APPENDIX C

Select Site Investigation Reports (Provided on CD)

Appendix A

Vashon Island Landfill & Transfer Station: Hydrogeologic Services

Proposed Scope of Work #2

October 23, 2006

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FINAL

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Vashon Island Landfill & Transfer Station:Hydrogeologic Services

Proposed Scope of Work #2

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Appendices

1.0. SUMMARY OF SERVICES & ESTIMATED HOURS

This document presents a scope of work recommended as a result of previous work started in the fall of 2005. A technical data report of the results from that work was completed in August 2005. The scope proposed in this document is intended to supplement work already completed and ongoing by the King County (KC) Solid Waste Division (SWD) at the Vashon Island Landfill & Transfer Station (VILF). This document is submitted to assist the SWD is evaluating potential impacts to the areas within and adjacent to the VILF property while taking into consideration the previous efforts and present understanding of contaminant transport modes at the site.

The first scope of work (SOW #1, Appendix A) was to map the geologic units on the southwestern hillslope, with the intent of correlating outcropping units to the underlying units at VILF. As a result of that work, there is a better understanding of the spatial orientation of saturation on the hillslope and identification of these areas with respect to property lines. Refinement of this conceptual model is ongoing and further recommendations are included here within.

This work plan proposes to conduct further surface water and groundwater investigations in the area of the hillslope to the west of VILF; extend characterization to the south; and to develop three-dimensional geospatial models for analyses and presentation purposes. The scope of work presented in this work plan will address the following questions:

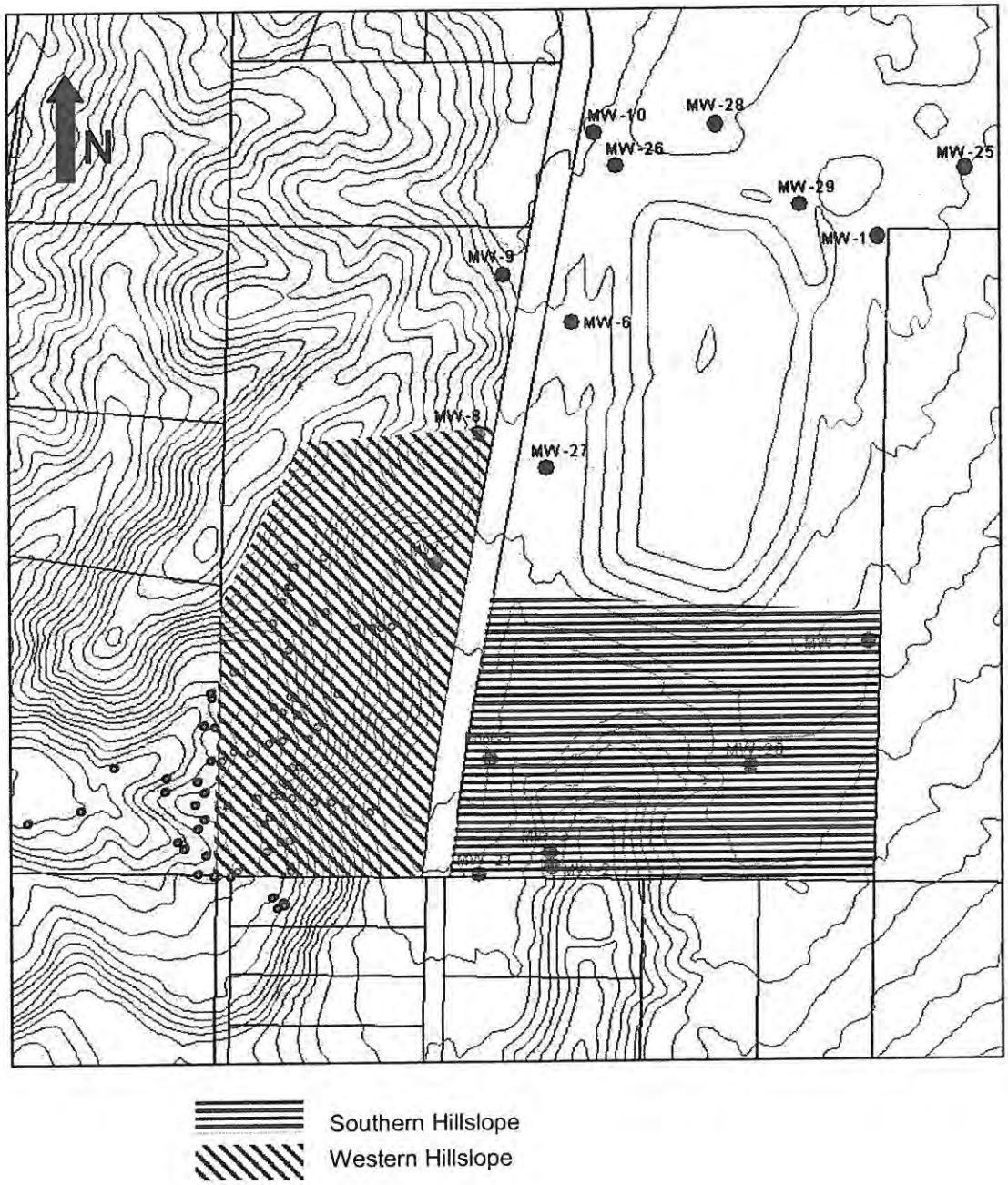
- Where do the coarse grained units of Unit C (Cc1, Cc2, and Cc3) outcrop on the hillslope?
- Is there any saturation in the Cc1 outcrop, if present?
- What water source is being sampled at sampling weirs SW1, SW2 and SW3?

