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1. Introduction

Vashon-Maury Island is an island that lies in the Puget Lowland encompassing about 36 square miles. All drinking water sources on the island (springs, surface water, and groundwater) are supplied by precipitation. Groundwater is the portion of precipitation that soaks into the ground and gets stored in underground geological water systems called aquifers. Every groundwater system is unique and dependent upon external factors such as the rate of precipitation, the interaction of groundwater with the streams and other surface water bodies, and the rate of evapotranspiration. These external factors all contribute to the overall water budget. Understanding the water budget for Vashon-Maury Island and how it changes in response to human activities and climate changes is important in determining the amount of drinking water that can be used on a sustained basis.

A long-term plan that describes and evaluates the different components of the Vashon-Maury Island water budget is being proposed to address needs and concerns identified by residents of Vashon-Maury Island and King County staff. Much interest has been expressed over the years in the sustainability of the water supply on the island, although to date there has not been a comprehensive study to address many major water supply issues.

This work plan is designed to provide a scientific evaluation of the water supply issues (both water quantity and quality related) on Vashon-Maury Island. This paper presents the objectives for this work plan, the overall scope of work required to satisfy the objectives, the estimated project schedule, and finally the expected deliverables.

2. Objectives

The work plan for the Vashon-Maury Island Water Resources Evaluation has four main objectives:

1. To monitor Vashon-Maury Island groundwater and surface water quantity and quality to allow for the identification of changes over time;
2. To build a comprehensive groundwater flow model that evaluates groundwater and surface water quantity and quality under various climate change and land-use scenarios;
3. To satisfy the goals of the countywide data management work plan for the Vashon-Maury Island region; and
4. To coordinate activities with the Vashon-Maury Island Groundwater Protection and Land Use Committees, the WRIA 15 watershed planning unit, and the citizens of Vashon-Maury Island.

3. Scope of Work

To satisfy the objectives of the project, it is anticipated that work will need to be done in four major areas. The first three areas, monitoring, modeling, and data management are closely interrelated and must be responsive to each other to satisfy the first three objectives of this work plan. The last area, project communication, addresses the fourth and final objective.

3.1. Monitoring

Groundwater, surface water, and precipitation will be monitored in an effort to better describe the Vashon-Maury Island water budget and overall water quality. Monitoring efforts on Vashon-

Maury Island will serve three purposes: (1) to identify changes and trends in groundwater and surface water quantity and quality; (2) to provide necessary data for model development and calibration; and (3) to have an early warning system on the impacts of pollution sources and groundwater extraction. It is assumed that the monitoring will be conducted by a combination of King County staff, volunteers, and consultant contracts. Sections 3.1.1 to 3.1.5 outline the major monitoring tasks by giving a description and rationale for each task and the anticipated schedule.

3.1.1. Groundwater quality sample collection

Description: This task will involve collecting groundwater samples from established well locations. Sample collection is already taking place on Vashon-Maury Island as part of King County's Ambient Monitoring Program. There are currently 22 public supply/private wells sampled semi-annually. The current Ambient Monitoring Program will be evaluated in 2004 for possible changes or modifications. There will be coordination with a statistician to refine the sample distribution and frequency. It is anticipated that as dedicated monitoring wells are installed (see Section 3.1.2), water quality sampling will be eventually shifted from the current water-supply wells to those wells. The current Sampling and Analysis Plan (SAP) for Vashon-Maury Island Groundwater Management Area will be updated to reflect the changes in the water quality monitoring.

Rationale: The three main reasons to implement routine monitoring of groundwater quality on Vashon-Maury Island are to: (1) establish the natural baseline quality of the system to detect future changes, (2) have an early warning system on the impacts of pollution sources, and (3) identify trends in groundwater quality caused by natural events, the impact of diffuse pollution, and changes in the hydrologic regime. This task supports the first objective of the project.

Schedule: The current program will be reevaluated and refined in 2004; the SAP will be updated to reflect those changes. This effort will continue through the end of 2010. By the end of 2010, it is anticipated that all sample collection for groundwater quality will come from dedicated groundwater monitoring wells.

