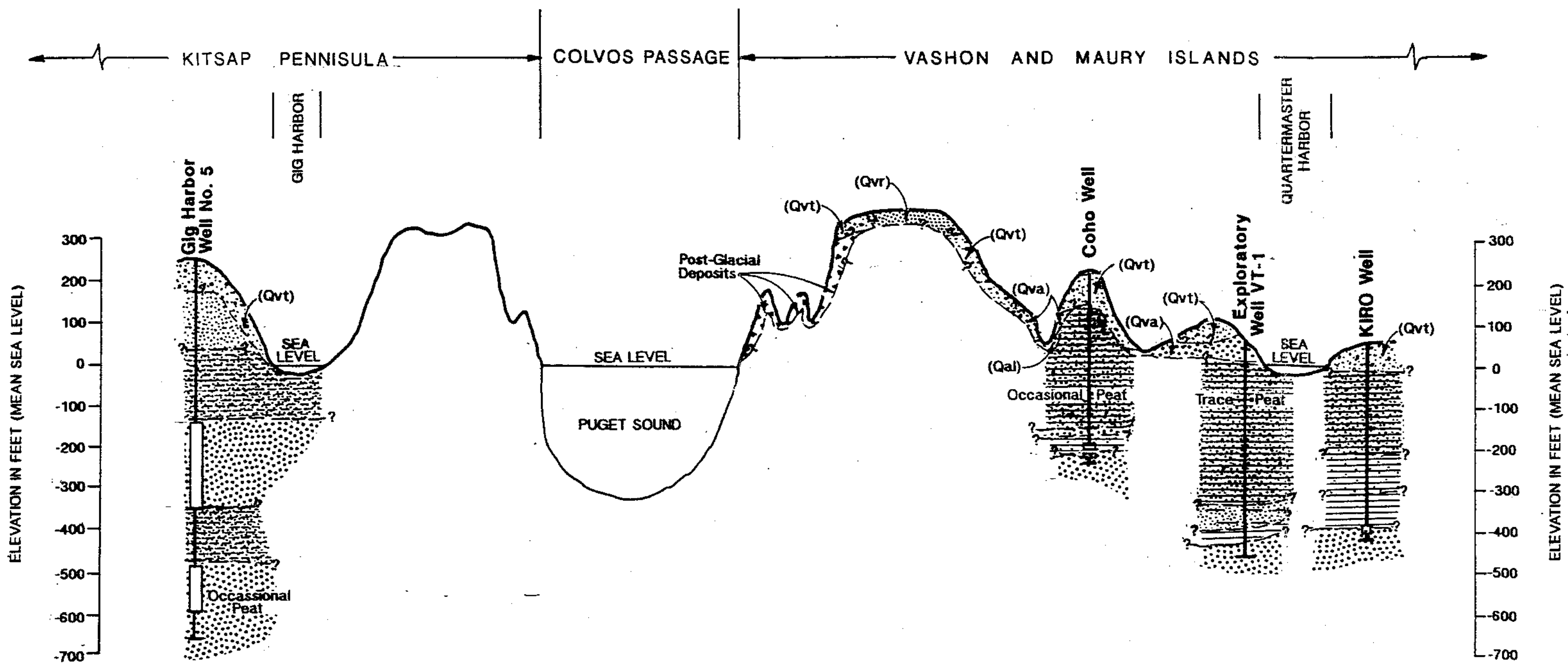
GERAGHTY & MILLER, INC.
Environmental Services

GEOLOGIC CROSS SECTIONS

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE
8.4

163135



SUBSURFACE UNITS LEGEND

- Clay
- Sandy Clay
- Interbedded Silt, Silty Clay and Clay
- Interbedded Silty Sand and Silt
- Sand
- Interbedded Sand, Silt and Sandy/Silty Gravel

Well Screen Interval

?— — —? Approximate Lithologic Contact

NOTE: Gig Harbor Well No. 5 data obtained from Hart Crowser Consultants, report dated May 1990. Coho Well data obtained from Carr/Associates, report dated June 11, 1991. KIRO Well data obtained from State of Washington water well log, dated October 1941.

SCALE: 1" = 1 MILE HORIZONTAL
VERTICAL EXAGGERATION 17.6X

SURFACE UNITS LEGEND

- Post Glacial Deposits: Landslide, mass wasting, beach deposits
- Alluvium (Qal): Cobble, gravel, sand and sandy silt
- Vashon Till (Qvt): Compact diamicton with subangular to rounded clasts
- Advance Outwash (Qva): Well-bedded sandy gravel and fine to medium grained sand
- Recessional Outwash (Qvr): Stratified sandy gravel and fine to medium grained sand

Surface units interpreted from Booth, D.B., 1991. Geologic Map of Vashon and Maury Islands, King County, Washington. U.S. Geologic Survey. Miscellaneous field studies Map MF-2161.

Ground surface elevations from Gig Harbor and Vashon Island, Washington 7.5 Minute U.S.G.S. Topographic Quadrangle Maps, Photorevised 1981 and 1968, respectively.

Map current as of 1993

GERAGHTY & MILLER, INC.
Environmental Services

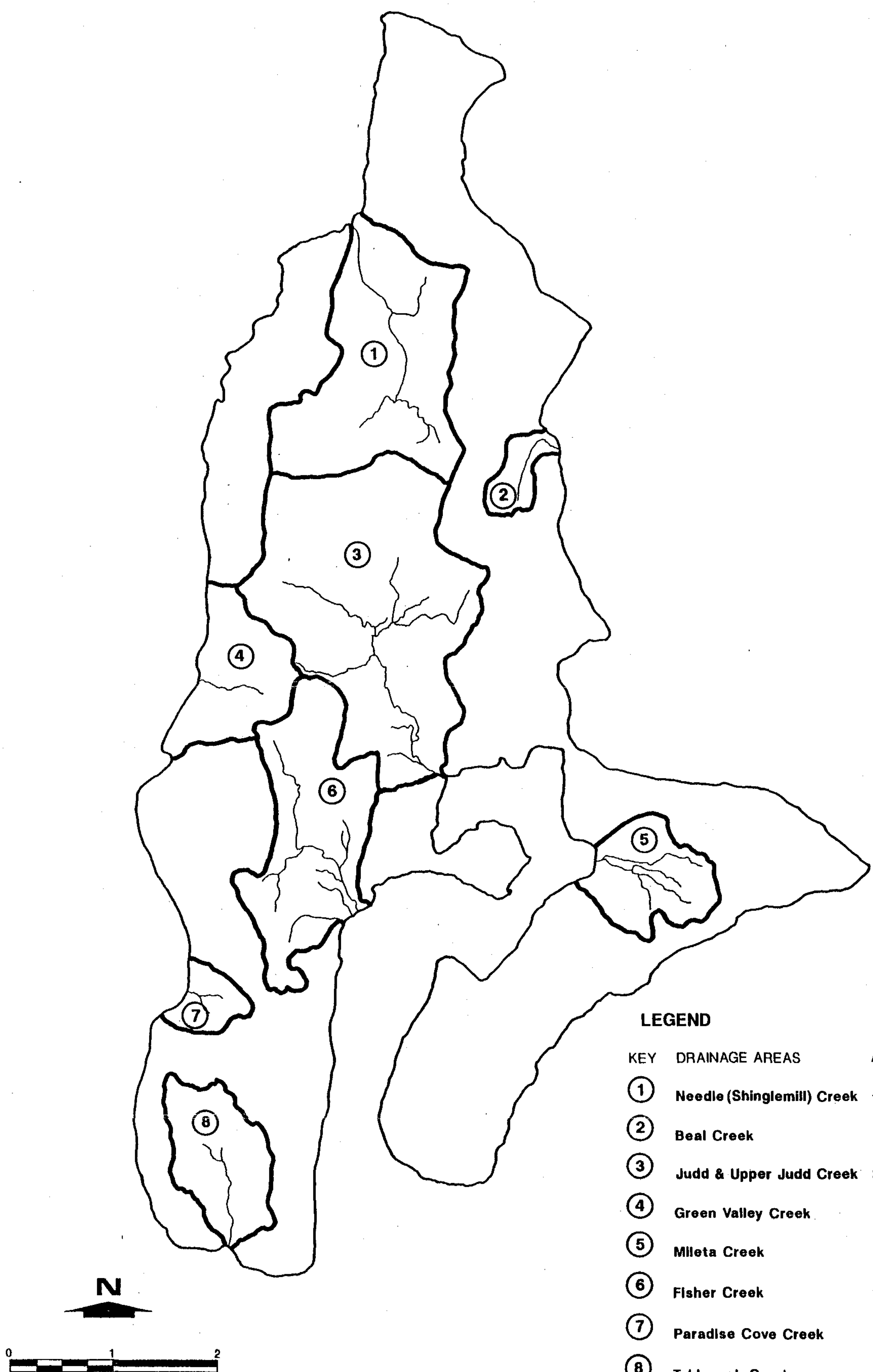
CROSS SECTION A-A' SHOWING HYDROSTRATIGRAPHY OF DEEP PRODUCTION WELLS

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE **8.6**

DRAFTER: SAC | APPROVED: LER | CHECKED: | DRAWING: | FILE NO.: | PRJCT NO.: WA028.02 | DWG DATE: APR 1993

DWG DATE: MAR 1993 | PRJCT NO.: WA028.02 | FILE NO.: | DRAWING: | CHECKED: | APPROVED: LER | DRAFTER: SAC



LEGEND

KEY	DRAINAGE AREAS	ACRES
1	Needle (Shinglemill) Creek	1996
2	Beal Creek	211
3	Judd & Upper Judd Creek	3149
4	Green Valley Creek	762
5	Mileta Creek	700*
6	Fisher Creek	1549
7	Paradise Cove Creek	200*
8	Tahlequah Creek	780

SOURCE: Modified from Carr 1983

* Estimated

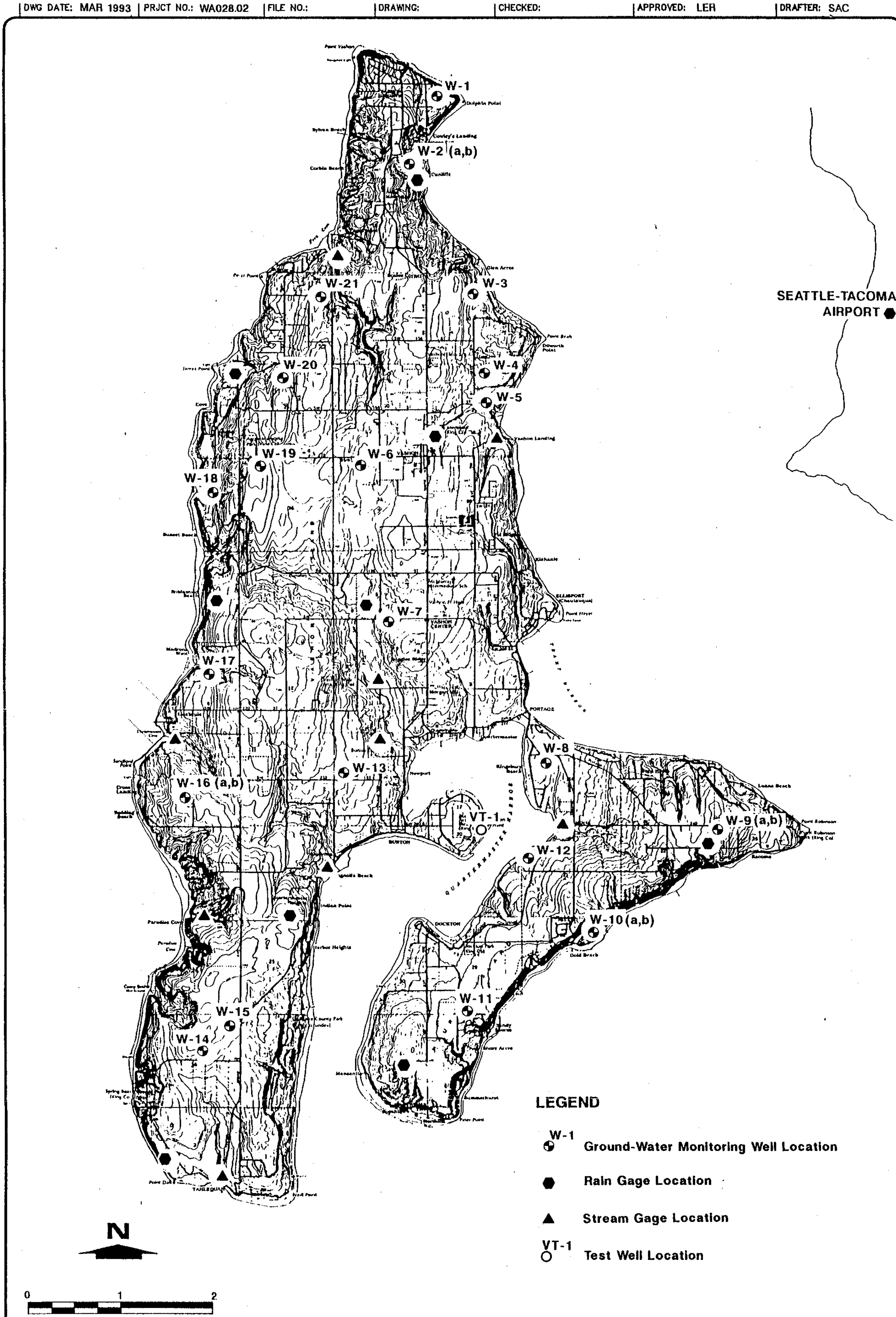
GERAGHTY & MILLER, INC.
Environmental Services

DRAINAGE BASIN MAP

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE 8.7

DWG DATE: MAR 1993	PRJCT NO.: WA028.02	FILE NO.:	DRAWING:	CHECKED:	APPROVED: LER	DRAFTER: SAC



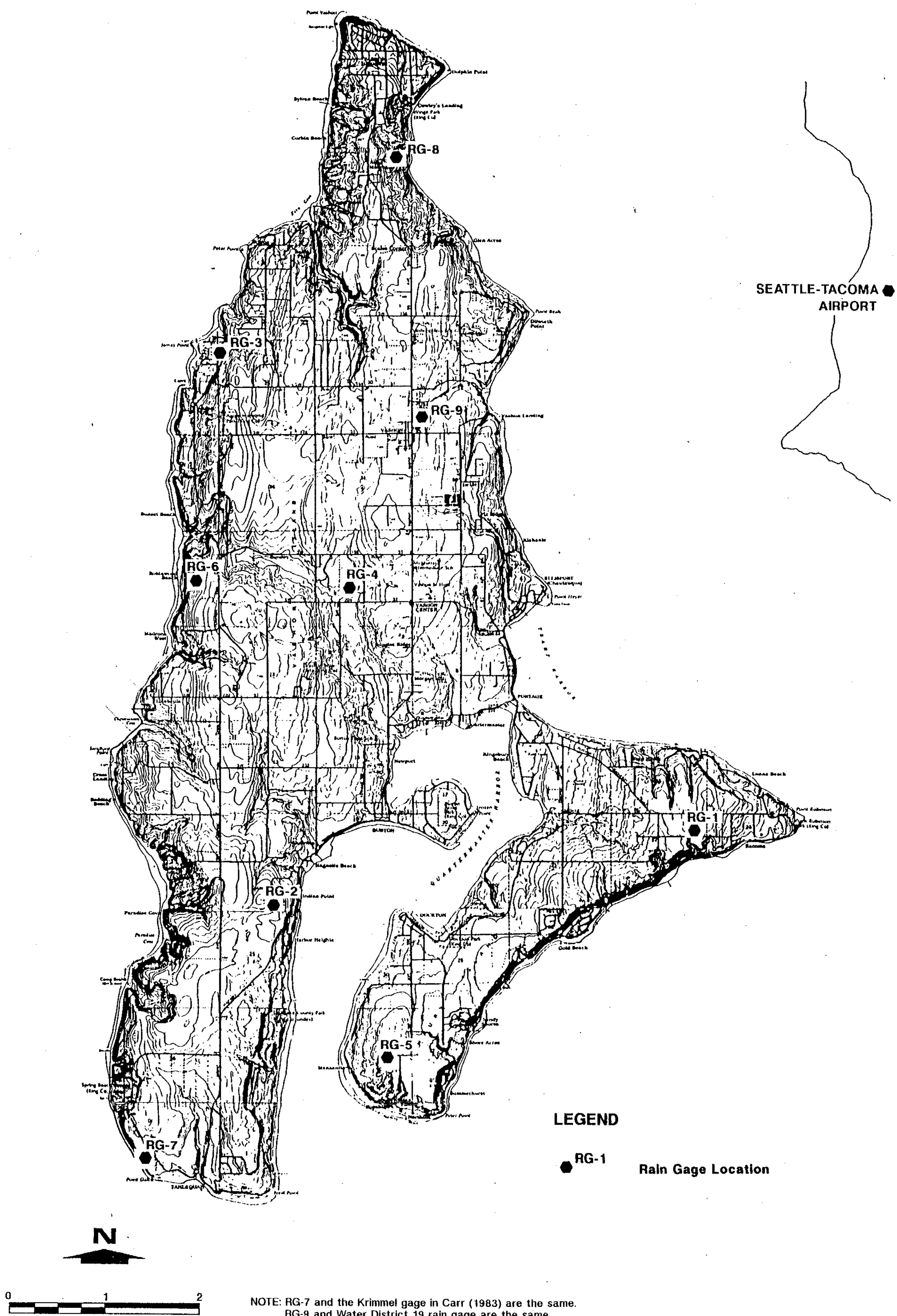
GERAGHTY & MILLER, INC.
Environmental Services

