Regional District of Nanaimo
Phase 1 Water Budget Project
Vancouver Island
Project Update

Waterline Resources Inc.
Nanaimo BC

REGIONAL DISTRICT OF NANAIMO

KERR WOOD LEIDAL
consulting engineers

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Introductions: Waterline Project Team

- Hydrogeology – Waterline Resources
  - Darren David, M.Sc., P.Geo.
  - David van Everdingen, P.hD, P.Geo
  - Matt Skinner, M.Sc., /GIS
- Surface Water Engineering - KWL
  - Craig Sutherland, M.Sc., P.Eng.

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Rationale for Geodatabase & 3D Visualization

- Data available electronically to the RDN (not public),
- Allows us to relate numerous datasets;
- Errors in the data become obvious;
- Communicate ideas about groundwater to non-hydrogeologists and the public;
- Helps resolves the myths/misconceptions about groundwater (e.g.: underground rivers);
- Bridge the gap between art and science;
- Convince users/stakeholders of why its important to participate in data collection/contribution.

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Conceptual Hydrogeological Models

- Data Compilation:
  - ✓ RDN Water Map and RDN Map;
  - ✓ Government maps/reports on geology/hydrogeology/hydrology;
  - ✓ Over 750 consultant reports/files in bibliography DB (300 compiled in Waterline geodatabase);
  - ✓ Data from over 9000 water wells (MOE DB, Obs wells, private wells, community systems wells, >900,000 water levels);
  - ✓ Water Quality data;
  - ✓ Stream flow monitoring data;
  - ✓ Groundwater and surface water use data.
- Integrate/synthesized to common datum:
  - ✓ 1:50,000 DEM;
  - ✓ 1:20,000 TRIM;
  - ✓ LIDAR.

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ARC GIS/ARC-Hydro Geodatabase

- Data Compilation Phase:
  - ✓ Critical Step: Data conditioning, filtering and refinement
  - ✓ Make geology consistent with GSC mapping study,
  - ✓ Consider SFU geology nomenclature,
  - ✓ Lithology refinement from 1000's to 100's to 18 types,
  - ✓ Enabled development of final hydrostratigraphy to link to mapped surface geology subsurface borehole geology;
  - ✓ Conceptual Geological Model.

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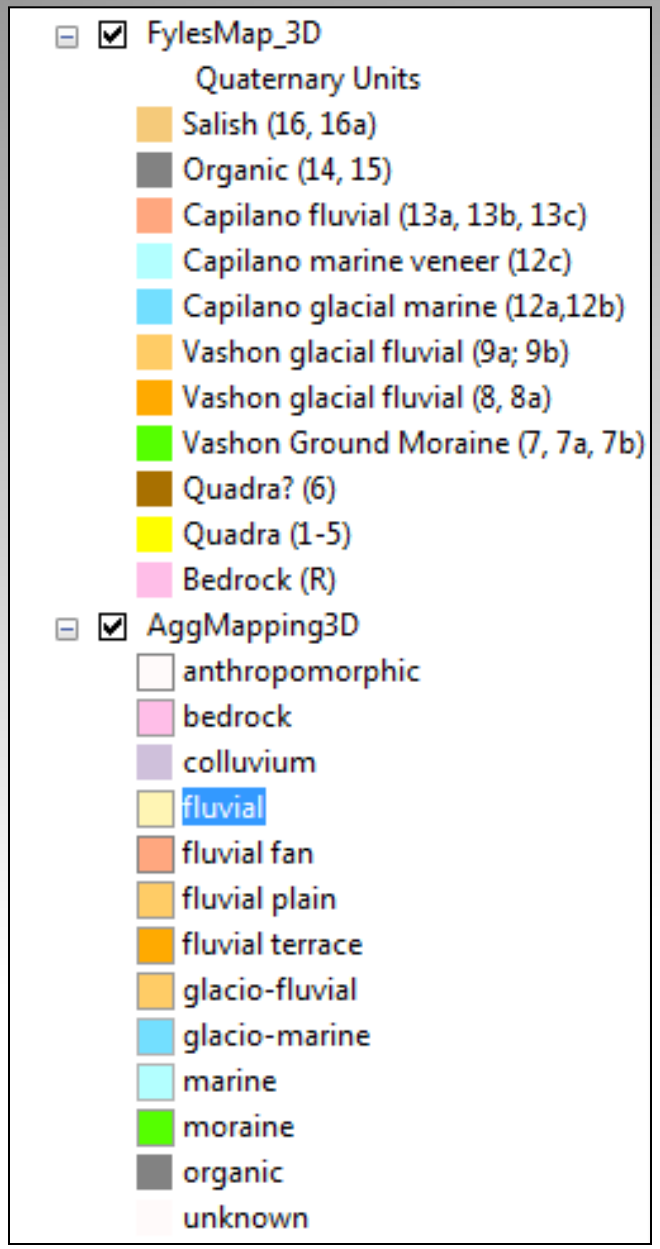

Stratigraphic Descriptions

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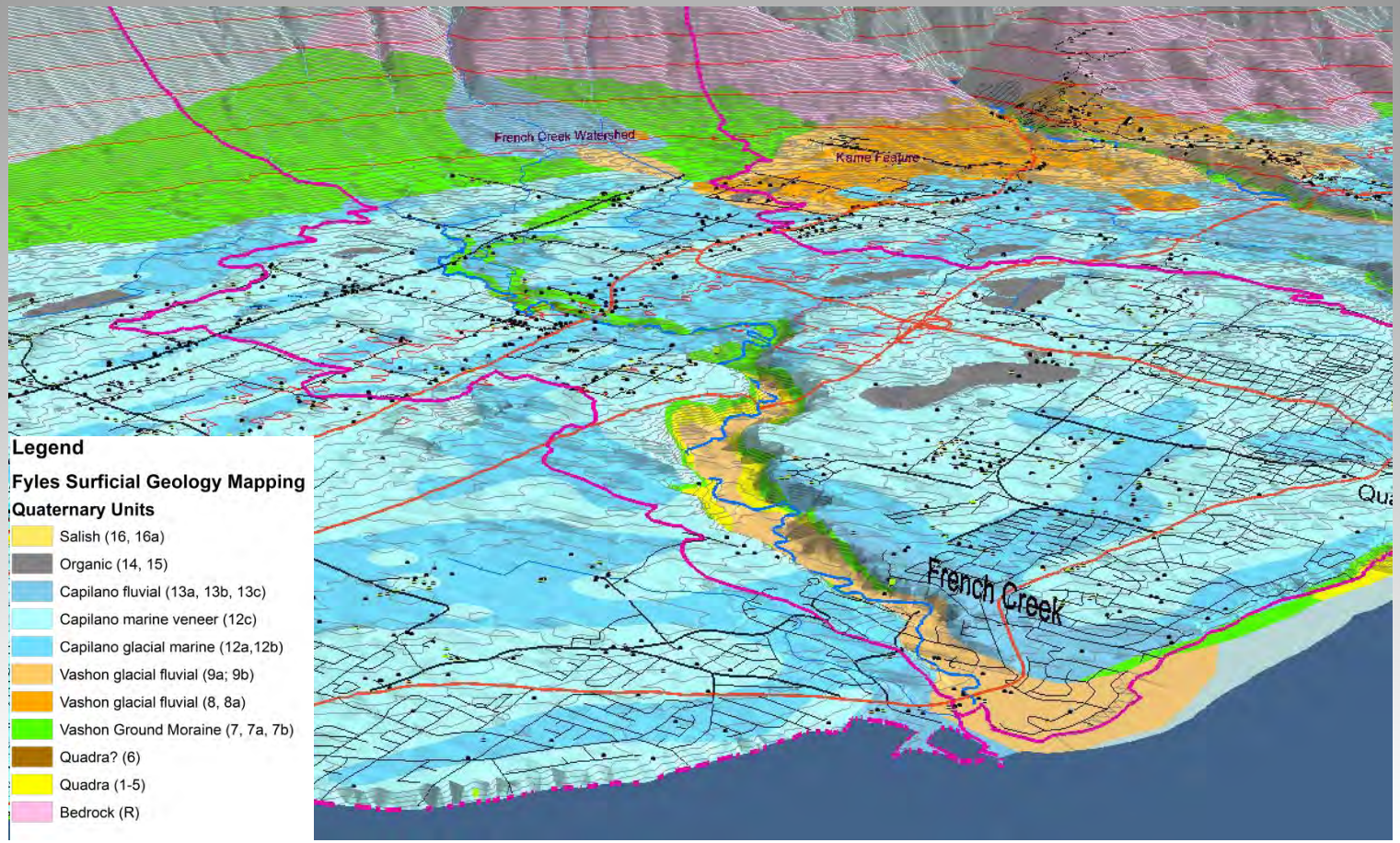
Conceptual Model – French Creek