3.1.2. Water-level measurements in dedicated monitoring wells

Description: Dedicated groundwater-monitoring wells will be drilled and installed throughout Vashon-Maury Island. The locations of these wells will be determined as the groundwater model is being developed. New locations may be close in proximity to streams to allow for analysis of surface water-groundwater interactions. As the model is developed and the limitations of existing water-level data are recognized, wells will be installed to fill in the data gaps.

During drilling, soil samples will be collected and a boring log describing subsurface soils will be completed (Log will also be input in EQUIS database program). Long-term pumping tests will be conducted at ~5 of the well locations; these tests will generate estimates of aquifer parameters (i.e. transmissivity and storativity) and identify potential boundary conditions and leakage. After installation and testing, these wells will be equipped with automatic water level recorders or data loggers that monitor water level fluctuations on a continuous basis. Water-level measurements will be downloaded from the data loggers twice per year by King County staff.

Rationale: To accurately monitor groundwater levels, you need dedicated monitoring wells that are unaffected by pumping. The installation of continuous water-level measurements allows for characterization of the magnitude, frequency, and cause of water-level fluctuations. Long-term water-level measurements serve as the primary data required for calibration and testing of

groundwater models. Fluctuations in water levels will be used to calibrate the groundwater model. They are also required to assess the effects of climate variability and to monitor the effects of regional aquifer development.

Schedule: Dedicated monitoring wells will be installed in 2005 and 2007. Each well will be equipped with an automatic water-level recorder, which will need to be retrieved off of the data loggers semi-annually. In 2003 and 2004, water level measurements will occur as part of the water quality sample collection efforts.

3.1.3. Distribution of precipitation

Description: A combination of volunteers on Vashon-Maury Island and King County Staff will record precipitation values. King County Staff will install continuous precipitation gages at select stream-gage locations. Volunteers will be used to supplement this data. King County will provide the equipment for the volunteers and King County staff will train the volunteers on the proper protocol. Locations will be based on availability of volunteers and modeling requirements.

Rationale: Precipitation values are needed on a microclimatic scale to estimate recharge to the aquifer. It is necessary for model input. Precipitation data also aid in the interpretation of water level changes in the monitoring wells.

Schedule: The volunteer component will begin in 2004. The installation of the continuous precipitation gages will coincide with the stream-gages installation. Once installation is complete, the data will need to be retrieved from the data loggers on a biannual basis.

3.1.4. Stream-flow gaging

Description: Two creeks on Vashon-Maury Island, Judd Creek and Shinglemill Creek, are monitored as part of the existing King County Department of Natural Resources and Parks (DNRP) stream-gage network. It is anticipated that six streams will be added to this stream-gage network.

Rationale: Other types of hydrologic information are a necessary part of any groundwater monitoring/modeling program. The stream-gage stations help describe the interaction of surface water and groundwater on Vashon-Maury Island. It is important to understand how the groundwater levels are related to stream flows since many endangered and threatened species rely on stream flows for survival. Stream discharge or stage levels are useful in examining the interaction between groundwater and surface water.

Schedule: The installation of stream gages will begin in 2004. The existing stream-gages will continue to be collected by King County DNRP. King County staff hours will be required install the stream-gages and collect the data after installation.

3.1.5. Water level survey

Description: A large water level survey on Vashon-Maury Island will be conducted to allow for a better description of groundwater flow in the major island aquifers. The water level measurements need to be taken at all the wells within a short period of time (around one week) so that the hydraulic heads in the aquifer are measured under the same hydrologic conditions. These measurements will be collected at all the wells twice, in the spring and fall, to gage seasonal

changes. Groundwater contour maps for the major aquifers on Vashon-Maury Island will be generated with the results of survey.

Rationale: This survey effort is necessary to contour the water levels in the major aquifers on Vashon-Maury Island. It also gives a better understanding about the patterns of groundwater flow, which is crucial to the development of an accurate model.

Schedule: The water level survey will take place twice over the course of one year. This task will be completed after the phase 1 model has been developed. It will be used to refine the phase 2 model. It is anticipated that it will take place in 2005.

