Aspect consulting
IN-DEPTH PERSPECTIVE

MEMORANDUM

Project No.: 060016-001-02

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State of Washington
Hydrogeologist
1537
Licensed Geologist
Erick W. Miller
11-01-06

To: Jalyn Cummings, LHG
c/o Deanna Jacobsen

From: **Erick W. Miller, LHG**
Senior Associate Hydrogeologist

Re: **Baseline Groundwater Technical Information Summary**

1 Introduction

The City of Bainbridge Island (COBI) contracted with Aspect Consulting to establish a groundwater monitoring well network and accompanying database for groundwater management purposes. This monitoring network will be used to inform and advise water managers, both public and private, regarding issues of saltwater intrusion and safe aquifer yield, and may be used in the future to support development of a groundwater model. This memorandum summarizes the baseline technical information that has been compiled and reviewed as the initial step in development of a groundwater monitoring well network. The memorandum:

- Summarizes the defined groundwater aquifer systems;
- Reviews the monitoring currently being performed by Kitsap Public Utilities District No. 1 (KPUD) and COBI;
- Identifies areas of significant groundwater withdrawals;
- Evaluates observed water level changes;
- Evaluates chloride measurements;
- Determines areas of concern for seawater intrusion or water level declines; and
- Summarizes criteria and concerns for development of the monitoring network.

Under Task 3 of this project, the areas of concern identified in this memorandum and the current monitoring programs will be subsequently evaluated during development of an island-wide monitoring well network.

This memorandum, although finalized on October 30, 2006, was originally presented in draft form on April 17, 2006. The data and conclusions presented herein represent the state of knowledge and interpretation as of the draft date.

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2 Summary of Findings

This baseline data evaluation compiled and reviewed relevant groundwater data from COBI, KPUD, Washington State Department of Health, and Kitsap County Department of Health (KDOH) and the WRIA 15 water quality assessment. Data from these sources were evaluated with respect to long-term aquifer declines (as indicated by water level changes) and seawater intrusion (as indicated by chloride concentrations).

COBI and KPUD currently monitor a total of 29 wells on Bainbridge Island (Table 1). Nineteen of these wells monitor the Fletcher Bay (FBA) and sea level (SLA) aquifers and the balance is divided between the Perched (PA), Semi-Perched (SPA) and Glaciomarine (GMA) aquifers. A description of these aquifer systems is presented in Section 3 of this memo. Each of these monitoring networks collects water level, chloride, specific conductance and production data which are relevant to the monitoring of safe aquifer yield and seawater intrusion. Aquifer safe yield is generally defined as the amount of water that can be withdrawn from an aquifer on a sustained basis without impairing natural groundwater quality or creating environmental damage (Fetter, 1980).

Areas of concern to be considered in development of the monitoring network include:

- Declining water levels within the FBA and SLA; and,
- Areas within a quarter-mile of the coast, particularly where relatively greater groundwater withdrawals are occurring, that may be at greater risk for seawater intrusion.

Analysis of water level changes for 11 wells over an approximate 15-year period ending in 2005 indicates water level increases ranging from 3 to 20 feet occurred at the north end of the island in the shallower PA, SPA, and SPA/SLA. Wells on the south end of the island indicated water level declines ranging from about 3 to 9 feet (ft) in the SLA, GMA, and FBA. Ensuring adequate monitoring of water levels in the FBA and SLA should be considered a priority in development of the groundwater monitoring network.

Most wells with elevated chloride levels are located within a ¼ mile of the coast. The available data suggest that the north island area (Seabold, Agate Point, and Port Madison) and the Eagle Harbor area may be more susceptible to seawater intrusion and should be considered in designing the monitoring network. Elevated chloride levels in inland wells are attributed either to isolated cases of upconing or wells installed within the freshwater/seawater transition zone. Three of the coastal wells (one south of Murden Cove and two near Eagle Harbor) with elevated maximum chloride concentrations correspond to areas of relatively greater withdrawal.

In addition to these areas of concern, development of the monitoring network will also consider:

- Representative geographic distribution and distribution within aquifers;
- Wells with an existing historic water level/water quality record will be given preference;
- Ongoing monitoring programs by KPUD and COBI;

- Water system wells will be given preference to individual private homeowner wells. Access to private homeowner wells is at greater risk when the property is transferred to new owners; and
- The monitoring network previously proposed by the USGS (Dion and others, 1988).

Development of the monitoring network will require development of a set of maps showing suitable wells for monitoring. Initial contact will be made with targeted well owners and purveyors to solicit participation in the monitoring program. Well owners who will allow access to their wells will be contacted by Aspect Consulting and a visit arranged to identify the suitability for sampling and water level measurements. Based on site visits and granted access, a final list of monitoring wells will be submitted to the City to obtain written property access agreements.