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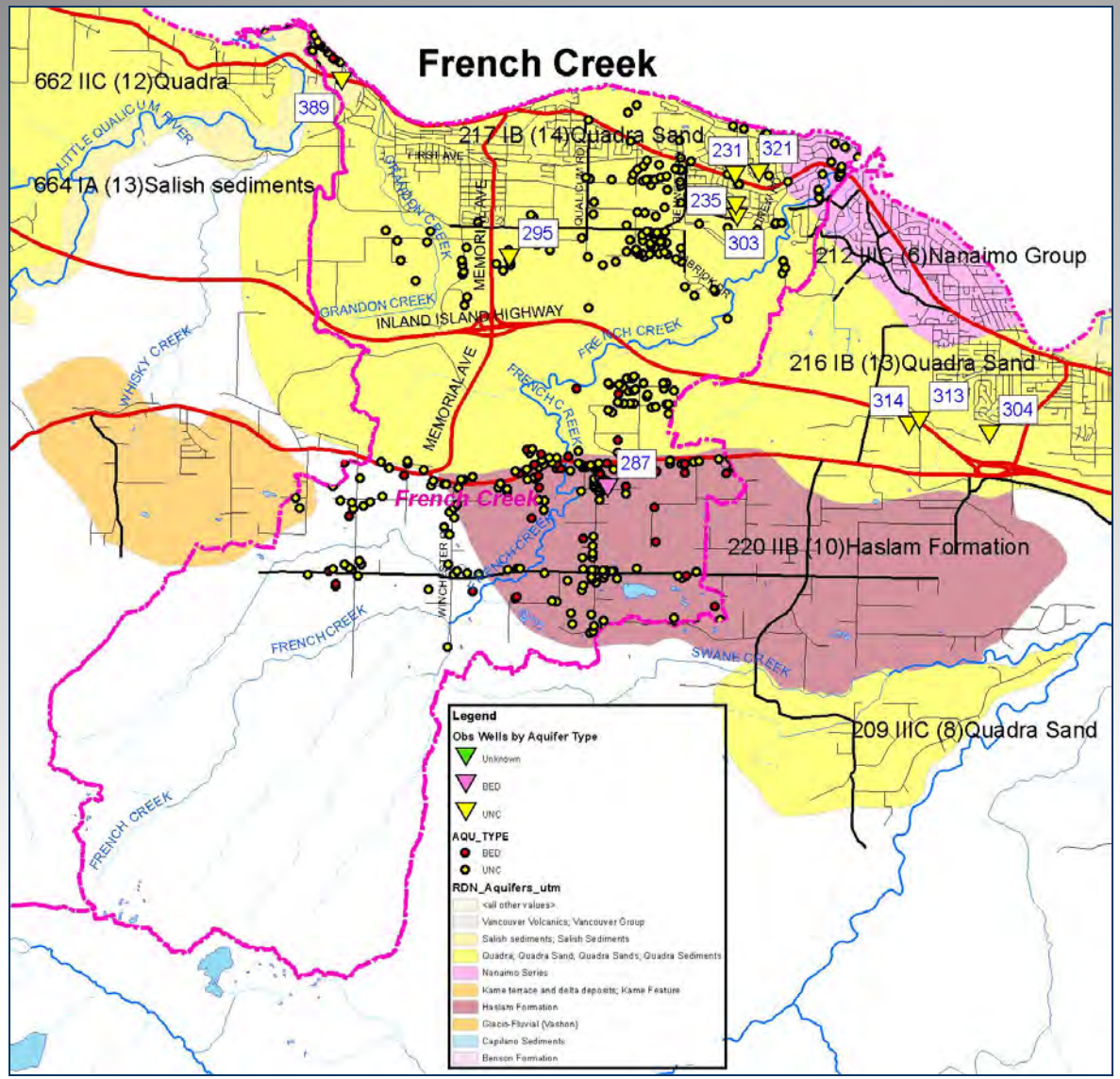

Conceptual Model – French Creek

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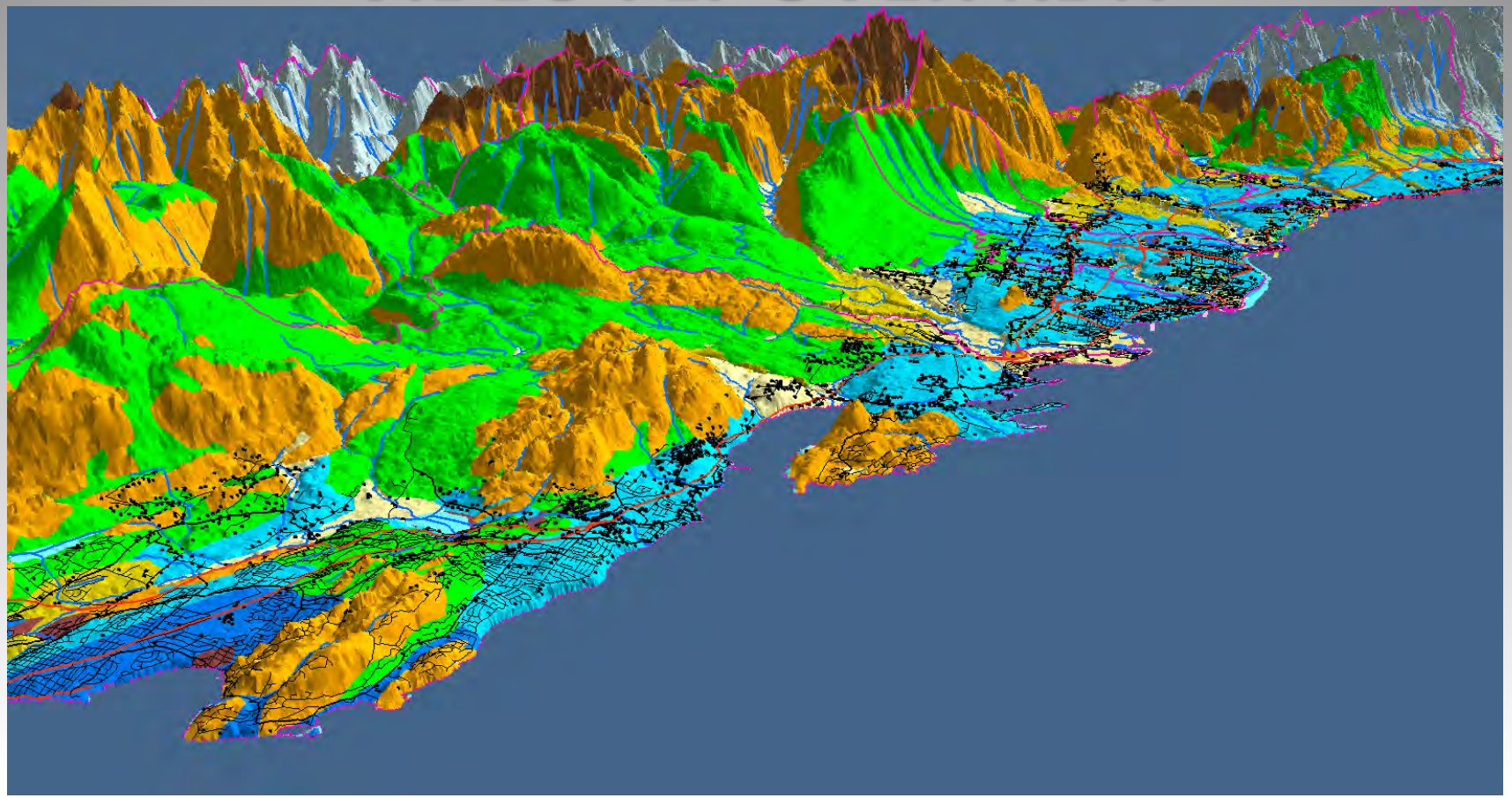
VIDEO FLY OVER RDN



- 4 x vertical exaggeration

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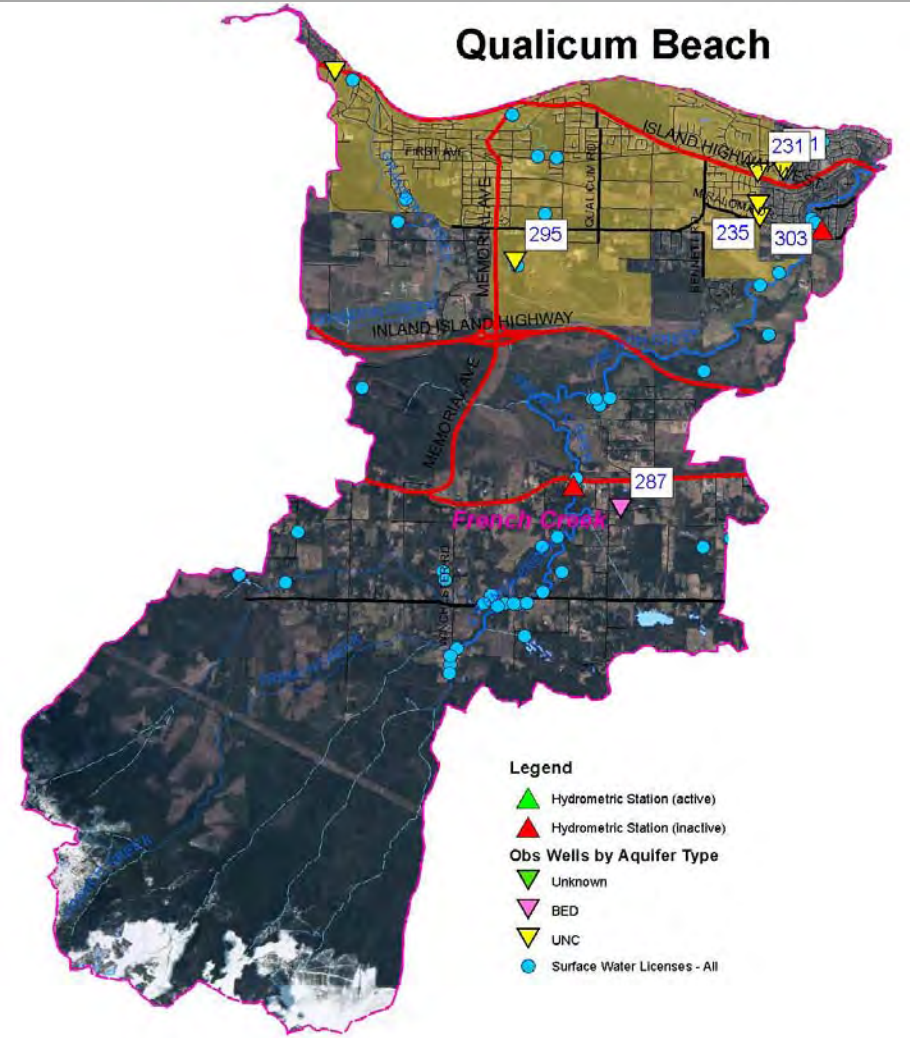
MOE Observation Wells