3.2. Modeling

It is anticipated that the model will be constructed in three phases. The construction of the groundwater model will rely heavily on the monitoring and data management components of this work plan.

3.2.1. Phase 1 Modeling

In phase 1, a large-scale steady-state model will be developed for Vashon-Maury Island groundwater budget. It is anticipated that the phase 1 model will be developed in the MODFLOW Model developed by the U.S. Geological Survey. MODFLOW is a finite-difference groundwater flow model capable of modeling in one-, two-, or, three-dimensions. The phase 1 model will be a three-dimensional model that describes the basic flow patterns of groundwater and provides annual average estimates of water supply for Vashon-Maury Island.

There are three main reasons to develop a phase 1 model: First, the results will guide future data collection and management efforts. Second, it will assist in the design and development of a phase 2 model. And third, it will give initial water budget estimates and groundwater flow patterns for the island.

The major tasks required to complete the phase 1 modeling are described below.

Task 1 – Prepare data for model input

Description: Data requirements for the phase 1 model include hydrogeologic information such as aquifer thickness and distribution, groundwater and river levels, recharge and discharge quantities, and aquifer properties. The phase 1 model will primarily use data from published reports and available well logs. The exclusive use of data from previously published reports in the model results in limited applications; this approach is only appropriate for use in the phase 1 model.

This task works in conjunction with the countywide data management activities.

Task 2 – Design a model grid and assign aquifer properties and boundary conditions

Description: This grid will be designed based on the hydrogeologic features of the subsurface. Physiographic features include the uplands, valleys, and streams. It is anticipated that the model will contain four layers and a grid spacing of X columns by XX rows (cell size approximately ¼ mile on a side). Each grid cell within the model will need to be assigned a number of different hydraulic aquifer parameters. These include hydraulic conductivity and storativity.

Task 3 – Run model simulations

Description: Steady-state model simulations will be performed once input is complete.

Task 4 – Model calibration and report submittal

Description: Model calibration involves changing input parameters until the model results match field observations. Comparisons will be made between model-simulated conditions and field conditions for selected data. A phase 1 model development and calibration report will be prepared. King County groundwater staff will develop the phase 1 model.

Phase 1 Modeling Schedule: The phase 1 model will be complete by the end of 2004.

3.2.2. Phase 2 Modeling

In phase 2, more refined groundwater and surface water models will be developed and linked together. It is anticipated that the groundwater model will be either a finite-difference or finite-element model that will allow for resolution to a relatively fine spatial and temporal scale. The surface water models will be developed in HSPF, as basic HSPF models are already developed for the two largest watersheds (Shinglemill and Judd Creeks). The two models will be linked together, and calibrated to available weather data, surface water data, and groundwater data. A phase 2 model development and calibration report will be prepared. It is anticipated that the combined surface water and groundwater model may be contracted to a consulting firm with expertise in developing similar scale models. The surface water models will likely be developed by King County staff in-house, with the model linkages then developed.

Completion of the phase 2 model will give King County the ability to evaluate the potential impacts to groundwater supplies caused by changes in climate and delineate the impacts from adding new public supply water wells on the existing well network. Groundwater budgeting will be done to assess future growth scenarios on the island. Some possible specific applications of this model include:

- Evaluating the impact of additional pumping wells on groundwater resources
- Determining the accuracy of wellhead protection areas
- Describing the interaction between groundwater and surface water sources.

Phase 2 Modeling Schedule: The phase 2 model work will begin in 2005.

3.2.3. Phase 3 Modeling

The phase 3 model will be a refined version of the phase 2 model that will allow for specific investigations in areas of concern on the island. Contaminant transport capabilities may be added to the model to evaluate potential pollutant sources. The refined groundwater and surface water model will be run under various land-use and global climate change scenarios. The model results for each of these scenarios will be compared and assessed to identify water budget issues and water quality issues.

The phase 3 model will be regularly calibrated to the continuous monitoring data collection activities. Recommendations will be made regarding possible future land use and groundwater management ideas. A phase 3 modeling report will be developed.

Phase 3 Modeling Schedule: The phase 3 model will begin after completion of the phase 2 model.

