CITY OF
BAINBRIDGE ISLAND

The Environmental Technical Advisory Committee will hold this meeting in person, in the City Hall Chamber Conference Room, 280 Madison Ave N, Bainbridge Island, WA
It is recommended that attendance be in person, but it is also accessible via the Zoom meeting platform.
Please click the link below to join the webinar:

Please click this URL to join. https://bainbridgewa.zoom.us/j/87040273950
Description: Environmental Technical Advisory Committee Regular Meeting

Or One tap mobile:
+12532050468,,87040273950# US
+12532158782,,87040273950# US (Tacoma)

Agenda for September 21, 2023, ETAC Regular Meeting

Call to Order / Roll Call / Conflict of Interest Disclosure

Members: Dylan Frazer, Ben Harrison, Melanie Keenan, Malcolm Gander, Brian Harmon

Council Liaison: Jon Quitslund

COBI Staff: Patty Charnas, Director, Planning & Community Development; Daria Hansen – Public Records Analyst

Approval of Agenda – September 21, 2023

Approval of Minutes – August 17, 2023 (5 min)

Council Liaison Report – Jon Quitslund (10 min)

Chair Report – Melanie Keenan will lead discussion (30 min)

Update on Groundwater Management Plan (GWMP) and discussion of- All **(35** min)

- Historic Bainbridge Island aerial photos possibly available through committee member's Harrison and Keenan link to recharge areas.
- Aspect April 19, 2023, GW Model Update memo. Previously submitted comments from Charlie Kratzer. (See Exhibit A)
- Status of request for data associated with Aspect April 2023 GW Model Update Memo.
- Surface Water Discussion
- Early Warning Level Discussion

- Review of San Juan County ordinance requiring new construction to define annual water volume needs. (See Exhibit B).
- Request Public Works Director to update ETAC on GWMP

Update on UAC meeting- All (10 min)

- GWMP update, COBI Water Utilities update by Chris Wierzbiki

Update on Comprehensive Plan and discussion - All (30 min)

- COBI Workshop September 27, 2023, September 28-October 29 Online Public Feedback. ETAC input for Kick-Off meeting.

  Sept. 27 - Oct. 29 (In person at Woodward Middle School Commons, 9125 Sportsman Club Rd)

  4:30-6 P.M. OPEN HOUSE-Drop-in to view materials and chat with project staff.

  6-8 P.M. WORKSHOP-Presentation and small group activities to gather your input.

  Sept. 28 - Oct. 29 (Participate in your own time online with a virtual workshop and public feedback)

- Sections to review current Comprehensive Plan
  - COBI Website, links to 2016 Elements https://www.bainbridgewa.gov/162/Comprehensive-Plan
  - Land Use Element
  - Environmental Element
  - Water Resource Element (See Exhibit C)
  - https://www.bainbridgewa.gov/DocumentCenter/View/7801/6-WATER-RESOURCES?bidId=
  - Utilities Element

Discussion of selection of new ETAC Chair – All (10 min)

Discussion of queries to new potential ETAC members and COBI tools to aid ETAC in reaching out to the public (All 5 min)

Other topics of interest – All (10 min)

Public Comment (5 min)

Adjournment – 5:00 p.m.

__Attachments:__

Exhibit A – Aspect April 19, 2023, GW Model Update memo including previously submitted comments from Charlie Kratzer.

Exhibit B
Excerpts from San Juan County's New Construction Ordinance and Water Volume

San Juan County has adopted a straightforward ordinance that follows their Comprehensive Plan by requiring all new construction to identify where they will obtain drinking-water-quality freshwater, and how much they will need annually. Here are excerpts from Chapter 18.60 Development Standards; 18.60.020 Water Supplies:

"A. All development must conform to the standards set by SJCC Title 8, Health and Safety, and must satisfy the policies of Element 4 of the Comprehensive Plan (Water Resources) regarding the availability and adequacy of the water resource, the protection of water quality, and the control or avoidance of pollution, and conservation of water."

"B.1. Provide documented evidence of available and adequate water quantity and quality for the intended use."

Exhibit C
2016 Comprehensive Plan Water Element

Environmental Technical Advisory Committee
Regular Meeting Minutes
Thursday, August 17, 2023
City Hall Chamber Conference Room

Call to Order (Attendance, Agenda, Conflicts of Interest)
Approval of Meeting Minutes from July 20, 2023
Council Liaison Report
Chair Report
COBI Staff Comments
- **Discussion and update on the GWMP**
- **Discussion of historic BI aerial photographs**
- **Discussion of San Juan County New Construction Ordinance**
- **Discussion of selection of new ETAC chairperson**
- **Discussion of public outreach for new ETAC members**

Call for Public Comment
Adjournment

Members Present:
Malcolm Gander, Brian Harmon, and Melanie Keenan attended in person. Dylan Frazer participated via Zoom.

Members Absent:
Ben Harrison was absent and excused.
(4 vacant positions)

COBI Staff and City Council Present:
Patty Charnas (Director, Planning & Community Development), Jon Quitslund (Council Liaison), Daria Hansen (Public Records Analyst).

Meeting called to order at: 3:01 p.m. There were no conflicts of interest disclosed.

Approval of July 20, 2023, Agenda:
> **Motion:** I move to approve the August 17, 2023, meeting agenda as presented.
> **Gander/Keenan**: Passed unanimously

Review & Approve Minutes – July 20, 2023
> **Motion**: I move to approve the July 20, 2023, minutes, with minor edits to wording for clarity.
> **Gander/Keenan:** Passed Unanimously

CITY OF BAINBRIDGE ISLAND

Environmental Technical Advisory Committee
Regular Meeting Minutes
Thursday, August 17, 2023
City Hall Chamber Conference Room

Council Liaison Report (Jon Quitslund):
The Shoreline Master Plan is scheduled to be discussed by Council at the September 26th meeting. There will also be an action on ETAC appointments at this meeting, if there are any people interested in joining.
The Council discussed a presentation by Chris Wierzbicki on the consultant's model predictions for the GWMP.

Chair Report (Melanie Keenan):
Wanted to discuss the aerial photographs of the Island, but as Ben isn't present, this will be put off until he can participate and share his information.

COBI Staff Comments:
None.

Discussion/update on the Groundwater Management Plan:
Melanie brought up her concerns on the information presented by Chris Wierzbicki in the GWMP report at the August 15th Council Study Session. An extensive discussion followed pertaining to the need for public commentary, participation and education on groundwater issues, the data used by Aspect to run their model and future predictions on water availability on Bainbridge, the need to include currently known data in models for accuracy in predicted scenarios, production wells and private wells and concerns with known and modeled future seawater contamination, and the draw-down, mining out and reconditioning of wells. Melanie emphasized the need for proper language and professional integrity when presenting information to the public.

Melanie mentioned that the current early warning system for high chloride levels, sea level intrusion and draw-down of wells, needs to be updated. She will share a previously created document regarding decommissioned wells around Eagle Harbor with Chris Wierzbicki. Discussion followed.

Melanie reiterated the idea that it would be helpful for the GWMP working group to periodically meet with the consultant to keep the process continually moving forward, as well as to keep the public regularly informed as the plan develops. How to involve all the stakeholders in this process? Discussion followed. Jon will bring concerns to the City Manager.

Discussion on how the GWMP fits in with the Comprehensive Plan, combining aquifer recharge zones, climate change impacts with watershed and surface water monitoring and the necessity of proper planning.

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Melanie volunteered to educate the Council on water issues and suggested regular short seminars to educate the public about aspects of the GWMP and how it is progressing. There could be discussions and slide show presentations; hydrogeology 101. Jon suggested utilizing the open-mic sessions put on by Charlie, as the best way to educate both the Council and the public on these issues. The city webpage also needs to be updated and used as an outreach tool. Dylan emphasized the need to stick to the current fact sheet to maintain consistency and avoid confusion.

Discussion of historic BI aerial photographs:
Waiting for Ben to be present to discuss.

Discussion of San Juan County New Construction Ordinance:
Malcolm explained the San Juan County Ordinance developed to address water usage with regards to new construction and suggested that something similar be adopted as a possible planning tool within the GWMP. Data estimates of current water use on Bainbridge Island are around 900 million gallons per year. How best to measure and manage water use going forward? Discussion followed.

Discussion of selection of new ETAC chairperson:
This topic was put off until Ben could be present. For now, Melanie will act as temporary chairperson and will prepare the meeting agendas.

Discussion of public outreach for new ETAC members:
Can we have city staff or volunteers keep up on the website? Discussion followed.

Public Comment:
None.

Adjournment- 4:20 p.m.

Aspect CONSULTING

MEMORANDUM

Project No. 220236

April 19, 2023

To: Chris Wierzbicki

From:

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4/19/2023

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Re: **Bainbridge Island Groundwater Model: Updates and Carrying Capacity Assessment**

This memorandum describes Aspect Consulting, LLC's (Aspect) findings from the updated aquifer system carrying capacity assessment and updates to the City of Bainbridge Island (COBI) groundwater model (hereafter: 2023 COBI model). The findings and recommendations discussed below will be used to address the sustainability of the Bainbridge Island aquifer system to support predicted population growth, water conservation goal setting, and stream flow preservation/restoration. As with all groundwater models, the 2023 COBI model is a simplified representation of complex subsurface conditions. As such, the findings based on groundwater modeling should be considered along with historically observed conditions to support the decision-making process. Thus, we recommend that the COBI Groundwater Monitoring Program (COBI, 2009) be continued, and that the Bainbridge Island model be reviewed periodically, updated as needed, and predictive findings be reassessed. We understand that the Groundwater Monitoring Program will be reviewed and possibly updated with the Groundwater Management Plan.

Summary of Findings and Recommendations

In summary, the 2023 COBI model was used to assess long-term changes in groundwater conditions associated with increased groundwater withdrawal rates. Adjustments to the model and input assumptions, described below, included consideration of future potential climate-change effects (decreased groundwater recharge rates and increased sea level) and a 50 percent increase in groundwater withdrawal across Bainbridge Island. In general, the 100-year (2021-2121) simulated model results indicated no seawater intrusion and the average rates of groundwater level decreases were less than the Early Warning Level (EWL)[1]. Further discussion on project background, groundwater model update methodology, and detailed conclusions and recommendations for future modeling assessments are provided below.

Project Background

The original Bainbridge Island model was developed and published in 2011 by the United States Geological Survey (USGS) in cooperation with COBI. This groundwater model is hereafter referred to as the 2011 COBI model. In 2015 and 2016 Aspect (Aspect 2015a, 2015b, and 2016) completed a groundwater data review and compilation, reviewed the USGS model and recommended updates and changes, and modified the groundwater model and used it to complete a Critical Aquifer Recharge Area assessment, aquifer system carrying capacity assessment, and operational scenario analysis; the model used for that work will be referred to as the 2016 COBI model. Also in 2016, the USGS published the Kitsap Peninsula groundwater model, which includes Bainbridge Island (Frans and Olsen, 2016); this model will be referred to as the 2016 Kitsap model.

Scope of Work

Under our current contract with COBI, Aspect is performing the following model updates:

- Task 1: Model Grid Refinement and Code Change
- Task 2: Sub-basin Modification
- Task 3: Model Updates and Validation
- Task 4: Aquifer Carrying Capacity Forecast

Model modifications and the approach for assessing the Bainbridge Island aquifer system carrying capacity are described below, followed by summaries of model results. This assessment builds upon Aspect's 2016 work and includes a set of recommendations for future carrying capacity assessments. The updated model documented in this memo will be referred to as the 2023 COBI model.

Model Updates

The 2023 COBI model updates required using the 2016 Kitsap model instead of the 2016 COBI model used for previous simulations. Aspect's attempts to update the 2016 COBI model resulted in several logistical problems that were more efficiently addressed by switching to Kitsap model.

Code Change

The model code is the set of calculations used to simulate groundwater conditions. Over time, different versions of model code have been released with different capabilities.

The 2016 COBI model used MODFLOW-SURFACT, an older, proprietary code that simulated the complex groundwater flow within the Puget Sound hydrostratigraphy (Hydrogeologic Inc., 1996).

[1] According to COBI's 2009 *Groundwater Monitoring Program Update* (COBI, 2009), an EWL is a monitoring criterion that, if exceeded, would result in appropriate Management Responses, of which there are two types: (1) additional investigations in order to determine if a potential problem is developing, and (2) protective or remedial actions where appropriate.

The 2016 Kitsap model was developed using MODFLOW-NWT, a publicly available code with capabilities similar to MODFLOW-SURFACT (Niswonger et al., 2011). The 2023 COBI model documented uses MODFLOW-USG, a publicly available code with the NWT solver (Panday et al., 2013), to take advantage of new capabilities including adaptive time stepping and ease future updates.