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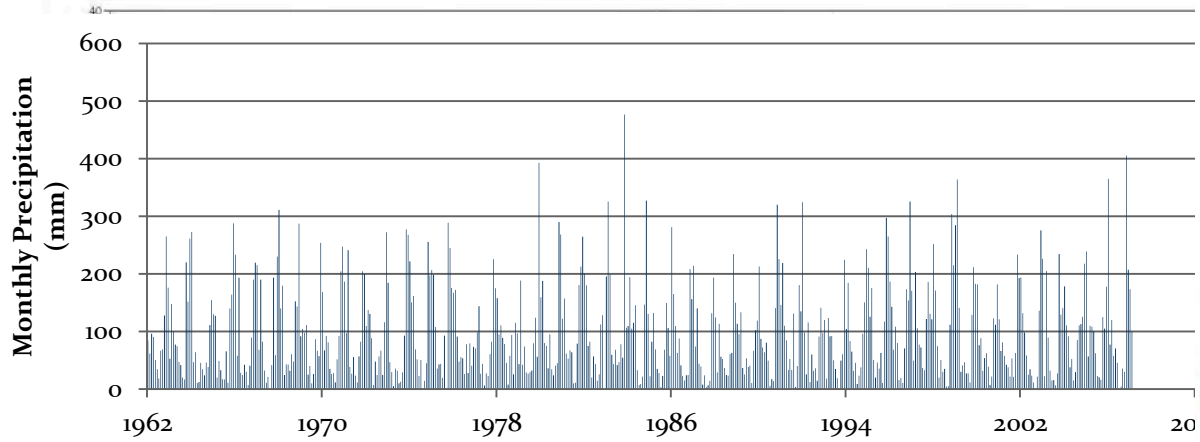
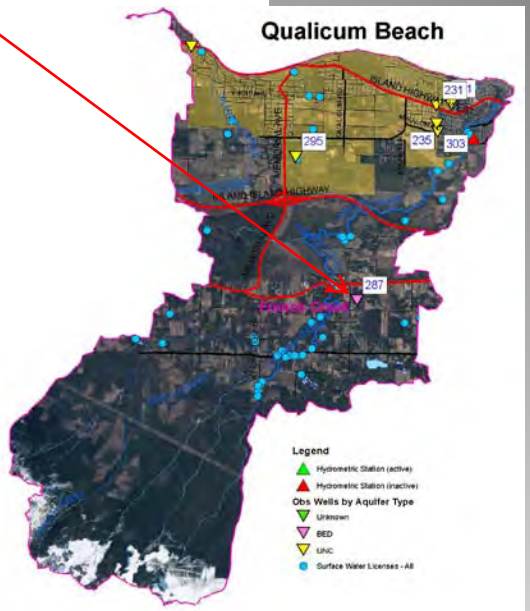
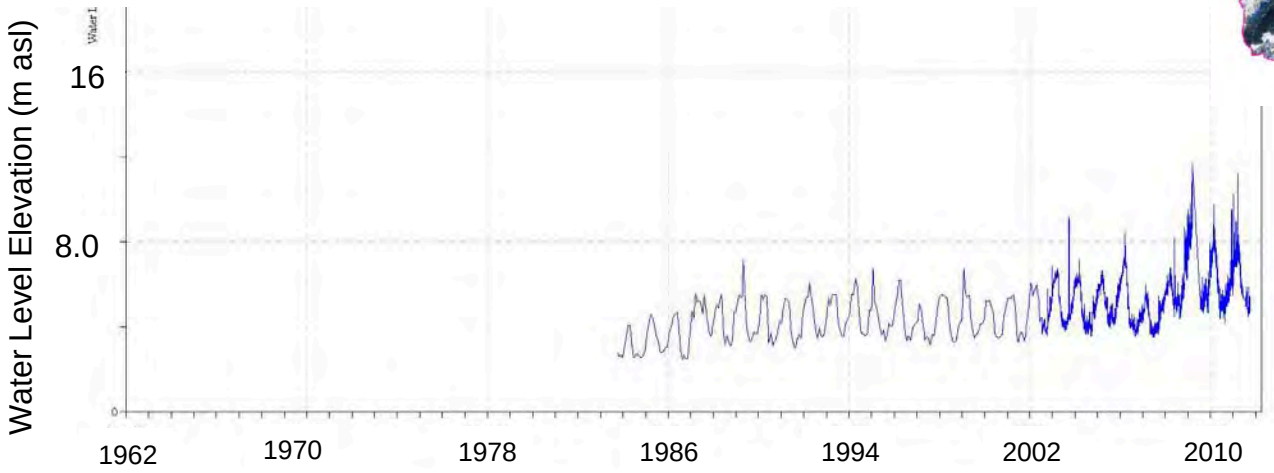
MOE Observation Wells

BC MOE OBS WELL 287
WTN: 53360







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MOE Observation Wells

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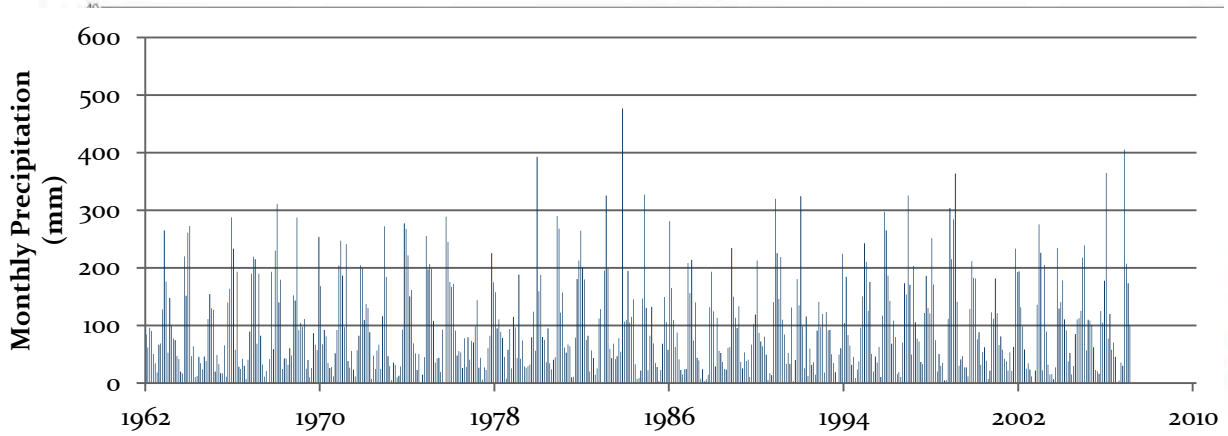