The proposed work (Table 1) is presented in sections representing separate activities. Each section has a table listing the hours per subtask and deliverables for each task. Labor estimates are subject to change due to offsite access issues, weather, labor availability, contract issues, remedial design concerns, and unforeseen circumstances. It is assumed that tasks are completed without interruption. Most of the field work labor hours are listed for one individual. The work could be completed in a shorter time span if additional helpers were made available.

Table 1. Tasks & Estimated Labor Hours

Task	Estimated Labor Hours
Task 1.0 Western Hillslope and Cc2 & Cc3 Seepage Faces	784 (~5 months)
Task 2.0 Southern Hillslope & Property Line Area	256 (~2 months)
Task 3.0 Visual Imaging	776 (~5 months)

Figure 1. Task Areas



2.0. WESTERN HILLSLOPE AND CC2 & CC3 SEEPAGE FACES – TASK 1

The bulk of the scope presented in SOW#1 is now complete. At this time, there is ongoing analysis of data. A technical data report was submitted to the SWD (KCWLRD 2006). As stated before, the general scope of work was to map the sediments on the hillslope and correlate them to units underlying the VILF. Recently acquired drill cuttings will assist in this interpretation. In order to fully characterize and confirm location of outcropping units on and off of KC property, additional field work is required and presented in Table 2. This section proposes that the sampling array be redesigned, a discharge measurement array be installed, the recent environmental evaluation report (B&H/UES, 2006) be reviewed, and the wells be installed onsite at the hillslope.

Table 2. Subtasks, Estimated Labor Hours, and Deliverables for Task 1.0

Report Section	Subtask	Estimated Labor Hours
2.1.1	Redesign and Install Sampling Array	256 (includes gager)
2.1.2	Install Discharge Measurement Weirs	160(includes gager)
2.1.3	Survey Weir & Sampler Locations	40 (Surveyor hours not included)
2.1.4	Collect Chemical Data from Weirs & Samplers	64*
2.1.5	Collect Discharge Data from Weirs	24*
2.2.1	Review of B&H/UES and Annual Report	8
2.2.2.1	Cc2 and Cc3 Well Installations	200
2.2.2.2	Cc2 and Cc3 Well Chemical Data Collection	24*
* Hours are for first event only. Includes prep time.		
Deliverables		
▪ Maps with sampling array recommendations and locations ▪ Tables of survey data, water quality and chemical analysis results. ▪ Hillslope Site Specific Health & Safety Plan ▪ Updated hydrogeologic map and cross sections ▪ Discussion and Recommendations		

2.1 Groundwater Seepage

Along the hillslope to the west and south of MW-4 and MW-14 are several focused groundwater seepage areas. Groundwater in outcropping units of Cc2 and Cc3 appear to be daylighting on the hillslope. Focused areas of seepage were noted during field activities completed for SOW#1. In addition, small streams and related source areas were mapped. As a result of this field work, it appears that the weirs were not located optimally. It is recommended that the weir array be redesigned and quarterly chemical and physical data be collected. Data from this task will assist in refining the hydrostratigraphic model and assist in designing a remedial system for collection of impacted water.

