Peak Water on Whidbey Island

# Introduction

In the multitude of climate change impacts facing the world, the nation, the PNW and Whidbey Island, **fresh water is the** **most important resource**[[1]](#footnote-1), and perhaps the most at risk. The main problem is that there is very little data on the current and future recharge rate that replenishes the water we extract through our wells. With our rapidly and extreme changing climate, recharging our freshwater supply will also change. Without recharge data, we simply don’t know when we will extract more fresh water than is recharged from rainfall, and rainfall is the only recharge source for our aquifer This poses a substantial risk to the people of Whidbey and its future livability. Peak Water data informs risk assessment and will help avoid irrecoverable tipping points.

The intended purpose of this *Peak Water Discussion Document* is to underscore the urgency to acquire recharge data so we can collectively manage our precious water supply to ensure its long-term sustainability. This situation is a critical phenomenon that warrants a new descriptor: **“Peak Water”** is a term I am creating, defined as **when the** **ratio between the amount of recharge (R) occurring to island aquifers and the amount of groundwater extraction (E) from island aquifers reaches 3 or less (R/E=3)[[2]](#footnote-2)**. To this end, we are providing an example model for predicting when Peak Water could occur. Readers are encouraged to make their own assumptions and see what the model shows as to when we may be expected to reach Peak Water.

 Whidbey Island fresh water comes from groundwater aquifers beneath the island (except for Oak Harbor and the Naval base which import water from Skagit County via a dedicated supply pipeline). Whidbey’s groundwater is finite and derived solely from precipitation. The island’s population is (conservatively) predicted to grow 25% over the next 20 years for many reasons, among them the desirability of our climate compared to other US locations, for example in the Southwest which is already experiencing emigration due to water distribution policies and scarcity of river and ground water. This growth is happening in the face of compounding uncertainties of an ever-changing climate. If current climate trends continue, the Pacific Northwest will be hotter, drier, experience periods of extreme rainfall / runoff and could well lead to long periods of drought[[3]](#footnote-3).

Population growth and climate change are not the only challenges that the recharge of our Island’s aquifer system faces. Presently there are about 7000 “independently operated” water extraction wells on Whidbey Island. New subdivisions are designed to guide water runoff into the Salish Sea rather than maximize its groundwater recharge-ability. Waste water treatment plants discharge millions of gallons of "treated” water into the Salish Sea.

The phenomenon I am calling Peak Water is not widely understood. A common term used for water planning is “availability” but, “availability” is not predictive of a continuous, sustainable supply. Hydrogeologists typically use the term “sustainable yield” to describe continuous and sustainable supply. The manner to determine continuous and sustainable supply is different for marine island freshwater aquifers than continental aquifers. Sustainable Yield requires scientific estimates of both recharge and extraction with the influence of surrounding saltwater. In the literature I have examined in the preparation of this paper, since 1968 the only recharge estimates were made about 25 years ago, and do not represent current or future climatic conditions.[[4]](#footnote-4). I use this recharge estimate in an example Peak Water modeling tool that produced the graph that appears on page 3 and the chart that appears on page 4 of this paper.

This Peak Water discussion document is presented as an educational tool for stakeholders to use in public and private planning. The 2025-2045 Island County Comprehensive Plan, now being developed, is mandated to include climate resilience in every Element. (“Element” is the designator of chapters within a municipal WA state Comprehensive Plan). Climate resilience depends on a continuous supply of fresh, clean water.

Applying the example Peak Water modeling tool indicates Whidbey Island could potentially reach Peak Water within twenty years. Although the predicted population growth, extraction rates, recharge rates, and R/E value of 3 used in this model are estimates that are subject to challenge, they are reasonable estimates that highlight the need for policymakers to focus on the issue of Peak Water. As a Whidbey Island community, both public and private sector stakeholders need to come together to measure and track the factors that lead to Peak Water and develop policies to avoid it being reached.