Grid Refinement and Model Extent

The 2016 COBI model used 800-foot by 800-foot cells. To provide greater resolution of simulated groundwater conditions. the Kitsap Model uses 500-foot by 500-foot cells. The extent of the Kitsap model was reduced to match that of the 2016 COBI model; the 2023 COBI model domain is shown in Figure 1 (attached).

Boundary Condition Modifications

Boundary conditions are used in groundwater models to simulate flow into or out of the model. Aspect made changes to boundary conditions when adapting the 2016 Kitsap model as described below.

- Surface water boundaries assigned to subsurface layers were removed.
- The 2016 Kitsap model uses stream boundary conditions to simulate complex groundwater/surface water interaction in creeks and streams, including gaining (in which groundwater discharges to the stream) and losing (in which streambed infiltration recharges the aquifer) sections of these surface water features. The complexity of these stream boundaries caused model instability during the code conversion from MODFLOW-NWT to MODFLOW-USG. To improve model stability, stream boundaries were converted to drain boundaries. Drain boundary conditions only allow for gaining conditions in streams, where any groundwater discharge to the stream is assumed to discharge to Puget Sound and does not re-infiltrate into the aquifer. This is a more conservative representation with respect to aquifer recharge, as streamflow is not allowed to reenter the subsurface.
- Drain boundaries were added to the top of layer 1 to simulate runoff and avoid simulating groundwater levels above ground surface.

The 2016 Kitsap model simulated return flow, from septic drain fields and golf course irrigation in the top layer. The original 2011 COBI model (and the 2016 COBI model) accounted for septic and irrigation return flow by reducing pumping rates to represent only consumptive use. This new implementation simulates moving groundwater from deeper aquifers to near ground surface.

Subbasin Implementation

Subbasins were delineated across Bainbridge Island to allow for more detailed analysis of groundwater-surface water interactions in watersheds of interest. The mapped watersheds are shown in Figure 2 (attached).

Simulation Period Extension and Validation

The 2016 COBI model simulated 1995 to December 2014 as monthly stress periods. The Kitsap model simulated annual stress periods from January 1985 to December 2004 and monthly stress periods from January 2005 to December 2012.

The 2023 COBI model simulation period extended the 2016 Kitsap model with monthly stress periods from January 2013 through December 2021. To provide consistency with dates over the model validation period, the 2016 Kitsap model stress period lengths were modified to account for leap years. Extending the model simulation period required assigning recharge and pumping rates for 2013 through 2021 as described in the subsequent sections.

Figure 3 shows the updated Bainbridge Island model timeframes compared to the previous 2016 carrying capacity assessment and the 2016 Kitsap model simulated periods. The predictive simulation is discussed in a subsequent section.

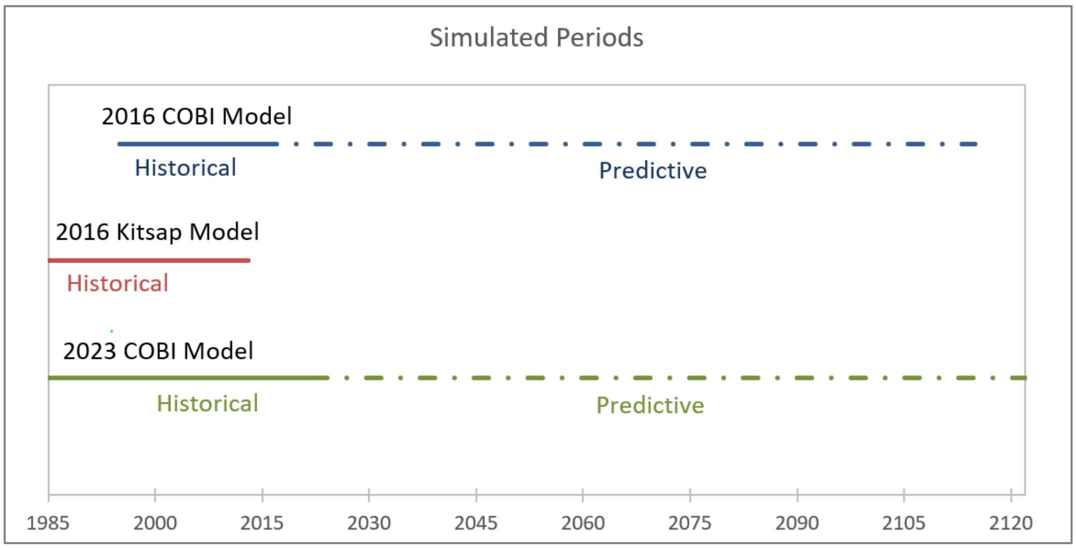

Figure 3. Simulated Periods

Recharge

Aquifer recharge from precipitation for the new simulation period (2013 – 2021) was determined using the same methods for the prior model update (Aspect, 2015b). Recharge was calculated from PRISM precipitation data (PRISM Climate Group, 2022) and the appropriate monthly recharge fraction from a USGS investigation of precipitation and aquifer recharge for till-mantled basins in the Puget Sound (Bidlake and Payne, 2001).

Well Pumping Rates

Well pumping rates were assigned from 2013 through 2021 depending on the data available and the well type. COBI and other public suppliers provided well production rates; monthly averaged production rates were assigned where possible. Pumping rates for wells without data were assigned based on well type. No new wells were added to the model; increased extraction due to population growth was simulated as increased pumping rates. Pumping rates were assigned in the following ways:

- **Wells with data**: The following 21 wells had mostly complete pumping data between 2013 and 2021, and we were able to assign monthly average pumping rates: Fletcher Bay PW, Harbor Crest, Head of the Bay Well #1, Head of the Bay Well #1A, Head of the Bay Well

#2, Head of the Bay Well #3, Head of the Bay Well #4, Head of the Bay Well #5, Head of the Bay Well #6, Hidden Cove Utilities Shop, Island Utilities Well 2, Island Utilities Well 3, North Bainbridge Well 09, North Bainbridge Well 07, North Bainbridge Well 03, Sands Road 2, Sands Road 1, Taylor Road Well, High School Well #2/Commodore, Island Utilities Well 1, North Bainbridge Well 10.

- **Domestic Wells**: An average annual growth rate of 0.63 percent was applied to the monthly pumping rates assigned for 2012 to estimate pumping rates for 2013 – 2021. This is consistent with the growth rate used between 2005 and 2012 in the original Kitsap groundwater flow model.

- **Septic return flow and other return flow**: No discernable pattern of growth was implemented between 2005 and 2012 for wells simulating septic and other return flows (such as golf courses). Monthly rates assigned for 2012 were repeated for 2013 to 2021.

- **All other wells:** Pumping rates at all other wells in the model (including those representing Group A and B water systems whose data was not provided) were increased based on average growth across systems as described. Typical group A and B water system growth was assessed from annual production for the following water systems: City of Bainbridge Island, Bill Point, Harbor Crest, Island Utility, North Bainbridge, South Bainbridge, Ferncliff, Bucklin Water System, Derby Downs, Emerald Heights Water, Graham Place Water System, Hidden Heights, Islandwood Estates, Meadowmeer, Phelps Road Water System, Place Eighteen, Ravens Reach, Rose Avenue Water Assoc., Walden Water System. These systems were considered as they had nearly complete total annual production data from 2013 to 2021 (accessed from the DOH Sentry database). Since complete data was not available for all water systems the percent change in production was calculated for all systems that had consecutive years of data. The percent change in production by year was normalized to production in 2012 and then applied on a yearly basis to all other wells in the model. Annual percent change in production ranged from a decrease of 2.63 percent to an increase of 7.44 percent.

In simulating wells, the “allow automatic flow reduction” option available in MODFLOW-USG was used. During the simulation, this option automatically reduces the pumping rate if the aquifer cannot sustain the assigned pumping rate without running dry. Automatic flow reduction is common in simulated wells that are assigned to a low permeability model cell. Automatic flow reduction can indicate a number of things: a disconnect between model layering and actual stratigraphy, an inappropriately assigned pumping rate, or a difference between actual and model aquifer parameters at that location. These disconnects arise due to generalizations that are necessary in modeling including spatial and temporal discretization and limited data and budgets for model development and calibration.

Validation

The success of the model updates, including code conversion, grid refinement, and extension of simulation period, was assessed through standard validation statistics and figures comparing measured and simulated groundwater elevations. The difference between the measured value and the simulated value is referred to as a residual. The mean residual represents the average difference between all measured and simulated values, and the sign of the mean residuals reflects whether the model is over- or under- predicting groundwater elevations (so a positive residual would indicate that on average, simulated values are lower than observed values). The standard deviation of residuals reflects variation in residuals values compared to the mean residual value; a low standard deviation indicates residuals are close the mean, a high value indicates residuals are spread out over a large range of values around the mean. The root mean squared error (RMSE) is a measure of the distance between simulated values and actual values.

The model extension (2013 – 2021) validation dataset included 4,294 groundwater elevations across 70 wells located on Bainbridge Island. Available groundwater elevation data was resampled on a monthly basis to align with model stress periods to compile this dataset.

Validation statistics are compared to original model calibration statistics in Table 1. Since the model domain was a reduced version of the original Kitsap 2016 model, the calibration statistics for the original 1985 to 2012 simulation period are recalculated and presented for the modified model domain. As shown in Table 1, the extended model period validation statistics agree with the calibration statistics for the original Kitsap Peninsula model. The mean residual is close to 0, indicating on average simulated groundwater elevations closely match observed water levels. Figure 4 (attached) shows observed water levels compared to simulated water levels; perfect agreement between observed and simulated water levels would plot as a straight line with a slope of 1. Groups of data points represent data from individual wells. Near vertical alignment of groups of data points indicates the storage parameters assigned in the model may be too low; near horizontal alignment indicates that the storage parameters may be too high. The RMSE divided by the total range in water levels in the groundwater system is less than 10 percent, which is the industry standard to consider a calibration acceptable (Anderson and Woessner, 1992; Drost et al., 1999). Based on these statistical measures and consistency with the 2016 Kitsap model, the updated 2023 COBI model documented in this memo is appropriate to simulate the groundwater flow system on Bainbridge Island.

Table 1. Validation Statistics

Calibration Statistic	USGS Kitsap Model[1]	Locations within focused model extent	
	1985 - 2012	1985 – 2012 (Original period)	2013 – 2021 (Extended Period)
Residual[2] Mean (feet)	3.7	-6.46	0.12
Residual Standard Deviation (feet)	47.01	45.97	34.16
RMS[1] Error (feet)	47.16	46.42	34.16
Minimum Residual (feet)	Not reported	-251.22	-171.13
Maximum Residual (feet)	Not reported	95.40	193.18

Calibration Statistic	USGS Kitsap Model[1]	Locations within focused model extent	
	1985 - 2012	1985 – 2012 (Original period)	2013 – 2021 (Extended Period)
Minimum Observed Water Level (feet)	Not reported	-49.70	-140.10
Maximum Observed Water Level (feet)	Not reported	597.70	284.50
Range of observations (feet)	647.4	647.40	424.60
Scaled Residual Standard Deviation	0.073	0.071	0.080
Scaled RMS Error	0.073	0.072	0.080
Number of observations	18,834	9,859	4,294

[1]Frans and Olsen (2016)
[2]A residual is the difference between the observed value and the simulated value.
[3]Root Mean Squared

Carrying Capacity Forecast

Defining Carrying Capacity

For groundwater modeling purposes, the concept of "carrying capacity" is defined as the safe yield for the aquifer system. The term "safe yield" has been used in previous reports (Aspect, 2006; Aspect, 2008; Aspect, 2016) to support establishing COBI's EWLs. Essentially, the principle of safe yield is the rate of groundwater withdrawal that is sustainable from multiple perspectives, such as water supply infrastructure, economics, ecological system health, and legal consideration. Indictors of safe yield can be measured by changes in groundwater availability and quality. For this memorandum, the EWLs (discussed in detail in the next section) adopted by COBI—including consideration of potential seawater intrusion and decline in aquifer water levels—were used as safe yield indicators. To address sustainability of the Bainbridge Island aquifer system to support predicted population growth and water conservation, the Bainbridge Island groundwater model was used to predict long-term (i.e., 100 years) groundwater flow conditions.

Approach for Assessing the Aquifer System Carrying Capacity

The approach for assessing the aquifer system carrying capacity involved simulating three concurrent stresses on the aquifer system:

1. Long-term increased groundwater withdrawal rates
2. Reduced recharge rates
3. Sea level rise

The long-term projected increase in groundwater withdrawal rates was selected to reflect both the increase in water supply demand associated with population growth as well as water conservation (i.e., anticipated decrease in water use per capita). Analysis from the University of Washington (UW) Climate Impacts Group was used (Mauger, et al., 2015) as the best available science for the effects of climate change on recharge and sea level rise in the Puget Sound area.