3 Summary of Defined Aquifers

The Level II Basin Assessment (Kato & Warren and Robinson & Noble, 2000) has identified and described the following principal aquifers on Bainbridge Island:

- **Perched Aquifer System (PA) –** This aquifer is comprised predominantly of Vashon Advance glacial outwash at higher elevations (>200 feet above mean sea level [ft MSL]) and is utilized predominantly by domestic wells. About 4 percent of wells are reported to be completed in this unit.
- **Semi-Perched Aquifer System (SPA) –** The semi-perched aquifer consists of wells typically completed between 100 and -20 ft MSL. About 25 percent of wells are reported to be completed in this unit.
- **Sea Level Aquifer (SLA) –** This aquifer is present from -40 to -230 ft MSL and is the most widely utilized aquifer system on the island. Fifty-three percent (53%) of wells are completed in the SLA. Wells completed between the SPA and SLA aquifers at elevations of -20 to -30 ft MSL are indicated as Semi-Perched/Sea Level aquifer (**SPA/SLA**).
- **Glaciomarine Aquifer System (GMA) –** This aquifer reportedly consists of water bearing units within a thick sequence of fine-grained glaciomarine drift. Wells in this aquifer are typically completed between -400 and -760 ft MSL. Several of island’s deep production wells and at least four domestic wells are completed in this aquifer, representing about 2 percent of wells.
- **Fletcher Bay Aquifer System (FBA) –** The FBA is the deepest identified aquifer on Bainbridge Island. Several large production wells are completed in this aquifer including the Fletcher Bay well. Wells in this aquifer are typically completed between about -690 to -1,010 ft MSL. While representing only about 1 percent of wells on Bainbridge Island, the metered KPUD and COBI FBA wells provide approximately 30 percent of the estimated total island groundwater production.
- **Bedrock Aquifer System –** A few wells are completed in the sedimentary Blakely Harbor and Blakeley Formations on the south end of Bainbridge Island.

Aquifer assignments made in this memorandum are based on comparison of screen elevation with aquifer elevation and lateral extent provided in the Level II Basin Assessment.

4 Overview of Current Monitoring

Groundwater monitoring data is currently being collected by KPUD and COBI. Wells currently monitored by COBI and KPUD are listed in Table 1 with the following information:

- Aquifer completion unit;
- Summary of study data collected (i.e., production, chloride, static water level);
- 2005 water production;
- Range of static water level measurement dates;
- Changes in static water level; and
- Maximum and median chloride concentrations.

The locations of the existing COBI and KPUD monitored wells are presented on Figure 1 in green and red, respectively, with symbol shape indicating aquifer completion zone. Other purveyors on Bainbridge Island may also collect data, but collection and evaluation of these data are beyond the scope of this memorandum. Historic data will be solicited from purveyors for wells selected for the monitoring network and incorporated into the database in accordance with Task 3 of the scope of work. Coverage areas of the major water systems provided by KPUD are also shown on Figure 1.

A total of 29 wells are currently monitored on Bainbridge Island by COBI and KPUD. Of these, 16 wells were active production wells in 2005. The PA, SPA and SPA/SLA are each monitored by two wells. The SLA has the greatest number of current monitoring wells (11), while the FBA and GMA are monitored by eight and two wells, respectively.

Static water levels are collected by COBI approximately three times annually and chloride and specific conductance are monitored approximately twice annually. Static water level data and chloride data are collected on a monthly and an approximate twice annual basis, respectively, at the KPUD monitored wells.

5 Groundwater Withdrawals

Areas of active pumping will disrupt the natural equilibrium of groundwater recharge and discharge and, as such, are a primary consideration in development of a monitoring well network. Figure 2 presents a map showing the distribution of groundwater withdrawals by ¼-¼ section (40 acres) on Bainbridge Island for 2005. The estimating methods and results are discussed in detail below.

5.1 Method to Estimate 2005 Groundwater Withdrawals

Wells were divided into public water systems (including both Group A and Group B wells) and single-family domestic wells. Public water system (PWS) wells were further divided into those with metered production and those which were unmetered.

For metered wells, production data was obtained directly from data supplied by KPUD and COBI. Adjustments to this dataset included estimating missing data when meters were out–of-service by applying the average 2005 withdrawal rate to the missing period and applying a calibration correction factor to the COBI booster pump meters.

Production for active public supply wells without meter data were estimated based on the present number of connections provided by the KDOH, average water use, and average household size. KPUD's North Bainbridge water system was selected as a surrogate for calculation of unmetered average water use. This system provides water to Day Road Industrial Park as well as domestic residences, but was considered to have relatively less commercial use than the Winslow water system, and more representative of unmetered systems. The year 2000 census data indicates that Bainbridge Island has an average household size of 2.52 people. Using this average household size and the number of connections on the North Bainbridge water systems, an average water use of 76 gallons per day per capita (gpdpc) was calculated from the metered data for year 2005. This value compares closely with a Kitsap County PUD average of 73 gpdpc for 2002 (EES, 2002). The water use for the unmetered public water systems was computed based on this average household size and 76 gpdpc use rate.

Production from domestic wells was estimated from a USGS estimate of water usage of 107 gpdpc for self-supplied domestic water use in Kitsap County (Lane, 2004). Approximately 1,000 domestic wells were identified from the KPUD well database. A water use estimate of 270 gallons per day (gpd) per well was obtained by multiplying an average household size of 2.52 people by the 107 gpdpc USGS estimate.