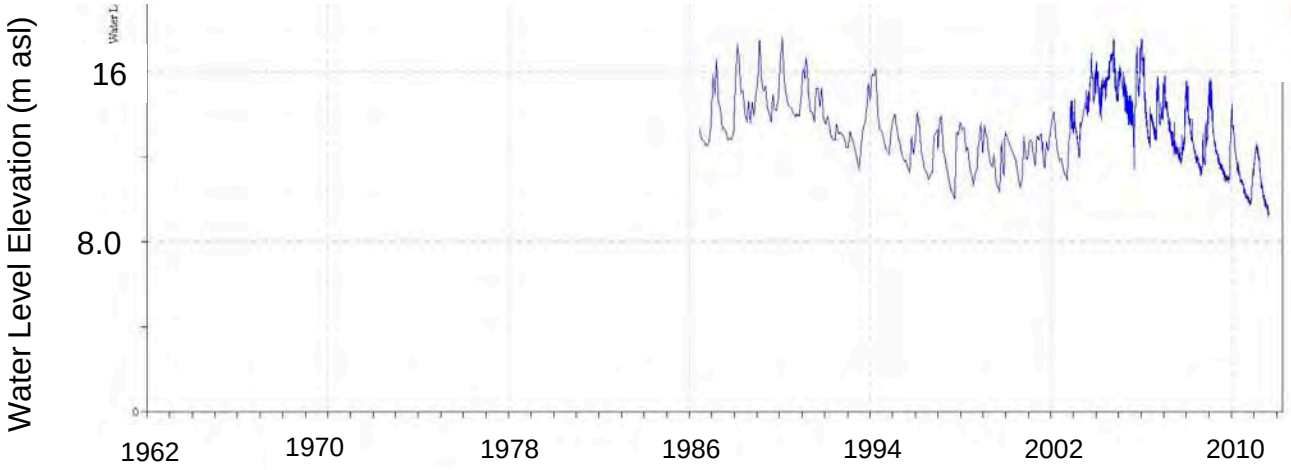

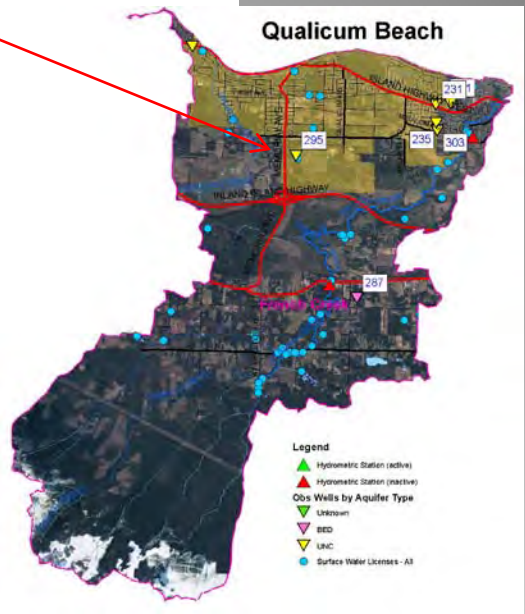

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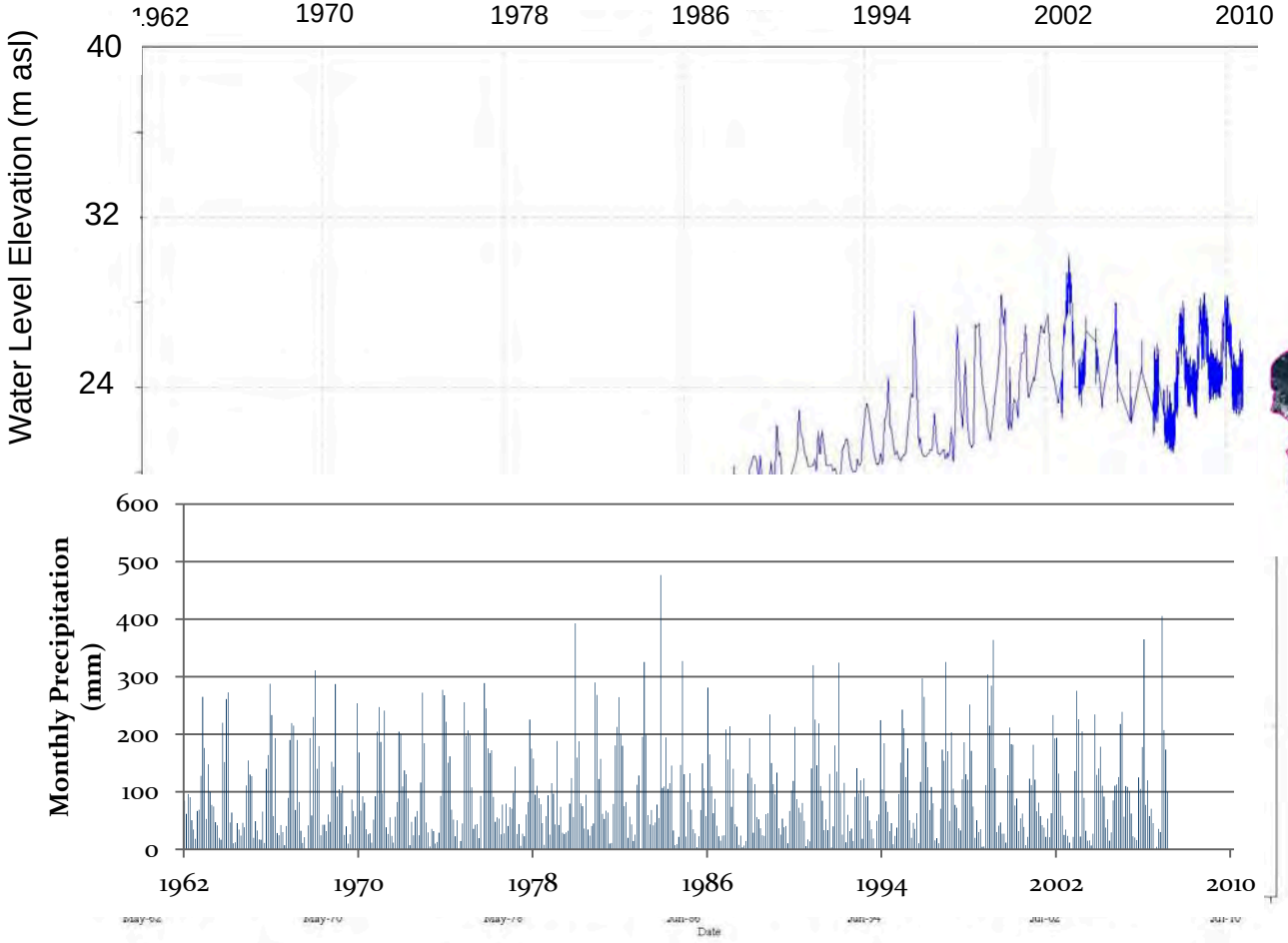
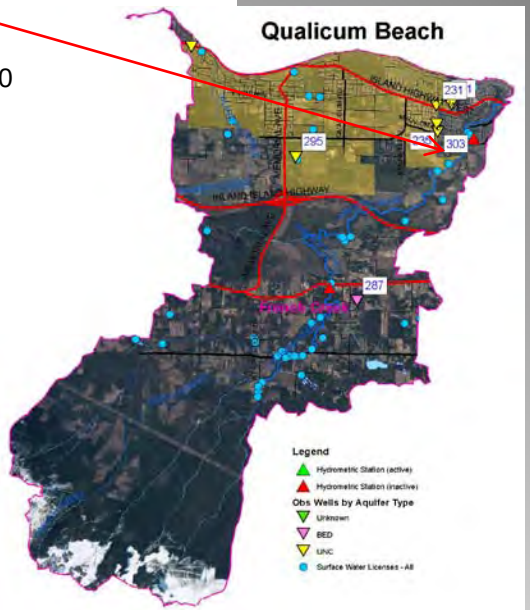
MOE Observation Wells

BC MOE OBS WELL 303
WTN: 43750





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MOE Observation Wells

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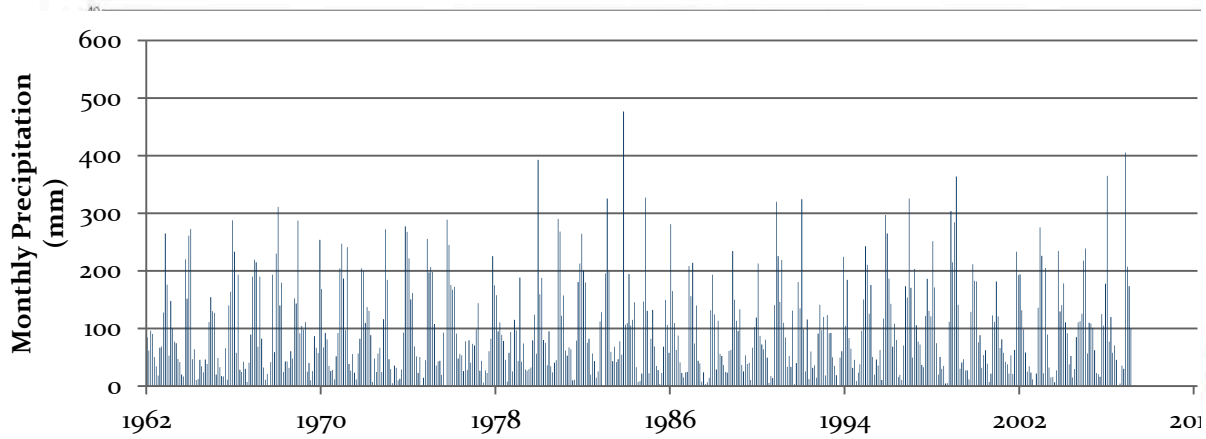
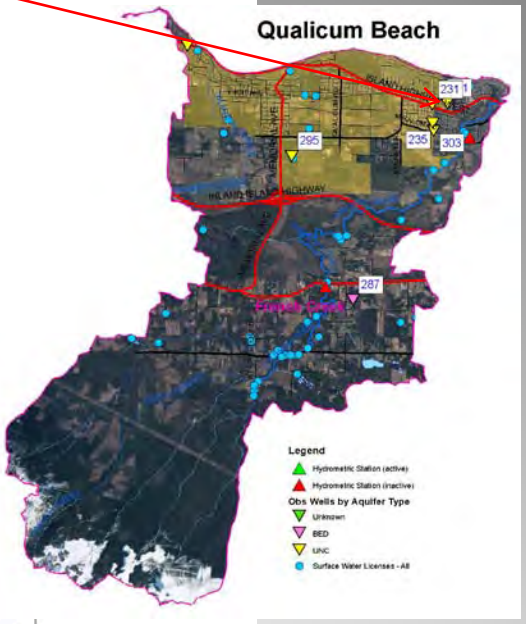
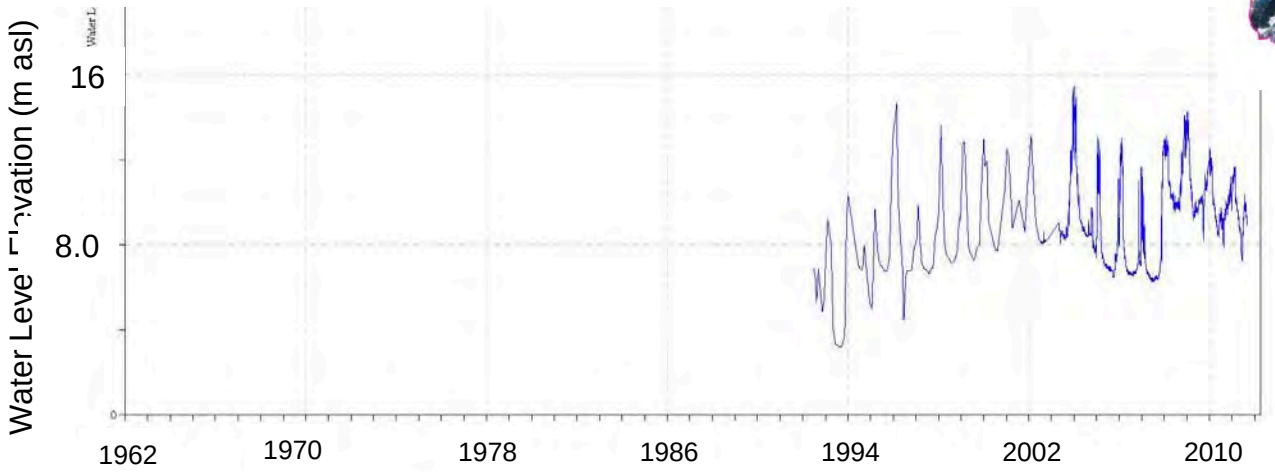
WTN: 48458