This approach was developed to quantify predicted changes in Bainbridge Island aquifer conditions for two safe-yield indicators with EWLs:

1. Seawater intrusion (with EWL of 100 milligrams per liter (mg/L) chloride); and
2. Rate of groundwater levels changes (with EWL of 0.5 feet per year for 10 years).

The on-Island groundwater balance for the entire aquifer system was also evaluated. The groundwater balance components do not have EWLs, and were evaluated to provide additional context on the predicted changes in groundwater conditions.

Predictive Timeframe

Consistent with the previous carrying capacity assessment (Aspect, 2016) this analysis considered an extended, 100-year timeframe. Historical groundwater modeling extends through 2021 and this model update uses a sustainability assessment period to simulate 2021 to 2121. The historical groundwater conditions calculated for the end of 2021 were used for initial conditions in the updated predictive model.

More conservative model assumptions were used in applying the updated model to assess safe yield (carrying capacity). The long-term stresses, including increased groundwater withdrawal, reduced aquifer recharge, and sea level rise were assumed to occur at the start of the simulation versus occurring gradually over time.

Increase in Groundwater Withdrawal Rates to Reflect Population Increase

Consistent with the 2016 carrying capacity assessment, this analysis assumed a 50 percent increase in groundwater withdrawals over 100 years. This assumption reflects 100 years of compounded 0.4 percent average annual increase in groundwater demand, or a shorter period of time with greater average annual increase in groundwater demand. Simultaneous population growth and water conservation could take many forms yielding a total 50 percent increase in groundwater withdraws, including the following examples:

- 100 years of 1 percent annual population growth and 0.6 percent annual water conservation
- 56 years of 1 percent annual population growth and no increase in water conservation

This assessment implemented a total 50 percent increase in groundwater withdrawal rates for the entire 100-year simulation period. That is, the model simulated 100 years of groundwater withdrawals at 150 percent of current average rates.

The 2023 COBI model simulates 1,363 wells on-Island and 1,989 wells off-Island (that portion of Kitsap County falling within the model domain). Groundwater withdrawal rates were increased by 50 percent for each well across the model area (Bainbridge Island and Kitsap Peninsula). The 2016 Kitsap model used the well boundary condition to simulate septic return flow (including 2,141 on Island and 6,555 off Island), and other return flow to the subsurface. These return flow rates were also increased 50 percent to reflect growth. Figure 5 shows the current, projected, and simulated groundwater withdrawal rates for total pumping in units of millions of gallons per year.

Consistent with the validation model, wells were simulated allowing for automatic flow reduction; that is if the aquifer represented by the model cell cannot sustain the assigned pumping rate, the pumping rate is automatically reduced to a rate that can be met. As the wells are currently implemented in the model, the projected demand could not be fully met. Allowing for automatic flow reduction, an increase of 44 percent was simulated. Automatic flow reduction impacted more wells off-Island; off-Island wells simulated a total pumping rate of 142 percent of the baseline, and on-Island wells simulated a 148 percent rate, which is closer to the target 150 percent. An alternative simulation approach would be to assign more groundwater demand in the model based on areas of planned development, including Group A or B well system expansion or new wells (Group A or B or domestic).

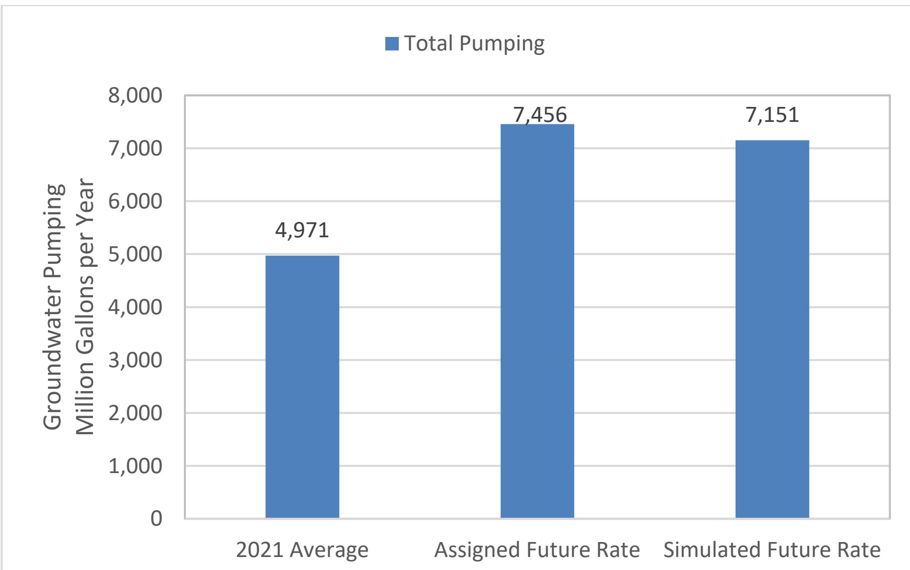

Figure 5. Current and Projected Groundwater Withdrawal Rates (Entire Model Domain)

Change in Recharge due to Climate Change

The UW Climate Impacts Group (Mauger, et al., 2015) simulated future changes in precipitation and runoff for representative hydrologic basins across Washington. Their modeling analysis indicates that by the year 2100, winter runoff is expected to increase in the Puget Sound area by up to 20 percent (which contributes to a reduction in recharge rates) due to more frequent, high-intensity (i.e., heavy) rain events. Warmer temperatures overall will also increase the evapotranspiration rates.

Consistent with the previous 2016 carrying capacity analysis, predictive model simulated long-term groundwater conditions assuming a total 20 percent decrease in recharge rates across the model area due to climate change. That is, the model simulated 100 years of recharge at 80 percent of current average recharge rates. Figure 6 shows the simulated recharge rates.

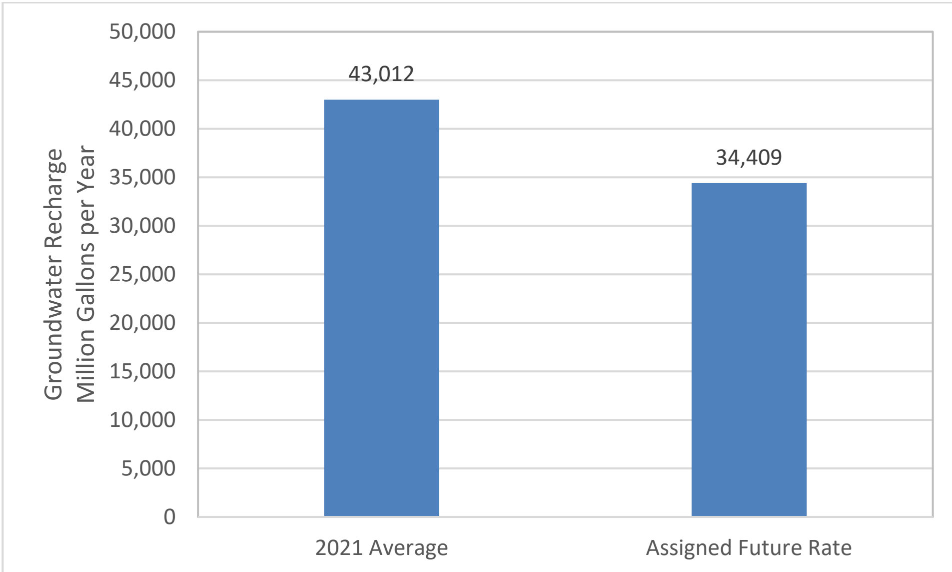

Figure 6. Current and Projected Recharge (Entire Model Domain)

Potential Sea Level Rise due to Climate Change

The UW Climate Impacts Group (Mauger, et al., 2015) projected sea level rise estimates ranging from 6 to 55 inches by the year 2100.

This updated analysis was consistent with the 2016 aquifer carrying capacity assessment, which assumed a 4-foot increase in mean sea level due to climate change. The assigned boundary condition accounted for the density of seawater assuming a density of 63.93 lb/ft^3. The increased sea level was applied to the entire predictive time frame.

Results of Aquifer System Carrying Capacity Assessment

The aquifer system carrying capacity assessment was based on those safe-yield indicators with EWLs adopted by the COBI, including the following:

1. Seawater intrusion (with EWL of 100 milligram per liter [mg/L] chloride)
2. Rate of groundwater level decline (with EWL of 0.5 feet per year for 10 years)

The on-Island groundwater balance (including potential changes in the groundwater discharge to surface water) for the entire aquifer system was also evaluated. The groundwater balance components do not have EWLs but were evaluated to provide additional context on the predicted changes in groundwater conditions.

Seawater Intrusion Assessment

Seawater intrusion is a primary constraint on groundwater supply development and a key indicator of safe yield, because it can be assessed using the predictive model, directly measured (based on empirical water quality data) and compared to the COBI EWL of 100 mg/L chloride. Within the COBI groundwater monitoring program, observed chloride concentrations have generally been below the EWL (Aspect, 2015a). The one historical exception where elevated chloride (i.e., above the EWL) was repeatedly measured includes a community well located near the shoreline and potentially tapping a thin water bearing zone near mean sea level. We understand that this well is now used with a reverse osmosis treatment system to augment supply.

The predictive model results indicate that groundwater from the Bainbridge Island aquifer system flows to Puget Sound and keeps the freshwater/seawater interface at a distance from the Bainbridge Island shoreline. The following findings were based on the 100-year model results for seawater intrusion as part of the aquifer system carrying capacity assessment:

- The Perched Aquifer and Semi-Perched Aquifer systems are well above sea level and did not show seawater intrusion.
- The Sea Level Aquifer system did not show seawater intrusion within the Bainbridge Island shoreline; the freshwater/seawater interface remained offshore at varying distances from the shoreline depending on location.
- The deeper aquifer systems (including the Glaciomarine Aquifer and the Fletcher Bay Aquifer) did not show seawater intrusion, because of thick aquitards and fresh groundwater flow sourced by off-Island recharge areas.

Rate of Groundwater Level Changes

The long-term rate of groundwater level changes is another indicator of the aquifer system carrying capacity. COBI established an EWL of 0.5 feet per year for 10 years.

The following rates of groundwater level change were based on comparing current (2021) and predicted groundwater levels in 100 years (2121):

- The Perched Aquifer system (Vashon recessional aquifer) showed an average 0.08 feet per year of water level decrease across the Island. Groundwater levels decreased more than the EWL in limited areas of the Perched Aquifer system. The perched aquifer is not a source aquifer and decreases in water levels will not water impact supply.
- The Semi-Perched Aquifer (Vashon Advance aquifer) system showed an average 0.06 feet per year of water level decrease across the Island. Simulated groundwater levels decreased more than the EWL in limited areas of the Semi-Perched Aquifer system which included one simulated well.
- The Sea Level Aquifer system showed an average 0.04 feet per year of water level decrease across the Island. Groundwater levels decreased more than the EWL in a limited area of Sea Level Aquifer system without water supply wells.
- The Glaciomarine Aquifer showed an average 0.03 feet per year of water level decrease across the Island. Groundwater levels decreased less than the EWL across the Glaciomarine Aquifer system.
- The Fletcher Bay Aquifer (referred to as the deep aquifer in Frans and Olsen (2013)) showed an average 0.05 feet per year of water level decrease across the Island. Groundwater levels decreased less than the EWL across the Fletcher Bay Aquifer system.

EWLs calculated by the model may be biased high due to low storage parameters assigned in the model identified during model validation (and illustrated in attached Figure 4 by near vertical groups of points).

Changes in Groundwater Discharge to Surface Water

The updated 2023 COBI model was used to evaluate potential changes in streamflow by calculating the discharge extracted from drain boundary conditions in the model. The calculations were made for the watersheds shown in attached Figure 2 and included the combined groundwater discharge to any surface water points including shoreline seeps, springs, wetlands, and stream channels. Overland runoff and streamflow are not simulated in the 2023 COBI model.

Simulated historical groundwater discharge to surface water is shown in Figure 7 (attached) with annual variability (1985 through 2004) and seasonal variability (January 2005 through December 2021) Groundwater discharge to surface water is higher in the winter and spring, and lower in the summer and fall.

The estimated changes in groundwater discharge under the carrying capacity scenario as compared to 2021 average conditions are shown in Figure 8 (attached). The figures show that predicted groundwater discharge to surface water is less than the historical baseline (2021 annual average) and is typically greater than the seasonal minimum. As listed in Table 2, the percent reduction in streamflow as compared to the historical baseline discharge under 2021 average conditions ranges from 15 to 58 percent.