2.1.1 Redesign and Install Sampling Array

In order to characterize the water chemistry for the hillslope seepage area, the present array is insufficient. A new sampling array will be designed and installed along the main seepage area of the hillslope. The recommended locations were included in the report for SOW#1 and are summarized in Table 3. Approximately six new locations will be sited near the focused seepage areas. An additional four new weirs will be installed at the downstream locations near the property line. A site visit by an experienced weir installer (KC Water & Land Division (WLRD) Stream Gauging Personnel) will be required to begin design and purchase of equipment for installation.

2.1.2 Install Discharge Measurement Weirs

Approximately four weirs designed to measure discharge, will be installed in the downstream portions of the seepage areas. The locations of the current weirs at SW2 and SW3 will be also be used for discharge measurements. The recommended measurement locations were included in the report for SOW#1 and are summarized in Table 3. These weirs will measure discharge rates of streams going offsite and the data can be used as a conservative value for design of a collection system. Another option is to install discharge rate measurement devices at the seepage locations. These groundwater seepage rates would provide a more accurate measurement for a collection system located further up the hillslope.

Table 3. Chemical Analysis Frequency Goals of Hillslope Wells, Weirs and Samplers

Type	Chemical Analysis Goal
Seepage Samplers & Wells	Every other month during rainy season (Oct. - April), quarterly during the dry season (May - Sept.), for one year. Analysis will be for the same suite sampled for in the monitoring wells at the VILF.
Stream Weirs	Every other month during rainy season (Oct. - April), quarterly during the dry season (May - Sept.), for one year. Analysis will be for a short list of conventionals and metals from the same suite sampled for in the monitoring wells at the VILF.

2.1.3 Survey Weir & Sampler Locations

Sampling locations will be surveyed by a KC surveyor. Accurate location data will be entered into the database and will be used to better refine the maps.

2.1.4 Collect Chemical Data from Weirs & Samplers

Water quality and sampling will be conducted at each location upon installation at all sampling locations. The array, frequency goal, and analytes will be reevaluated after reviewing one year of data. Table 3 shows the frequency goal of sampling.

2.1.5 Collect Discharge Data from Weirs

Discharge measurements will be recorded from the sampling weirs on a monthly basis for a period of one year in order to observe any seasonal changes. At the end of that time period, the array and frequency goal of measurements will be reevaluated after reviewing one year of data.

2.2 Hydrostratigraphic Mapping

The mapping for SOW#1 is ongoing. Accurate mapping of the Cc1, Cc2, and Cc3 contacts requires more effort. An important part of this task includes evaluating potential for offsite impact from these units and related streams to the western property.

2.2.1 Review of the Environmental Evaluation (B&H/UES 2006) & Annual Reports

Recently reported chemical and geological data and annual water chemistry from wells and weirs will be reviewed. This task will be to better refine the hydrostratigraphic model.

2.2.2 Investigation of Potential Offsite Impact to the West

In order to provide enough information for the SWD to consider further actions, it is recommended that the potential for offsite impact to the west be evaluated. This task will better refine the hydrostratigraphic model and assist in answering questions related to offsite impacts. Included in this task are mapping of offsite surficial units, evaluating drilling techniques, and installing two wells on the hillslope on KC property.

2.2.2.1 *Cc2 & Cc3 Well Installations*

It is recommended that two wells be installed on the hillslope, one screened in Cc2 and the other in Cc3. Lithologic data from the borehole and chemical and physical parameters from the soil and groundwater in the well will better refine the hydrostratigraphic model and assist in answering the questions related to offsite contamination in this area.

The hillslope area is a wild landscape with steep slopes, wet and muddy areas, has road access and is covered with trees, holly bushes and salmon berry bushes. Maintaining a safe workplace will require some effort. There are many falling limbs, especially during and after storm events. As a result, it will be important to identify a cost effective method to collect the data that will take into consideration these constraints. It is assumed that a Hillslope Site Specific Health & Safety Plan will be prepared by editing the VILF Health & Safety Plan for drilling. The labor estimates on this task is may change due to inclement weather, drilling rig issues, and site conditions.

Upon completion of well installation, water quality parameters will be measured and groundwater samples collected for chemical analysis. Costs for possible contractor labor hours are not included.

2.2.2.2 *Cc2 & Cc3 Well Chemical Data Collection*

Groundwater samples will be collected on the frequency as indicated in Table 3 for a period of one year in order to observe any seasonal changes. At the end of that time period, the sampling frequency and chosen analytes will be reassessed.