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MOE Observation Wells

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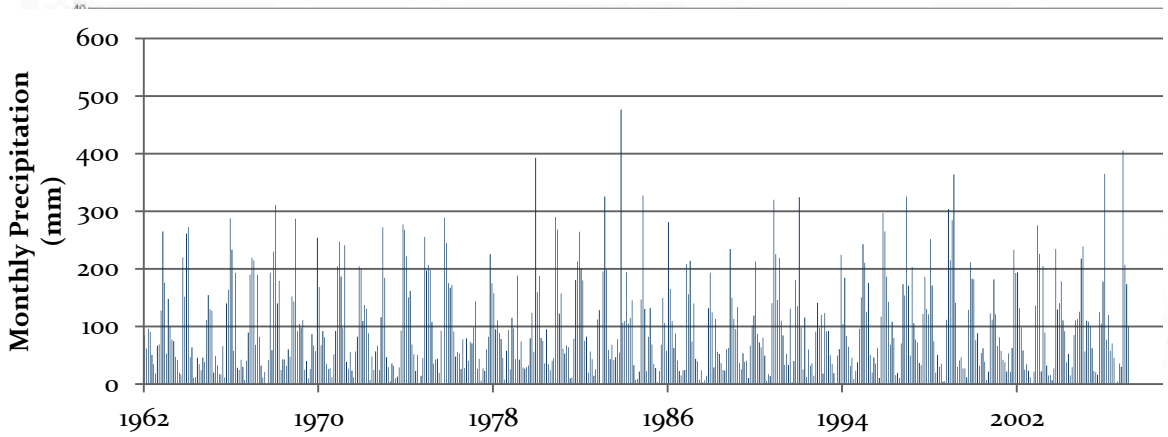
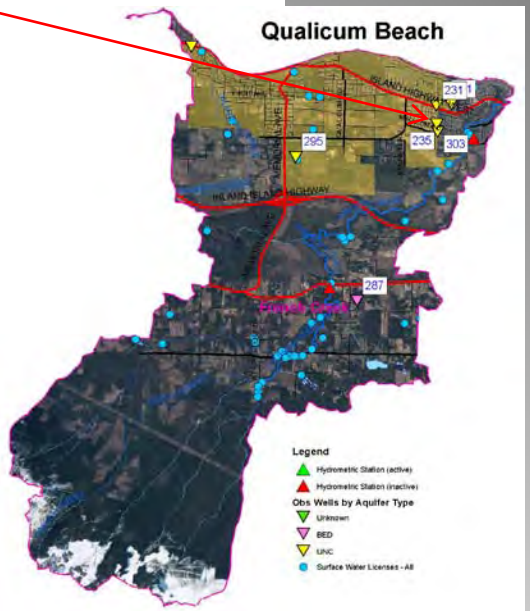
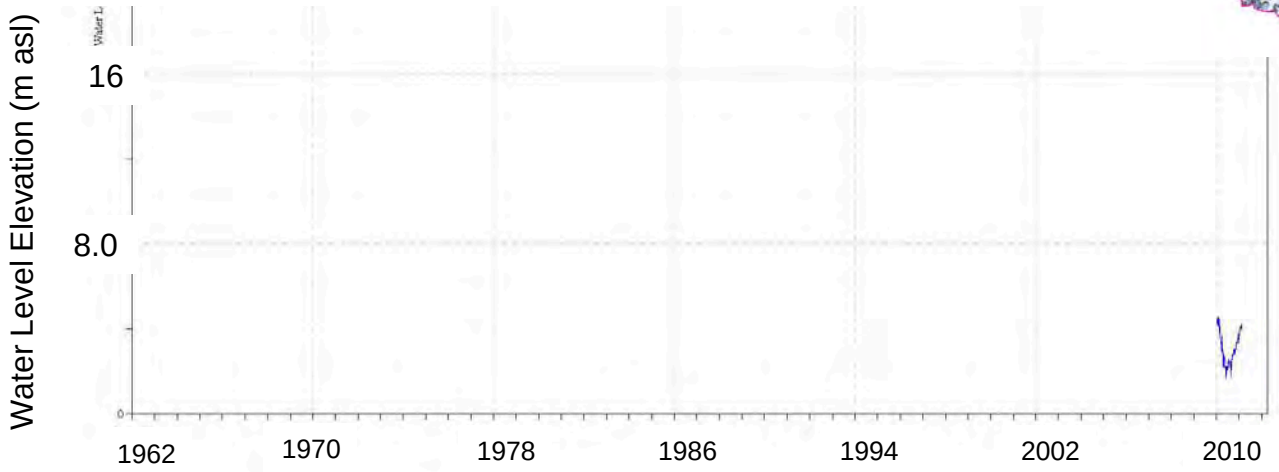
WTN: 102925







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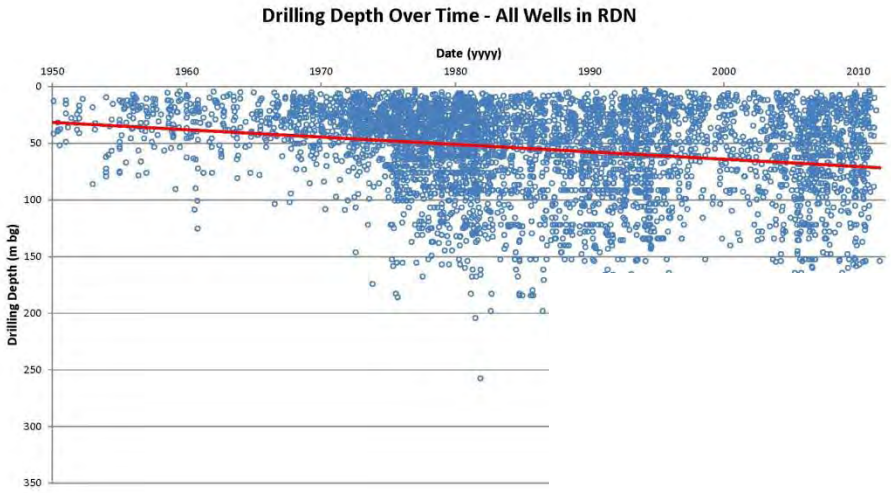
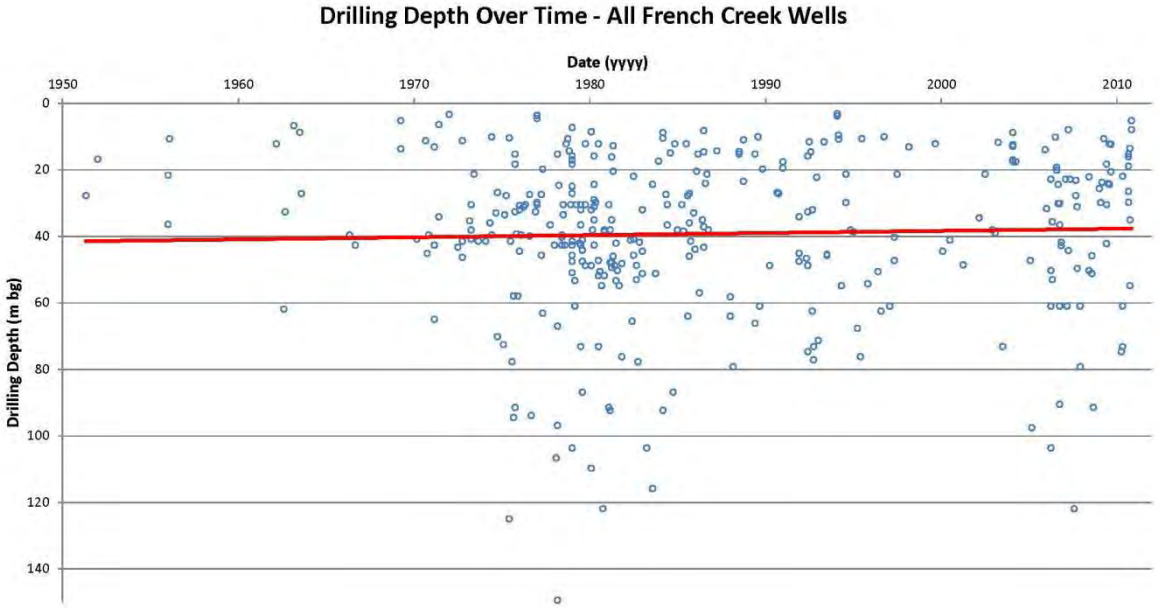
Well Drilling Depth Vs Time