Table 2. Decrease in Groundwater Discharge to Surface Water

Watershed	Baseline Groundwater Discharge to Surface Water (cfs)	Decrease in Groundwater Discharge to Surface Water (cfs)	Percent Decrease
Agate Passage	0.36	0.11	29%
Port Madison	1.38	0.32	23%
Manzanita Bay	1.11	0.44	40%
Sunrise	1.21	0.27	22%
South Beach	0.54	0.08	15%
Blakely Harbor	1.01	0.18	18%
Pleasant Beach	0.69	0.20	29%
Eagledale	0.44	0.15	33%
North Eagle Harbor	0.53	0.29	55%
Gazzam Lake	0.10	0.06	58%
Fletcher Bay	1.60	0.39	24%
Murden Cove	1.78	0.41	23%

Groundwater Balance Changes

The groundwater balance is expected to change in the future due to increased groundwater withdrawals and decreased recharge rates. Groundwater balance components are typically difficult to measure directly (such as recharge and groundwater underflow). Thus, this groundwater balance assessment relies on modeling results without actual field measurements. The values discussed below reflect the entire model domain, not just Bainbridge Island.

The relationship between groundwater balance inputs and outputs for the Bainbridge Island aquifer system is shown in the following equation:

$R_{ppt} = (W_{ppg} - W_{RF}) + D_{sw} + (GW_{ps} - GW_{kp})$

Where:

Inputs include:

R_{ppt} is precipitation recharge.

W_{RF} is septic and other return flow

Outputs include:

W_{ppg} is groundwater withdrawals;

D_{sw} is groundwater drainage to surface water (such as seeps to bluffs, creeks, streams, etc.); and

$(GW_{ps} - GW_{kp})$ is the net lateral groundwater underflow (groundwater flow toward Puget Sound submarine seeps (GW_{ps}) and groundwater flowing from the Kitsap peninsula in deeper aquifers (GW_{kp})).

To balance the 50 percent increase in groundwater withdrawals and the 20 percent decrease in recharge, the model showed projected changes in groundwater drainage to surface water (approximately 21 percent decrease) and lateral groundwater flow (approximately 20 percent decrease). Figure 9 compares the water balance components under current and projected conditions, based on model results[2].

The updated 2023 COBI model results showed aquifer storage will be reduced by approximately 32,300 million gallons between current and projected conditions, reflecting the water level decreases described above. These groundwater balance results should be carefully interpreted, considering that the model has not been calibrated to observed flows.

[2] The difference between groundwater balance inputs and outputs reflects the modeling methods, and results are within an acceptable level of accuracy for predictive purposes.

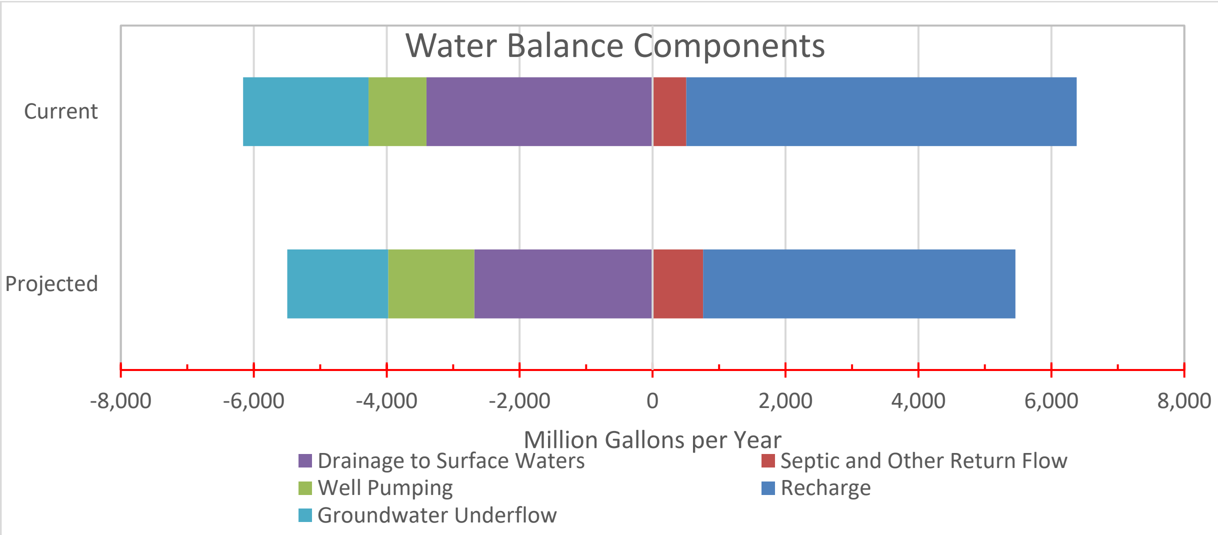

Figure 9. Current and Projected Groundwater Balance Components (Bainbridge Island Only)

Table 3. Water Balance Components (Million Gallons per Year)

Water Balance Component (Million Gallons per Year)	Projected	Current
Recharge	4,700	5,875
Septic and Other Return Flow	759	506
Well Pumping	-1,297	-873
Drainage to Surface Waters	-2,681	-3,401
Groundwater Underflow	-1,519	-1,886

Recommendations for Future Assessments

The Bainbridge Island aquifer system carrying-capacity assessment described above provides an evaluation of long-term changes in groundwater conditions predicted with concurrent stresses on the aquifer system, including increased groundwater withdrawal rates, decreased recharge rates, and sea level rise. To address the sustainability of the Bainbridge Island aquifer system to support predicted population growth and water conservation, our recommendations for future assessments are listed below:

1. Simulate a range of projected future groundwater withdrawal rates, based on input from COBI staff. The assumption of a 50 percent increase over current withdrawal rates was based on the 2016 carrying capacity memo. This assessment did not account for the possible decommissioning of shallow private wells on parcels to be served by expanded public water systems in the future.

2. This assessment simulated increased groundwater demand at existing wells potentially resulting in exaggerated groundwater level declines. An alternative simulation approach would be to assign increased groundwater demand to new Group A or B wells, or new domestic wells based on historical and planned development strategies.

3. Recalibration of model storage parameters may be warranted based on the alignment of data shown in attached Figure 4. Areas assigned lower-than-actual aquifer storage (represented by vertical groups of points in Figure 4) simulate greater-than-actual groundwater level decreases.
4. Perform additional analysis to better characterize the effects of decreasing groundwater levels on shallow wells (e.g., domestic wells). This analysis would identify wells impacted by automatic flow reduction to determine if the assigned pumping rate could not be sustained due to model limitations or actual aquifer limitations. This information may support focused groundwater level monitoring.
5. Validate the groundwater model to stream baseflows. This effort would need to be supported by a stream gaging program. At this point, the updated model has not been validated to stream baseflows, and therefore it is uncertain how well the model simulated surface water – groundwater interactions. Predictive model results can inform focused monitoring and/or mitigation efforts.
6. Provide periodic Bainbridge Island model review, updating the model as needed with new wells, groundwater withdrawal schedules, and groundwater monitoring data. Predictive scenarios should be reassessed using refined assumptions about projected groundwater withdrawal rates, recharge rates, and sea level rise.
7. Continue to implement the Groundwater Monitoring Program. These data provide critical information to support model updates and the decision-making process.

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Limitations

Work for this project was performed for the City of Bainbridge Island (Client), and this memorandum was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This memorandum does not represent a legal opinion. No other warranty, expressed or implied, is made.

All reports prepared by Aspect Consulting for the Client apply only to the services described in the Agreement(s) with the Client. Any use or reuse by any party other than the Client is at the sole risk of that party, and without liability to Aspect Consulting. Aspect Consulting's original files/reports shall govern in the event of any dispute regarding the content of electronic documents furnished to others.

Attachments: Figure 1 – Model Domain
Figure 2 – Bainbridge Island Subbasins
Figure 4 – Comparison of Observed and Modeled Water Levels
Figure 7 – Groundwater Discharge by Basin
Figure 8 – Change in Groundwater Discharge to Drainages

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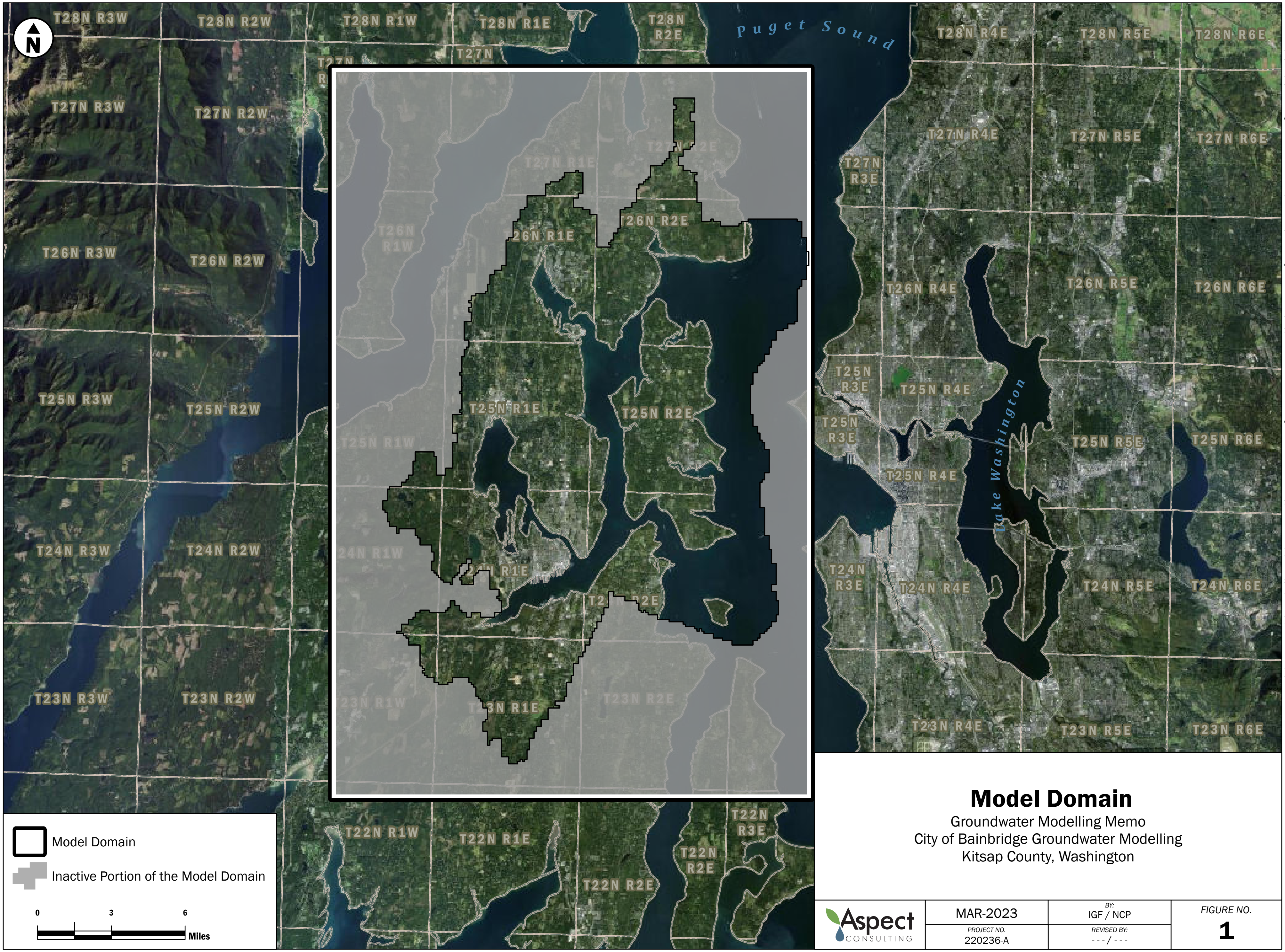
FIGURES



Model Domain

Groundwater Modelling Memo
City of Bainbridge Groundwater Modelling
Kitsap County, Washington

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	PROJECT NO. 220236-A	REVISED BY: - - - / - - -	1

Data source credits: None || Basemap Service Layer Credits: Source: Esri, USDA FSA

