Hydrogeology Concepts and Considerations for RCW 90.94 Streamflow Restoration in WRIA 10 & 12
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• All pore spaces (openings) below the water table are full of groundwater.

• Tops of water tables generally mimic surface topography, and fluctuate seasonally and from year to year.
Under natural conditions, groundwater moves from areas of recharge to areas of discharge at springs or along streams, lakes, and wetlands.
Aquifer -- saturated geologic material permeable enough to yield economical quantities of water

Aquitard -- saturated geologic material with low permeability; well yields low; also called “confining layer”

Confined Aquifer -- saturated material below aquitard permeable enough to transmit useful water quantities

Canadian Geoscience Education Network
https://www.cgenarchive.org/bowen-island-underground.html
Vashon Glaciation lasted about 19,000 to 16,000 BP.
Pierce County Geology

WA DNR Report of Investigations 33
Groundwater – Surface Water Relationships

A) GAINING STREAM

B) LOSING STREAM

USGS Circular 1186
Spokane River losing Reach between Post Falls and Greenacres (Barker Road)

Discharge in cfs

- 2003 at Post Falls
- 2003 at Barker

USGS Circular 1186
There can be gaining and losing reaches within the same stream or river, and that relationship can change during the year.

Magnitude of gains and losses can fall within measurement error of individual flows, making things harder to interpret.
**Baseflow**: component of streamflow derived from groundwater inflow or discharge.

Baseflow is important for both water quantity and temperature.
Comparison of Estimated Monthly Mean Baseflow, Mean Surface Runoff, and Mean Streamflow
Station 12047300
Morse Creek Near Port Angeles, Wa.

Note: vertical axis presented in log scale
Baseflow maintains summer streamflow throughout most of Washington.
In Washington groundwater baseflow contributes 68% of total annual flow for 594 studied gages (WSB 60)
When well is drilled into a confined aquifer and water level rises above the confining unit, the well is referred as an artesian well. If water flows out of well at land surface it is referred to as artesian flowing well.
Pumping a well forms a cone of depression

Unconfined

Confined

Heath, 1983
Pumping groundwater from a well (conservation of mass) always causes...

(1) decline in groundwater level (head) at and near the well, and

(2) diversion to the pumping well of groundwater that was moving slowly to its natural, possibly distant, area of discharge.
Groundwater pumping can generally deplete streamflow in two ways:

- **Groundwater capture** - interception of groundwater flow that is tributary to a stream. This effect usually continues after pumping ends.
- **Induced streambed infiltration** - groundwater pumping pulling surface water from a stream toward a well.
Groundwater Velocities are Generally Low

• Groundwater movement normally occurs as slow seepage through pore spaces in unconsolidated earth or networks of fractures and solution openings in consolidated rocks.

• A velocity of 1 foot per day or more is a high rate of movement, and velocities can be as low as 1 foot per year or decade.

• By contrast streamflow velocities generally are measured in feet per second. A velocity of 1 foot per second equals about 16 miles per day.
Groundwater travel time is not an indication of the speed at which pumping effects propagate.
With regard to water rights and surface water availability in Washington, concerns usually involve...
WRIs 10 & 12
Hydrogeology
Significant WRIAs 10 & 12 Hydrogeology Studies


Chambers-Clover Technical Assessment, Final Report. 2003 report prepared for Tacoma-Pierce County Health Department by consultants with assistance of Chambers-Clover Planning Unit
Puyallup watershed hydrostratigraphic and geologic and units.
From USGS Puyallup River Watershed hydrogeologic characterization (USGS SIR 2015-5068)
Geologic cross section through portion of Puyallup watershed.
From USGS Chambers-Clover Creek watershed hydrogeologic characterization (USGS SIR 2010-5055)
Sequence in USGS SIR 2010-5055 indicating extent of all eight aquifers (youngest to oldest)
Unit: A1 aquifer
Unit: A2 confining unit
Unit: A3 aquifer
Unit: B confining unit
Unit: C aquifer
Unit: D confining unit
Unit: E aquifer
Unit: F confining unit
Unit: G undifferentiated deposits
Grid with 1,000 by 1,000 feet cells for Chambers–Clover Creek watershed groundwater-flow system numerical simulation (Johnson, et al., 2011)
<table>
<thead>
<tr>
<th>Model Simulation</th>
<th>Recharge (precipitation and return flows)</th>
<th>Withdrawal amount (public and residential)</th>
<th>Withdrawal location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation 1</td>
<td>Decrease precipitation recharge by 20 percent</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Steady-State</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simulation 2</td>
<td>Increase return flows by 15 percent</td>
<td>Increase public and residential withdrawals by 15 percent</td>
<td>No change</td>
</tr>
<tr>
<td>Steady-State</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Simulation 3</td>
<td>Increase return flows by 15 percent</td>
<td>Increase public and residential withdrawals by 15 percent</td>
<td>Deepen all public and residential withdrawals</td>
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<tr>
<td>Steady-State</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simulation 4</td>
<td>Increase return flows by 15 percent</td>
<td>Increase public and residential withdrawals by 15 percent</td>
<td>Deepen only group A public withdrawals</td>
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<tr>
<td>Steady-State</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simulation 5</td>
<td>Increase monthly return flows by 15 percent</td>
<td>Increase monthly public and residential withdrawals by 15 percent</td>
<td>No change</td>
</tr>
<tr>
<td>Transient</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Simulation 6</td>
<td>Increase monthly return flows by 15 percent</td>
<td>Increase monthly public and residential withdrawals by 15 percent</td>
<td>Deepen only group A public withdrawals during summer months</td>
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<tr>
<td>Transient</td>
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</table>
RCW 90.94 Considerations
Ecology recommends relying on more than one method for estimating numbers of future wells including: population projections, historic building permit data, and/or historic well log drilling rates.