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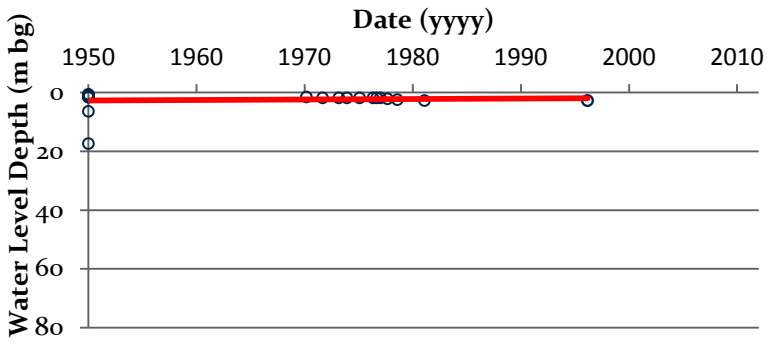
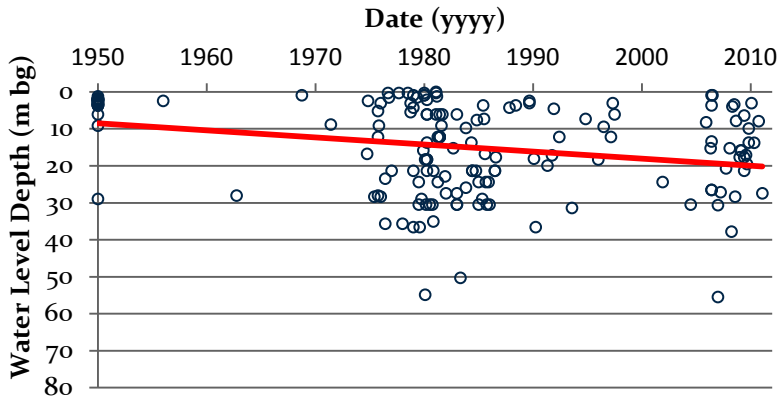
Water Level vs Time – FC Aquifers

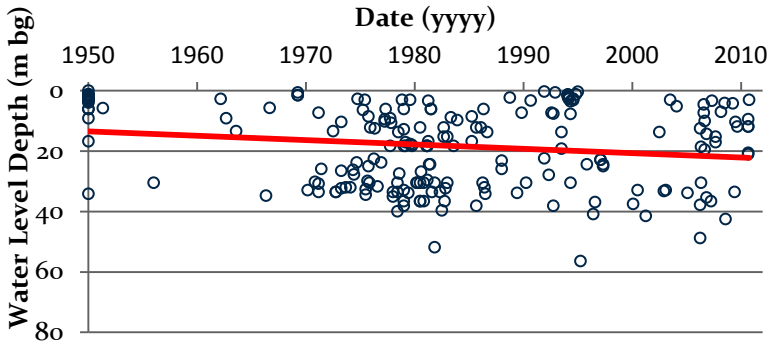
RDN Aquifer 212 Nanaimo Group Water Levels Over Time



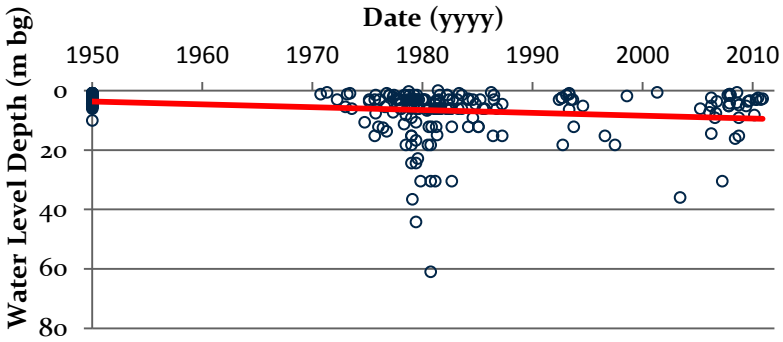
RDN Aquifer 216 Quadra Sand Water Levels Over Time



RDN Aquifer 217 Quadra Sand Water Levels Over Time



RDN Aquifer 220 Haslam Fm. Water Levels Over Time



Summary of Water Level Trends

Aquifer	Name	# Records	Drilling Depth		Water Level		Trendline	Est. Change (m)
			Average	Std Dev	Average	Std Dev	Trendline	Since 1950
212	Nanaimo Group	45	27.4	26.1	6.5	6.7	decreasing depth to water	-1
216	Quadra Sand	222	35.1	27.9	14.7	12.1	increasing depth to water	11.5
217	Quadra Sand	263	33.8	21.5	18.0	13.3	increasing depth to water	9
220	Haslam Formation	394	33.0	33.0	6.1	7.5	increasing depth to water	5.6

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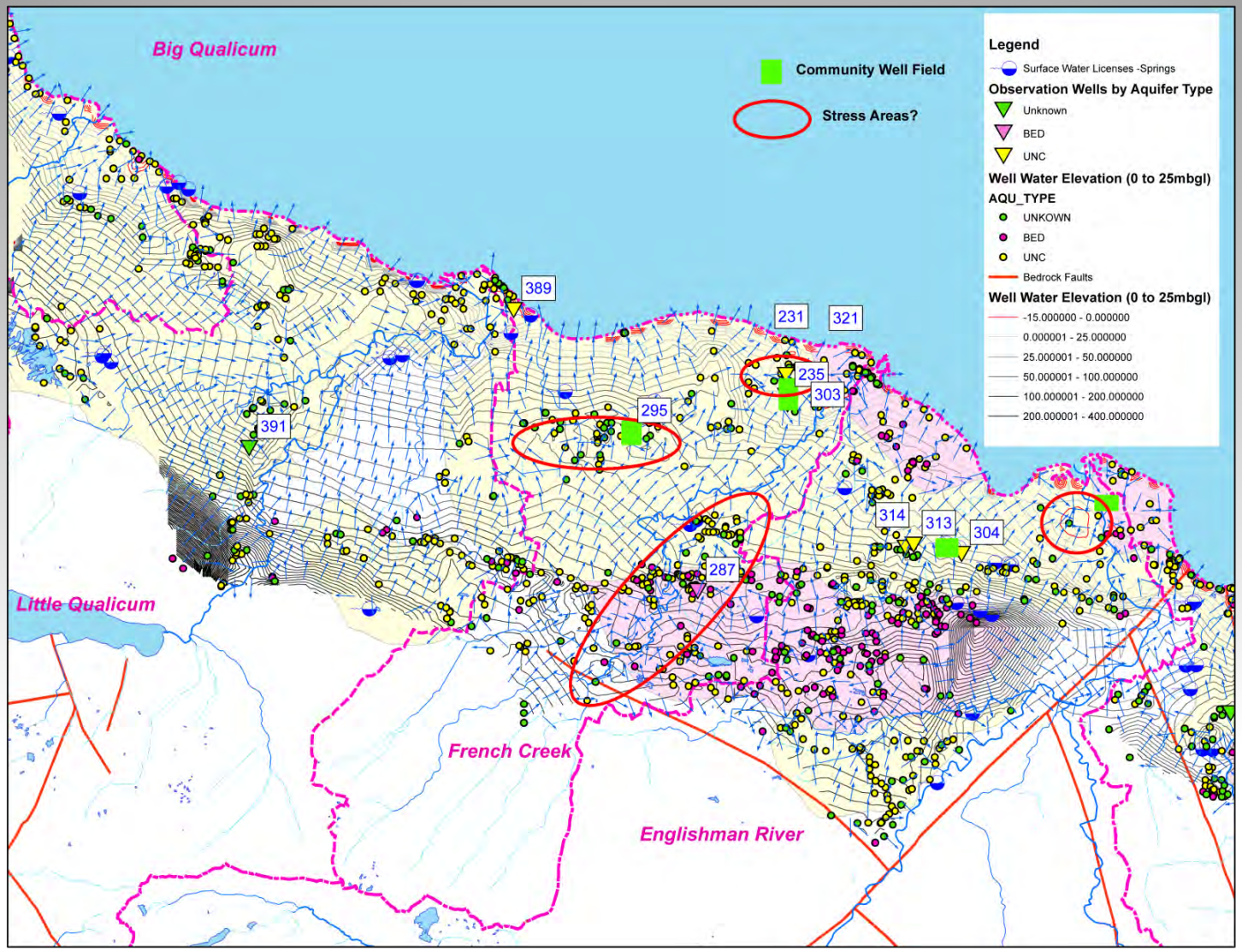
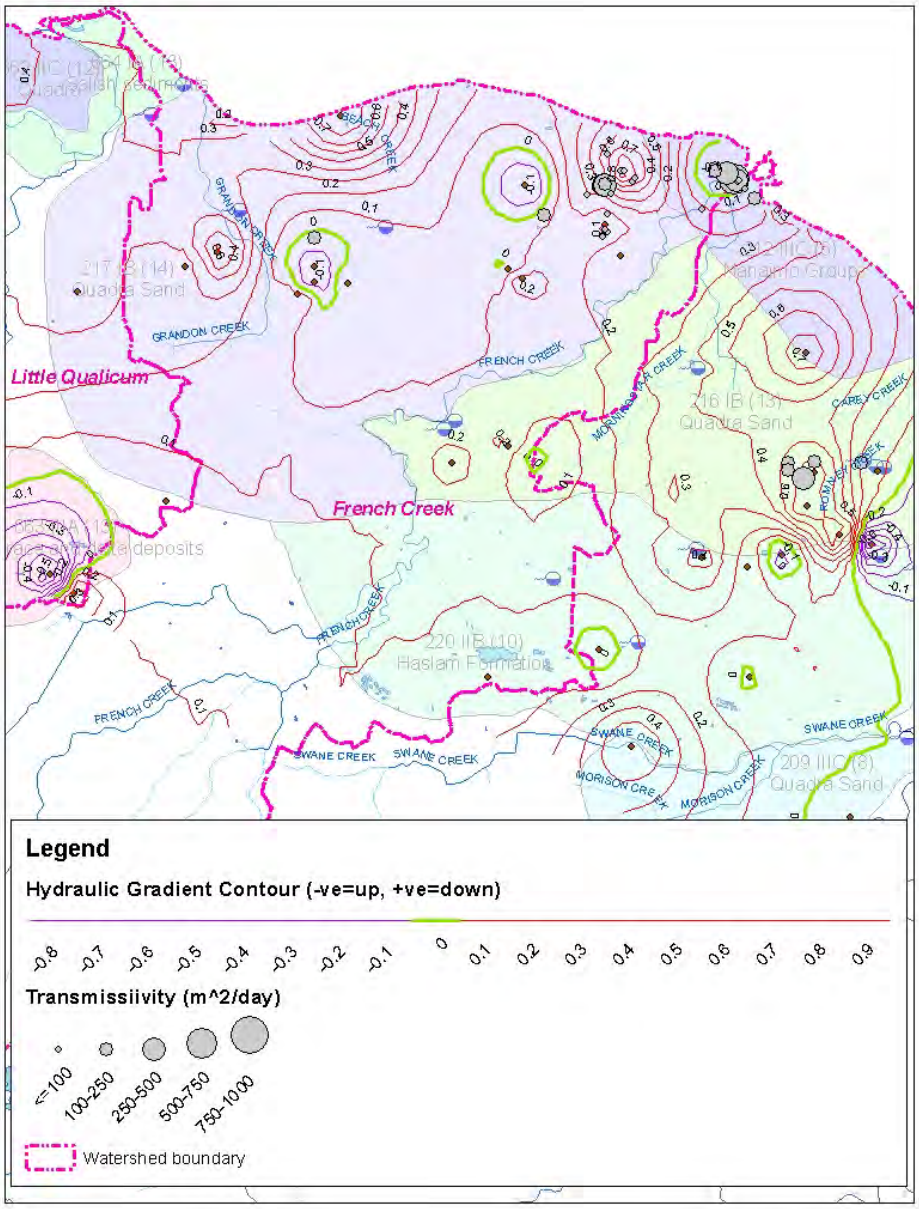
Piezometric Surface (0-25 m deep wells)