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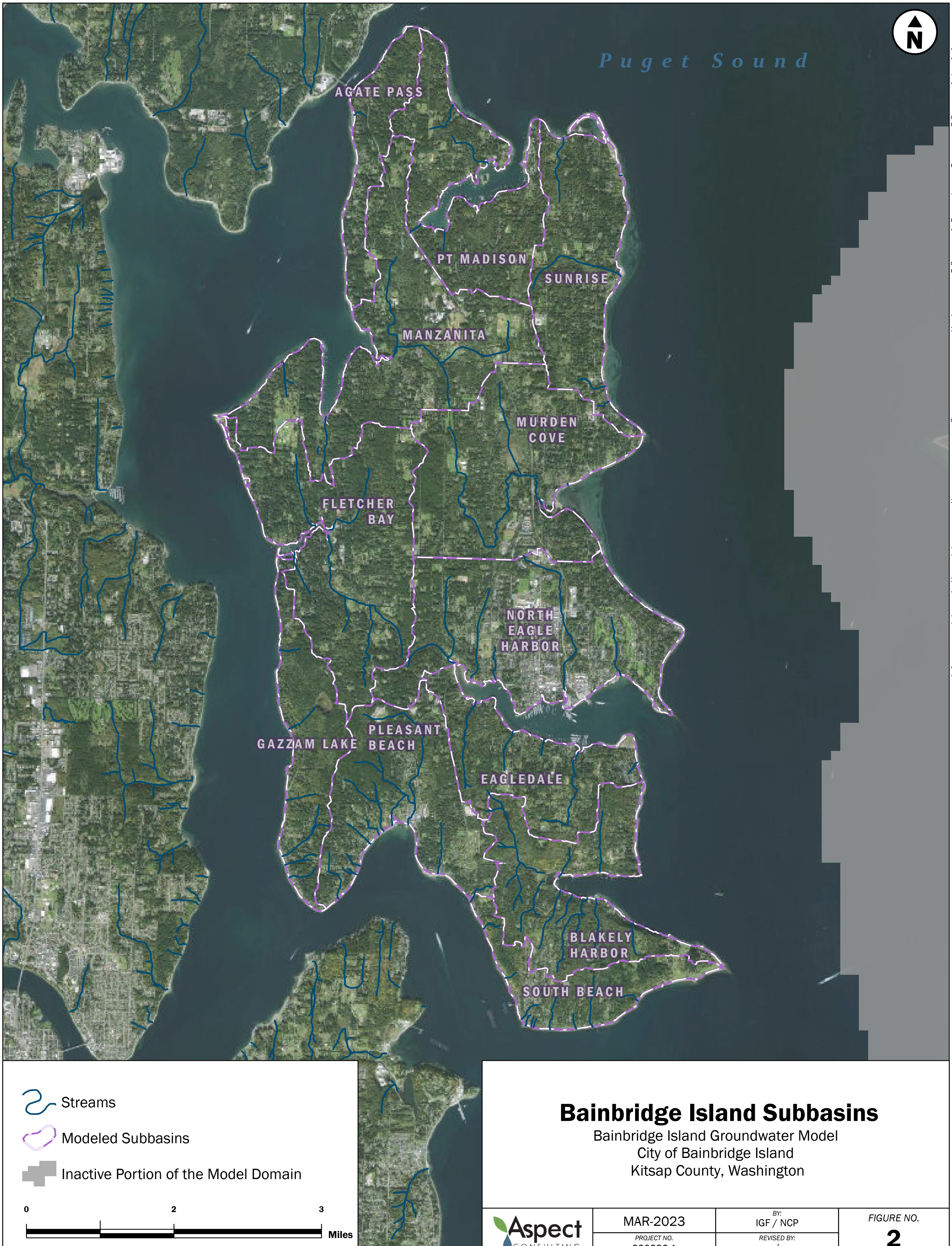

Bainbridge Island Subbasins

Bainbridge Island Groundwater Model
City of Bainbridge Island
Kitsap County, Washington

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	PROJECT NO. 220236-A	REVISED BY: - - - / - - -	

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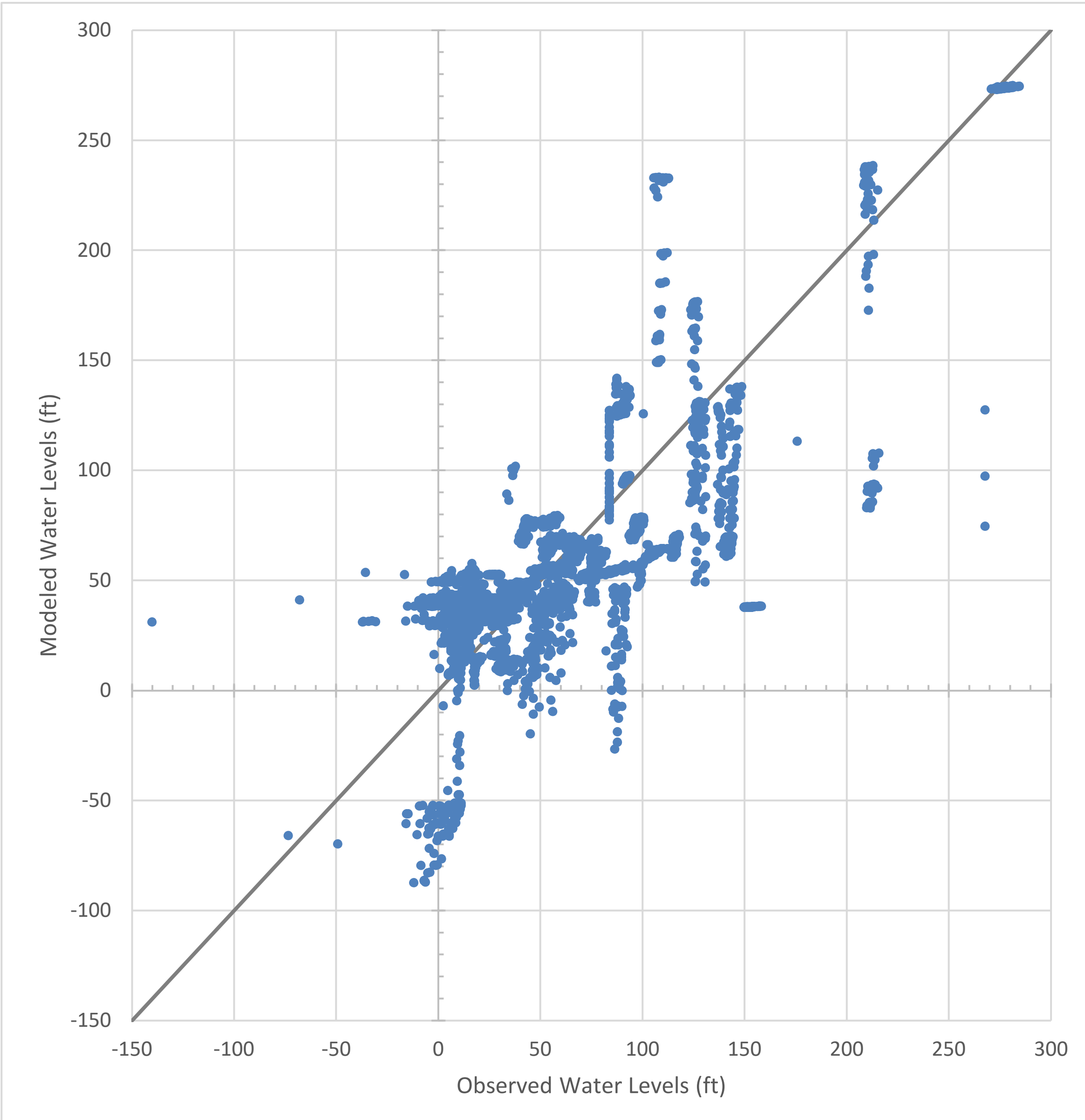

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Figure 4
Comparison of Observed and Modeled Water Levels
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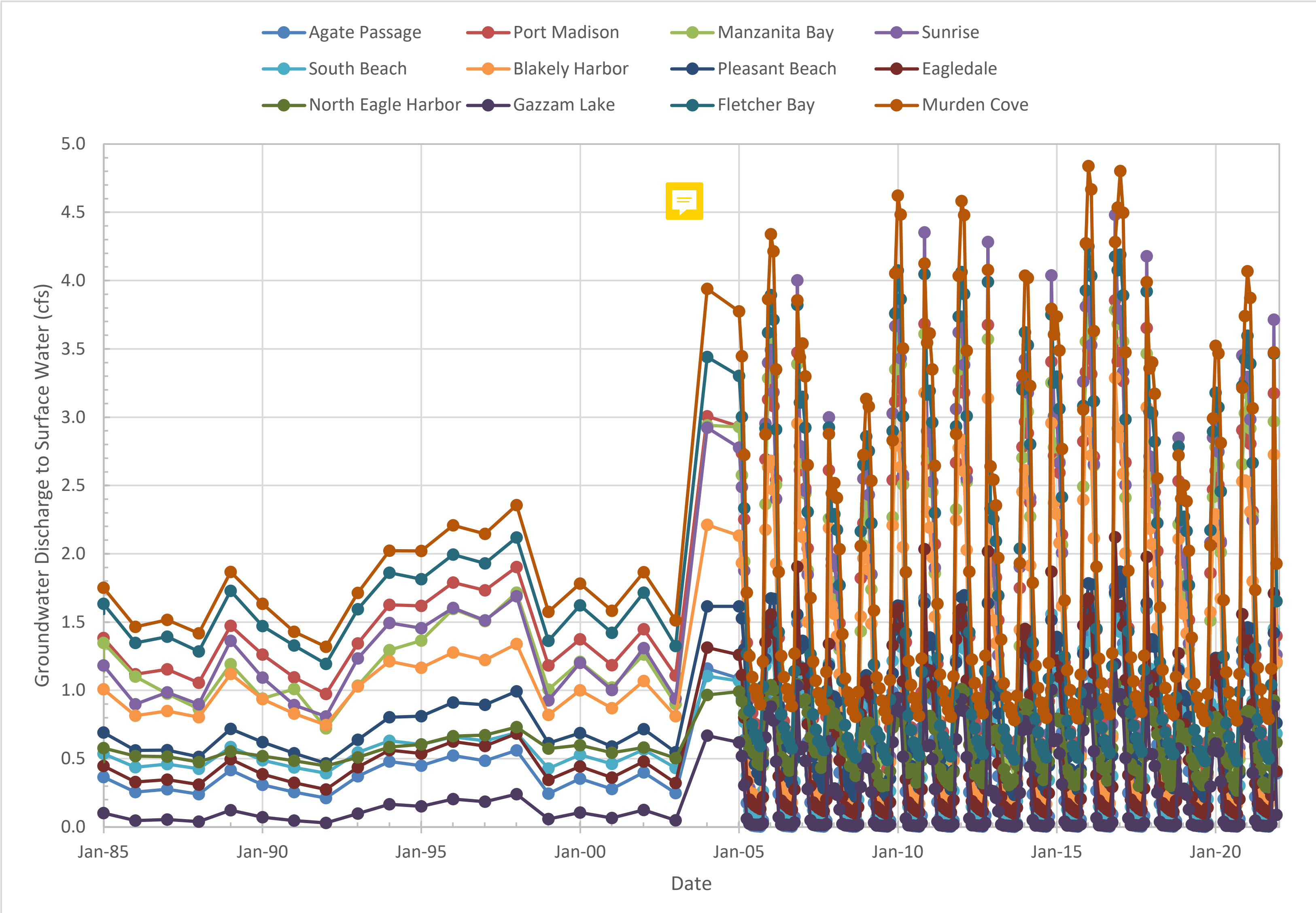

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Figure 7a
Groundwater Discharge by Basin