RAIN GAGE, STREAM GAGE, AND WELL LOCATIONS

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE 8.8

DWG DATE: MAR 1994	PRJCT NO.: WA0028.008	FILE NO.:	DRAWING:	CHECKED:	APPROVED: LER	DRAFTER: SAC



NOTE: RG-7 and the Krimmel gage in Carr (1983) are the same.
RG-9 and Water District 19 rain gage are the same.

SOURCE: Geraghty & Miller 1993.

GERAGHTY & MILLER, INC. *Environmental Services*

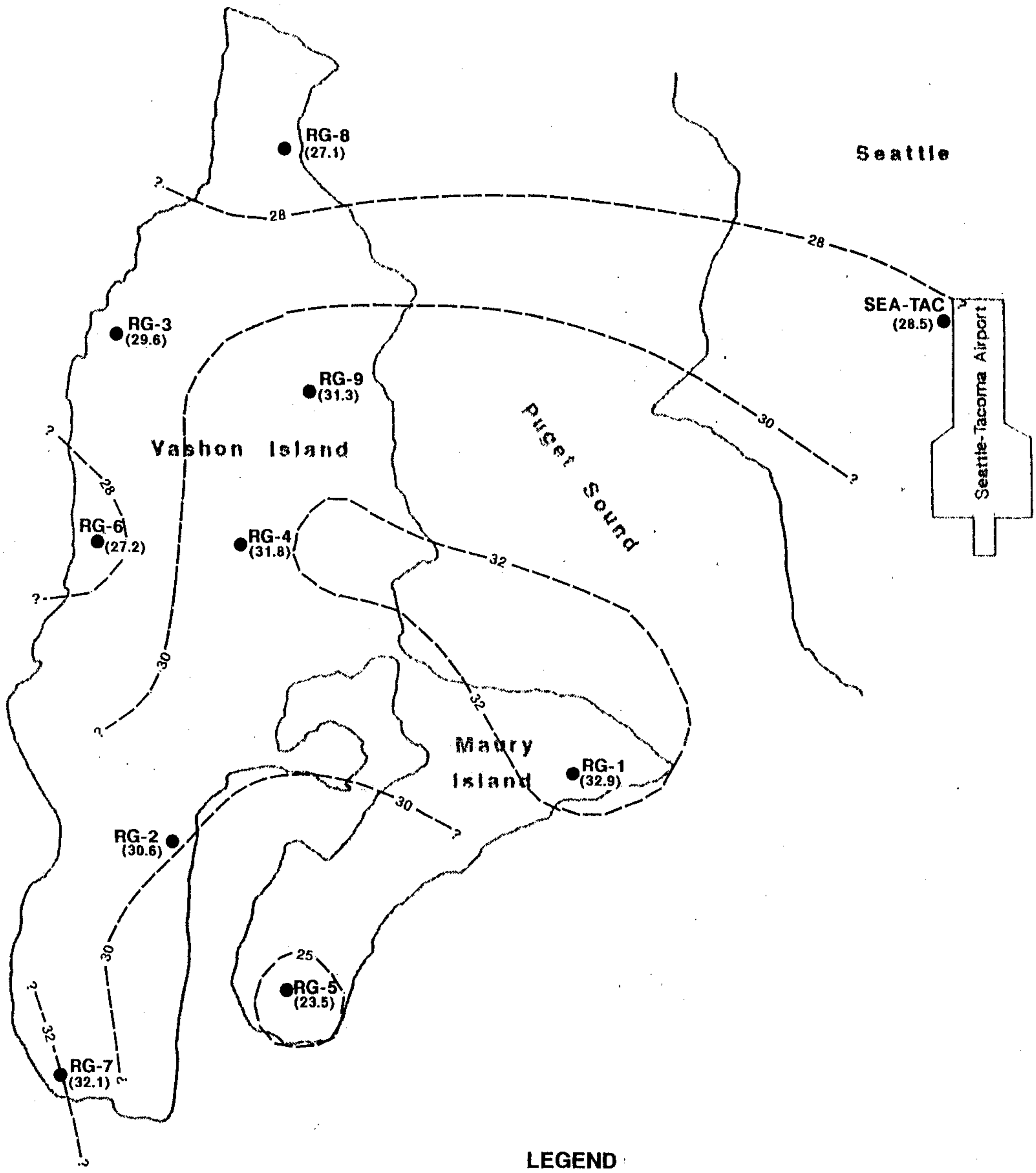
RAIN GAGE LOCATIONS

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE **8.9**

DWG DATE: MAR 1993 | PRJCT NO.: WA028.02 | FILE NO.: | DRAWING: | CHECKED: | APPROVED: LR | DRAFTER: SAC

163135



LEGEND

RG-1 ● Location of Rainfall Gaging Station

(27.2) Total Rainfall Shown in Parentheses;
*Rainfall Data Included Are March-December 1989

-------- Lines of Equal Total Rainfall

N

0 1/2 1 1 1/2 2
Approximate Scale in Miles

SOURCE: Geraghty & Miller 1993.

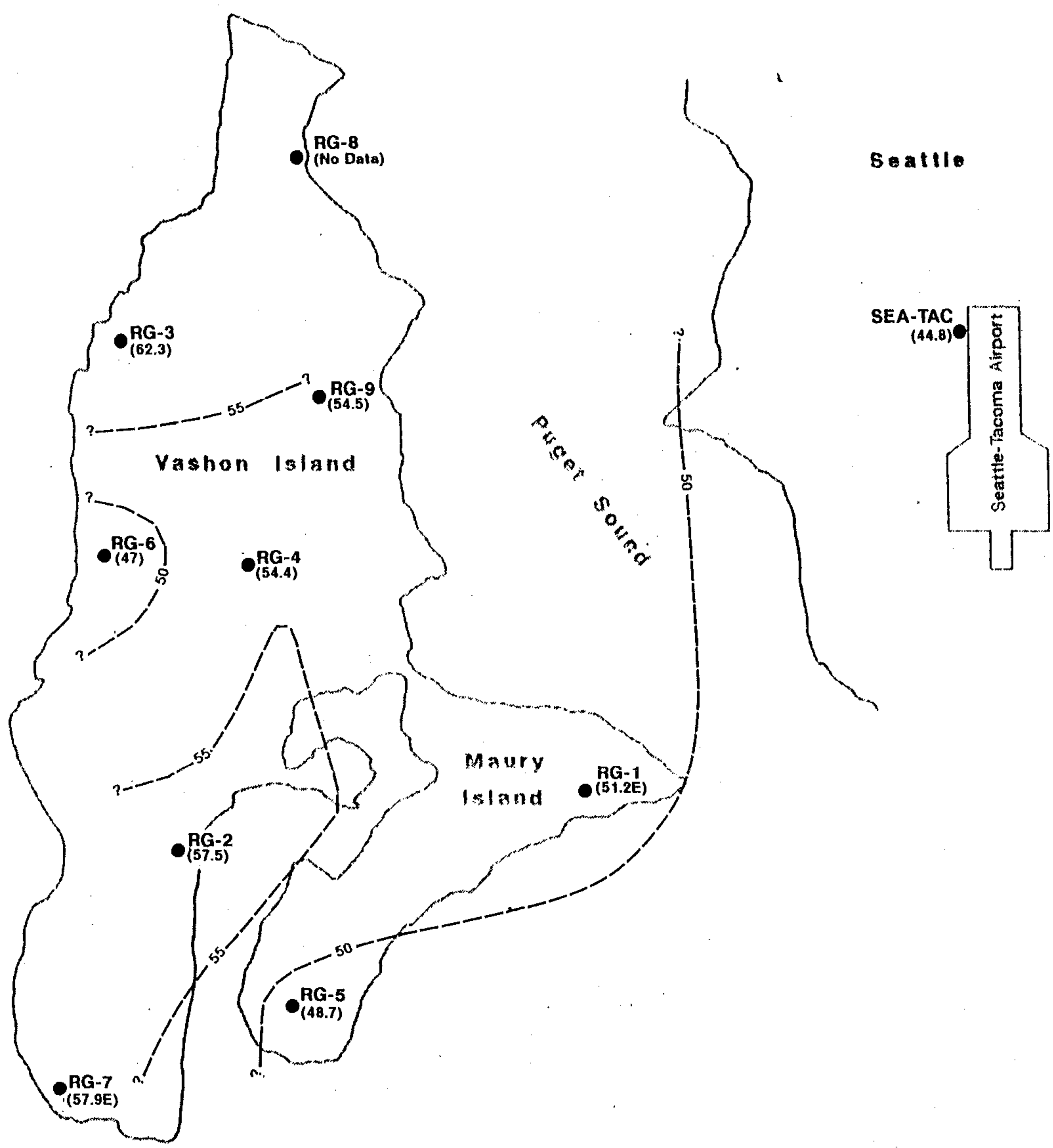
GERAGHTY & MILLER, INC. *Environmental Services*

1989 ISOHYETAL (TOTAL RAINFALL) MAP*

VASHON GROUND WATER MANAGEMENT PLAN

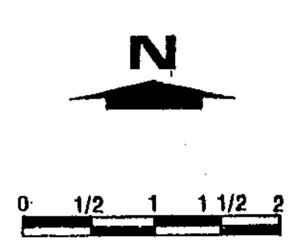
FIGURE **8.10**

DWG DATE: MAR 1993 | PRJCT NO.: WA028.02 | FILE NO.: | DRAWING: | CHECKED: | APPROVED: LR | DRAFTER: SAC



LEGEND

● RG-1	Location of Rainfall Gaging Station
(62.3)	Total Annual Rainfall Shown in Parentheses; Qualified with E Where Estimated Data Are Included
— — —	Lines of Equal Total Rainfall



SOURCE: Geraghty & Miller, 1993.

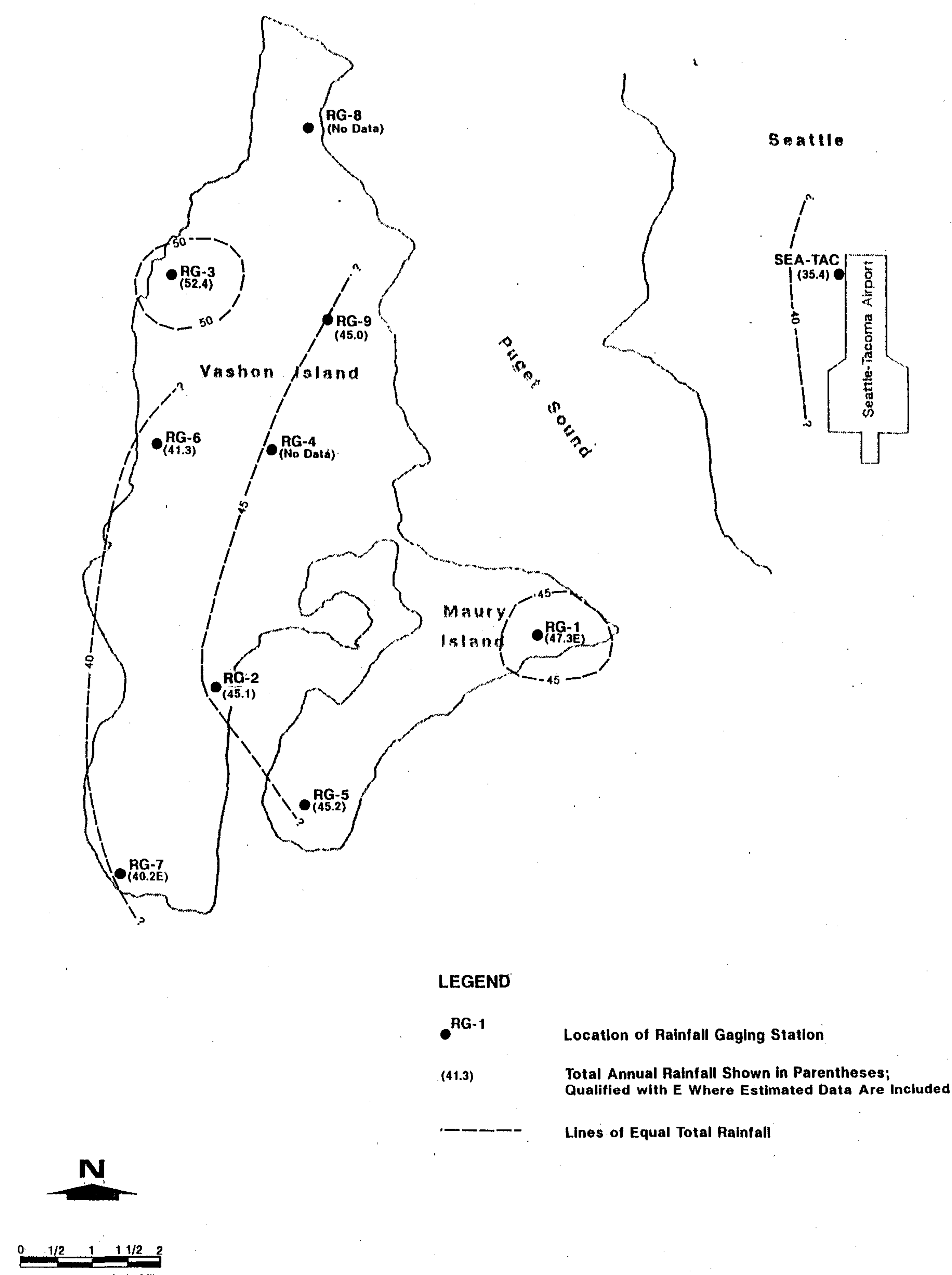
GERAGHTY & MILLER, INC.
Environmental Services