Water use was summed for each of the water systems and wells within the ¼-¼ sections and are presented as groundwater withdrawal in acre-ft per year (Figure 2). Groundwater withdrawals shown on Figure 2 total to approximately 2,550 acre-ft per year. The total water use shown on Figure 2 is likely an underestimate as some domestic wells do not have well logs on file with Washington Department of Ecology (Ecology) and would, therefore, be missing from the KPUD database.

An alternative estimate was calculated from a per capita combined residential and commercial use of 115 gallons per day computed for city of Bremerton (EES, 2002) and a 2005 population of 22,500 (COBI, 2006). The alternative total 2005 usage is 2,900 acre-ft per year and may overestimate usage since Bainbridge Island is largely residential.

5.2 Discussion

The areas on Figure 2 with production exceeding 100 acre-ft annually correspond with wells supplying the major water supply systems. A large area of relatively concentrated with-drawals occurs along the south edge of Eagle Harbor. Several water systems are present in this area including well 35J03 (Bill Point), well 35G03 (COBI's Taylor Avenue well), and well 34F07 (Island Utility). Other areas of relatively greater withdrawal (more than 5 acre-ft per year) and located within ¼-mile (see Section 5) of the coast line occur at four locations along the west side of the island, at two locations near east Port Madison, along the south side of Murden Cove, near the Wing Point area, and along Rich Passage. These coastal areas with higher withdrawals may be more susceptible to seawater intrusion and will be considered in development of the monitoring network for monitoring of lateral seawater intrusion.

6 Groundwater Level Changes

Available groundwater level data were analyzed to evaluate long-term trends in aquifer storage. The natural balance between groundwater recharge and discharge is influenced by variations in annual precipitation, by groundwater withdrawals, and by land use changes that affect recharge. Declining water levels are an indication of aquifer discharge exceeding recharge. Aquifers with declining water levels will be considered an area of concern in development of the groundwater monitoring network. Figure 3 presents changes in water levels between the two, three-year average periods of 1988-1990 and 2003-2005, representing water level changes over an approximate 15-year period.

6.1 Method to Evaluate Water Level Changes

Water level data for 38 wells from the COBI and KPUD sources were compiled into a single spreadsheet. The available data indicates significant water level monitoring began in the mid 1980s on Bainbridge Island. For years 1985-2005, the number of records in each year were inspected to identify periods with sufficient data to calculate water level changes. A plot of cumulative departure from mean precipitation was also prepared. The periods 1988-1990 and 2003-2005 (calendar years) were identified as periods with similar precipitation records (a cumulative departure from the mean of about 10 inches per year and a falling water level trend) and were used to compute water level changes between 1988-1990 and 2003-2005 periods. A subset of 11 wells were identified with sufficient data for averaging (most wells had six or more measurements per year)

Duplicate entries (same value reported by multiple sources) and water levels affected by pumping were removed before averaging. For pumping wells, the time allowed to reach static water level (SWL) could influence the measurement. The analysis of water level changes assumes that a similar procedure (i.e., recovery period prior to taking the SWL measurement) was used for all static water level measurements. The data was inspected and adjusted to ensure an even annual distribution of water level measurements so the average water level would not be biased by readings concentrated during any one season.

6.2 Discussion

The water level changes for the 11 wells are presented in Figure 3. Wells with an increase in water level from 1988-1990 to 2003-2005 are shown in blue and wells with a decrease are shown in red. Large water level increases occurred at the north end of the island in the PA, SPA and SPA/SLA. The increases ranged from 3 to 20 ft with the greatest increase occurring at the 09H01 (North Bainbridge well 3). Wells on the south end of the island indicated water level declines ranging from about 3 to 9 feet (ft) in the SLA, GMA and FBA. The greatest water level decline shown in Figure 3 occurred in well 20K04 (Fletcher Bay).

Water level trends in the FBA were further evaluated by examining the water level data from wells 34F07 (Island Utility Well 1), 09G04 (North Bainbridge Well 9), 21JO6 (Sands Avenue Well 1) and 33B03 (Bloedel Deep Well). These wells did not meet the criteria for inclusion in calculation of the water level decline, shown in Figure 3, but do provide additional water level data to evaluate water level changes in the FBA. The locations of these wells are shown on Figure 1. Well 34F07 (Island Utility Well 1 Deep) in the FBA exhibited about a 13-foot decline from 1990 to 2005. Water level data for well 09G04 (North Bainbridge Well 9) suggest an approximate 5-foot water level decline from 1994 to 2005. A water level decline of over 20 ft is indicated in well 21 JO6 (Sands Avenue Well 1) between 1989 and 2005; however, static water levels in this well may be influenced by the pumping schedule of well 21J07 (Sands Avenue Well 2), depending on pumping schedules at the time. No apparent change in water levels was noted for well 33B03 (Bloedel Deep Well) between 1995 and 2005.