Bainbridge Island Groundwater Model
City of Bainbridge Island, WA

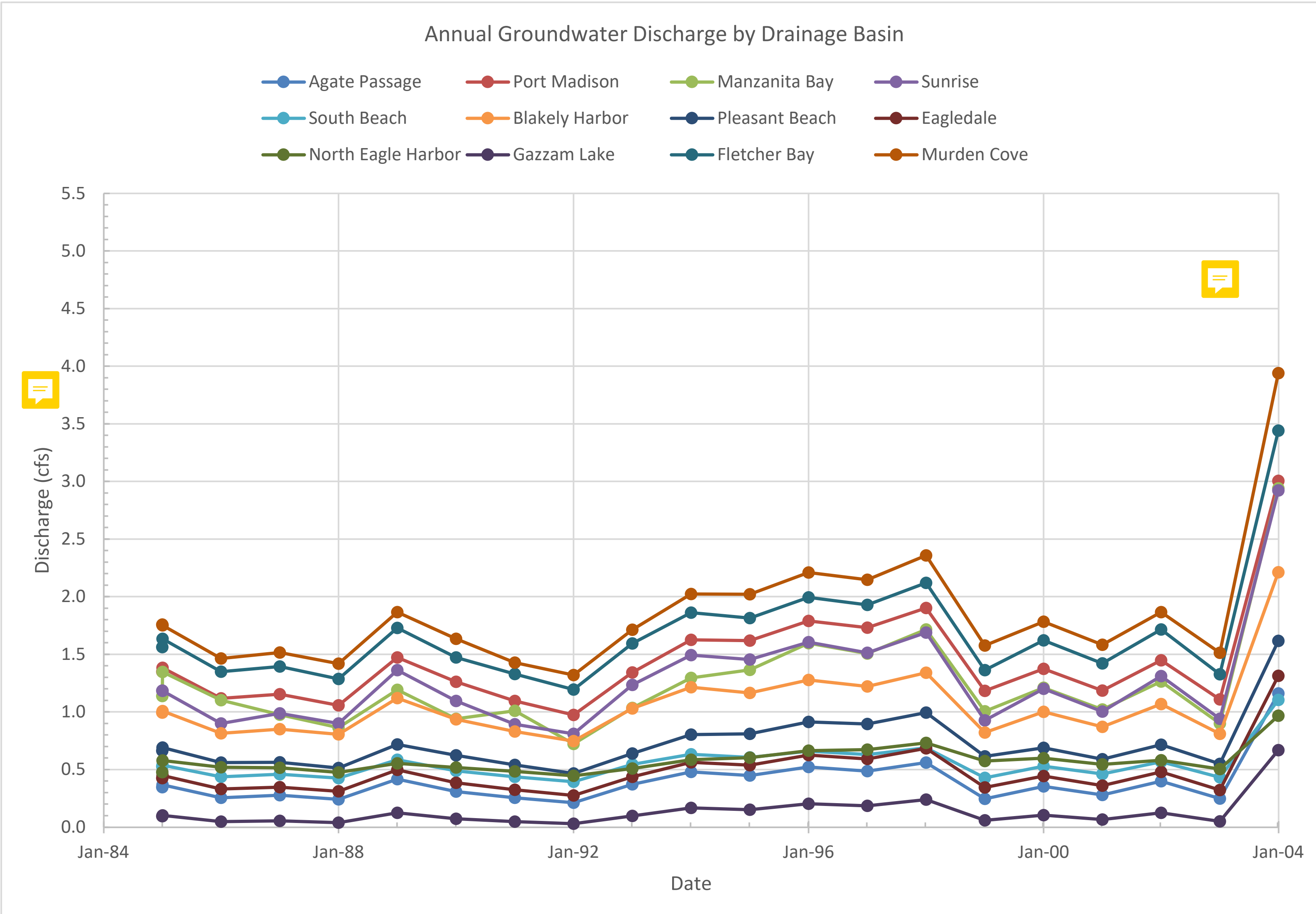

Figure 7b

Groundwater Discharge by Basin

Bainbridge Island Groundwater Model

City of Bainbridge Island, WA

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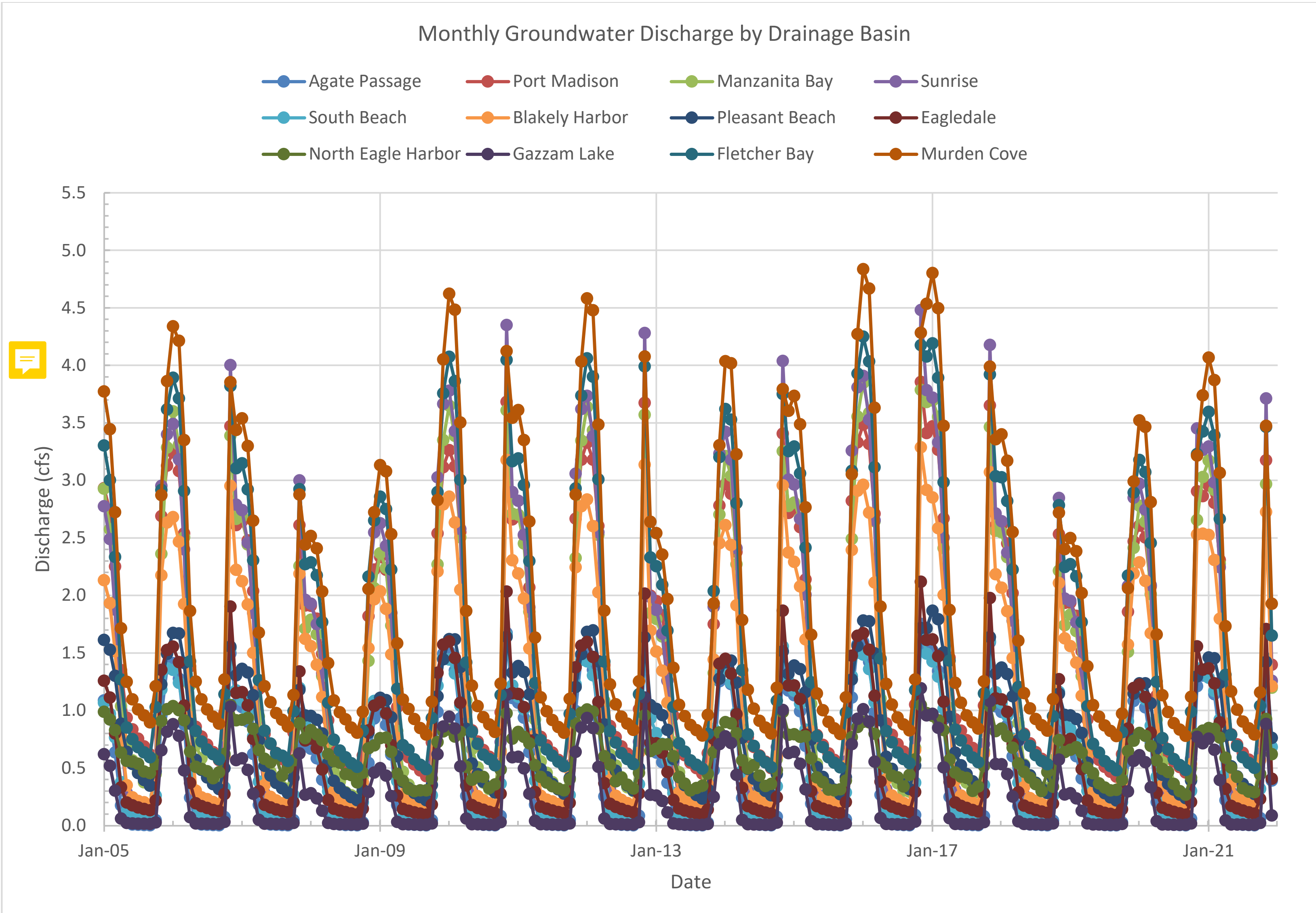

Figure 7c
Groundwater Discharge by Basin
Bainbridge Island Groundwater Model
City of Bainbridge Island, WA

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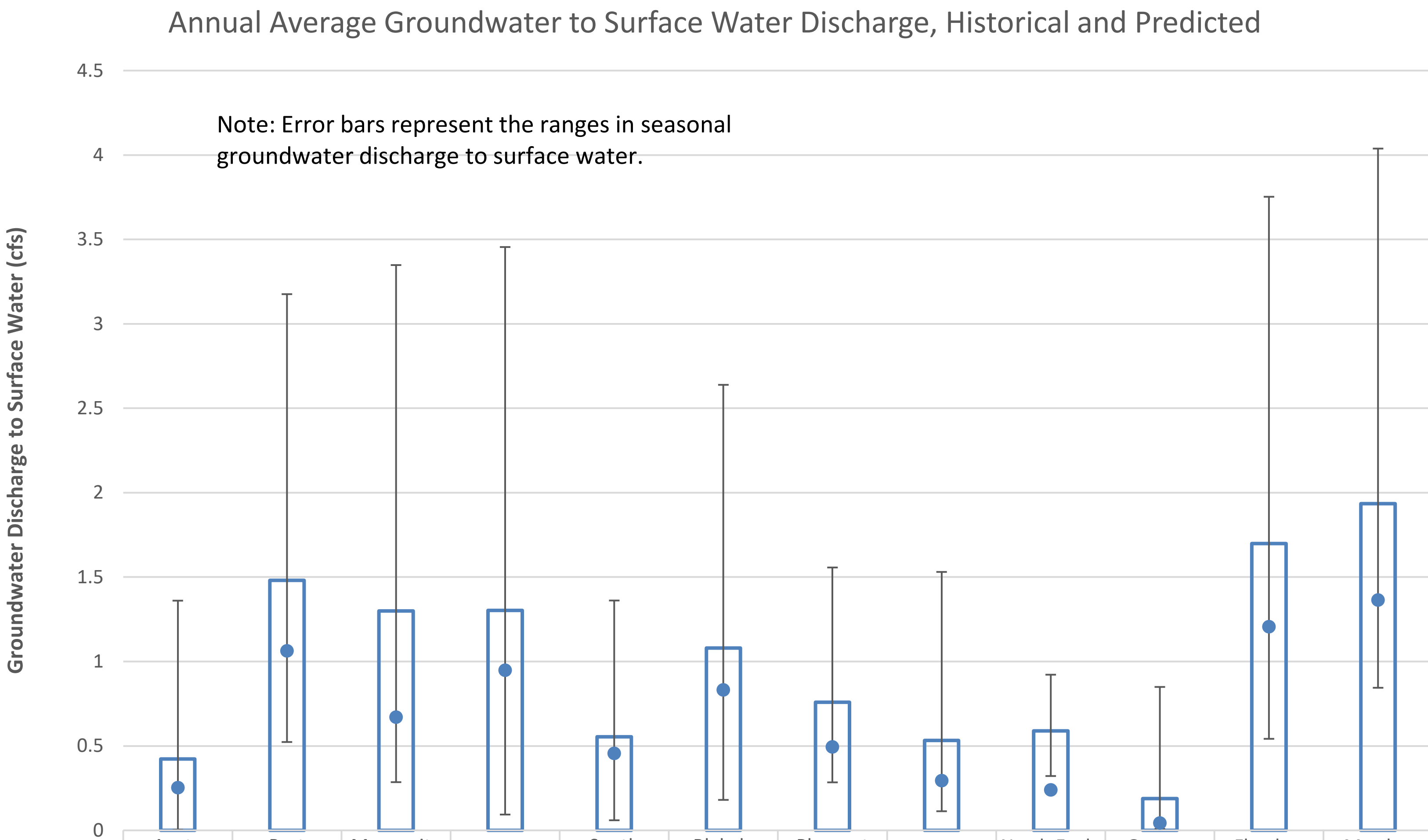

	Agate Passage	Port Madison	Manzanita Bay	Sunrise	South Beach	Blakely Harbor	Pleasant Beach	Eagledale	North Eagle Harbor	Gazzam Lake	Fletcher Bay	Murden Cove
Historical	0.42	1.48	1.30	1.30	0.55	1.08	0.76	0.53	0.59	0.19	1.70	1.93
Predicted	0.25	1.06	0.67	0.95	0.46	0.83	0.49	0.30	0.24	0.04	1.21	1.37

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4/19/2023
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Figure 8
Change in Groundwater Discharge to Drainages
Bainbridge Island Groundwater Model
City of Bainbridge Island, WA

WATER RESOURCES ELEMENT

TABLE OF CONTENTS

WATER RESOURCES INTRODUCTION

Bainbridge Island is solely dependent on groundwater for its drinking water and requires a holistic perspective to understand the interdependence among the Island's three primary water resources: *groundwater*, surface water and *stormwater*. Although these waters are typically regulated and managed independently, they are in nature, intimately connected.

Precipitation that is not evaporated or taken up by plants will follow one of three paths. It may infiltrate into the ground where it is called *groundwater*. It may drain directly into *streams* and harbors where it is called surface water or it may be captured by manmade *infrastructure* such as street drains, ditches or detention/retention ponds where it is called *stormwater*.