Peak Water is like the canary in the coal mine. If we continue our current growth strategies and methods, Peak Water will happen and we will enter a period of urgency to change our practices and it may be too late because the water cycle takes years, perhaps decades for rainfall recharge to reach Whidbey’s aquifer systems. Land use patterns are also very slow to evolve. Likewise, building codes and construction rules may impede optimal water reuse strategies such as “gray water” applications, and many such restrictions are imposed statewide or even nationally through legislation. And, legislation also takes years to manifest.

The following graphic results from the assumptions and calculations used in generating the first predictive model of Peak Water.



Peak Water occurs when the ratio between the amount of recharge (R) occurring to island aquifers and the amount of groundwater extraction (E) from island aquifers that do not cause undesirable saltwater intrusion reaches 3. R/E= 3 is presented as a guide, not an absolute number. The appropriate ratio will depend on local hydrodynamics but must be much above 1 to minimize saltwater intrusion to vulnerable wells.

 The MS Excel formulas are available for experimentation by concerned entities to make their own assumptions.[[5]](#footnote-5)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Year** | **Recharge Gallons (-0.019% per year)** | **Extraction Rate (in billions of gallons per year)** | **Population**  | **R/E** |
| 1968 | 40.00 | 1.00 | 23,400 | 40.0 |
| 1970 | 39.00 | 1.10 | 27,011 | 35.5 |
| 1980 | 34.00 | 1.60 | 41,011 | 21.3 |
| 1990 | 29.00 | 2.33 | 60,195 | 12.4 |
| 2000 | 24.00 | 2.83 | 71,886 | 8.5 |
| 2004 | 22.00 | 2.90 | 74,800 | 7.6 |
| 2010 | 19.00 | 3.15 | 78,700 | 6.0 |
| 2020 | 14.00 | 3.70 | 86,857 | 3.9 |
| 2021 | 13.50 | 3.75 | 87,566 | 3.7 |
| 2022 | 13.00 | 3.80 | 86,682 | 3.5 |
| 2024 | 12.00 | 3.90 | 85,852 | 3.1 |
| 2045 | 1.50 | 4.95 | 102,635 | 0.3 |

**ASSUMPTIONS:**

Recharge = Gallons decrease each year from 1968 to 2045 = -0.5 B gallons/year (about 2%) This is simply a first raw estimate by the authors and is estimated from the only available data point from 1999. Better estimates of changing recharge can be made using rainfall infiltration modeling as the USGS did in 1999, and inputting future climate change data predicted by the University of Washington Climate scientists.

Extraction = 100 gallons per day per person per year times the reported population for Island County. The population includes Oak Harbor (which uses piped water from Anacortes’ Water Rights on the Skagit River) but does not include water used for agricultural or industrial purposes. These assumptions are for demonstration purposes only and concerned entities are encouraged to further refine them. Population growth has been approximately one percent per year and was assumed in this model for the future.

# What is Peak Water?

* Peak Water is a term that describes the condition at which the demand for water creates undesirable effects to our fresh water supply.
* It can occur at different time periods and locations on Whidbey depending on the groundwater sources and uses of water.
* Peak Water can have serious consequences for human and environmental health, such as water scarcity, saltwater intrusion, pollution, carrying capacity, and degradation of ecosystems.
* On Whidbey Island, Peak Water is constrained by rainfall recharge in order to remain sustainable.

# Whidbey’s island aquifer system

* Whidbey’s aquifer system consists of glacial sediment that holds and transmits groundwater.
* Fresh water aquifers on Whidbey Island was designated a “Sole- Source Aquifer” by the Federal Environmental Protection Agency (EPA) in 1982. This designation requires preservation for sustainable future use because there is no other viable source of fresh water for Whidbey and Camano Islands.
* Whidbey Island’s sole-source aquifer system supplies 100% of the drinking water for the island (except for Oak Harbor and Naval Base) and has no feasible alternative sources. Oak Harbor and the Naval Base receive water from Anacortes’ Water Rights on the Skagit River with a time-limited Agreement that has to be renewed periodically.
* Whidbey’s aquifer system is bounded, both around and underneath at depth, by the saltwater of the Salish Sea, which prevents fresh water from entering the aquifer from other sources, such as rivers and other underground freshwater aquifers. Rainwater is the only natural source of fresh water.
* Whidbey’s sole-source, aquifer is highly vulnerable to overexploitation and saltwater intrusion especially in the face of population growth and climate change.