Water levels will be influenced by the rate of recharge and by withdrawals. Both of these influences are significant with respect to monitoring, that is, aquifer withdrawals must be examined within the context of natural variations in recharge. The FBA is highly confined and shows the greatest water level changes in response to pumping (Kato & Warren and Robinson & Noble, 2000). Water level declines in the FBA and SLA and the relatively high reliance on these aquifers indicate that accurate water level monitoring of these aquifers should be a key component of the monitoring network, particularly on the south end of the island. At present, seven wells completed in the FBA are monitored (Figure 1). The adequacy and potential for expansion of this monitoring network will be examined under Task 3.

7 Seawater Intrusion and Chloride Distribution

Marine saltwater surrounds Bainbridge Island on all sides. When saltwater occurs at depths, it constrains the recovery of groundwater from wells. Pumping of wells that penetrate too deep or are located too close to the coast, or are pumped at excessive rates may induce movement of saltwater into freshwater. A few wells appear to have been affected by seawater intrusion, but additional monitoring and data analysis is necessary to more fully characterize seawater intrusion.

Seawater and freshwater are fully miscible; however, where they are in contact with minimal turbulence at the interface, freshwater tends to form a layer that floats above the denser seawater. Salt water extends laterally beneath coastal groundwater aquifers. Without mixing, a lense of fresh groundwater would theoretically “float” above saltwater, with its base at a height about 40 times as great as its height above sea level. This theoretical configuration is known as the Ghyben-Herzberg principle. The idealized interface, in the real world, is replaced by a “transition zone” between freshwater and seawater which can extend from tens to hundreds of feet vertically. The transition zone results from mixing of the idealized seawater/freshwater interface as a result of constant tidal motion and geologic discontinuities.

Lateral intrusion of seawater into an aquifer occurs as a result of general lowering of the fresh groundwater head causing the transition zone to move inland as a result of decreased recharge, increased pumping or a rise in sea level. Pumping from wells can also induce upward intrusion of saline water from the transition zone, termed “upconing”. The amount of degradation related to upconing depends on the height of the well bottom above the transition zone, the presence/absence of geologic barriers and pumping schedule.

Total dissolved solids are present in seawater of normal salinity of about 35,000 milligrams per liter (mg/L). Chloride is present in normal seawater salinity at concentrations of about 19,000 mg/L. Chloride, because of its conservative or non-reactive behavior, provides a convenient means to measure seawater intrusion. Recommended drinking water standards for chloride concentration are 250 mg/L, Ecology action threshold is 100 mg/L, and the screening level for this study is selected to be 40 mg/L. These criteria are discussed further below. Federal and state drinking water standards include Secondary Maximum Contaminant Levels (SMCL) for chlorides (250 mg/L), total dissolved solids (500 mg/L) and specific conductance of 700 micromhos per centimeter (µmhos/cm).

The WRIA 15 Water Quality Assessment Report indicates background concentrations for chloride of about 10 mg/L or less; however, chloride elevated above 10 mg/L does not necessarily indicate seawater intrusion. Chloride levels may be elevated above background for other reasons, such as surface sources of contamination, relic seawater within an aquifer or sea spray. Ecology draft seawater intrusion policy (Washington Department of Ecology, 1990) would have prohibited new water rights and discouraged new building permits where chloride levels exceed 100 mg/L. USGS (Dion and others, 1988) used a value of 100 mg/L as a conservative background level above which indicates seawater intrusion.

Wells completed above sea level were examined from the USGS (Dion and others, 1988) data to arrive at a screening tool for preliminary evaluation of chloride data. Chloride concentrations between 20 and 30 mg/L were identified for two wells completed above sea level. A conservative value (compared to 100 mg/L value) of 40 mg/L chloride was used as a preliminary screening tool to indicate on-set of seawater intrusion and will be reviewed as the study progresses.

7.1 Development of Chloride Map

Figure 4 presents a map showing the distribution of chloride from data obtained from COBI, KPUD, and WA DOH.

Data from the various sources were compiled based on available identifiers (mostly Ecology unique well identification) or by name if the Ecology unique well ID was missing. KPUD well coordinates were used to plot well locations. After compilation, the data were summarized into maximum and median values. Non-detect values were assigned at half the detection limit. In addition to these data sources, chloride data were obtained from the WRIA 15 report, although these data lacked coordinates and were not mapped, but are discussed below.

Maximum and median chloride concentrations are displayed in Figure 4, and symbols are color-coded according to concentration using the following categories:

- 0-40 mg/L – Wells generally not impacted by seawater intrusion.
- 40-100 mg/L – Wells between this study's screening value and the Ecology early warning value.
- 100-250 mg/L – Wells between the Ecology early warning value and the SMCL.
- >250 mg/L – Wells greater than the SMCL.

7.2 Discussion

The discussion of chloride presented below is subdivided into inland wells and coastal segments. The majority of elevated chloride values are associated with wells located within a ¼ mile of the coast line.

7.2.1 Inland Wells

Two of the wells (15P05 and 28P01) located more than a ½ mile from the coast appear to have elevated chloride values, while a third well (16A04) appears to be an anomalous value. Well 15P05 (private well) had a one-time chloride measurement of 50 mg/L in March 1993. The total depth of this well is 50 ft below sea level, indicating the elevated chloride concentrations could be indicative of upconing. Similarly, well 28P01 (private well) is completed at a total depth of 106 ft below sea level. The single chloride measurement of 110 mg/L in February 1993 may be related to upconing.