Groundwater may be pumped from wells to provide drinking water or irrigation or seep out of the ground into *streams*, springs and harbors where it is again called surface water. Likewise, *stormwater* may discharge into a nearby stream or harbor and become surface water or infiltrate into the ground and become *groundwater*. (see Fig.WR-1)

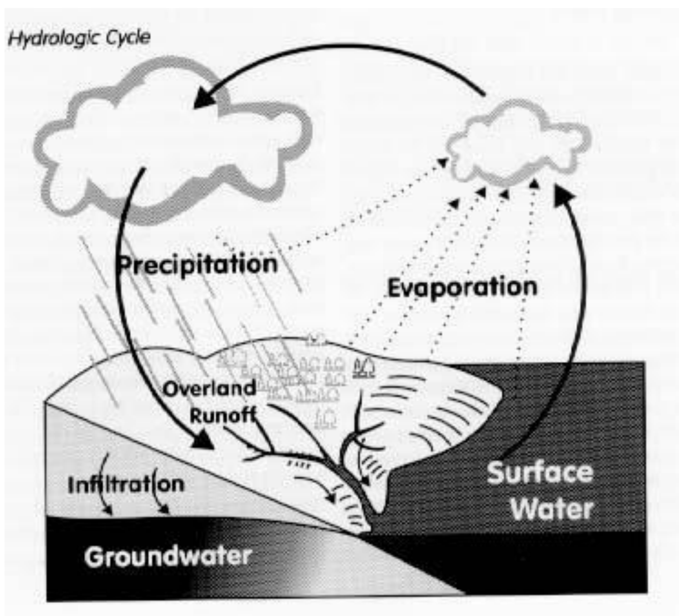

Fig. WR-1 The Hydrologic Cycle

In order to successfully protect and manage any one of these waters one must protect and manage all three. To address these interrelationships, a separate Water Resources Element has been developed as follows:

- General water resources management policies
- *Groundwater* protection and management policies
- Surface water protection and management policies
- *Stormwater* protection and management policies
- Residential on-site sewage system policies
- Contaminated sites policies
- Public education and outreach policies

Land Use Connection

In the development of policies related to the management of our Island water resources, it is important to understand the links between water resources quality and quantity and *land use*. Most water quality and habitat integrity impacts are caused by the way land was or is used. Developed land allows for rapid *runoff* and inundation of natural conveyance systems such as *wetland*s and *streams*. Rapid *runoff* can cause damage through flooding, erosion and water-borne contamination.

In addition, *household*s create sewage that needs disposal either by a wastewater treatment plant or by residential on-site sewage systems. Wastewater treatment plants are reasonably effective at cleaning wastewater but do not at present provide complete removal of nitrogen nor treat for contaminants of emerging concerns that include but are not limited to, byproducts of medications, recreational drugs, health and beauty products and caffeine.

Residential on-site sewage systems can fail and cause contaminants to enter the surface water and/or *groundwater*. Even functioning systems, depending upon *density* and proximity to surface water and *groundwater*, can contribute to accumulations of nitrogen and contaminants of emerging concern in these waters.

Use of fertilizers, pesticides and other chemicals for cropland, lawns and gardens, and vehicle and *household* cleaning and maintenance as well as improper pet and livestock waste management can add significant contamination to surface water, *stormwater* and *groundwater*.

Commercial and industrial uses, past and present, leave behind pollutants in our soils. In particular, historic *land use*s such as large row crop agriculture, lumber, petroleum and others have left behind legacy pollutants in sediments both on upland properties and in the sediments along the bottoms of our *streams*, harbors and nearshore areas.

Without proper coordination of the regulations that will implement policy statements, conflicting signals may be given when dealing with water resources issues. For example, a surface water problem may be resolved by efficiently collecting and removing all water from the area whereas a *groundwater recharge* issue may require that the water be kept on-site to allow for infiltration.

Another conflict arises when infiltration of *stormwater* competes for space with on-site sewage system drain fields. There are physical limitations to the rates of infiltration and absorption based on soil types which may make it impossible to have both of those facilities on the same site. Where development occurs in important *aquifer recharge areas*, special consideration is needed to preserve the volume of *recharge* available to the *aquifer* and to protect the *groundwater* from contamination. A key component of water resources protection and adaptive management is adequate monitoring in order to assess impacts of current land use and the effectiveness of applied management actions.

The overriding theme that runs through all of the policies and *goal*s in this element is the preservation and protection of water quality, water quantity, and ecological and hydrologic function.

Climate change

The 2016 Bainbridge Island Climate Impact Assessment, which is referenced in this Comprehensive Plan, establishes that a primary concern of *climate change* is the impact on *water resources*, especially for an island location like Bainbridge Island that relies solely on an *aquifer* system for its drinking water. *Climate change* projections indicate that over the coming decades sea level may rise up to four feet in the Puget Sound region, the ocean will become more acidic and climatic conditions are likely to become warmer. This will result in more intense rain events during the wet season with longer, drier summers, though overall annual volume of rainfall under current models is expected to remain approximately the same.

Ocean acidification will likely impact aquatic species survival and assemblages in our marine areas and sea level rise will likely impact habitat and built *infrastructure* in our nearshore areas including homes, businesses and public facilities such as roads and sewer facilities.

Wetter conditions during the wintertime will increase water availability but may cause flooding or diminish water quality. More intense and frequent storms or heavier rainfall events can cause *stormwater* inundation and localized flooding, chronic flooding, non-infiltrated run-off, erosion and landslides. Increased intensity of rainfall may also diminish *aquifer recharge* rates as saturated soils are less able to absorb large amounts of water falling over short periods of time.

Warmer, drier conditions in the summertime will increase evaporation rates and water demand by plants, wildlife and people, and may diminish water quality. Dry conditions decrease water availability resulting in reduced stream flow and diminished *aquifer recharge*. Warmer and drier conditions can also reduce water quality, both by increasing in-stream temperatures and by concentrating contaminants in smaller volumes of water.

WATER RESOURCES VISION 2036

Bainbridge Island's water resources (precipitation on the surface and in the ground) are climate resilient and demand and quantity are adequate for all forms of life on the Island. *Aquifers* are continuously monitored and maintained above the early warning level. The water quality for most of the consumed water is monitored to ensure quality fully meets the standards for drinking water.

Education on water conservation results in a significant reduction in the average water consumption per *household*. The Bainbridge Island *groundwater* model is regularly updated with new data and results from model runs are used to maintain long-term *sustainability* of the Island's water resources. *Low impact development* techniques are applied to all *land use*s and redevelopment.

GOALS & POLICIES

GENERAL WATER RESOURCES

GOAL WR-1

Manage the water resources of the Island in ways that preserve, protect, maintain, and where possible restore and enhance their ecological and hydrologic function.

- Degradation of water resources is not allowed.
- The long-term *sustainability* of the Island's water resources is maintained, taking into account future climatic conditions and their effects on the water cycle.
- New development and population growth are managed so that water resources remain adequate and affordable for the indefinite future.
- *Groundwater*, surface water and *stormwater* monitoring, data assessment and reporting are current and available including future projections of availability, quality and need.
- Use current and future technology to maintain and protect water resources.

Policy WR 1.1

Study future climate and demand scenarios to accurately plan for future water resource conditions.

Policy WR 1.2

Groundwater, surface water and *stormwater* are resources that *shall* be protected and managed to preserve water quality and quantity, and to retain natural ecological and hydrologic function.

Policy WR 1.3

The City will provide sustainable water resource planning, protection, management and monitoring in coordination with government agencies at all levels, drinking water purveyors, Tribes, non-profit organizations, and other stakeholders.

Policy WR 1.4

Apply the policies in this element together with the protective measures set by the City's Shoreline Management Master Program, *Critical Areas* Ordinance and any other environmental or water resources management ordinance established by the City and in compliance with county, State, and federal laws and regulations.

Policy WR 1.5

Identify the areas of the Island that are the most vulnerable to pollution from concentrations of fecal coliforms and nitrates (for example, septic fields, agricultural activities, or fertilizers), and monitor those areas to determine if and when preventative or restorative measures are warranted.

GROUNDWATER PROTECTION AND MANAGEMENT

GOAL WR-2

Protect the quality and quantity of groundwater on the Island to ensure clean and sufficient groundwater for future generations.

Policy WR 2.1

Recognize that the Island functions as an *aquifer recharge area*. *Low impact development* techniques are essential for maintaining *aquifer recharge*.

Development, if any in areas with high *aquifer recharge* should be limited to low impact uses and less intense development. Low impact uses include development for buildings, roads or parking that has a reduced area of impact on the land. Low impact uses do not depend on regular applications of fertilizers or pesticides.

Low impact development is an environmentally-friendly approach to site development and *stormwater* management emphasizing the integration of site design and planning techniques that conserve and protect the natural systems and hydrologic functions of a site.

Policy WR 2.2

Identify and assess areas of high *aquifer recharge* as part of a *land use* application. Minimize the effect of development on these areas.

Policy WR 2.3

To promote efficient use of *groundwater* resources, encourage the expansion of existing water systems rather than encouraging shallow or individual residential wells.

Policy WR 2.4

Assess the impacts of proposed activities and development on the flow of springs and *streams* and levels of *wetland*s that are either sustained by *groundwater* discharge or contribute *recharge* to *groundwater*, and require an assessment of anticipated hydrologic impacts. Activities or development may be restricted if the report indicates any adverse impacts.

Policy WR 2.5

In cooperation with the appropriate regulatory agencies (e.g., Washington State Department of Health and the Kitsap Public Health District) institute new wellhead protection procedures.

Policy WR 2.6

Reduce the use of pesticides and herbicides by encouraging integrated pest management techniques and less toxic alternatives.

Policy WR 2.7

Establish a stakeholder group to develop an Island-wide *groundwater* management plan and work with Kitsap Public Utility District to update the Kitsap County Coordinated Water System Plan.

Policy WR 2.8

Develop an incentive based program to encourage exempt well owners to regularly monitor and report the quality of their well water and identify leaks using tools such as flow meters

Policy WR 2.9

Recognizing that the Island *aquifer* system is a Sole Source *Aquifer* as designated by EPA, consider creation and application of one or more aquifer conservation zones for appropriate areas of the Island and institute an added level of development and re-development permit review to prevent or mitigate potential pollutant-generating activities or activities that could affect stormwater runoff and aquifer recharge associated with a proposed *land use*. The Island's aquifers are protected through critical area regulations and Revised Code of Washington (RCW) 36.70A.550.

Policy WR 2.10

Retard seawater intrusion into our groundwater through the development and application of a comprehensive seawater intrusion prevention program.

Policy WR 2.11

Develop a water conservation program for all water uses on the Island.

Policy WR 2.12

Encourage water re-use and reclamation to serve as a supplementary source for high-water users such as industry, parks, schools and golf courses as approved by the Washington State Department of Health.

Policy WR 2.13

Require the retention of native landscapes to promote water quality and to reduce the need for irrigation.

Policy WR 2.14

Develop a program that incentivizes and facilitates innovative methods for homeowners and business owners to use stormwater and grey water as approved by the Washington State Department of Health and the Kitsap Public Health District.

Policy WR 2.15

Maintain a comprehensive program of *groundwater* data gathering, analysis, and reporting including modeling, hydrogeologic and geologic studies, and monitoring of static water levels, water use, water quality, surface water flows and acquisition of other data as necessary.

Policy WR 2.16

Develop and maintain a publicly-available system to report groundwater levels on a timely basis.

SURFACE WATER PROTECTION AND MANAGEMENT

GOAL WR-3

Achieve no net loss of ecological functions and processes necessary to sustain *aquatic resources* including loss that may result from cumulative impacts over time.

Over recent decades awareness has grown of the importance of preserving and protecting *aquatic resources*. *Aquatic resources* have a number of important ecological functions, processes and values. These functions vary but include providing water quality protection, flood plain control, shoreline stabilization, contributions to *groundwater* and stream flows, and wildlife and fisheries habitat. *Aquatic resources* also have values as natural areas providing aesthetic, recreational and educational opportunities that *should* be preserved for future generations.

Policy WR 3.1

Development in regulated aquatic *critical areas* or their associated water quality buffers shall not be allowed unless application of *development regulation*s would deny any reasonable use of property. In such cases, minimize the allowed use and associated impacts, to maximize environmental protection.

Policy WR 3.2

Require that vegetated buffers be maintained between proposed development and the aquatic resource in order to protect the functions and values of such systems. Restore degraded buffers to enhance their function. Allow reductions in vegetated buffers only in areas where such reductions, if consistently applied, would not result in significant cumulative impacts to *aquatic resources* and *fish and wildlife habitat*.

Policy WR 3.3

Require that buffers be retained in their natural condition wherever possible while allowing for appropriate maintenance. Where buffer disturbance has occurred, require re-vegetation with appropriate species, with a preference for native species, to restore the buffers' protective values.

Vegetated buffers facilitate infiltration and maintenance of stable water temperatures, provide the biological functions of flood storage, water quality protection and *groundwater recharge*, reduce amount and velocity of run-off, and provide for wildlife habitat.

Policy WR 3.4

Ensure that development activities are conducted so that *aquatic resources* and natural drainage systems are maintained and water quality and quantity are protected.

Policy WR 3.5

Prior to any clearing, grading or construction on a site, all *wetland*s, *streams* and buffer areas are to be specifically identified and accurately located in the field in order to protect these areas during development.

Policy WR 3.6

Herbicides and pesticides approved for use near aquatic resources may only be used in aquatic resource areas and buffers when applied by licensed applicators.

Policy WR 3.7

Prohibit access to aquatic *critical areas* by *farm* animals. Require a *farm* management plan for agricultural activities within proximity of *aquatic resources* addressing water quality and other natural resource protection.