# How does Peak Water relate to sole source island aquifers?

* Unpredictable climate changes can lead to a decline in the water level and pressure of the aquifer, and thereby affect nearby wells’ ability to draw groundwater. A decline in the water level and pressure of the aquifer also leads to an increase in the salinity of the groundwater by saltwater intrusion.
* As the freshwater lens[[6]](#footnote-6) in the aquifer shrinks, the saltwater intrusion from the surrounding ocean can reach wells and contaminate the drinking water supply.
* This can pose a serious threat to the health and livelihoods of our island communities, especially near shorelines, because they depend on the aquifer and are most vulnerable to saltwater intrusion.
* Therefore, managing the demand and supply of water is crucial for ensuring the sustainability and resilience of the island ecosystems and populations.

# Predicting Peak Water on Whidbey Island

Whidbey Island is the largest island in Puget Sound, Washington, with a population of about 80,000 people. (Oak Harbor and the Naval base do receive fresh water diverted from the Skagit River under Anacortes’ water right). The rest of the island relies on a sole-source island aquifer system for its domestic, agricultural, and industrial water needs. The aquifer system consists of multiple layers of sand and gravel, separated by clay and silt, which form a more or less elliptical lensof freshwater floating on top of saltwater. The freshwater lens is recharged by rainfall and discharges directly to the Salish Sea or by springs, streams, wetlands, and wells. The island has experienced significant population growth and development in the past decades, which have increased the demand and withdrawal of water from the aquifer system.

Modeling Peak Water on Whidbey Island

There are three elements that predict Peak Water (PW):

1. The rate of withdrawal (Extraction) from the total volume of water extracted by the nearly 7000 wells on Whidbey.
2. The amount of rainwater that seeps into the saturated zone of the aquifer, known as Recharge. Recharge is a net amount of rainwater, minus runoff, evaporation and transpiration from plants, and is estimated to be about 10-20% of the rainfall. Recharge has a significant time delay, which must also be considered.
3. The limit of the amount of fresh aquifer water on Whidbey Island that is sustainable (minimize saltwater intrusion). This number should be better evaluated and may be more appropriate by watershed and local hydrodynamics.
4. The Peak Water factor of 3 is also an estimate of the water physically available for extraction, estimated at about 30% of the recharging water to the aquifer.

Peak Water can be identified and predicted with the simple formula: R/E>3 (Recharge divided by Extraction must be greater than 3).

When will Peak Water occur?

Because data on exact quantities are not available, Peak Water is determined by three basic estimates:

1. Extraction is estimated by multiplying the human population times the estimated amount each person consumes in a year. Official estimates by Hydrogeologists and water system planners range from 85 g/d/person to 115 g/d/person. In the PW calculation included on Pages 2 & 3, we’ve used 100 g/d/person.
2. Recharge estimating is a lot less defined. USGS studies (1999, 2004, 2014) determined between 10-20% of rainfall as the amount that reached the aquifer. The Island County Water Management Plan of 2004 estimated the amount as 4” to 10” depending on location on Whidbey and Camano Islands and amounted to about 22 billion Gallons per year of recharge in 1999. The single data point used in our Peak Water estimates in the included chart.
3. The PW factor of 3 is also an estimate based on the physically extractable 30% of free water in the aquifer. In other words, Peak Water occurs when the R/E reaches around 3.