1990 ISOHYETAL (TOTAL RAINFALL) MAP

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE **8.11**

DWG DATE: MAR 1993 | PRJCT NO.: WA028.02 | FILE NO.: | DRAWING: | CHECKED: | APPROVED: LR | DRAFTER: SAC



SOURCE: Geraghty & Miller 1993

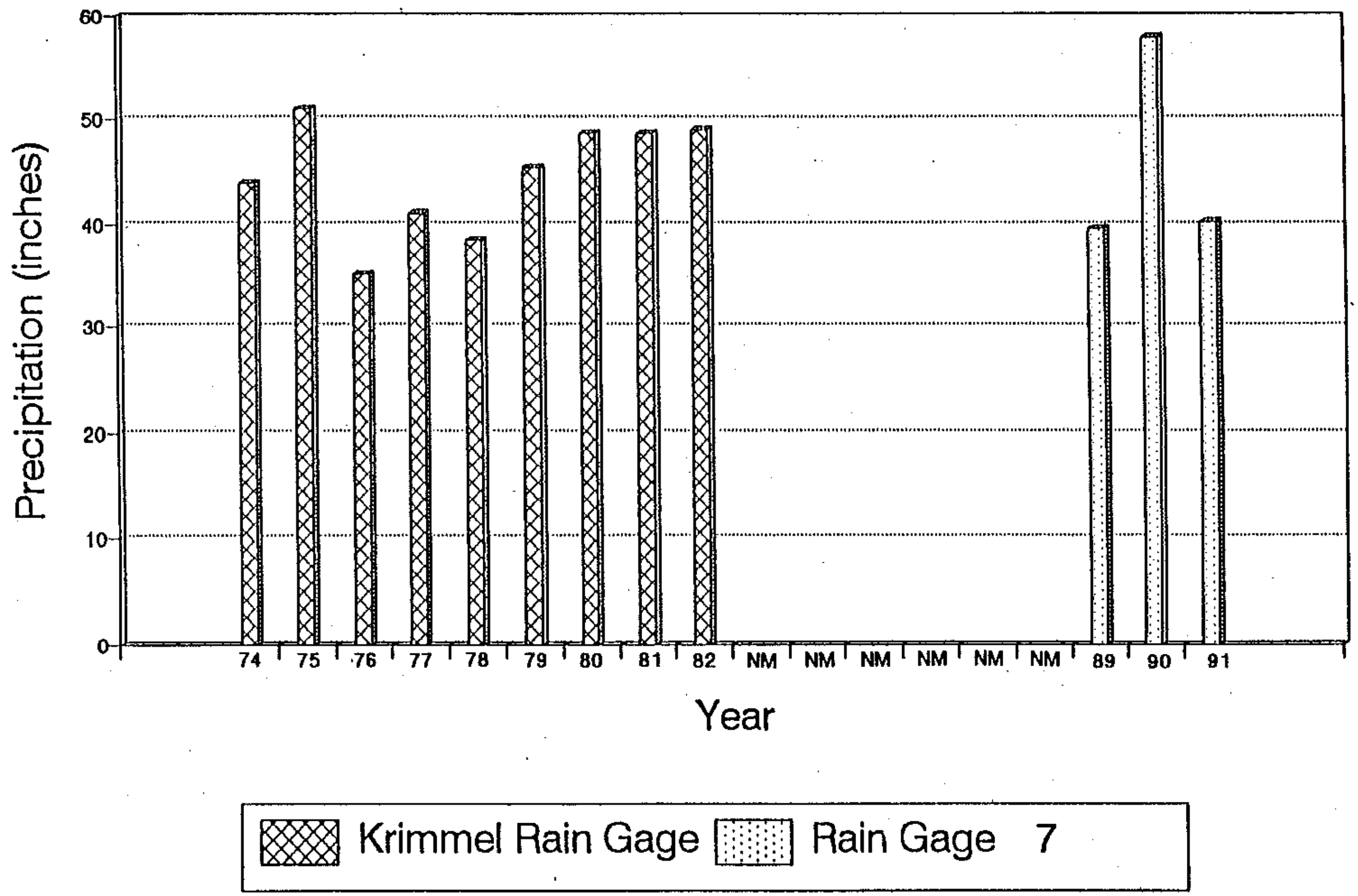
GERAGHTY & MILLER, INC.
Environmental Services

1991 ISOHYETAL (TOTAL RAINFALL) MAP

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE **8.12**

DWG DATE: MAY 1993	PRJCT NO.: WA028.02	FILE NO.:	DRAWING:	CHECKED:	APPROVED: LER	DRAFTER: SAC



NOTE: Rain gage 7 is called Krimmel rain gage in Carr 1983.

NM = Not Measured

Source of 1974-1982 Data: Carr 1983.

GERAGHTY & MILLER, INC.
Environmental Services

ANNUAL RAINFALL AT RAIN GAGE 7

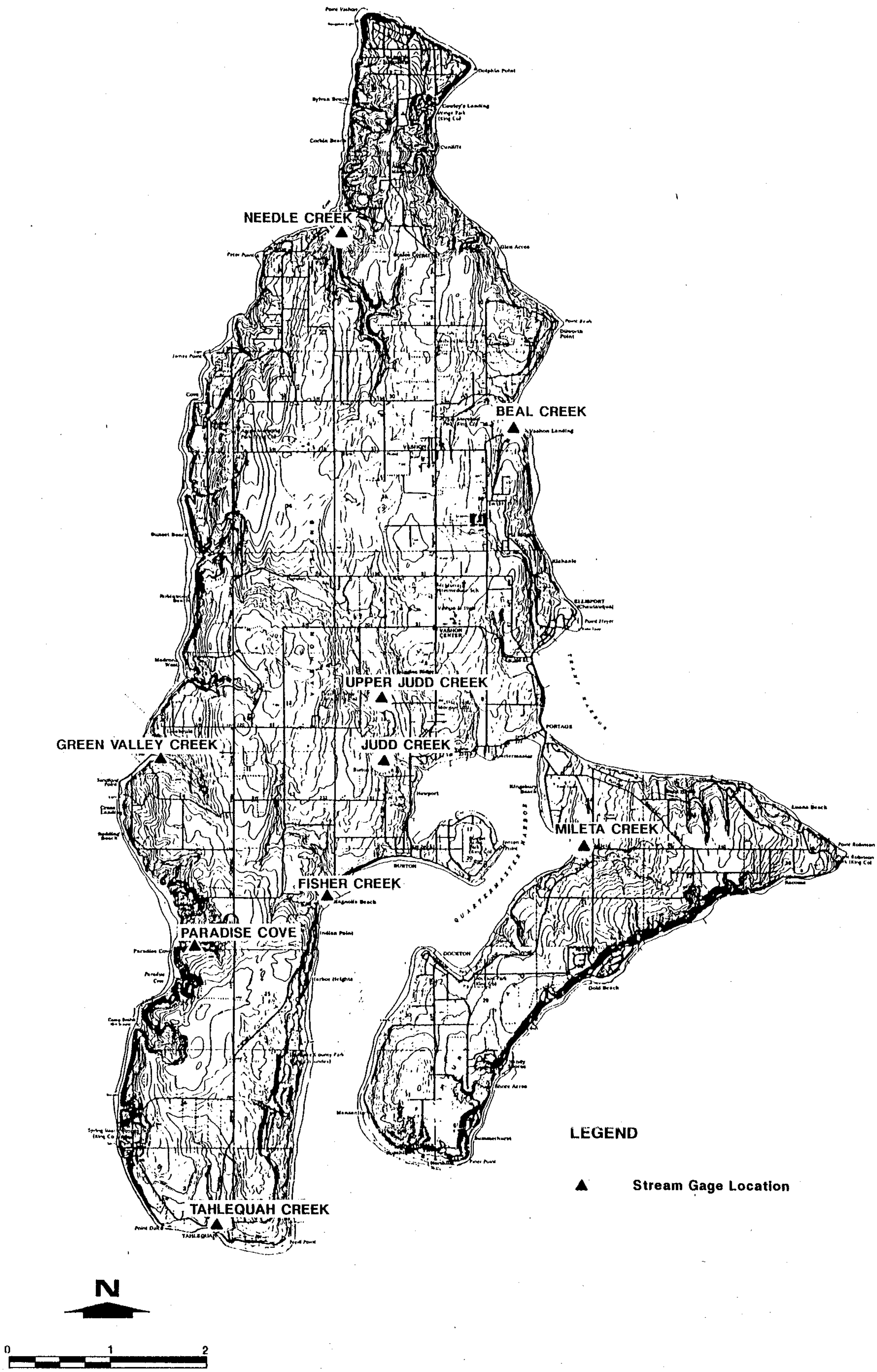
VASHON GROUND WATER MANAGEMENT PLAN

FIGURE

8.14

163135

DWG DATE: MAR 1993	PRJCT NO.: WA028.02	FILE NO.:	DRAWING:	CHECKED:	APPROVED: LER	DRAFTER: SAC



SOURCE: Geraghty & Miller. 1993.

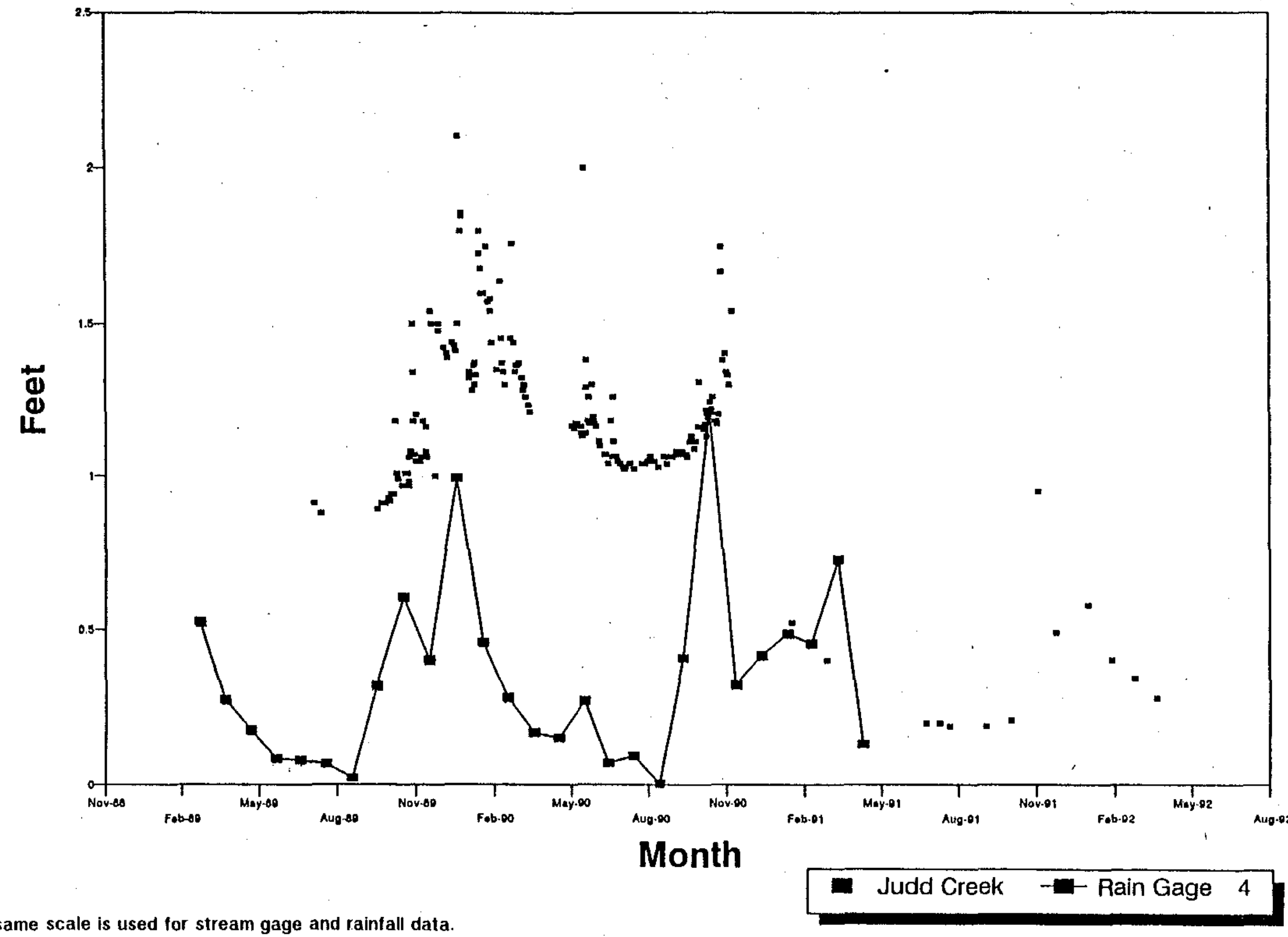
GERAGHTY & MILLER, INC.
Environmental Services

STREAM GAGE LOCATIONS

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE **8.15**

DWG DATE: MAR 1993	PRJCT NO.: WA028.02	FILE NO.:	DRAWING:	CHECKED:	APPROVED: LER	DRAFTER: SAC



NOTE: The same scale is used for stream gage and rainfall data.

GERAGHTY & MILLER, INC.
Environmental Services

Map current as of 1993

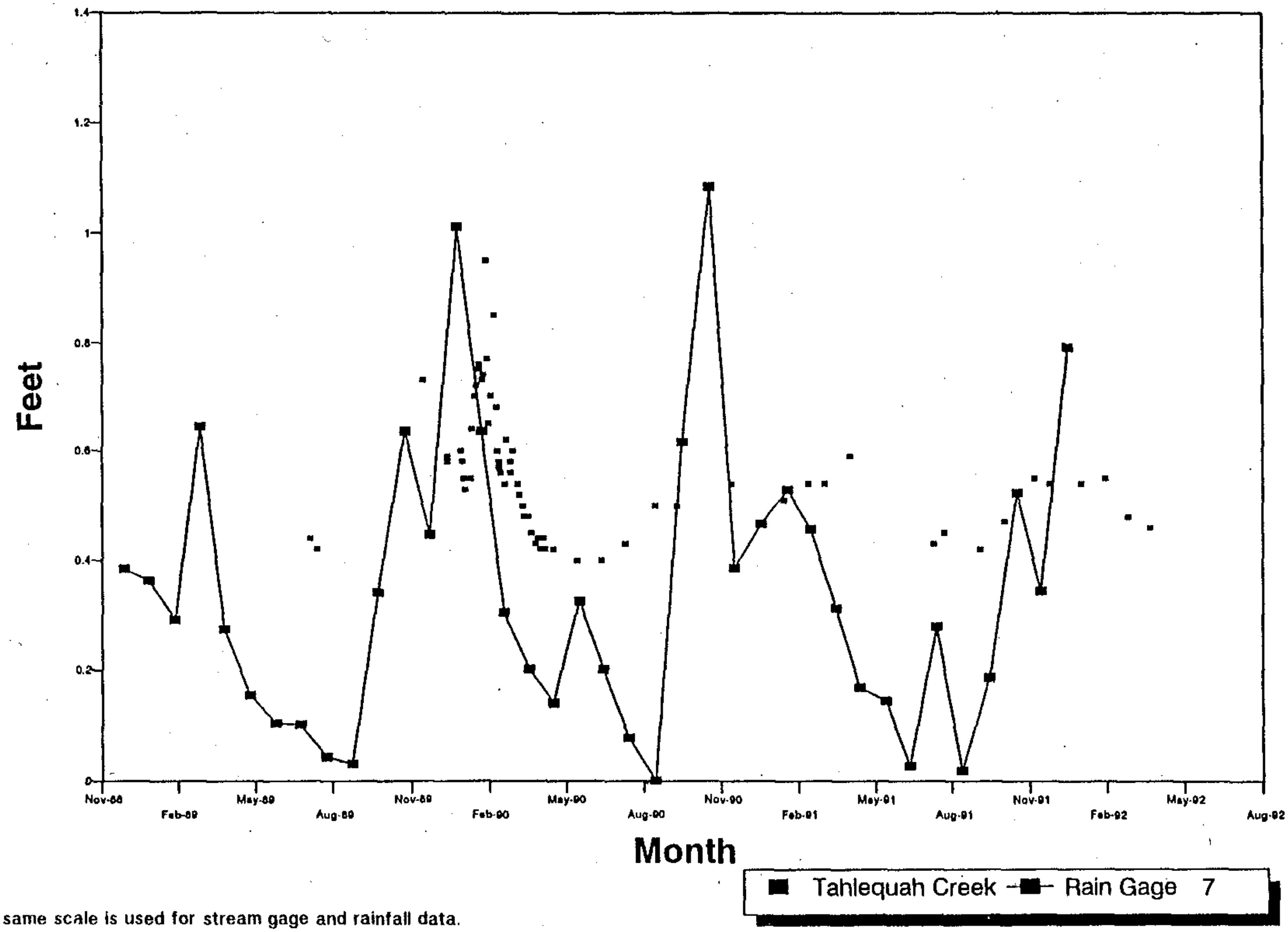
STREAM GAGE DATA VS. RAIN GAGE DATA
JUDD CREEK VS. RAIN GAGE 4

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE **8.16**

163135

DWG DATE: MAR 1993	PRJCT NO.: WA028.02	FILE NO.:	DRAWING:	CHECKED:	APPROVED: LER	DRAFTER: SAC



NOTE: The same scale is used for stream gage and rainfall data.

