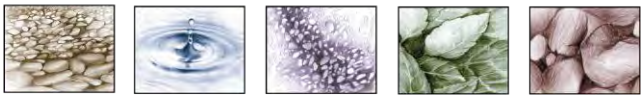
Associated Earth Sciences, Inc.



Technical Memorandum

Date:	**February 12, 2013**		**Page 1**
To:	**Juniper Beach Water District Attn: Kevin Plambeck**	**Project Name:**	**Leque Island Restoration**
From:	**Charles S. Lindsay L.G., L.Hg. David J. Baumgarten L.G., L.Hg.**	**Project No:**	**EH130023A**
Subject:	**Technical Review of Pacific Ground Water Group Hydrogeologic Report**		

This technical memorandum provides our preliminary questions and comments regarding Pacific Groundwater Group (PGG) technical report titled "Hydrogeologic Evaluation of Proposed Leque Island Restoration," dated December 2012. These preliminary questions and comments were prepared within the limited comment time period granted by the United States Environmental Protection Agency (EPA) for this project.

We understand that the purpose of the PGG study was to evaluate *"the potential for increased salinization of groundwater beneath Camano Island"* resulting from the Leque Island Restoration project. Based on our understanding of the project area and our review of the PGG document, we have significant concerns regarding the adequacy of the PGG study in addressing the potential ground water quality and quantity impacts on the Camano Island Sole Source Aquifer that underlies Camano Island and the resulting impacts on the Juniper Beach Water Association (JBWA) water system. Our preliminary comments and questions regarding the PGG report are presented below.

Overview/Major Comments

One of the primary concerns of the Juniper Beach Water Association in the early stages of the proposed Leque Island project was that the initial hydrogeologic evaluation used to support the project was of limited scope, fundamentally flawed, did not include site specific data, and was primarily based on regional hydrogeologic information. Consequently, the JBWA requested that potential impacts from the proposed Leque Island project be evaluated by the completion of a comprehensive, project area specific, hydrogeologic study that had the goal of addressing potential water quality and quantity impacts to the JBWA water system and the Camano Island Sole Source Aquifer which underlies the northeast portion of Camano Island.

The JBWA further requested that the new hydrogeologic evaluation develop additional site specific information and utilize the significant amount of project area specific geologic/hydrogeologic and water use information that the JBWA and others have developed over the past several decades. As a result of the JBWA comments, the EPA required WDFW to complete a detailed hydrogeologic evaluation of Leque Island and the northeastern portion of Camano Island to address these concerns.

It should be noted that during the multi-year site specific study and the preparation of the PGG report, no representative of the project proponents or their consultants contacted the JBWA or their representatives and requested information regarding the JBWA well construction details/locations, pumping rates, water rights, daily water use, seasonal water use, static/pumping water levels, and aquifer testing information. Furthermore, our review of the project results presented in the PGG December 2012 report indicates that not only was the available JBWA site specific data not utilized by PGG in the construction and operation of their mode,l but inaccurate assumptions were made regarding the water system's hydrogeologic setting and operational activities. For example, PGG modeled water use at the JBWA as a withdrawal from a single well at a continuous pumping rate of 9 gpm (annual withdrawal of 14.5 ac-ft). According to the PGG report this was based on a *"delivery rate of 109 gpd/hookup based on reported 2009-2011 water use"* (Table C-1). This assumption and much of the other water use input data to the PGG model is inaccurate and inappropriate as indicated below.

1. The JBWA uses four production wells with the closest well being located approximately 3,500 feet west of Davis Slough. We were not able to determine the location of the single JBWA well used in the PGG model based on the information in the PGG report. The location of the modeled well relative to Leque Island can have a significant impact on the model results.

2. Carl Garrison (Garrison Engineering) is the JBWA water system engineer. Mr. Garrison has indicated that typical average water use for the JBWA is currently 145 gallons per day (gpd) per equivalent residential connection and the system currently has a total of approximately 123 connections. Mr. Garrison also indicated that the maximum daily system demand is 450 gpd/connection, which is commonly reached during the summer months. Therefore, the average daily and typical peak summer time water use of the water system is significantly greater than what was assumed by PGG.

3. PGG modeled the JBWA water use based on their inaccurate assumption of current use. The JBWA has water rights for a total annual withdrawal of 63.9 ac-ft, and can potentially serve a total of approximately 256 connections in the future. The use of the JBWA full water right would result in an annual average pumping rate of roughly 40 gpm, which is over 4 times the modeled rate assumed by PGG.

4. PGG did not account for single-residential well domestic use due to the assumption that *"pumping on the island is assumed to be largely non-consumptive due to septic effluent returns."* This is an unrealistic and inaccurate assumption. The northeast end of Camano Island is underlain by a relatively thick layer of low permeability glacial till. The majority of the single family domestic wells are completed within Aquifer D which is located beneath the glacial till unit. It is likely that less than 75% of the septic return flow would infiltrate through the till and become recharge to Aquifer D.

5. PGG estimated the effect of irrigation well withdrawal based on a review of irrigation water rights in the project area. The affect of irrigation water use was input into the model based on an average annual pumping rate of 213 gpm for seven irrigation wells. PGG ignores the fact that irrigation water use in the project area would only occur during the 170 day irrigation season which extends from roughly mid April through September. By averaging the irrigation water use over a year, the PGG model significantly underestimates the potential impact of irrigation water use, specifically during the critical summer months.