Discharge/ Recharge Areas - Vertical Gradients

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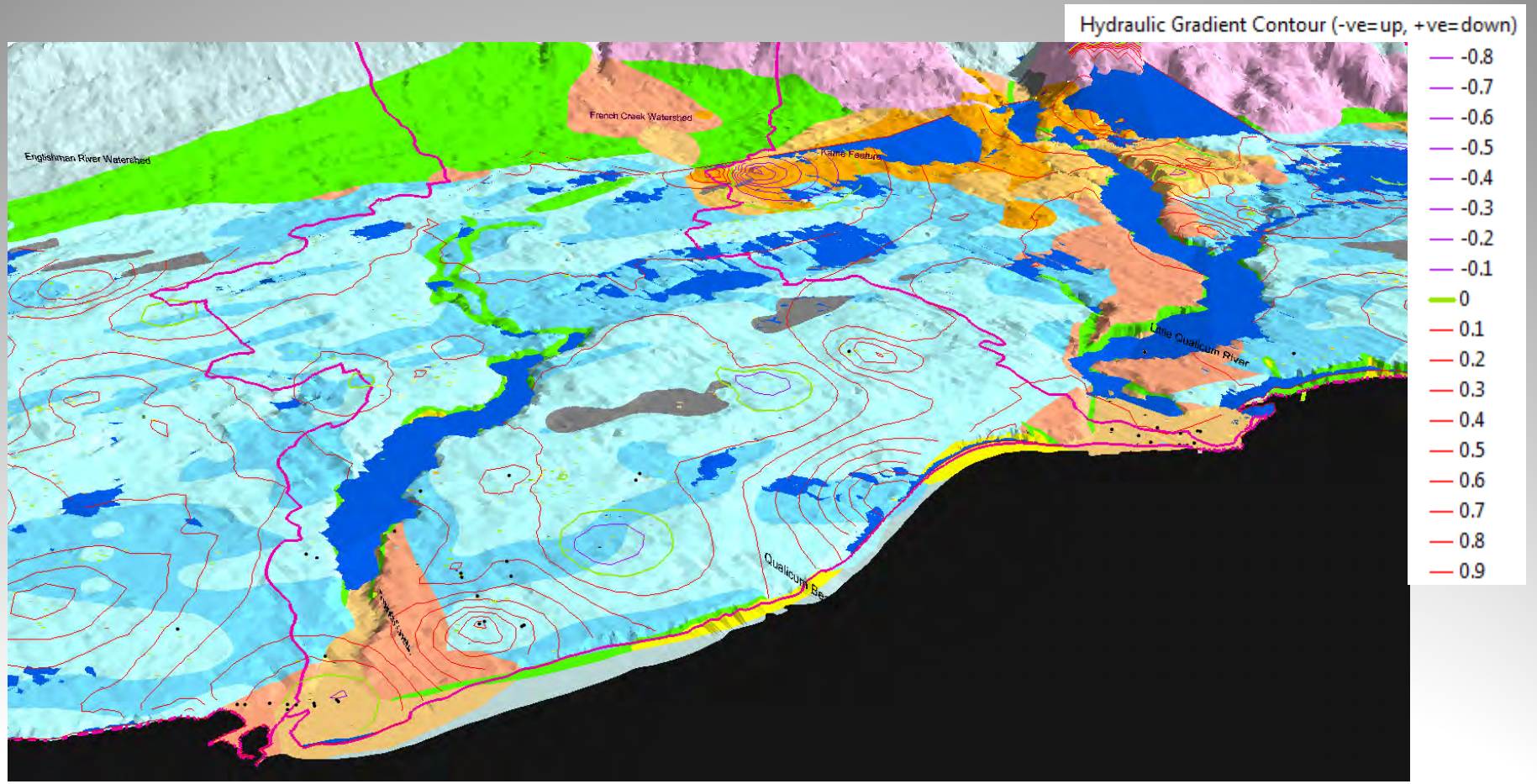
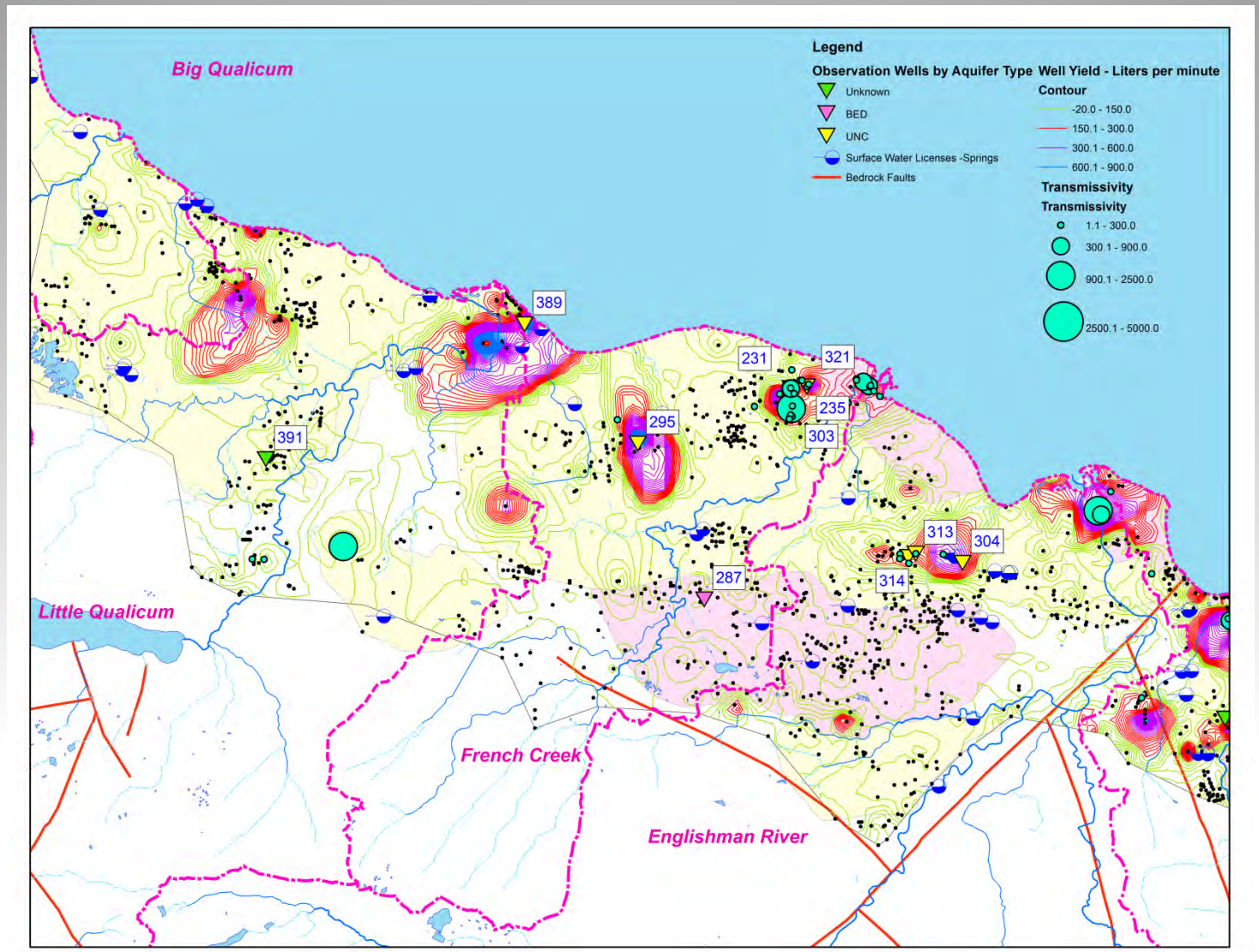
Recharge-Discharge Areas