GERAGHTY & MILLER, INC.
Environmental Services

Map current as of 1993

STREAM GAGE DATA VS. RAIN GAGE DATA
TAHLEQUAH CREEK VS. RAIN GAGE 7

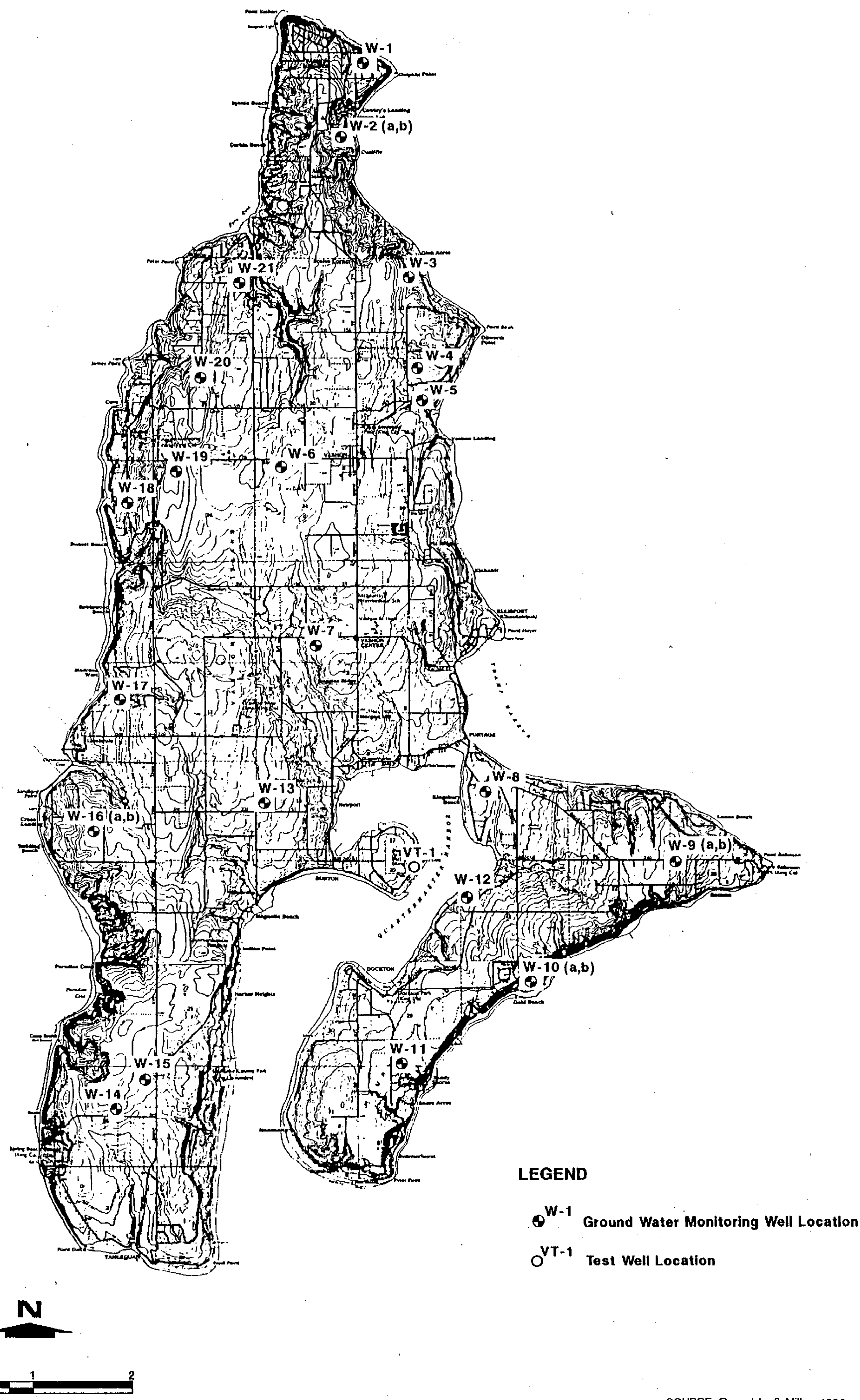
VASHON GROUND WATER MANAGEMENT PLAN

FIGURE

8.17

163135

DWG DATE: APR 1993	PRJCT NO.: WA028.02	FILE NO.:	DRAWING:	CHECKED:	APPROVED: LER	DRAFTER: SAC

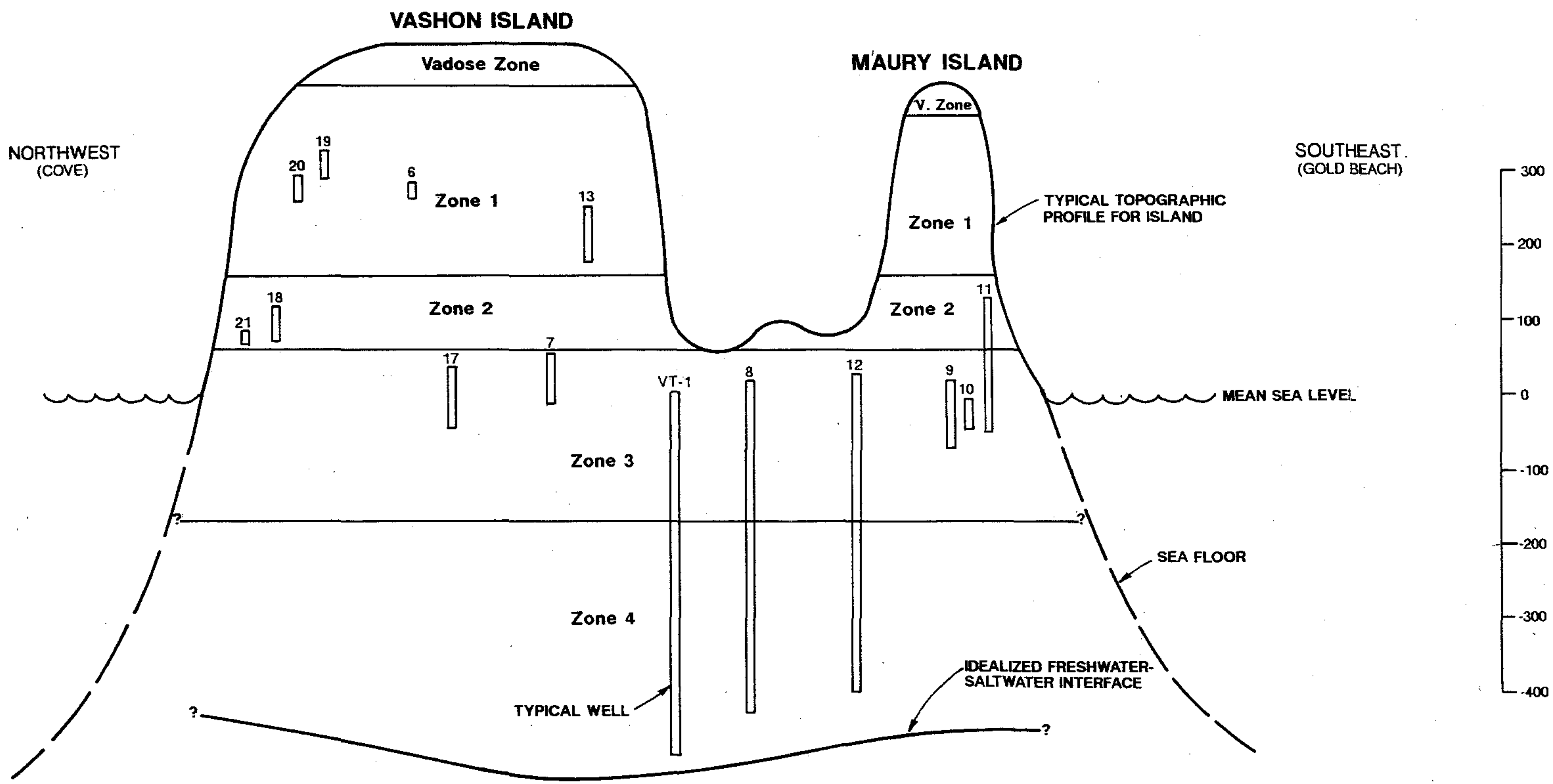


SOURCE: Geraghty & Miller 1993.

GERAGHTY & MILLER, INC. *Environmental Services*	WELL LOCATIONS VASHON GROUND WATER MANAGEMENT PLAN	FIGURE 8.18

158186

DRAFTER: SAC. | APPROVED: LER | CHECKED: | DRAWING: | FILE NO.: | PRJCT NO.: WA0028.OOB | DWG DATE: MAR 1994



NOTES: Hydrostratigraphic zones do not necessarily relate to geologic zones.

Aquifer zones shown have been simplified. Actual zones are more complex.

Wells were projected onto section line. Well ID noted above well.

NOT TO SCALE HORIZONTALLY

GERAGHTY & MILLER, INC.
Environmental Services

Map current as of 1993

GENERAL SCHEMATIC OF HYDROSTRATIGRAPHIC ZONES

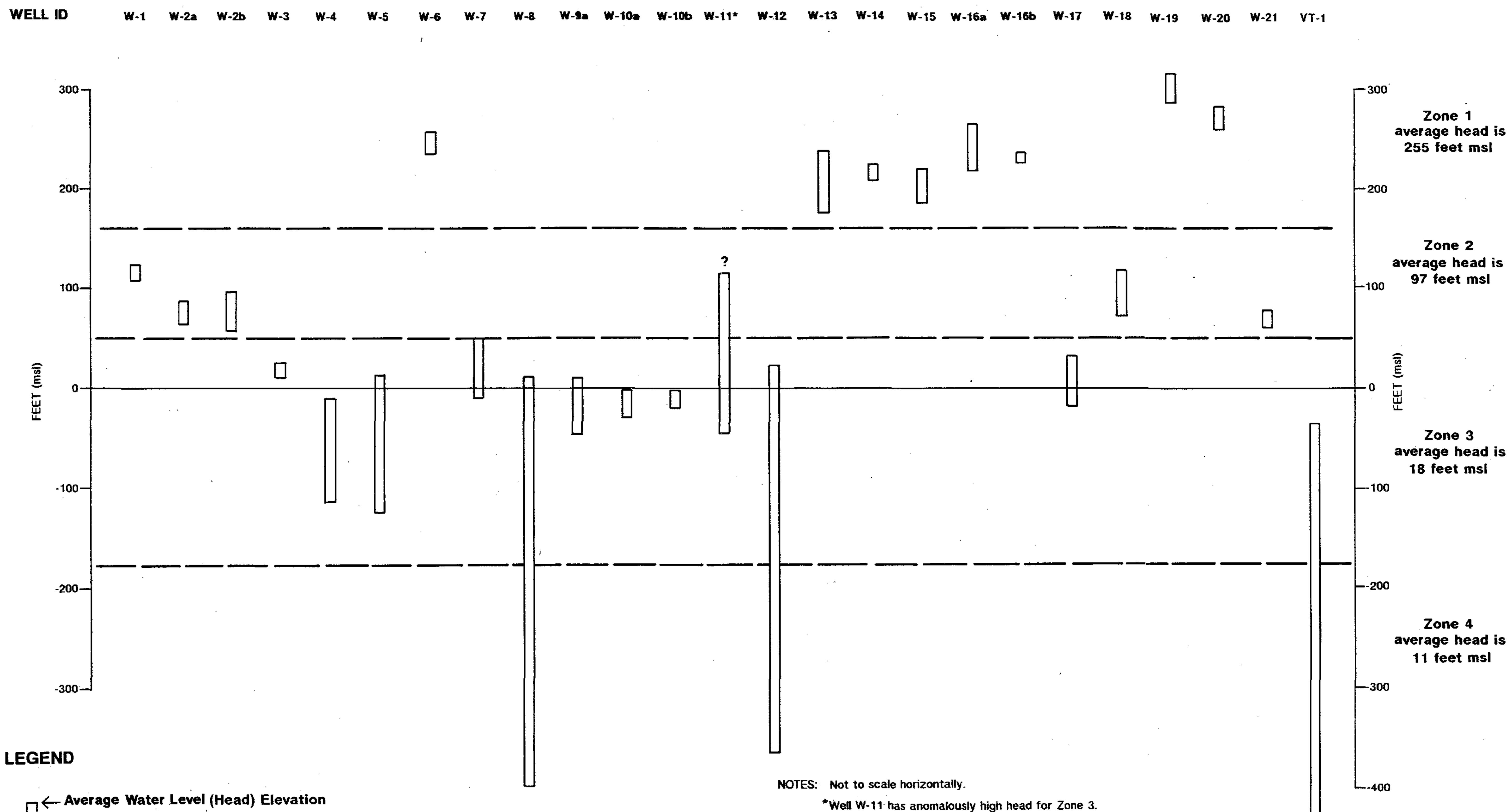
VASHON GROUND WATER MANAGEMENT PLAN

FIGURE

8.19

156186

DRAFTER: SAC
APPROVED: LER
CHECKED:
DRAWING:
PRJCT NO.: WA0028.00B FILE NO.:
DWG DATE: MAR 1994



LEGEND

← Average Water Level (Head) Elevation

← Elevation of Mid-Point of Well Screen

msl Mean Sea Level

—— Arbitrary Divisions Between Water-Bearing Zones

NOTES: Not to scale horizontally.

*Well W-11 has anomalously high head for Zone 3.

This is not a cross section. Hydrostratigraphic units do not necessarily relate to geologic units.