3.0. SOUTHERN HILLSLOPE & PROPERTY LINE AREA – TASK 2

An understanding of the hydrostratigraphic units near the southern property line is required in order to better characterize the flow paths from the site. This is especially important within the north-south aligned channel deposit, Cc1. Where this channel directs groundwater is important in evaluating potential impacts to adjacent and nearby properties and to the closest public water supply well, located downgradient of the VILF.

This section proposes that the latest report be reviewed and an initial mapping assessment is proposed as preparation for onsite hydrostratigraphic mapping in this area of the VILF. This mapping event is to be carried out similarly to the western hillslope activities completed in the SOW#1. Table 4 indicates the proposed subtasks, estimated labor hours, and deliverables for this task.

Table 4. Subtasks, Estimated Labor Hours, and Deliverables for Task 2.0

Report Section	Subtask	Estimated Labor Hours
3.1	Report Review	4
3.2	Initial Mapping Assessment	32
3.3	Onsite Field Mapping	160
3.4	Survey Locations	60 (Surveyor hours not included)
Deliverables		
▪ Updated hydrogeologic map and cross sections ▪ Discussion and Recommendations		

3.1 Report Review

A review of the recent environmental evaluation report (B&H/UES 2006) will be completed and the data for the southern boundary will be incorporated into the following tasks.

3.2 Initial Mapping Assessment

There is about 100 feet of topographic relief in the southern portion of the VILF. An analysis of outcropping/subcropping units south of the VILF footprint in the vicinity of the ponds and outfall area is required to evaluate the need to go offsite for further characterization. This initial assessment would indicate probable locations of outcropping/subcropping units and if any, associated daylighting groundwater from hillslopes along the creek flowing into Judd Creek.

3.3 Onsite Field Mapping

Upon completion of the initial mapping assessment, field mapping of sediments onsite will be conducted. This task will be carried out similarly to the field work on the southwestern hillslope in the SOW#1. Due to the reworking of refuse, backfill and native soils in this area, this effort may require a more invasive sampling technique (i.e. hand auger). Included in this task are observations of saturated areas and seeps.

3.4 Survey Locations

Mapping and offsite well locations will be surveyed by a KC surveyor. Accurate location data will be entered into the database and will be used to better refine the maps.

4.0. VISUAL IMAGING – TASK 3

Three-dimensional (3D) geospatial models are a useful analysis tool and effective presentation tool. Visual imaging software, such as RockWorks™, can be a powerful tool to show images to in-house decision makers, regulatory personnel and the public. The geospatial conceptual model is often difficult for non-technically minded individuals to visualize without the help of a 3D model. This section proposes that RockWorks™ be used to develop a geospatial model of the VILF area to assist in answering questions pertinent to protecting human health and environment. The first section presented here describes the types of geospatial models that will assist the SWD in this task. The second section proposes a training period to transfer knowledge of the models and associated software to the SWD personnel.

This following sections present some basic steps and information related to developing a geospatial model for the VILF. It is assumed that the SWD has a support agreement with RockWorks™ and that there would be access to online or telephone assistance from RockWorks™ and EQuIS.

Table 5. Subtasks, Estimated Labor Hours, and Deliverables for Task 3.0

Report Section	Subtask	Estimated Labor Hours
4.1	Update EQuIS Database	200
4.2	Preparation of Geospatial Models	400
4.3	Prepare RockWorks™ Training Sessions	40
4.3	RockWorks™ Training – Power user	80
4.3	RockWorks™ Training – Occasional User	32
4.4	Presentations	24
Deliverables		
▪ "How to" Manual for similar SWD projects ▪ Documentation on preparation of each geospatial model for the VILF ▪ Electronic versions of PowerPoint presentations and RockWorks™ demonstrations.		

4.1 Update EQuIS Database

In order to build the geospatial models, some data needs to be entered into and upgraded in EQuIS database. It is understood that the SWD has both EQuIS 3 and EQuIS 5 versions for

chemistry and geologic data, respectively. It is recommended that the EQuIS 3 data be migrated to the EQuIS 5 version. This will make data extraction more efficient in this and other tasks. Upon migration, the data can then be exported in a format used by RockWorks™. This procedure is a more efficient process for some data than directly entering the raw data into RockWorks™. An initial assessment of the database will be required to propose a more realistic estimate of labor hours.

4.2 Preparation of Geospatial Models

Geospatial models can be built once the required data has been entered into the EQuIS and RockWorks™ database. This time period involves becoming familiar with the software, entering required data into RockWorks™, and downloading, importing and converting files. These are basic steps to being development of three different geospatial models. The sections below describe each model and gives examples of the data required to build each model.