3.3. Data Collection & Management

The successful development and implementation of a long-term monitoring and modeling program requires an explicit identification of data management issues and methods. Data management involves compiling, organizing, and synthesizing existing and collected data. The management activities for this project are a subset of the activities planned throughout King County. A countywide data management work plan is currently being developed that identifies:

- The types of data that will be collected
- Data sources
- The storage methods used for the data
- The accessibility of that data by technical staff and the public

The draft data management work plan will be completed in 2003, with a final plan by mid-2004. Data management activities will continue throughout development of the plan and the project. The data management tasks are described below in Sections 3.3.1 to 3.3.5.

3.3.1. Data gathering from other sources

Description: All of the existing reports and data sources for this region will be gathered and organized.

Schedule: This task will be done in 2004.

3.3.2. Characterization of hydrogeology

To characterize the hydrogeology of the study area, work will be performed in three main areas. These areas include quantifying the recharge and discharge on the island, mapping the distribution of aquifer parameters, and constructing hydrogeologic cross-sections and maps.

Recharge and Discharge Quantities

Description: The task will quantify the geographic distribution of recharge/discharge rates over the model area (Vashon-Maury Island). Recharge quantities will be estimated using the method applied by Bidlake (2001) in Kitsap County, Washington. An inventory of the pumping rates on a monthly basis at all Group A wells and the private, non-exempt wells will provide the primary estimates of discharge. Discharge/recharge quantities from streams and springs will initially be estimated using previously published results. As the stream-gage network gets underway, these values will be incorporated.

The following data sources will need to be compiled to complete this task

1. Land-Use Map
2. Vegetation Cover
3. Precipitation Distribution (Time and Space)
4. Surface Geology and Soils
5. Monthly stream flow data

6. Pumping rates on a monthly basis at Group A wells
7. Pumping rates on a monthly basis at private, non-exempt wells
8. Estimates for withdrawal at private, exempt wells

Schedule: The initial estimates of the model area recharge and discharge will be completed in late 2003 to early 2004. These estimates will be used as input to the phase 1 groundwater flow model. The estimates for recharge and discharge will be refined as the monitoring aspects of this project begin. Updates to these estimates will occur yearly with an eventual goal of potentially updating them monthly.

Aquifer Parameters Mapping

Description: Maps showing the distribution of transmissivity and storativity for each aquifer will be developed. These values will mostly come from the aquifer pump tests and published reports.

Schedule: These maps will be drafted after completion of the pumping tests (projected to be in 2005 and 2007)

Construct hydrogeologic maps and cross-sections

Description: Work being performed for this task includes:

- Collecting subsurface geologic data (i.e., borehole or well logs) for Vashon-Maury Island from sources at King County and in state agency offices in Olympia and elsewhere.
- Providing a list of boring logs on Vashon-Maury Island in a database that includes groundwater information.
- Performing geologic field mapping on the islands to aid in the development and verification of geologic units for interpretation of maps and cross sections; using these data to update previous geologic mapping (to a 1:24,000 scale) and create geologic cross-sections.
- Providing a table of high, medium, or low susceptibility, for each reinterpreted geologic unit on Island, to allow for future revision of mapping of “areas of susceptibility to groundwater contamination.”

Schedule: This task will be contracted out to the University of Washington in 2004. All deliverables are expected to be completed in 2004.

3.3.3. Data storage, updating, and analysis

Description: The types of data that will be stored, updated, and analyzed on a yearly basis include:

1. Water level Contour Maps
2. Recharge/Discharge Estimates
3. Inventory Report on Group A, Group B and private, exempt wells
4. Potential Contamination Sources
5. Trends in water quality parameters

6. Relationships between water levels, stream levels, and precipitation will be analyzed.

Schedule: This will be an on-going task beginning in 2004. The level of effort for this task will be highest in the short-term (i.e. 2004) while a database is prepared and the methodology for storage and updating of data is established.

3.3.4. Preparation of annual data reports

Description: An annual data report will be produced each year. This report will synthesize all of the data from the year and include any products generated from analysis of the data.