To account for portion of water not consumptively used, water use estimates can be adjusted to account for water that will not return to hydrologic system.
From Ecology ESSB 6091 Streamflow Restoration Water Use Estimate Recommendations

Household Consumptive Indoor Water Use (HCIWU):

60 gpd * 2.5 people per house * 365 days * 0.00000307 AF/gal. * 10% cons. use = 0.017 AF/YR

Household Consumptive Outdoor Water Use (HCOWU):

<table>
<thead>
<tr>
<th></th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>Sept.</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Irrig. requirements (in.)</td>
<td>0.63</td>
<td>2.72</td>
<td>4.11</td>
<td>2.75</td>
<td>0.90</td>
<td>11.11</td>
</tr>
</tbody>
</table>

Assuming outdoor watering area of 0.4 acre:

Irrigation Requirements (in.) = 11.11 inches/12 inches per feet * 0.4 acres = 0.37 AF/YR

Factoring in assumed application efficiency of 75 percent,

0.37 acre-feet ÷ 75% application efficiency = 0.49 acre-feet

Factoring assumed outdoor water use consumption of 80%:

0.49 acre-feet x 80% consumed (20% return flow) = 0.39 acre-feet

Basin-wide Household Consumptive Water Use (BHCWU):

Consumptive water use by future permit-exempt domestic wells for WRIA or subbasin:

BHCWU = number of houses served by permit-exempt domestic wells * (HCIWU + HCOWU)

1. Assuming all houses discharge wastewater via septic systems
When & Where Consumptive Use Impacts Will Occur

- RCW 90.94 requires high priority offset projects to replace 20-year water use in-time and in same subbasin.
- Estimating timing of groundwater impacts on streams with precision is complicated due to lags between when a well is pumped and when those impacts propagate to a stream.
Due to hydrogeologic variability, uncertainty regarding new well locations, limited money, and limited time, planning groups will not be able to model pumping effects in detail.
Conceptual Groundwater Understanding

Conceptual groundwater models provide overall hydrogeologic understanding.

In water resources terms this generally considers:

- spatial delineations of recharge and discharge areas
- identification of pathways from unsaturated zones through saturated zones to groundwater receptors
- analyses and estimates of time scales of flow and effects of groundwater pumping
Seasonal vs. Steady State

- Magnitudes of aquifer pumping pulses decay over distance and time as effects spread out.
- In this example water-level changes range from a distinct pump-on – pump-off pattern, to a relatively constant impact.
- In most instances in western Washington it is reasonable to assume streamflow depletion will essentially be steady state - especially beyond distance of few thousand feet.
Spatial Considerations

• Even when planning groups assume steady state conditions, they will need to consider how steady state pumping effects are distributed spatially.

• Conceptually, one option is to assume all pumping effects will remain within a subbasin and be distributed evenly to all surface water bodies.

• In those instances where most future wells are likely to be shallow and congregated near a stream particularly important to fish, another option would be to conservatively assume depletion impacts are entirely attributed to streams closest to pumping well.
Significance of Scale

When evaluating the hydrologic impacts of new permit-exempt domestic wells or water offset projects on surface water an important consideration is what the magnitude of impacts or benefits will be relative to size of the water bodies.
Context of RCW 90.94

• Structure of mitigation under RCW 90.94 is fundamentally different than mitigation for groundwater permits.
• Typically water right permits require offsetting impacts of groundwater pumping in-time and in place.
• RCW 90.94 allows mitigation for permit-exempt domestic wells to occur anywhere within a WRIA, provided watershed plans achieve a Net Ecological Benefit (NEB).
• Per RCW 90.94 when Ecology reviews plan addendums it will be looking for:
  (1) “actions that the planning unit determines to be necessary to offset potential consumptive impacts to instream flows associated with permit-exempt domestic water use.”
  (2) actions that “will result in a net ecological benefit to instream resources within the water resource inventory area.”
• This means placing offset projects in places most beneficial to fish is probably more important than understanding specific impacts from permit-exempt domestic well pumping.
Questions?

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