Well 16A04 (Meadowmeer Well 2) had a single high reading (120 mg/L in June 1999), but that value was judged to be anomalous as maximum chloride values preceding and post dating this measurement are less than 7 mg/L and the base of the well is completed 57 ft above MSL. The elevated concentration, if not related to analytical error, does not appear to be related to seawater intrusion.

7.2.2 West Side Wells

Four wells with apparently elevated maximum chloride levels were identified along the west side of the island. Wells (20K04) (Fletcher Bay Well), 20G04 (Clark Acres Water), 16E04 (Islandwood Estates) and 09F01 (Little Manzanita Water) ranged from 47 to 120 mg/L, although the Fletcher Bay well maximum value is an apparent outlier.

Well 09F01 had a maximum chloride concentration of 94 mg/L reported for June 1989. By November 1989, this concentration had decreased to 18 mg/L. No other data were available for this well. Well 20G04 had a single measurement with a reported chloride concentration of 68 mg/L in January 1989.

Well 16E04 (Islandwood Estates) showed a maximum chloride level of 96 mg/L and median of 4 mg/L. This well exhibited a rising trend in chloride concentrations in the late 1990s. Reductions in pumping or other factors may have led to diminished chloride levels that occurred between August 1998 and April 1999. This well apparently has not been surveyed and the elevation of the completion depth of the well relative to sea level is unknown.

Fletcher Bay well (20K04) had a single time chloride value of 48 mg/L in October 2001. The following data suggest this value is anomalous.

- Quarterly Cl measurements in 2002 were all low (5 mg/L),
- 2002 annual pumpage exceeded that of 2001,
- Peak monthly pumpage in 2002 was greater than 2001,
- Pumping elevation in 2002 was lower than 2001, and
- 2002 is further into a drying trend that started in 1999.

As such, the 48 mg/L value is considered an outlier.

7.2.3 North Island Wells

The north portion of Bainbridge Island, north of the Port Madison inlet, has the two highest chloride levels identified in the data reviewed. Well 34L06 (Samson Water Systems) is completed in the SLA and had elevated chloride of 424 mg/L in August 1993, the first available data for this well. Chloride concentrations in this well declined after this measurement and were reported less than 5 mg/L for the most recent available data (August 2004). The WRIA 15 report indicated the Seabold Water System well completed in the SLA increased in chlorides from a low value in 1998 to a chloride concentration of 419 mg/L (December 2000). No data was available for this well after this date to review subsequent trends. The Level II basin assessment indicates elevated specific conductance for three wells located along the west side of the north portion of Bainbridge Island.

7.2.4 East Side Wells

Four wells, 23K04 (private well), 27F03 (Bainbridge Green), 27L06 (private well), and 35E06 (private well) were identified on the east side of the island with chloride concentrations ranging from 42 to 351 mg/L. Only a single reported chloride value was available for each of these wells. These wells are completed in the SLA or SPA and three of these wells are located adjacent to Eagle Harbor. Wells 23K04, 27F03, and 35E06 correspond to areas of relatively higher groundwater withdrawals.

7.3 Monitoring Implications

The WRIA 15 water quality report indicates that a threshold distance between a ¼ and ½ mile of the coast may exist for seawater intrusion (Golder Associates, Inc., 2003). Inland wells identified on Figure 4 with elevated chloride levels are likely related to upconing or completion of the well screen or open interval within the transition zone. Wells located within a ¼ mile of the coast may be indicative of either lateral intrusion or upconing. Chloride monitoring should focus on wells located within ¼ mile of the coast. The available data suggest the north island area (Seabold, Agate Pass and Port Madison) and the Eagle Harbor area may be more susceptible to seawater intrusion and should be considered in designing the monitoring network.

8 References

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Washington Department of Ecology, 1990, Draft Seawater Intrusion Policy dated November 30, 1990.

Attachments:

Table 1 - COBI and KPUD Monitored Wells Data Summary
Figure 1 - Water Systems and Currently Monitored Well Locations
Figure 2 - Estimated 2005 Groundwater Withdrawals
Figure 3 - Groundwater Level Change
Figure 4 - Historic Chloride Concentrations in Groundwater