Schedule: The data reports will be produced annually starting in 2004.

3.3.5. Dissemination of data

Description: The data generated and compiled for this project needs to be disseminated through a web-based interface or some other mechanism. Specific details about this task will be included in the data management work plan for King County. This activity will coordinate with the countywide effort to disseminate groundwater data.

Schedule: Work on this task will begin in 2004. More specific schedule details will be included in the countywide data management work plan.

3.4. Project Communication

Communication at all levels will be an important component of this work plan. The three main areas of communication include project management, project coordination and education and outreach.

3.4.1. Project management

The project will be managed by Stephanie Brown who is within the Science and Data Management Section of the Water and Land Resources Division in the Department of Natural Resources and Parks. Jim Simmonds, the head of the Water Quality and Quantity Unit, will act as project director and Dr. Ken Johnson will be the senior technical expert.

3.4.2. Project coordination

This project will entail continuous open coordination between King County staff and members of the Vashon-Maury Island Groundwater Protection Committee, the Vashon-Maury Island Land Use committee, and the public on Vashon-Maury Island. It is proposed that this coordination will occur through the development of a technical subcommittee of Vashon-Maury Island residents that meet regularly with King County staff to discuss issues related to the scope, schedule and budget. At these meeting, there will be the opportunity for input and recommendations. Reporting to the full committees is anticipated on a regular basis. Project updates will be produced on an annual basis and shared with King County staff, the Vashon-Maury Island Groundwater Protection Committee, and the Vashon-Maury Island Land Use Committee.

Coordination will also be needed with the WRIA 15 watershed-planning unit. Kitsap County is leading the development of a watershed plan for WRIA 15 (required under the Watershed Planning Act (RCW 90.82), formally known as HB 2514) of which Vashon-Maury Island is a part. The anticipated schedule for certain tasks and deliverables may change if necessary for coordination with this unit.

3.4.3. Education, outreach, and public involvement

The results from this project will be used to promote stewardship on Vashon-Maury Island and direct education and outreach efforts. The various aspects of this work will inform the island residents on water-resource related issues. There will also be opportunities for public input during each phase of the project.

4. Project Schedule

This scope of work is intended to cover about the next seven years of monitoring, modeling, and data management activities within Vashon-Maury Island. The tentative schedule of the major project milestones is:

2004:

- Collect groundwater quality samples from existing water supply wells,
- Install the stream gages and precipitation stations,
- Finalize data management work plan,
- Develop phase 1 groundwater model,
- Compile other studies and data sources,
- Begin characterization of hydrogeology,
- Initiate data storage, updating and analysis efforts, and
- Develop a way to disseminate data.

2005: Continue monitoring and data management efforts, install first round of monitoring wells, conduct water-level survey, possibly hire consultants to develop phase 2 model

2006: Continue monitoring and data management efforts, develop phase 2 groundwater model and surface water model

2007: Continue monitoring and data management efforts, install second round of monitoring wells, continue development of phase 2 groundwater and surface water models

2008: Continue monitoring and data management efforts, link phase 2 groundwater and surface water models, and calibrate to existing data

2009: Continue monitoring and data management efforts, model various land-use and global climate change scenarios

2010: Continue monitoring and data management efforts, develop recommendations (as appropriate) for future land use and groundwater regulation/management. Review work plan.

5. Deliverables Summary

Report	Due Date
Annual project update reports	2004, 2005, 2006, 2007, 2008, 2009
Complete Work Plan (This document)	2003
Revised Sample and Analysis Plan for monitoring	2004
Annual Data Reports	2004, 2005, 2006, 2007, 2008
Data Management Work Plan	2004
Installation of stream gages and precipitation stations	2004
Updated geologic cross-sections of Vashon-Maury Island	2004
Updated table of high, medium, or low susceptibility, for each reinterpreted geologic unit on Island	2004
Database of boring logs and well constructions diagrams	2004
Phase 1 model development and calibration report	2004
Phase 2 model scope of work (for consultant selection)	2005
Phase 2 model development and calibration report	2008
Phase 3 model scenario report	2010
Revised Work Plan for the future	2010