4.2.1 Lithologic

This model represents the USCS descriptions of sediments encountered in onsite and offsite investigations. The detail presented by this model would be useful to answer questions related to flow pathways and detailed analysis of chemical processes. Aquifer and saturated zones can be included in this model. Some examples of data required to be in the database are lithologic names, elevations, and location data.

4.2.2 Hydrostratigraphic

This model represents the geologic units and related aquifers present at and proximal to the VILF site. This model would be most useful in presenting images to the decision makers, regulators, and the public. Some examples of data required to be in the database are elevations of contacts between geologic units (such as Unit B, Cf and Cc2), water level elevations, elevations related to groundwater that daylights on the hillslope, and location data.

4.2.3 Contaminant

This model represents contaminant data within the hydrostratigraphic units. Contaminants of most concern to human health and environment would be identified by the SWD and data entered in to the RockWorks™ database. A geospatial model showing water quality and impacts can be useful towards siting future monitoring wells. The chosen water quality parameters or contaminants of concern would be required to be in the database.

4.3 RockWorks™ Training

Upon developing the models, this knowledge will be transferred to the SWD personnel. For comparison to commercial rates, custom (classroom) training sessions from RockWare® (maker of RockWorks™) run from $3,000-$8,500, plus travel expenses for one or two trainers. It is assumed that travel to the RockWare® training room in Colorado is not an option. However, if it is, those rates are $1,000 per day for up to 3 people.

A power user within the SWD will be identified as the main person responsible for maintaining the geospatial models, developing new ones, and for assisting occasional users with the software. The power user will initially provide minor assistance to others learning the software. Preparation for this training would include documentation for developing the geospatial models, sort of a "How-to" manual for the SWD type projects. Training for the power user would be over a two week period.

A group of three occasional users will be identified to receive training. The training event will be in the form of two 4-hour workshops, assuming there are enough licenses. If there are not enough licenses to allow a group workshop, the training sessions will become individual sessions with each of the three occasional users. The sessions will cover the skills required to perform basic tasks to navigate the software and view the model.

4.4 Presentations

It is recommended that presentations be given to the SWD and WLRD to report on the results of using RockWorks™ and EQuIS on this project. It would be advantageous to demonstrate how using this software helped to answer questions and to show others the physical setting at the VILF. It is recommended that other parties working on similar landfill settings be invited to these presentations. More importantly, it would be helpful to SWD in communicating results to agencies prior to report submittal.

5.0. REFERENCES

Berryman & Henigar, Inc. (B&H) and Udaloy Environmental Associates (UES) (B&H/UES). 2006. *Vashon Island Closed Landfill Environmental Evaluation*. March.

King County Water and Land Division (KCWLRD). 2006. *Vashon Island Landfill Hillslope Report for Scope of Work #1*. August.

Appendix A - Scope of Work #1

Evaluation of Hillside Hydro eolo y

- Define the study area, which will include areas from the landfill to downgradient of the western boundary of the property.
- Prepare two preliminary geologic cross sections in the study area. This includes review of geologic borings across the site, using elevations at boreholes as reported in data reports, and extracting data from the GIS website for a recent topographic contour map. Units of interest are the coarse grained units within Unit C; Cc1, Cc2, and Cc3.
- Prepare a preliminary hillside hydrogeologic map with projected outcrops of the coarse grained units in Unit C.
- Conduct hydrogeologic reconnaissance of the hillside within the property boundary. This includes refining the locations of the Unit C outcrops and seepage areas, collecting sediment and water samples, conducting field water quality analysis, and marking locations for survey data collection. Field work to be completed by Sevin Bilir with possible assistance required of Eric Ferguson (WLRD) or Dan Swope (the SWD).
- Review of field results and collected data.
- Prepare final hydrogeologic cross sections, maps, and water quality data tables.
- Finalize a report to present results and recommendations.

Deliverables

• Daily verbal/email field reports.
• Report
  • Updated hydrogeologic cross sections of study area.
  • Updated hydrogeologic map of study area.
  • Water quality data table.
  • Surveying data table.
  • Discussion and Recommendations.

Activity	Estimated Labor Hours	Schedule
Task Management1	24	n/a
Preparation of preliminary hydrogeologic maps and cross-	24	Week 1
Field Mapping and Field Data Collection	40	Week 2
Surveying2	16	Week 3
Data Analysis	32	Week 4
Preparation and submittal of report	24	Week 5

Notes:

1 Miscellaneous meetings and communications.

2 Work to be completed by surveyor.