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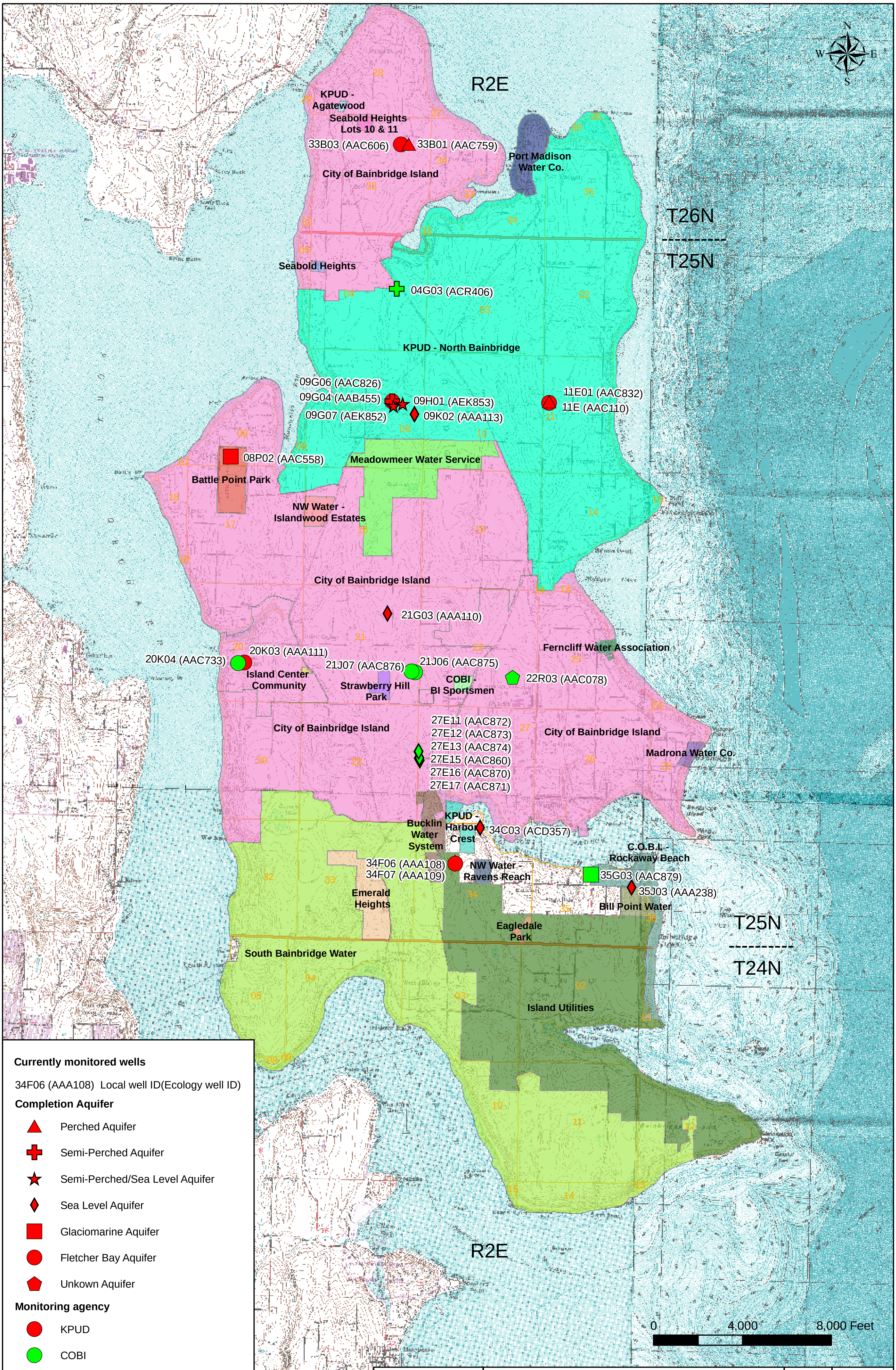
Table 1
COBI and KPUD Monitored Wells Data Summary
City of Bainbridge Island Groundwater Management,
Bainbridge Island, WA