Policy WR 3.8

Require mitigation to compensate for unavoidable impacts to aquatic *critical areas*. Mitigation *should* be designed to achieve no net loss in functions and processes of *aquatic resources*.

Policy WR 3.9

Promote *watershed*-based mitigation to meet federal regulations, improve mitigation success and better preserve the ecological function of the island's *watershed*s.

Policy WR 3.10

Work with state and local health departments to evaluate the merits of new technologies such as grey water capture, package treatment plants and composting toilets as alternatives to septic and sewer systems.

Policy WR 3.11

Consider the impacts of *climate change* and ocean acidification when developing regulations or approving capital projects related to *aquatic resources* including marine nearshore, *wetland*s, *streams*, lakes, creeks, associated vegetated areas and *frequently flooded areas*.

Policy WR 3.12

Stream relocation will only be allowed where relocation would result in improved stream ecosystem function.

Policy WR 3.13

Degraded channels and banks *should* be rehabilitated by various methods (e.g., culvert replacement, volunteer efforts, public programs or as offsetting mitigation for new development) to restore the natural function of the riparian habitat for fish and wildlife.

Policy WR 3.14

Protect, preserve and enhance fish and wildlife habitat and adjacent riparian areas to ensure sustainable populations of resident aquatic life.

Policy WR 3.15

Require the construction of public facilities to avoid encroachment into and disturbance~~s~~ of *aquatic resources*.

Policy WR 3.16

Ensure a comprehensive program of surface water inventory, data gathering and analysis. The program *shall* include monitoring and assessment of physical, chemical and biological health of surface water ecosystems to include *streams*, ephemeral *streams*, lakes, *wetlands* and marine waters. This may include water, flow, sediment, habitat, pollutants, submerged aquatic vegetation, fish and shellfish tissue, aquatic species diversity and other ecosystem health indicators.

Policy WR 3.17

Support a community-wide program to educate Island residents about alternatives to using and disposing of herbicides, pesticides, and other household chemicals, to reduce impacts to marine shoreline areas, wetlands, streams, and other environmentally sensitive areas.

Policy WR 3.18

Promote and support volunteer or community-driven restoration projects.

STORMWATER PROTECTION AND MANAGEMENT

GOAL WR-4

Rather than capture and carry stormwater away as a waste stream, protect it from pollutants and retain it on site to replenish *aquifers* and maintain *wetlands* and natural stream flows, preserving or mimicking the natural water cycle to the maximum extent practicable.

Policy WR 4.1

Comply with all requirements of the City's National Pollutant Discharge Elimination System Phase II Municipal *Stormwater* Permit (NPDES Permit).

Policy WR 4.2

Provide ongoing opportunities for the public to participate in the decision-making process involving the development, implementation and update of the City's *Stormwater* Management Program through advisory councils, public hearings, and *watershed* committees.

Policy WR 4.3

Improve and maintain an education and outreach program designed to reduce or eliminate behaviors and practices that cause or contribute to adverse *stormwater* impacts and encourage the public to participate in stewardship activities.

Policy WR 4.4

Identify and eliminate sources of pollutants to the City's *stormwater* drainage system through proactive field screening techniques such as effluent monitoring, system inspections and cleaning, and commercial and industrial business inspection, and through the enforcement of the City's Illicit Discharge Detection and Elimination ordinance.

Policy WR 4.5

Ensure development of and adherence to required public and private *stormwater* pollution prevention plans for public facilities, construction sites and commercial and industrial *land use*. Encourage the use of such plans where not specifically required.

Policy WR 4.6

Ensure development of and adherence to erosion and sediment control plans on all construction and development sites of any size.

Policy WR 4.7

Develop and actively enforce a strong *low impact development* (*LID*) ordinance to require any and all *LID* methods and practices for new development and redevelopment to the maximum extent practicable and reasonable.

Policy WR 4.8

Prioritize *LID*-based retrofit of public and private *stormwater* drainage systems and built assets through the inventory, management and fiscal planning process.

Policy WR 4.9

Incentivize *LID* retrofit of current built environment.

Policy WR 4.10

Use *watershed* and basin plans to reduce *stormwater* impacts and *non-point source pollution*.

Policy WR 4.11

Comply with all requirements specifically identified by the City's permit for any Total Maximum Daily Load (TMDL) in which the City is a stakeholder.

Policy WR 4.12

Conduct effectiveness monitoring and assessments to continue to adaptively manage *stormwater* to ensure optimal protection.

RESIDENTIAL ON-SITE SEWAGE SYSTEMS

GOAL WR-5

Ensure that sewage is collected, treated and disposed of properly to prevent public health hazards and pollution of *groundwater*, Island surface water and the waters of Puget Sound.

Policy WR 5.1

Regulations and procedures of the Washington State Department of Health and the Kitsap Public Health District apply to all on-site disposal systems. Coordinate with these agencies to assure regular inspection, maintenance and repair of all *sanitary sewer* and on-site systems located on the Island.

Policy WR 5.2

Request notification of all waivers or variances of Kitsap Public Health District requirements such as modification of setbacks, vertical separation, minimum lot size, reserve drainfield, etc., prior to issuance and subsequent modifications by the Kitsap Public Health District of an approved Building Site Application.

Policy WR 5.3

Allow alternative systems such as sand filters, aerobic treatment, composting toilets and living-systems when approved by the Kitsap Public Health District.

Policy WR 5.4

Require coordination between the on-site septic and *storm drain*age disposal systems designs to ensure the proper functioning of both systems.

Policy WR 5.5

Assist the Kitsap Public Health District in developing a program to require proper maintenance of all on-site waste disposal systems in order to reduce public health hazards and pollution. This program *shall* include periodic system inspection and pumping when necessary.

Policy WR 5.6

Work with the Kitsap Public Health District on a collaborative program to fund and pursue grants or low-cost loans for low and moderate-income *household*s to repair failed septic systems. Incentivize maintenance, repair and replacement of systems for any income level.

Policy WR 5.7

Allow on-site waste disposal systems serving more than one *household* only with assurance of proper design, operation, management and approval from the Kitsap Public Health District.

Policy WR 5.8

Provide the service of operation and maintenance management for approved large on-site *sanitary sewer* systems or community *sanitary sewer* systems in coordination with the Kitsap Public Health District.

Policy WR 5.9

Support the Kitsap Public Health District in maintaining and improving a public education program to foster proper construction, operation and maintenance of on-site septic systems.

Policy WR 5.10

Support the Kitsap Public Health District in developing and maintaining an ongoing inventory of existing on-site disposal systems to provide needed information for future studies.

PUBLIC EDUCATION AND OUTREACH

GOAL WR-6

The City, in concert with federal, state and local governments, public water purveyors, watershed councils, non-profits, citizens and other appropriate entities will continue to improve and implement comprehensive public education and outreach program to promote protection and management of all water resources.

Policy WR 6.1

Educate and inform the public about:

- The purpose and importance of aquatic environments, their vulnerabilities and observed status and trends in ecological health and function;
- Expected *climate change* impacts and how these will affect the Island's water resources and their beneficial uses;
- The characteristics of the *aquifer* system, the Island's dependency upon it and its vulnerability to contamination (including seawater intrusion) and depletion;
- The Environmental Protection Agency's Sole Source Aquifer Designation Program and what this designation means for the Island's *aquifer* system;
- Wellhead protection and the critical importance of restricted chemical use or storage within the protection area around wells;
- Critical *aquifer recharge areas* (or other special conservation areas) and the purpose they serve to the *aquifer* system;
- How to report spills or illicit dumping of hazardous waste or other pollutants and how to access information about location and status of contaminated sites;
- How to find information about their well and how to properly maintain it;
- Methods to identify wastewater indoors and outdoors and practices to conserve water such as native landscaping, xeriscaping and water use reduction or reuse;
- Resources for streamside and shoreline landowners;
- Water resources protection best management practices for commercial, industrial, residential, agricultural and other *land uses* to prevent or reduce pollution. These practices include but are not limited to, septic system maintenance, pet and livestock waste management, landscaping and gardening, *farm* plans, appropriate methods for use, storage and disposal of hazardous materials and other chemicals, on-site drainage system maintenance and automotive care.

Policy WR 6.2

Promote opportunities for citizen stewardship and involvement.

Policy WR 6.3

Provide *LID* technical guidance and workshops to businesses and contractors working on the Island.

WATER RESOURCES IMPLEMENTATION

To implement the goals and policies in this Element, the City must take a number of actions, including adopting or amending regulations, creating outreach and educational programs, and staffing or other budgetary decisions. Listed following each action are several of the comprehensive plans policies that support that action.

HIGH PRIORITY ACTIONS

WR Action #1 Adopt *aquifer conservation zoning regulations* and innovative permit review processes designed to protect the Island's surface and ground waters.

Policy WR 1.4

Apply the policies in this Element together with the protection measures set by the City's Shoreline Master Program, *Critical Areas* Ordinance and any other environmental or water resources management ordinance adopted by the City and in compliance with county, State, and federal laws and regulations.

Policy WR 2.1

Recognize that the Island functions as an *aquifer recharge area*. *Low impact development techniques* are essential for maintaining aquifer recharge.

Policy WR 2.9

Recognizing that the Island *aquifer* system is a Sole Source *Aquifer* as designated by EPA, consider creation and application of one or more aquifer conservation zones for appropriate areas of the Island and institute an added level of development and re-development permit review to prevent or mitigate potential pollutant-generating activities or activities that could affect stormwater runoff and aquifer recharge associated with a proposed *land use*. The Island's aquifers are protected through critical area regulations and Revised Code of Washington (RCW) 36.70A.550.

Policy WR 4.7

Develop and actively enforce a strong Low Impact Development (LID) ordinance to require any and all *LID* methods and practices for new development and redevelopment to the maximum extent practicable and reasonable.

Policy LU 12.4

Protect *aquifer recharge* functions throughout the Island, all of which is an *aquifer recharge area*, through the application of *critical areas regulations,* Shoreline Master Program use regulations, *low impact development regulations*, and the wellhead protection regulations administered by the Kitsap Health District.

WR Action #2 Adopt an Island-wide Groundwater Management Plan. Take the actions necessary- capital improvements, code changes, etc.- to capture, clean and re-infiltrate as much stormwater as reasonably possible.

Policy WR 2.7

Establish a stakeholder group to develop an Island-wide groundwater management plan and work with Kitsap Public Utility District to update the Kitsap County Coordinated Water System Plan.

WR Action #3 Incorporate *Low Impact Development* principles, goals and approaches into all land use and development codes.

NOTE: Same Action in Environmental Element

WR Action #4 Apply *adaptive management* to assure that land use on the Island will continue to be adequately served by the available water resources.

Policy WR 3.16

Ensure a comprehensive program of surface water inventory, data gathering and analysis. The program *shall* include monitoring and assessment of physical, chemical and biological health of surface water ecosystems to include *streams*, ephemeral *streams*, lakes, *wetland*s and marine waters. This may include water, flow, sediment, habitat, pollutants, submerged aquatic vegetation, fish and shellfish tissue, aquatic species diversity and other ecosystem health indicators.

Policy WR 4.12

Conduct effectiveness monitoring and assessments to continue to adaptively manage *stormwater* to ensure optimal protection.

MEDIUM PRIORITY ACTIONS

WR Action #5 Launch a program of public education about how individual actions can help protect the quality and quantity of the Island's surface and groundwaters.

Policy WR 2.11

Develop a water conservation program for all water uses on the Island.

Policy WR 2.13

Develop a program that incentivizes and facilitates innovative methods for homeowners and business owners to use stormwater and grey water as approved by the Washington State Department of Health and the Kitsap Public Health District.

Policy WR 3.17

Support a community-wide program to educate Island residents about alternatives to using and disposing of herbicides, pesticides, and other household chemicals, to reduce impacts to marine shoreline areas, wetlands, streams, and other environmentally sensitive areas.

Policy WR 3.18

Promote and support volunteer or community-driven restoration projects.

Policy WR 6.2
Promote opportunities for citizen stewardship and involvement.

WR Action #6 Consider adopting seawater intrusion regulations in coordination with Kitsap County.

Policy WR 2.10
Retard seawater intrusion into our groundwater through the development and application of a comprehensive seawater intrusion prevention program.

OTHER PRIORITY ACTIONS

WR Action #7 Work with other jurisdictions and the environmental and development communities to promote programs and projects to protect the Island's surface and ground waters.

Policy WR 2.5
The City, in cooperation with the appropriate regulatory agencies (e.g., Washington State Department of Health and the Kitsap Public Health District) will institute new wellhead protection measures.

Policy WR 3.10
Work with state and local health departments to evaluate the merits of new technologies such as greywater capture, package treatment plants and composting toilets, as alternatives to septic and sewer systems.