The PGG report states *"The 3D model was run in steady-state mode, and therefore does not simulate seasonal variations."* The report also states that *"The largest relative rise in Leque Island groundwater levels will occur in the summer months. While PGG did not attempt to simulate summer conditions, model predicted impacts for average annual conditions were so small that significant summer impacts are unlikely."* This conclusion is based on modeling scenarios that included inaccurate and flawed data. Potential impacts to the JBWA water system and the Camano Island Sole Source aquifer should have been evaluated based on the time period with the highest potential for seawater intrusion which is during the summer when both domestic and irrigation water use are at their peak and the largest rise in ground water levels will occur on Leque Island. Furthermore, any potential impacts analysis should be based on the maximum water use generated resulting from the full use of all potential future connections to the JBWA and the maximum of their water rights. It should be noted that the Leque Island project could be considered an impairment of the JBWA water rights if it results in a degradation of water quality in the JBWA production wells to the degree where the water cannot be put to its intended beneficial use.

In summary, the PGG ground water model and modeling scenarios used to develop/support the conclusions presented in the PGG December 2012 report are based on inaccurate data and assumptions. The model does not utilize available critical project area information and the modeling scenarios do not accurately represent the time period when the potential ground water quality and quantity impacts are most likely to occur. As a result, the model design and data input is skewed towards minimizing potential ground water quality and quantity impacts from the proposed Leque Island project.

Specific Questions and Comments

Due to the limited review/comment time period dictated by the Environmental Protection Agency (EPA), we were unable to complete a detailed analysis of the newly presented data and the complex regional ground water flow model presented in the PGG report. However we have provided some specific comments and questions below.

Section 3.3: Hydrogeology

- The logs for the specific WSDOT wells and GeoDesign Inc. explorations were not included in the report. Therefore, we were unable to independently evaluate subsurface conditions presented in the report.

Section 3.3.2: Aquifer Properties

- Only one very short term (15 minute), low rate pumping test (1.8 gpm) was conducted in one of the eight monitoring wells. This amount of aquifer testing is inadequate to characterize the aquifer conductivity in the monitoring area.

- None of the available data from several pump tests and aquifer characterizations completed for the JBWA were used in development of the aquifer parameters. This is available site specific data that should have been utilized in the model.

Section 3.3.3: Groundwater Levels and Flow Directions

- The methodology and reasoning for the brackish water density corrections was not presented and it is unclear as to why actual head values were not utilized. It is also unclear if the contour maps presented from the modeling output are actual heads or corrected head values or a combination of both.

Section 4.0: Proposed Restoration Design

- Text states *"Thus post-restoration groundwater salinities on Leque Island are expected to show little change from current salinities"*. Figure 4-2 shows six stations, why are existing and restoration salinity conditions only shown for Stations 5 and 6 which are noted as (outside of restoration area), and not on Leque Island? Also the salinity for Station 5 shows much higher salinity concentrations under the restored condition even though it is already noted as south of the existing dike, and outside of the restoration area. Why is there a markedly different salinity profile for pre- and post-restoration for Station 6 also noted to be located south of the existing dike and out of the restoration area. Stations 1 through 4 are on Leque Island but no existing salinity conditions are shown?

- Recharge to the existing Leque Island is noted as 8 inches per year of fresh rain water. Under the restored condition the text states up to 365 inches per year of recharge of brackish water due to daily tidal inundation. How can this not affect (increase) salinity of ground water on Leque Island under the restored condition?

Ground Water Modeling

- Under the current condition ground water flow is to the east under the Camano Island upland, to the east in the "monitoring area" and to the east across Leque Island. Under the post-restoration condition ground water flow simulations still show a ground water flow direction to the east under the Camano Island upland. However, the easterly component of ground water flow that extended from the Camano Island upland through the monitoring area and easterly across Leque Island to the Stillaguamish River, is now reversed. Ground water flow is now to the west from Leque Island through the monitoring area and brackish ground water is carried beneath local portions of eastern Camano Island. Therefore, the ground water modeling results indicate that the project will impact ground water quality in the Camano Island Sole Source Aquifer.

- Table C-3 indicates Aquifer C was included in the model simulations. However, no discussion or output indicating the ground water flow direction or potential impacts to Aquifer C are provided in the report.

- The 2-D model used to predict *"Modeled average head distribution"* under the restoration condition on Leque Island (Figure 4-5) shows the head for each K value modeled slightly above an elevation of 7 feet. This corresponds with the drain cell elevations to simulate fully saturated soil conditions and no recharge. Why was an average constant head elevation of 6.9 feet, noted in the text.

- Are the ground water elevation contours on Figure C-12 and C-13 for the pre-restoration condition corrected for the density of brackish water within the well casings, so the maps portray equivalent freshwater heads calculated at the well screens or are the contours uncorrected head values". The ground water contours shown on the Camano upland are approximately 6.6 feet. Survey controlled water levels in Juniper Beach Well JBWD-6 was approximately 1.5 feet above mean tide level in a study AESI conducted in November 2007.

- The horizontal hydraulic conductivity estimated from a pump test on a new Juniper Beach Water District well was 50 ft^2/day, which is an order of magnitude less than the horizontal hydraulic conductivity used in the GS model for this area of the model domain.

- What is the justification for the low hydraulic conductivity value (8 ft/day) on the westernmost portion of the Camano Upland in the GS model and a similar very low K value in the LA model.

- The cross sections show water levels in the Camano Island uplands are *"without established survey control"*. Figure 5-2 shows a number of wells on the upland used in calibration. The upland well water levels are described as not being collected concurrently with the lowland wells. Is there survey control on any of the upland well water levels used in the calibration process? Was there any effort made to get water levels from the upland concurrent with the lowland data?

- Was there any thought given to a future increase in ground water withdrawal on the Camano Upland by water associations or through irrigation, or are the model results based on an assumption that there will be no increase in withdrawal on the upland.?

- Page C-6 "The steady state model is intended to represent long-term average conditions; however long-term monitoring of static water levels in largely absent in the study area". Juniper Beach Water District has long-term water level monitoring data for the upland area which they were and are willing to provide.

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