Ecology ID	Local Name	Well Name	Aquifer Completion Unit	Monitoring Agency	Summary of Data Collected	2005 Water Production (acre-ft)	Static Water Level Data			Chloride Concentration Data		
							Start Date	End Date	Change (ft)	Maximum (mg/l)	Median (mg/l)	Number of Measurements
AAA108	25N/02E-34F06	Island Utilities Monitoring Well (160')	Sea Level Aquifer	Kitsap Public Utility District	SWL	-	1/30/85	11/30/05	-3	-	-	-
AAA109	25N/02E-34F07	Island Utilities Well (SO-1)	Fletcher Bay Aquifer	Kitsap Public Utility District	SWL, Chloride	-	4/21/88	11/30/05	-	3.0	3.0	3
AAA110	25N/02E-21G03	Formerly KPUD Island Center TW, now in private ownership	Sea Level Aquifer	Kitsap Public Utility District	SWL	-	4/25/75	11/30/05	-4	-	-	-
AAA111	25N/02E-20K03	KPUD Fletcher Bay Observation Well	Fletcher Bay Aquifer	Kitsap Public Utility District	SWL, Chloride	-	5/1/73	1/31/06	-9	6.7	3.8	7
AAA113	25N/02E-09K02	KPUD North Bainbridge Well 6	Sea Level Aquifer	Kitsap Public Utility District	SWL, Chloride	-	8/15/79	11/30/05	6	15.0	10.0	2
AAA238	25N/02E-35J03	Bill Point Water Well 3	Sea Level Aquifer	Kitsap Public Utility District	SWL	-	11/20/90	9/12/94	-	-	-	-
AAB455	25N/02E-09G04	KPUD North Bainbridge Well 9	Fletcher Bay Aquifer	Kitsap Public Utility District	Production, SWL, Chloride	197	9/1/92	11/30/05	-	17.0	8.0	20
AAC078	25N/02E-22R03	Commodore	Semi-Perched Aquifer	City of Bainbridge Island	Production, SWL, Chloride	20	9/10/80	1/12/06	-	5.9	2.5	13
AAC110	25N/02E-11E	KPUD North Bainbridge Well 10	Fletcher Bay Aquifer	Kitsap Public Utility District	SWL, Chloride	-	4/7/05	3/2/06	-	13.6	13.6	2
AAC558	25N/02E-08P02	Bainbridge Island Parks Battle Point Park	Glaciomarine Aquifer	Kitsap Public Utility District	SWL, Chloride	-	10/29/84	11/30/05	-3	7.0	5.2	29
AAC606	26N/02E-33B03	Bloedel Reserve Deep Well	Fletcher Bay Aquifer	Kitsap Public Utility District	SWL, Chloride	-	6/28/95	1/31/06	-	10.0	9.6	4
AAC733	25N/02E-20K04	Fletcher Bay	Fletcher Bay Aquifer	City of Bainbridge Island	Production, SWL, Chloride	279	4/24/78	1/12/06	-	47.6	2.9	49
AAC759	26N/02E-33B01	Bloedel Reserve Farm Well	Perched Aquifer	Kitsap Public Utility District	SWL, Chloride	-	3/2/77	1/3/06	3	5.9	4.4	12
AAC826	25N/02E-09G06	KPUD North Bainbridge Well 1	Semi-Perched Aquifer	Kitsap Public Utility District	SWL	-	7/17/77	11/30/05	3	-	-	-
AAC832	25N/02E-11E01	KPUD North Bainbridge Well 8	Perched Aquifer	Kitsap Public Utility District	SWL, Chloride	-	2/22/85	11/30/05	10	3.7	3.0	4
AAC860	25N/02E-27E15	Head of the Bay #1A	Sea Level Aquifer	City of Bainbridge Island	Production, SWL, Chloride	2	2/4/88	1/12/06	-	5.0	2.9	50
AAC870	25N/02E-27E16	Head of the Bay #2	Sea Level Aquifer	City of Bainbridge Island	Production, SWL, Chloride	86	8/10/71	1/12/06	-	5.0	3.8	41
AAC871	25N/02E-27E17	Head of the Bay #3	Sea Level Aquifer	City of Bainbridge Island	Production, SWL, Chloride	38	1/12/06	3/16/06	-	5.0	2.9	45
AAC872	25N/02E-27E11	Head of the Bay #4	Sea Level Aquifer	City of Bainbridge Island	Production, SWL, Chloride	3	5/16/83	1/12/06	-	8.0	3.2	44
AAC873	25N/02E-27E12	Head of the Bay #5	Sea Level Aquifer	City of Bainbridge Island	Production, SWL, Chloride	20	5/16/83	1/12/06	-	25.0	2.9	43
AAC874	25N/02E-27E13	Head of the Bay #6	Sea Level Aquifer	City of Bainbridge Island	Production, SWL, Chloride	2	10/8/85	1/12/06	-	20.0	3.8	43
AAC875	25N/02E-21J06	Sands Avenue #1	Fletcher Bay Aquifer	City of Bainbridge Island	Production, SWL, Chloride	125	3/29/89	1/12/06	-	14.4	10.0	34
AAC876	25N/02E-21J07	Sands Avenue #2	Fletcher Bay Aquifer	City of Bainbridge Island	Production, SWL, Chloride	167	1/31/91	1/12/06	-	13.0	10.0	44
AAC879	25N/02E-35G03	Taylor	Glaciomarine Aquifer	City of Bainbridge Island	Production, SWL, Chloride	23	3/1/94	1/12/06	-	5.8	4.0	30
ACD357	25N/02E-34C03	KPUD Harbor Crest	Sea Level Aquifer	Kitsap Public Utility District	Production, SWL, Chloride	4	2/10/83	11/30/05	-6	13.0	5.0	50
ACR406	25N/02E-04G03	Hidden Cove	Semi-Perched Aquifer	City of Bainbridge Island	Production, SWL, Chloride	483	2/29/84	1/12/06	-	5.9	5.0	17
AEK852	25N/02E-09G07	KPUD North Bainbridge Well 7	Sea Level Aquifer	Kitsap Public Utility District	Production, SWL, Chloride	83	11/4/82	1/31/06	7	10.2	8.7	11
AEK853	25N/02E-09H01	KPUD North Bainbridge Well 3	Sea Level Aquifer	Kitsap Public Utility District	Production, SWL, Chloride	81	2/17/86	11/30/05	20	7.7	5.0	4
-	25N/02E-28F	Johnson Farm	Semi-Perched Aquifer	City of Bainbridge Island	SWL	-	1/29/02	1/5/06	-	-	-	-



Aspect consulting
IN-DEPTH PERSPECTIVE
179 Madrone Lane North, Bainbridge Island, WA 98110, (206) 780-9370
811 First Avenue #480, Seattle, WA 98104, (206) 328-7443

Water Systems and Currently Monitored Well Locations
Bainbridge Island, Washington