GERAGHTY & MILLER, INC.
Environmental Services

Map current as of 1993

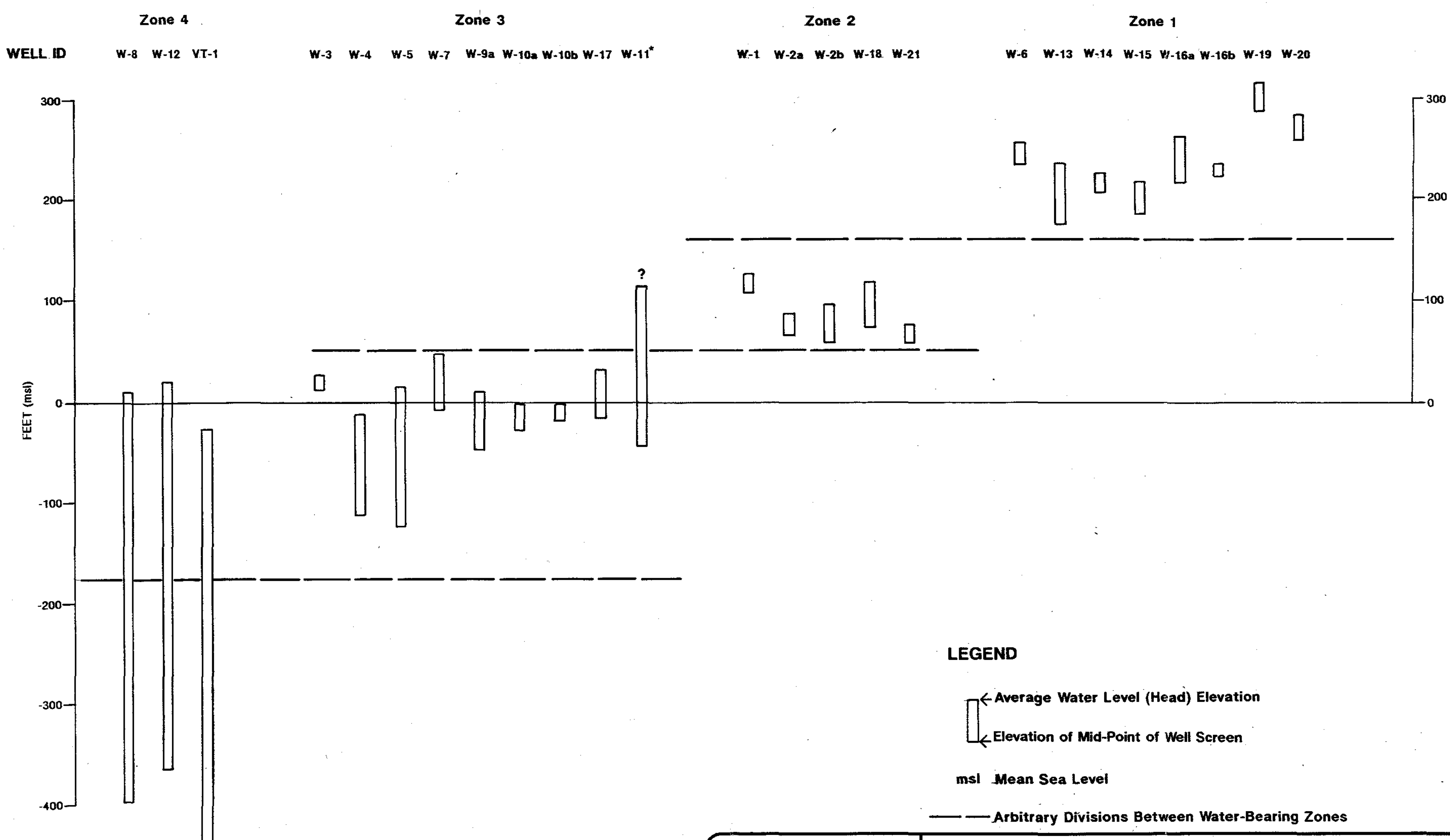
DISTRIBUTION OF MONITORING WELLS IN AQUIFER ZONES

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE

8.20

156186



NOTES: Not to scale horizontally.

* Well W-11 has anomalously high head for Zone 3.

This is not a cross section. Hydrostratigraphic units do not necessarily relate to geologic units.

DRAFTER: SAC | APPROVED: LER | CHECKED: | DRAWING: | PRJCT NO.: WA0028.OOB | FILE NO.: | DWG DATE: MAR 1994

GERAGHTY & MILLER, INC.
Environmental Services

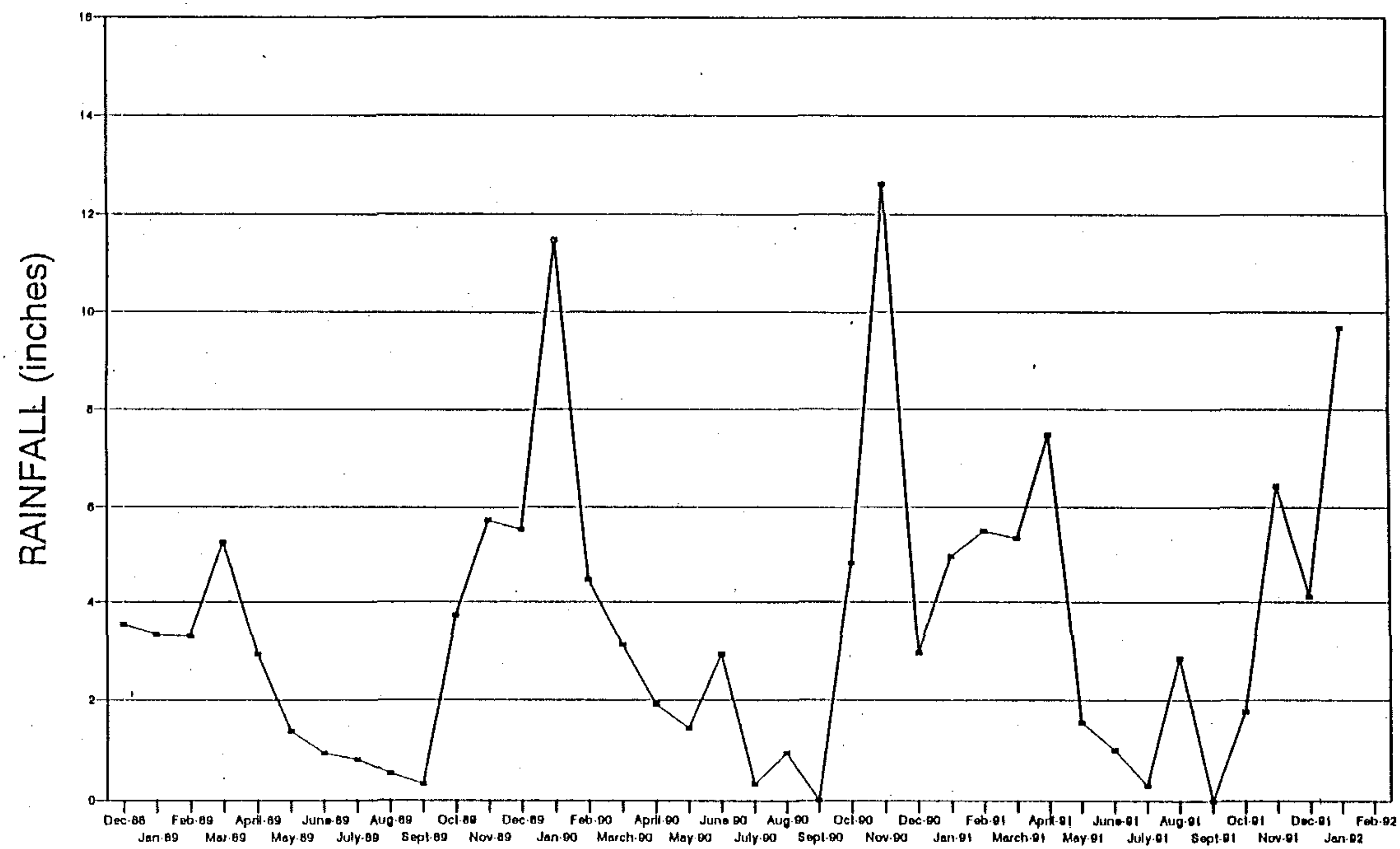
Map current as of 1993

MONITORING WELLS GROUPED IN EACH AQUIFER ZONE

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE 8.21

DWG DATE: APR 1993 | PRJCT NO.: WA028.02 | FILE NO.: | DRAWING: | CHECKED: | APPROVED: LER | DRAFTER: SAC



SOURCE: Geraghty & Miller 1993.

GERAGHTY & MILLER, INC.
Environmental Services

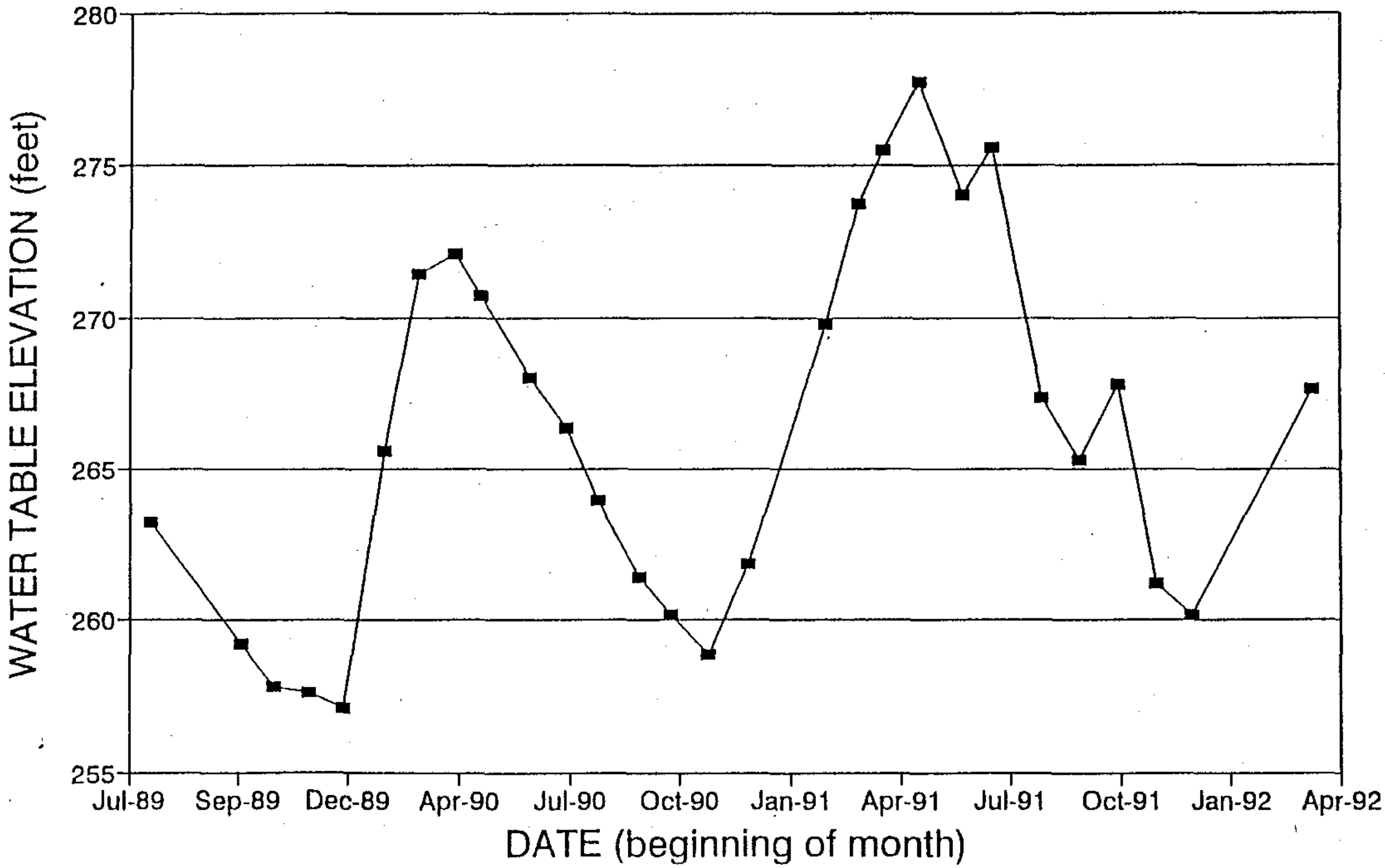
MONTHLY RAINFALL, RAIN GAGE 6

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE 8.22

163135

DWG DATE: APR 1993 | PRJCT NO.: WA028.02 | FILE NO.: | DRAWING: | CHECKED: | APPROVED: LER | DRAFTER: SAC



SOURCE: Geraghty & Miller 1992.