# Why we must consider Peak Water

The greatest challenge of managing water resources on Whidbey is estimating the amount and quality of water *sustainable* in the aquifer. Complete hydrogeologic modeling is very complex, expensive, and will still have much uncertainty. It requires monitoring and modeling the hydrogeological processes that affect the freshwater lens, such as precipitation, transpiration, evaporation, infiltration, recharge, groundwater flow and discharge. These processes are complex and influenced by many factors, such as climate variability, land use change, pumping rates, aquifer/aquitard permeabilities, groundwater levels and sea level rise. We recommend as a starting point improving aquifer monitoring with an adequate array of true monitoring wells. Sensitivity modeling (using future climate conditions) of rainfall infiltration (like the USGS did around 1999) should also be done to better understand changing recharge to our aquifers. Improving the data that goes into Peak Water prediction will allow policy makers to better assess the carrying capacity of the island’s sole source water system and implement effective policies for *sustainable* water use.

Four urgent actions to take

The overall goal is for our Island community to adapt to increasing population and climate change (longer dry periods, increased density rainfall, rising sea levels, etc.), and avoid discovering Peak Water after it happens, Because infiltrating rainfall takes years and perhaps decades to reach our aquifers, the rainfall effects of today may not be realized until it is too late to manage water as a sustainable resource.

1. Acquire and develop more extensive and reliable data to support a Peak Water prediction tool. Perhaps investing in using the USGS infiltration modelling tool with current data and future anticipated climatic conditions data.
2. Continue and improve policies and programs that encourage more efficient usage of extracted water and better land use planning that increases the recharge of our aquifers (including wastewater treatment and more effective septic systems), prevent stormwater from running into the Salish Sea, and generally keep fresh water high within the island watershed.
3. Build into the Comprehensive Plan strategies and technologies, i.e. Low Impact Development (LID), available in both Extraction and Recharge today and new emergent technologies. Determining and executing them takes planning and implementation of ordinances and initiatives. This is Climate Resilience.
4. The dispersion of our “independently operated” well water systems suggest the need for a collectively managed entity (like a Public Utility Service District) to provide operational expertise and funding for small and large well water systems. Public Utility Service Districts are common in the State of Washington and are regulated by the Washington Utilities and Transportation Commission. PUDs also have many funding possibilities including Public Bonds.

 We encourage our entire Island community, both private and public, to get involved and take actions that will ensure the sustainability of our Island’s sole source aquifer system. Now is the time, we are the ones who can make a difference

This paper was written by Perry Lovelace and peer reviewed by the Groundwater Cohort, a working group of Whidbey Climate Action (WhidbeyClimate.org), and the Core members of Whidbey Climate Action. Special thanks go to Douglas Morrell, Mitch Allen, Meade Brown, Jake Stewart, Anne Tearse, Edwin Anderson, Peter Morton, David Haskell, Kiki LaPorta and Terra Anderson for their expertise and editorial input. Susan Edwards created the MS Excel graphical analysis.

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1. In 1982 the USGS designated Whidbey’s aquifer system as a “sole source aquifer” a designation rarely used. [↑](#footnote-ref-1)
2. The word “Peak” refers to the period when use of our water supply is shifting from sustainable (renewable) to unsustainable (unrenewable), not to volume or amount. [↑](#footnote-ref-2)
3. How and when precipitation arrives can be more pertinent than annual volume as it relates to effective percolation and aquifer recharge.  Extended and intensifying summer drought conditions cause soil hardening that reduces soil permeability and increases water runoff in intensifying rain events.

The Penman-Monteith equation estimates that for every 1-degree Celsius increase in temperature, evapotranspiration increases by 4-7%.  We already breached a1.4-degree Celsius average temperature increase globally -for the first time- last year.  This means that evapotranspiration increased globally last year.  The University of Washington Climate Groups’ long-range modeling would reflect a 35-50%+ increase in evapotranspiration for Island County. [↑](#footnote-ref-3)
4. Island Co Water Resource Management Plan, 2005, page 3 [↑](#footnote-ref-4)
5. For access to the formulas, contact Perry Lovelace (perry.lovelace@gmail.com) [↑](#footnote-ref-5)
6. A **freshwater lens**, also known as a Ghyben-Herzberg lens, is a convex-shaped layer of fresh groundwater that floats above denser saltwater.  [↑](#footnote-ref-6)