DATE: Oct 2006	PROJECT NO. 060016
DESIGNED BY: EWM	
DRAWN BY: ACM	FIGURE NO. 1
REVISED BY: ACM	

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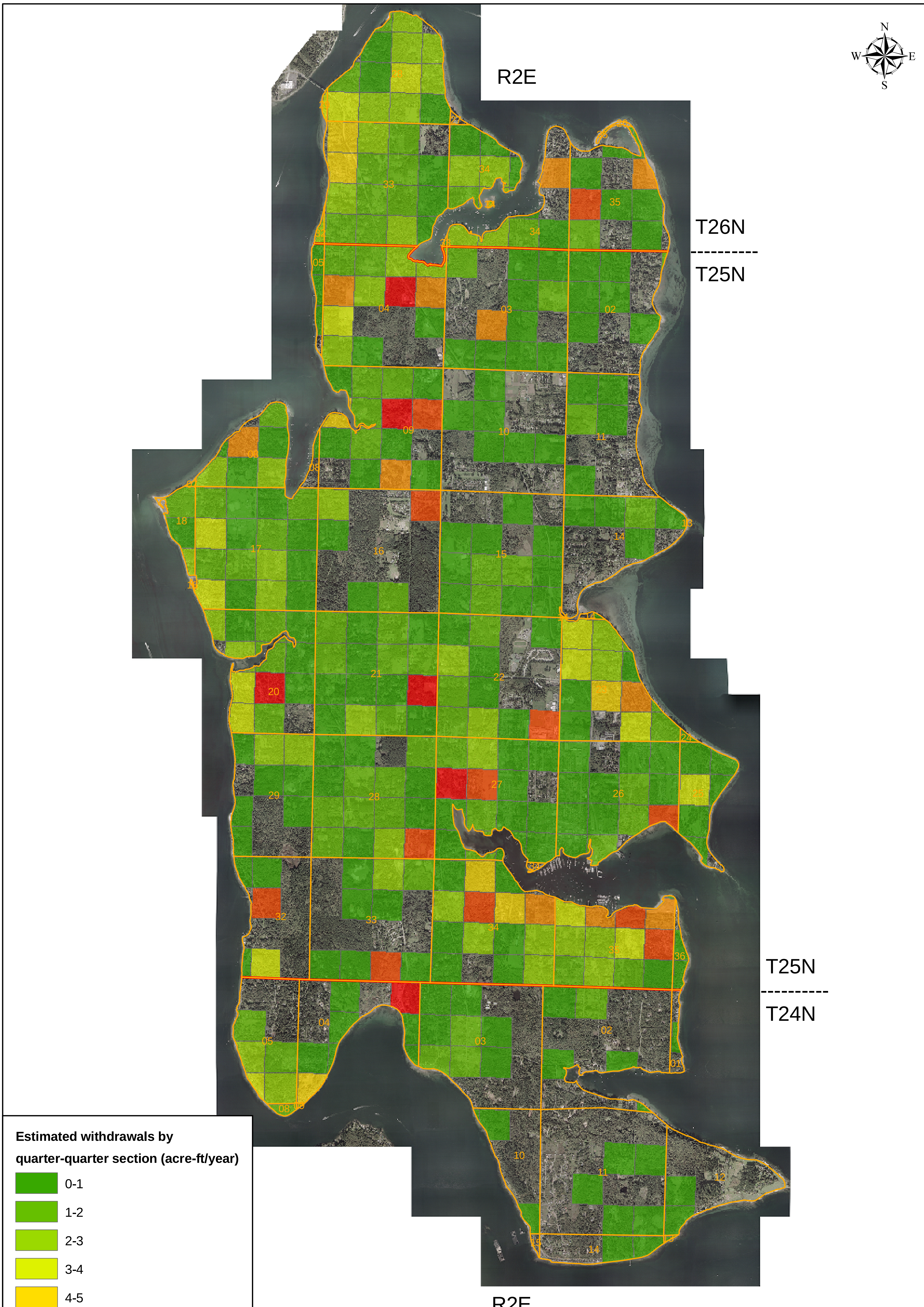

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Estimated 2005 Groundwater Withdrawals
Bainbridge Island, Washington

Oct 2006	PROJECT NO. 060016
EWM	
ACM	FIGURE NO. 2
ACM	

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34F06 (AAA108)/-3 Local well ID(Ecology well ID)/Water level change

Completion Aquifer

- Perched Aquifer
- Semi-Perched Aquifer
- Semi-Perched/Sea Level Aquifer
- Sea Level Aquifer
- Glaciomarine Aquifer
- Fletcher Bay Aquifer

Water level change[1]

- Negative
- Positive
- Sections
- Township and range

[1]Water level changes are based on average water level readings in 1988-1990 compared to average water level readings in 2003-2005. See text for discussion of data sources and limitations.

0 4,000 8,000 Feet

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Groundwater Level Changes
Bainbridge Island, Washington

DATE: Oct 2006
DESIGNED BY: EWM
DRAWN BY: ACM
REVISED BY: ACM
PROJECT NO. 060016
FIGURE NO. 3

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