GERAGHTY & MILLER, INC. *Environmental Services*

WATER-TABLE ELEVATIONS, WELL W-16A

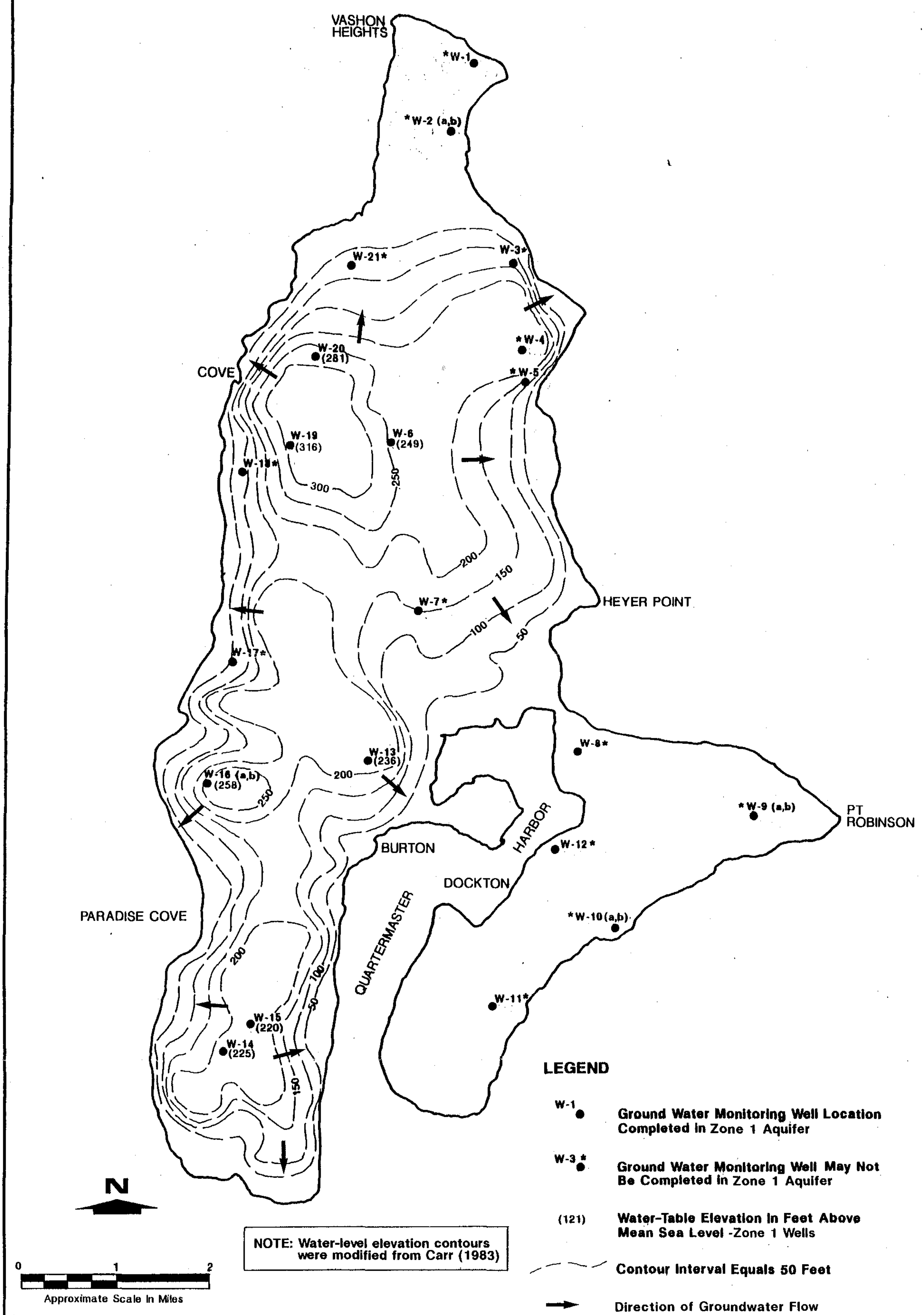
VASHON GROUND WATER MANAGEMENT PLAN

FIGURE

8.23

163135

DWG DATE: MAR 1994	PRJCT NO.: WA0028.00B	FILE NO.:	DRAWING:	CHECKED:	APPROVED: LER	DRAFTER: SAC



GERAGHTY & MILLER, INC.
Environmental Services

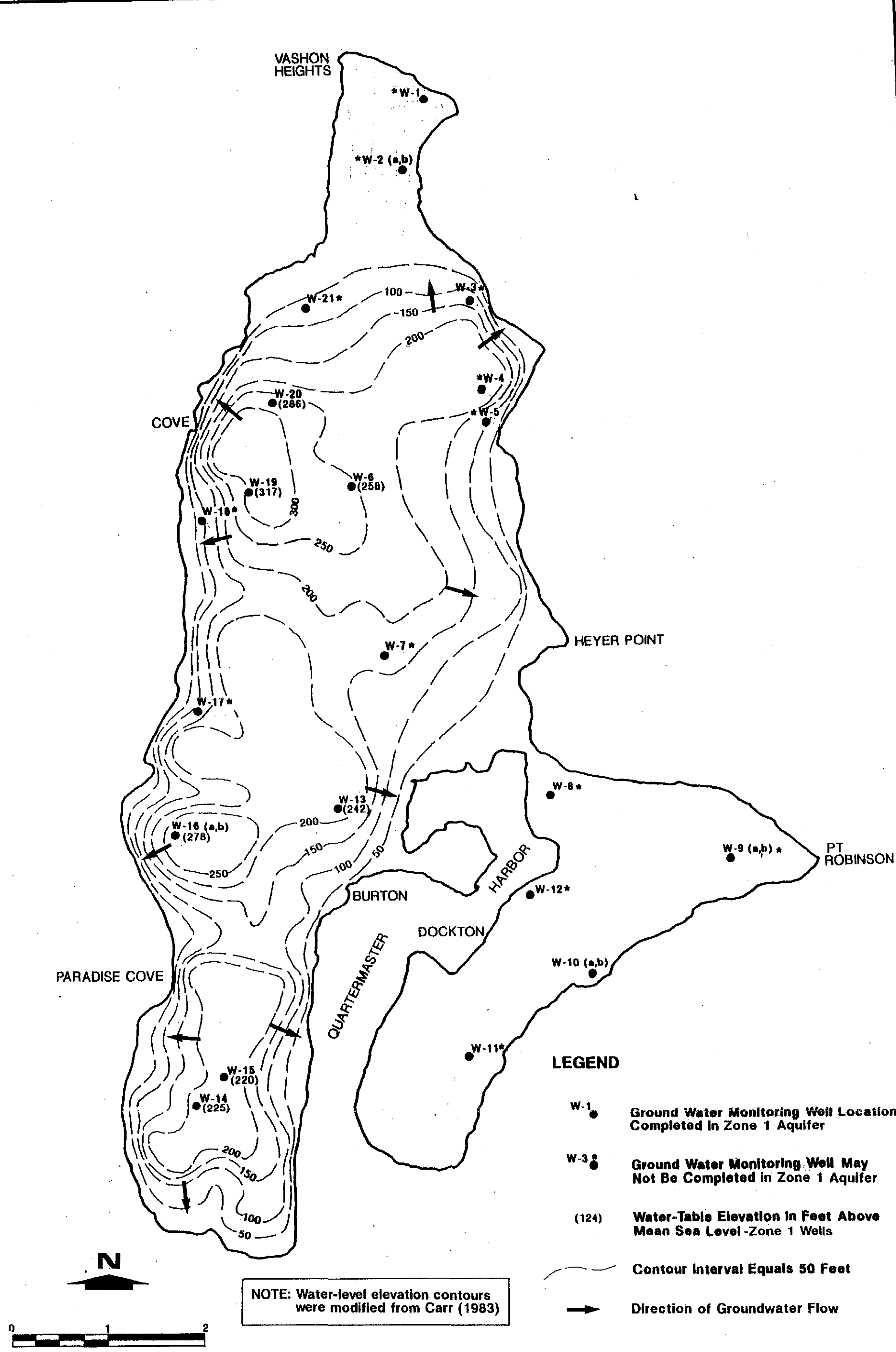
Map current as of 1993

GENERALIZED WATER-TABLE ELEVATIONS FOR ZONE 1 AQUIFER, NOVEMBER 1989

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE 8.24

DWG DATE: MAR 1994 | PRJCT NO.:WA0028.00B | FILE NO.: | DRAWING: | CHECKED: | APPROVED: LER | DRAFTER: SAC



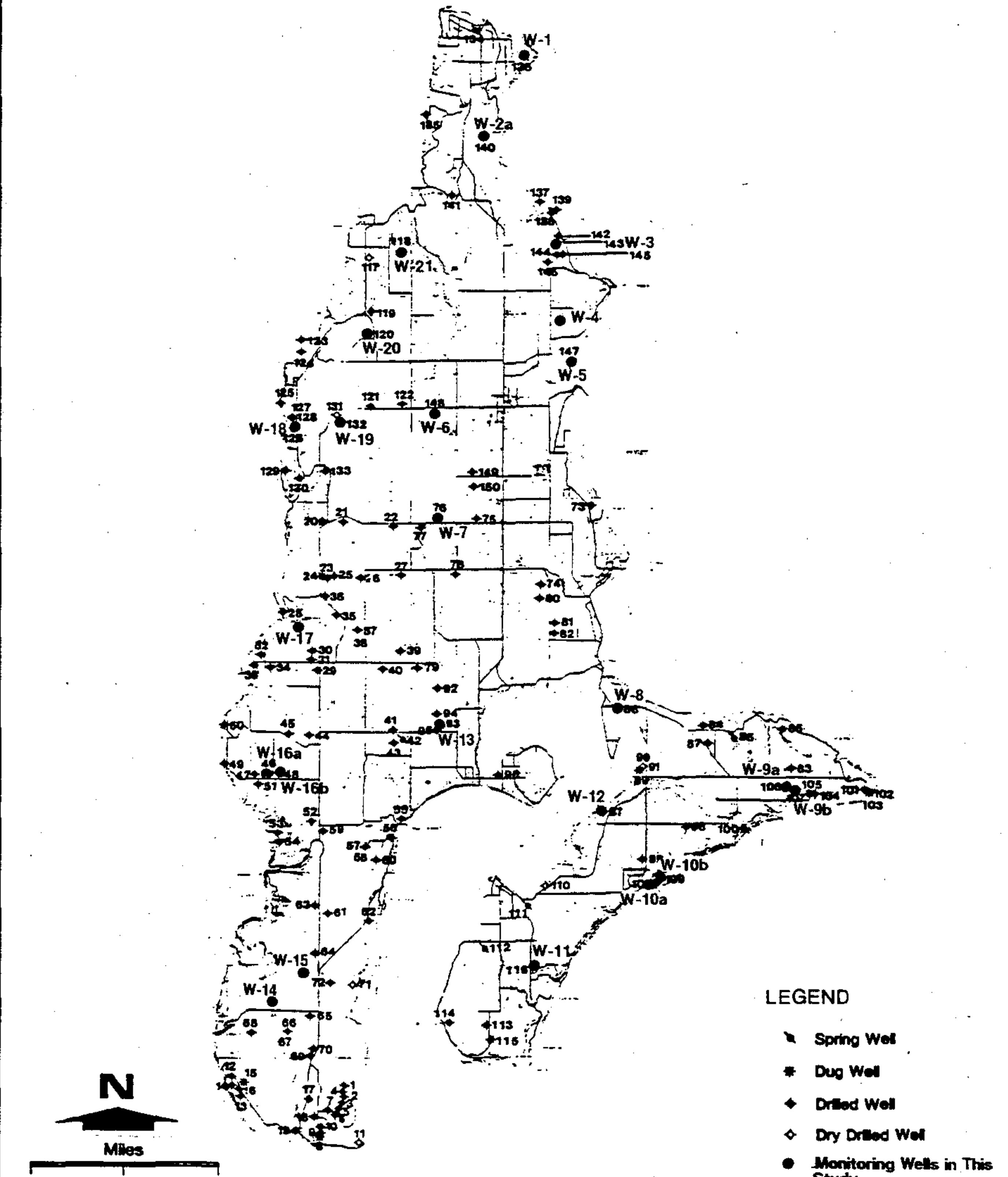
GERAGHTY & MILLER, INC.
Environmental Services

GENERALIZED WATER-TABLE ELEVATIONS FOR ZONE 1 AQUIFER, APRIL 1991

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE 8.25

156186



SOURCE: Carr 1983.

DRAFTER: SAC | APPROVED: LER | CHECKED: | DRAWING: | FILE NO.: | PRJCT NO.: WA0028.0OB | DWG DATE: MAR 1994

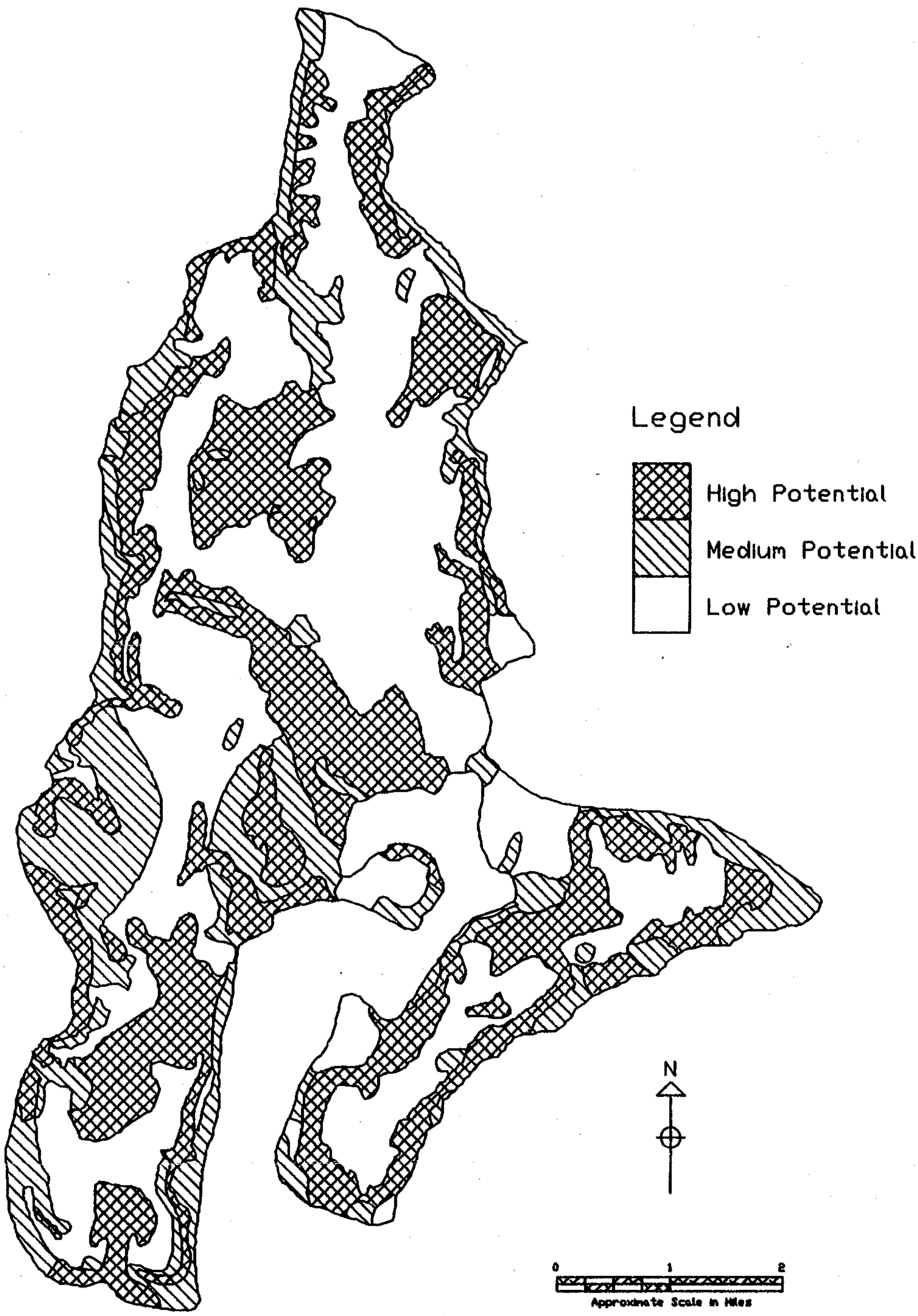
GERAGHTY & MILLER, INC.
Environmental Services

WELL LOCATION MAP

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE 8.27

DWG DATE: DWGDATE | PRJCT NO.: PRJCTNO | FILE NO.: FILENO | DRAWING: DRAWING | CHECKED: CHECKER | APPROVED: MANAGER | DRAFTER: DRAFTER



GERAGHTY & MILLER, INC.
Environmental Services

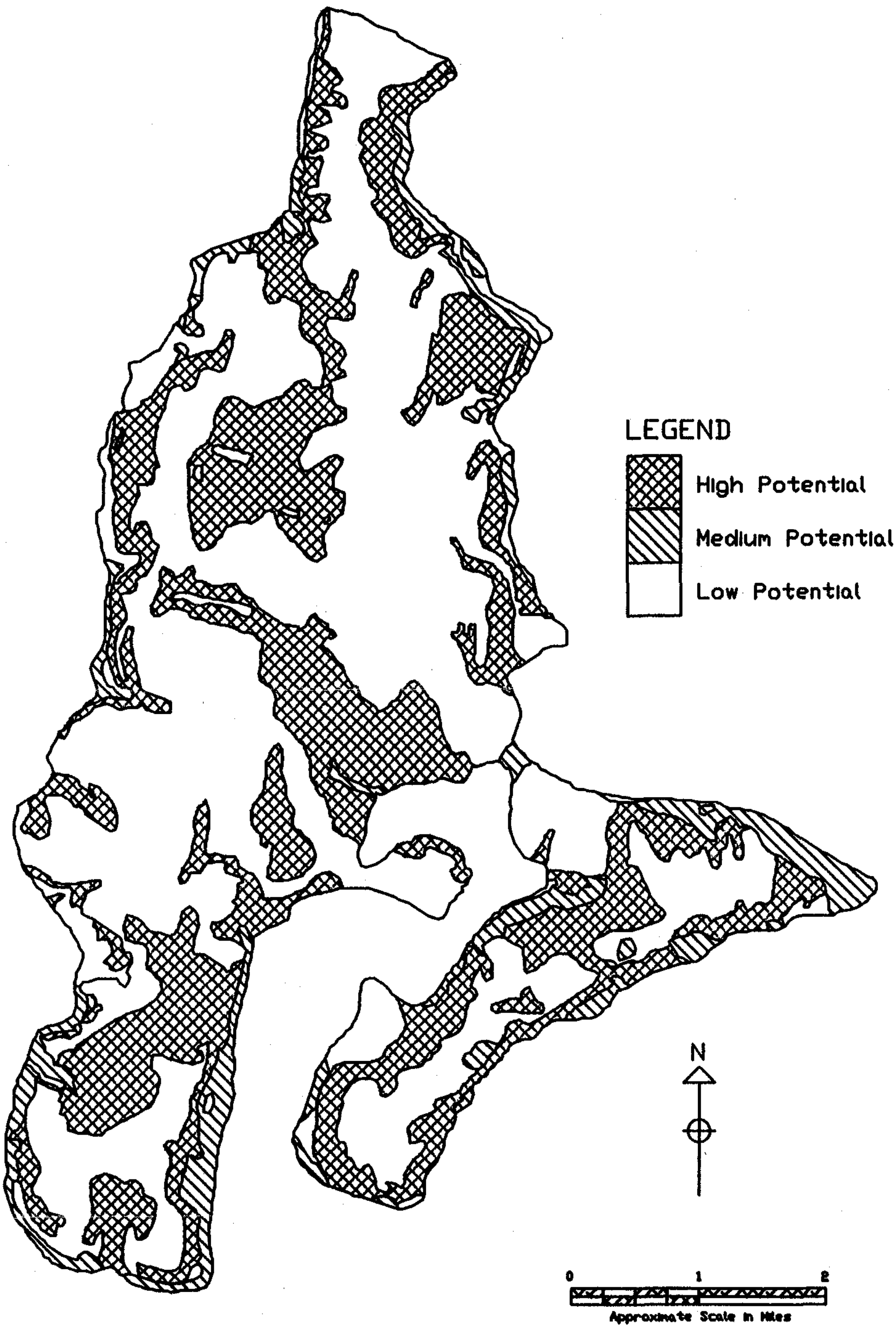
Map current as of 1993

VASHON GROUND WATER MANAGEMENT

Physical Susceptibility

FIGURE 8-28a

DWG DATE: DWGDATE | PRJCT NO.: PRJCTNO | FILE NO.: FILENO | DRAWING: DRAWING | CHECKED: CHECKER | APPROVED: MANAGER | DRAFTER: DRAFTER



NOTE: Geologic units from BOOTH (1991).

GERAGHTY & MILLER, INC.
Environmental Services

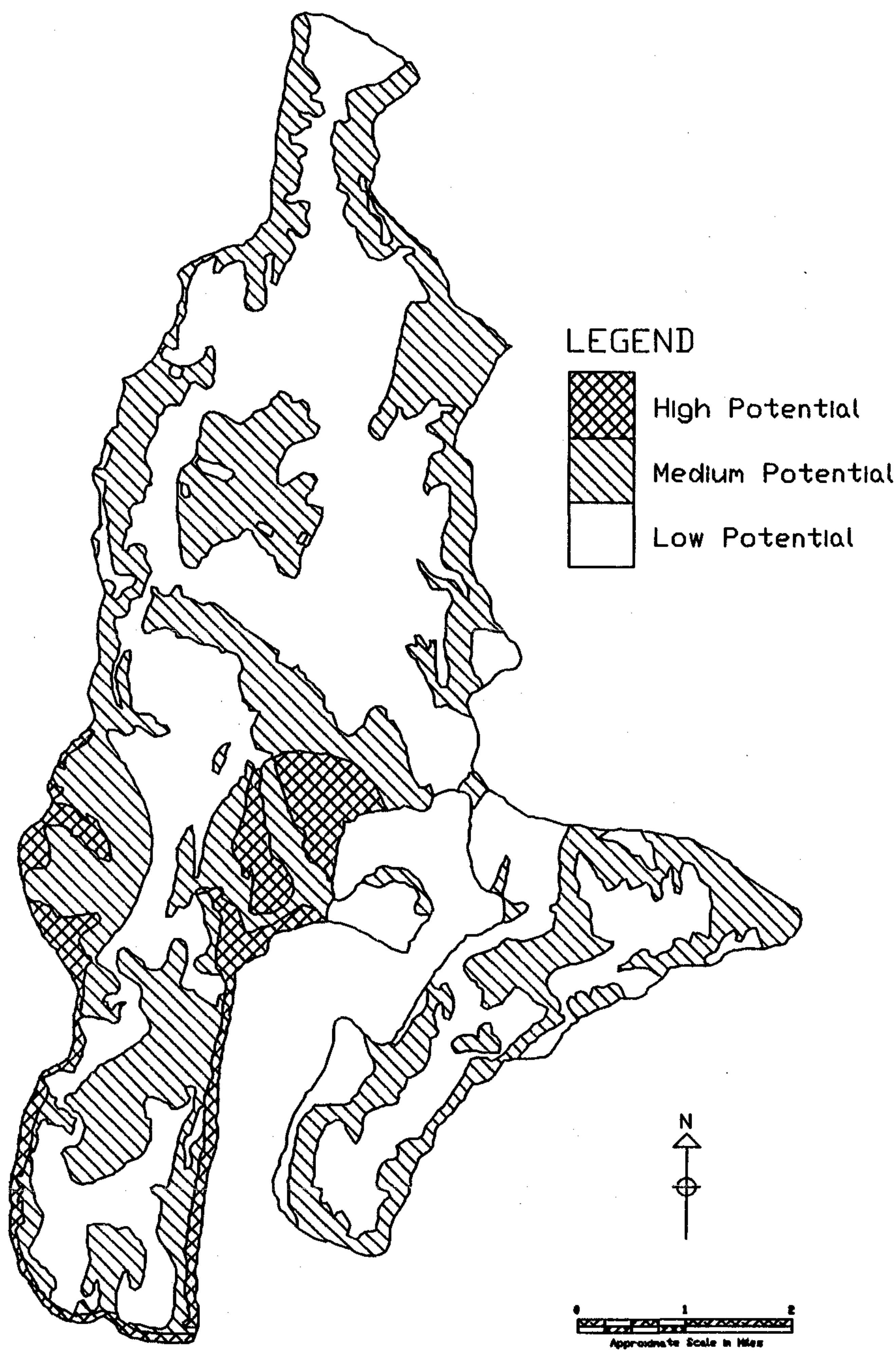
VASHON GROUND WATER MANAGEMENT

Surface Geology Permeability Potential

FIGURE 8.29

Map current as of 1993

DWG DATE: DWGDATE | PRJCT NO.: PRJCTNO | FILE NO.: FILENO | DRAWING: DRAWING | CHECKED: CHECKER | APPROVED: MANAGER | DRAFTER: DRAFTER



GERAGHTY & MILLER, INC.
Environmental Services

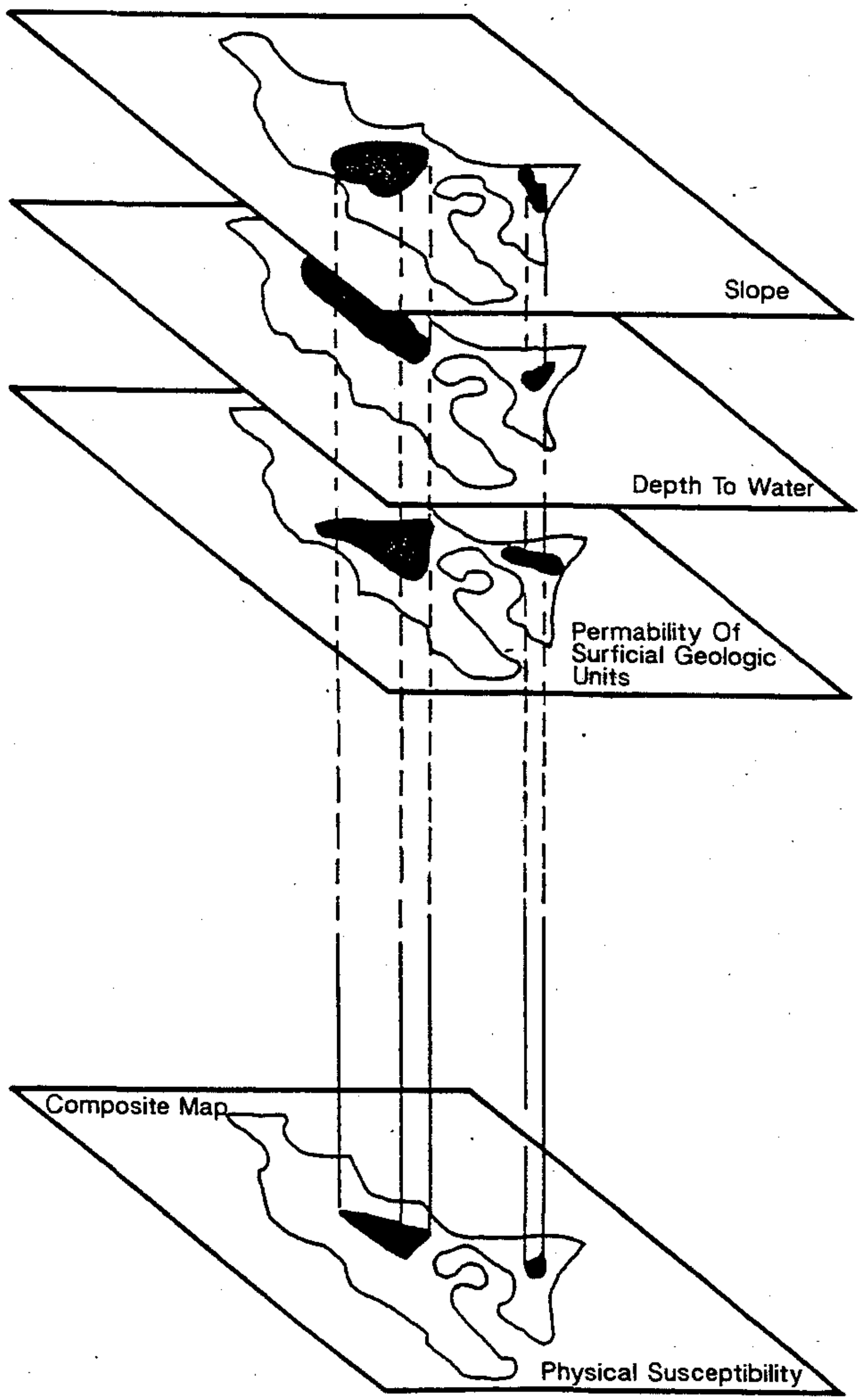
VASHON GROUND WATER MANAGEMENT

Depth-to-Water Susceptibility Potential

FIGURE 8.30

Map current as of 1993

156186



Modified from Carr 1983.

DRAFTER: SAC | APPROVED: LER | CHECKED: | DRAWING: | PRJCT NO.: WA0028.00B | FILE NO.: | DWG DATE: MAR 1994

GERAGHTY & MILLER, INC.
Environmental Services

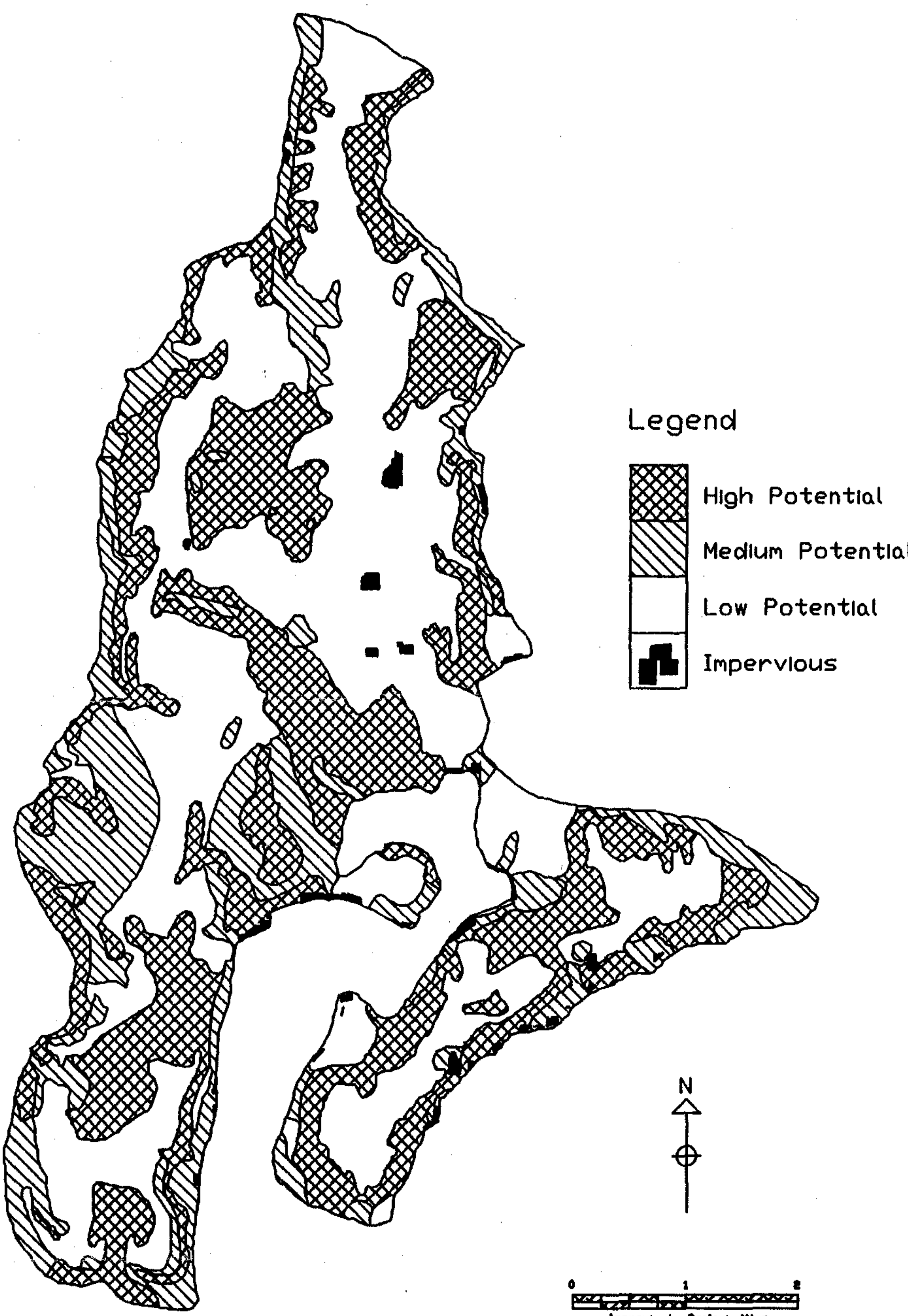
PHYSICAL SUSCEPTIBILITY MAP
COMPOSITE - EXAMPLE

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE

8.32

DWG DATE: DWGDATE | PRJCT NO.: PRJCTNO | FILE NO.: FILENO | DRAWING: DRAWING | CHECKED: CHECKER | APPROVED: MANAGER | DRAFTER: DRAFTER



GERAGHTY & MILLER, INC.
Environmental Services

Map current as of 1993

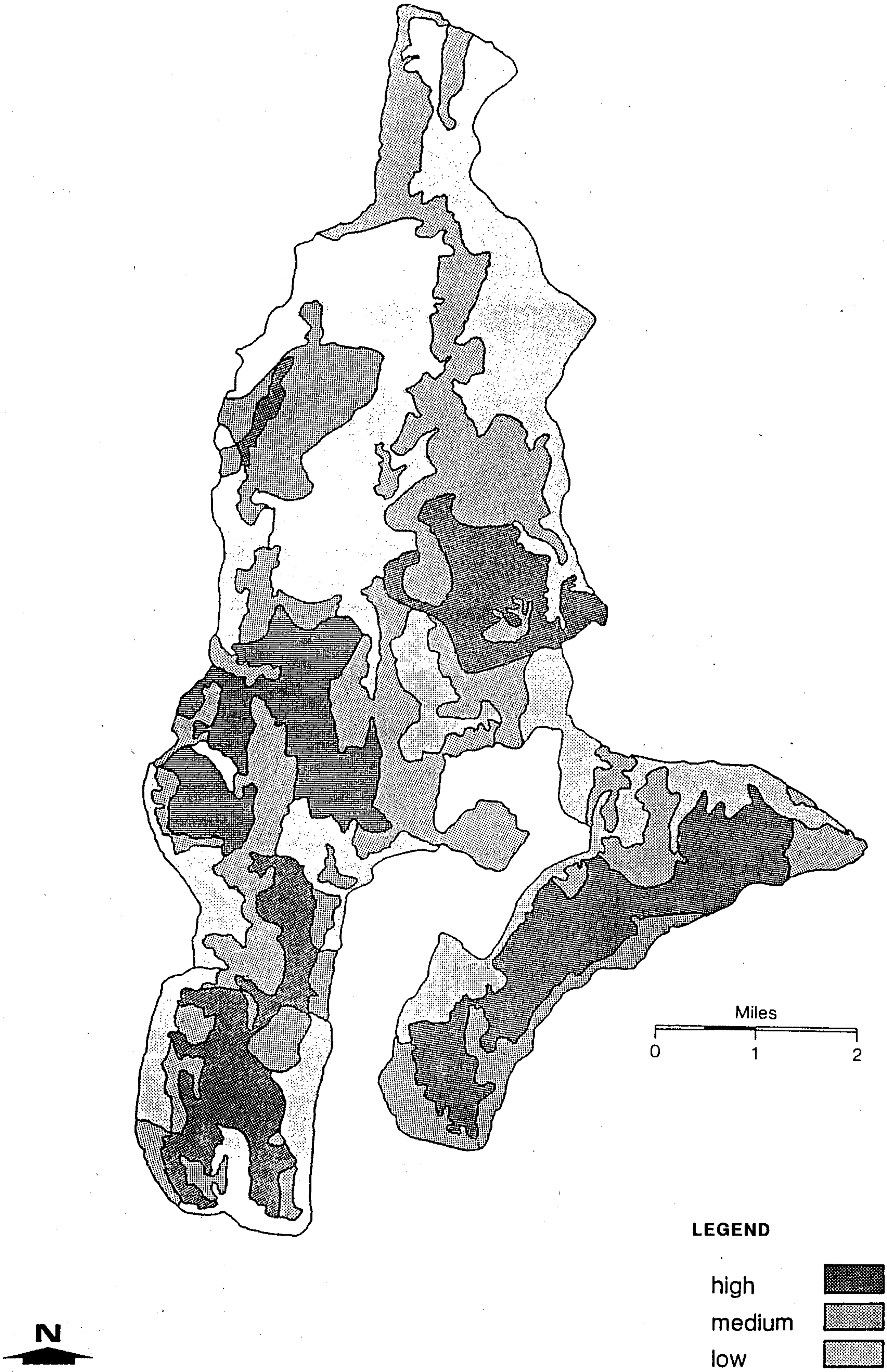
VASHON GROUND WATER MANAGEMENT

Physical Susceptibility with Impervious Surfaces

FIGURE 8.33

DWG DATE: MAR 1994	PRJCT NO.: WA0028.00B	FILE NO.:	DRAWING:	CHECKED:	APPROVED: LER	DRAFTER: SAC

163135



SOURCE: Carr 1983.

GERAGHTY & MILLER, INC.
Environmental Services

Map current as of 1993

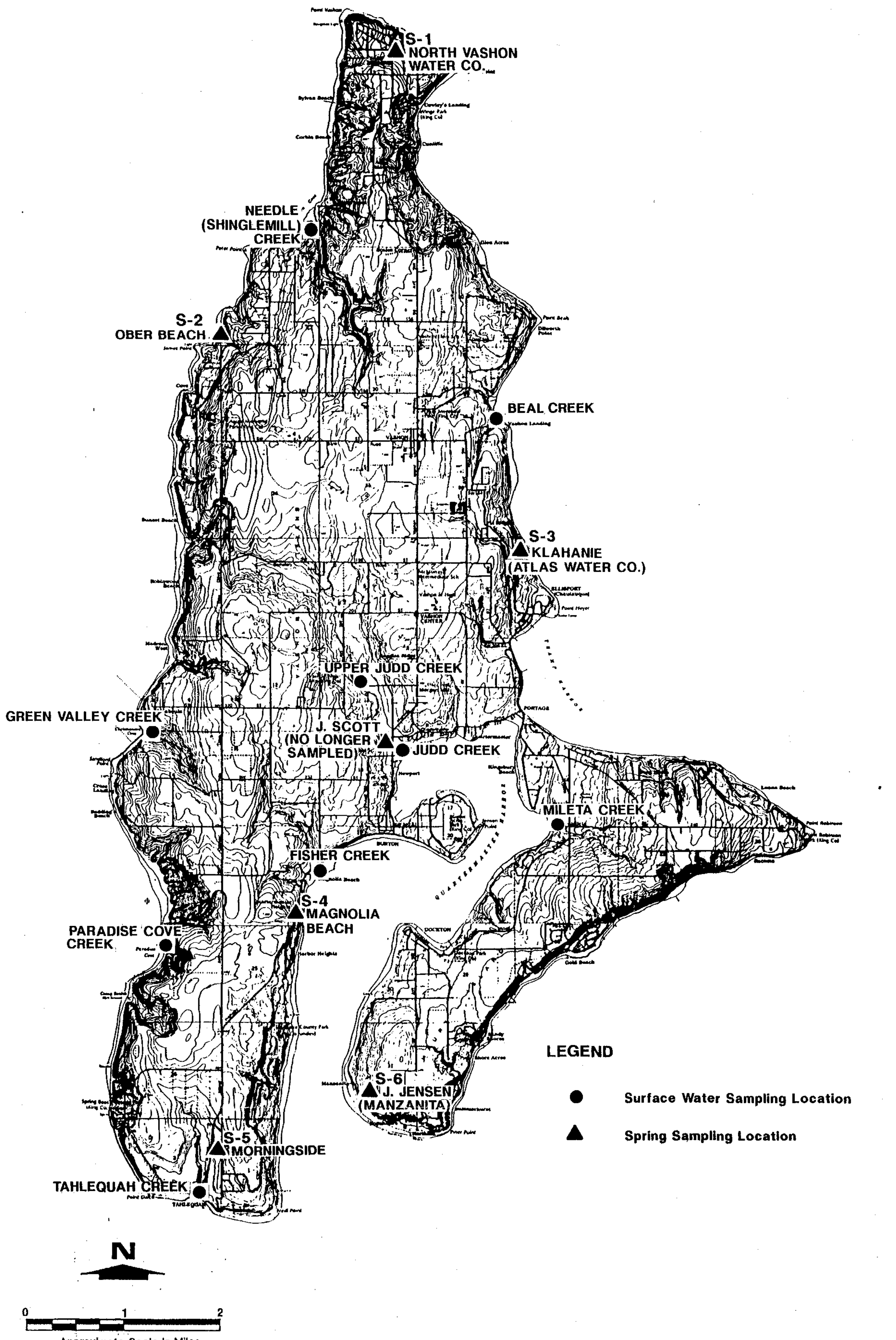
1983 RECHARGE POTENTIAL MAP

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE **8.34**

DWG DATE: APR 1993 | PRJCT NO.: WA028.02 | FILE NO.: | DRAWING: | CHECKED: | APPROVED: LER | DRAFTER: SAC

163135



NOTE: Marine and shellfish samples collected offshore in the Sound.

GERAGHTY & MILLER, INC.
Environmental Services

Map current as of 1993

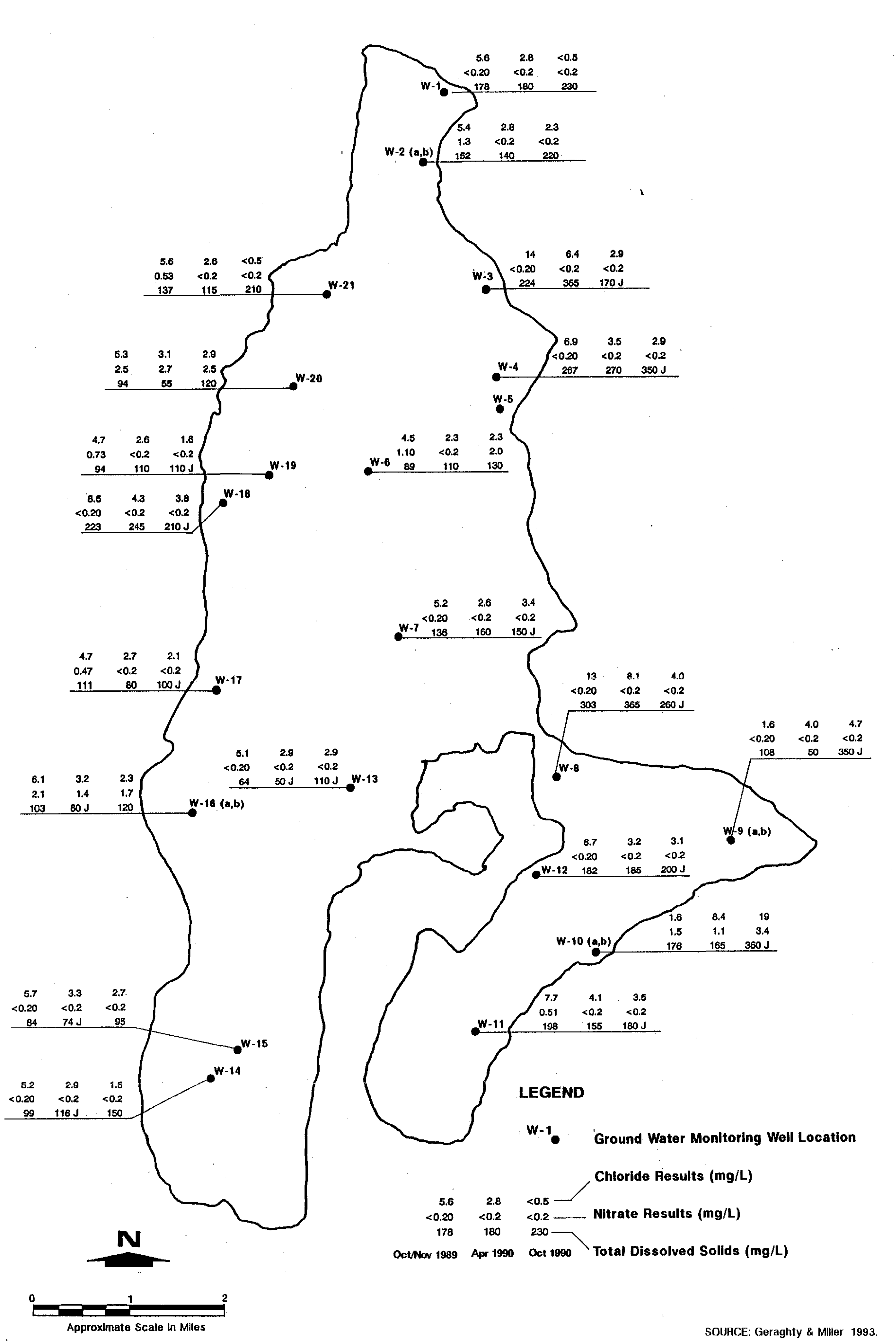
SURFACE WATER AND SPRING WATER SAMPLING LOCATIONS

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE

8.35

DWG DATE: APR 1993	PRJCT NO.: WA028.02	FILE NO.:	DRAWING:	CHECKED:	APPROVED: LER	DRAFTER: SAC



SOURCE: Geraghty & Miller 1993.

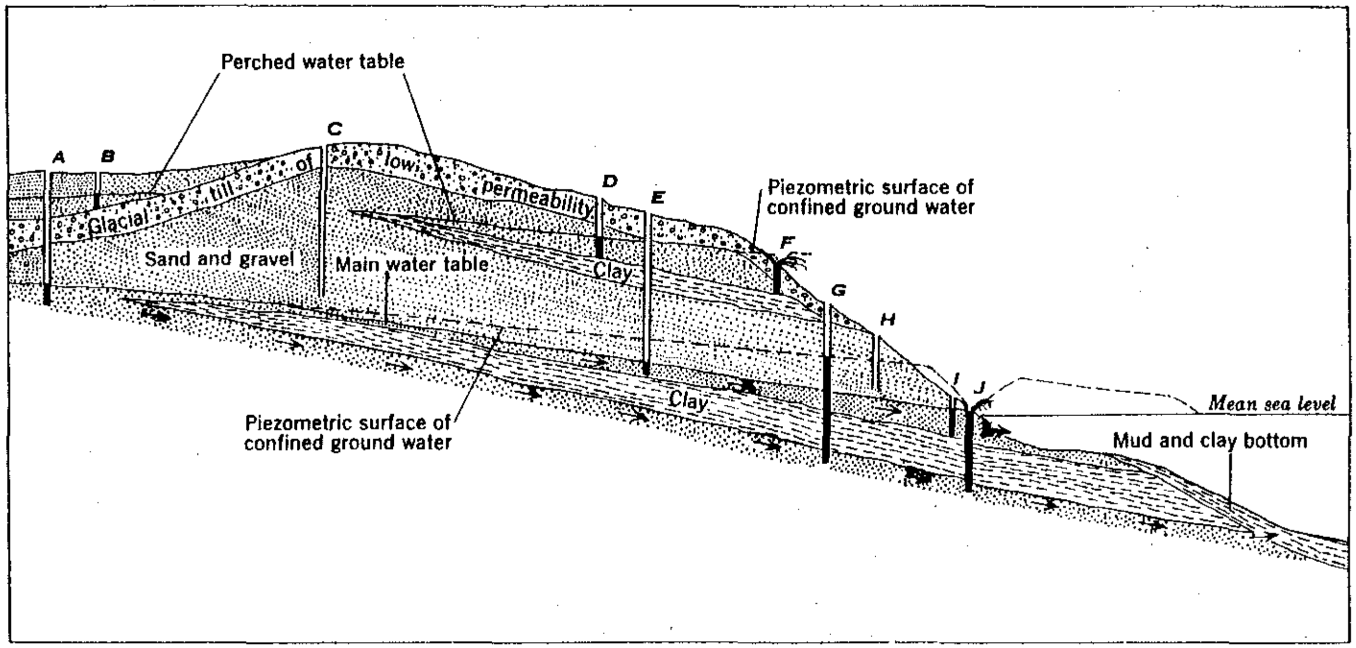
GERAGHTY & MILLER, INC.
Environmental Services

GROUND WATER QUALITY RESULTS FOR CHLORIDE, NITRATE, AND TOTAL DISSOLVED SOLIDS FOR OCTOBER/NOVEMBER 1989, APRIL 1990, AND OCTOBER 1990

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE **8.36**

DWG DATE: MAR 1994	PRJCT NO.: WA0028.OOB	FILE NO.:	DRAWING:	CHECKED:	APPROVED: LER	DRAFTER: SAC



Diagrammatic section showing various occurrences of ground water. Arrows indicate direction of ground-water movement. Well *A* yields unconfined water from below the water table; well *B* yields perched water from a water body perched on glacial till; at well *C* water was not encountered owing to insufficient depth; well *D* yields perched water from water body perched on clay zone; well E yields unconfined water from below the water table; well *F* yields confined perched ground water and flows because land surface is lower than the head developed on the water body as a result of the presence of the till cover; well *G* yields confined water from water body confined by clay zone; at well *H* water was not encountered owing to insufficient depth; well *I* yields unconfined water from below the water table; and well *J* yields confined ground water and flows because the land surface is below the piezometric surface.

NOT TO SCALE

SOURCE: Geology and Groundwater Resources, Kitsap County, Washington USGS Water Supply Paper 1413

GERAGHTY & MILLER, INC.
Environmental Services

Map current as of 1993

SCHEMATIC OF INTERFINGERING WITHIN GEOLOGIC SEDIMENT LAYERS

VASHON GROUND WATER MANAGEMENT PLAN

FIGURE

9.1

163135