Well Yield and Aquifer Transmissivity



Surface Water Budget

- **P + SWin + GWin + ANTHin = ET + SWout + GWout + ANTHout + ΔS** Where;
  - ✓ P = precipitation,
  - ✓ SWin = surface water flow in,
  - ✓ GWin = groundwater flow in,
  - ✓ ANTHin = anthropogenic or human inputs such as waste discharges (Exclude sewer service areas),
  - ✓ ET = evaporation and transpiration,
  - ✓ SWout = surface water flow out,
  - ✓ GWout = groundwater flow out
  - ✓ ANTHout = anthropogenic or human removals or abstractions,
  - ✓ ΔS = change in storage (surface water, soil moisture, groundwater)

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Groundwater – Surface Water Linkage

- **Underway….**
- **Calculate Darcy & volumetric groundwater flux (in and out) based on mapped aquifer properties:**
  - ✓ Aquifer Transmissivity,
  - ✓ Measured Hydraulic Gradients,
  - ✓ Cross sectional area interacting with creek/river.

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KWL Watershed Distributed Hydrology Model

- Model Predicts stream flow at un-gauged locations:
  - ✓ Watershed Scale (from 10s km^2 to 100s km^2)
  - ✓ Average monthly time scale (both current climate and future climate predictions)
  - ✓ Used in rainfall, and snowmelt dominated watershed

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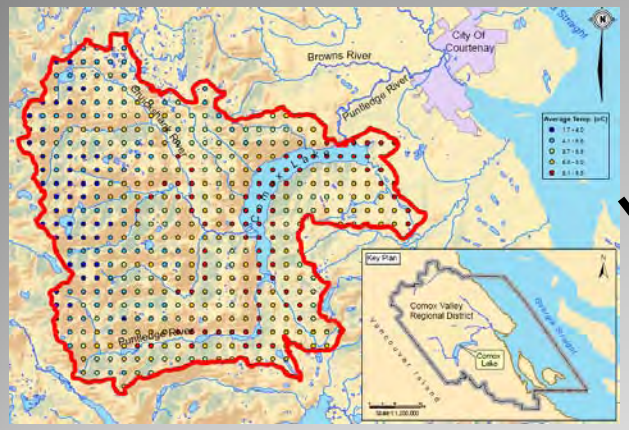
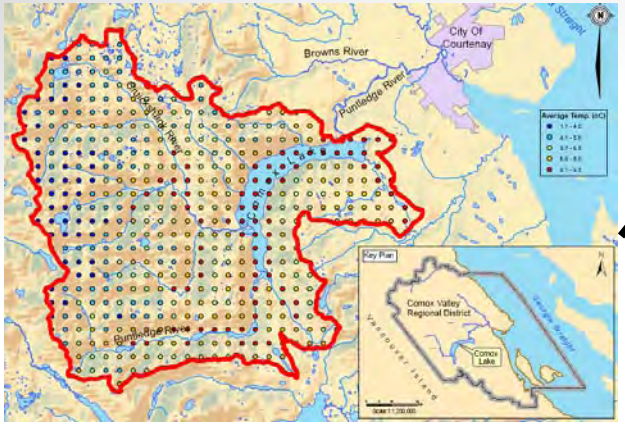
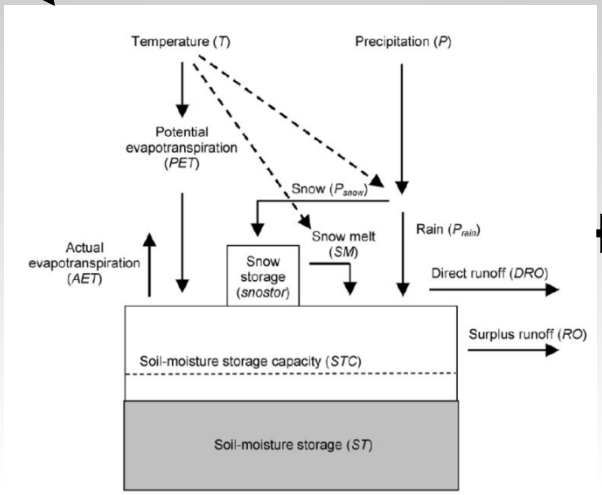
How the Model Works



Gridded (1 km²) Precipitation and Temperature





Monthly Water Balance Model (USGS)

Flow Accumulation/ Routing (KWL RHAM)

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KWL Watershed Distributed Hydrology Model

- **What the Model Can do:**
  - ✓ Efficiently estimates average flows over large areas and multiple watersheds for water supply/water balance purposes;
  - ✓ Indicates change inflow along watercourse (ie: contributions from tributary streams);
  - ✓ Preliminary climate change impact assessment.
- **What the Model can NOT do:**
  - ✓ Detailed single event modeling (ie: flood hydrology);
  - ✓ Detailed (ie: daily or hourly) flow forecasting.

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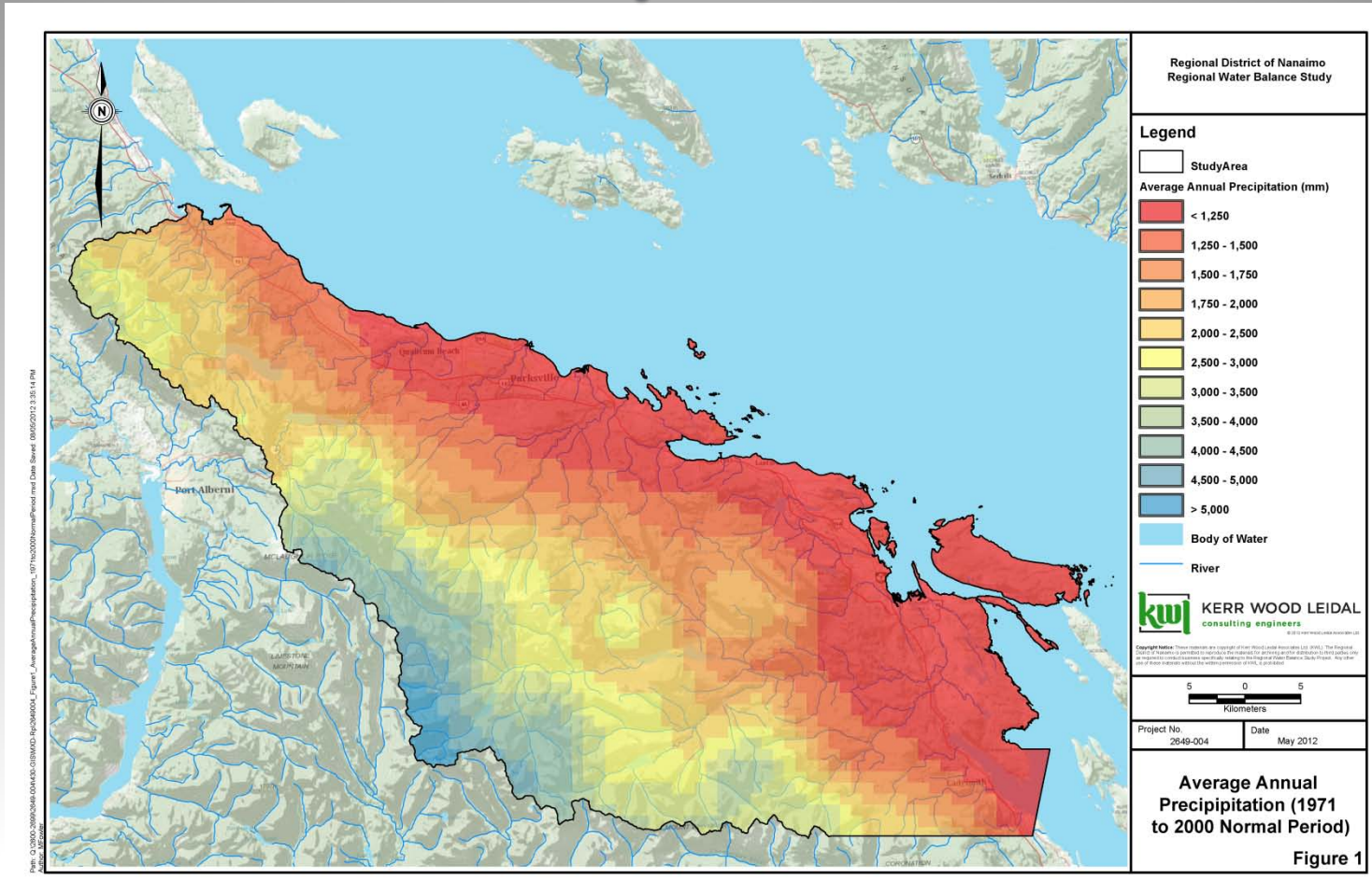
Precipitation



- Total annual precipitation:>5000 mm Mtns, <1250 mm on coast;
- 70-80% of precipitation from Oct-Mar

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Preliminary Water Balance

- French Creek Water Balance Model
  - ✓ Watershed characteristics:
  - ✓ Area = 86.6 km^2
  - ✓ Elevation: Median=130 m, Max=1,080 m
  - ✓ Mean Annual Discharge (Estimated) = 2.33 m^3/s

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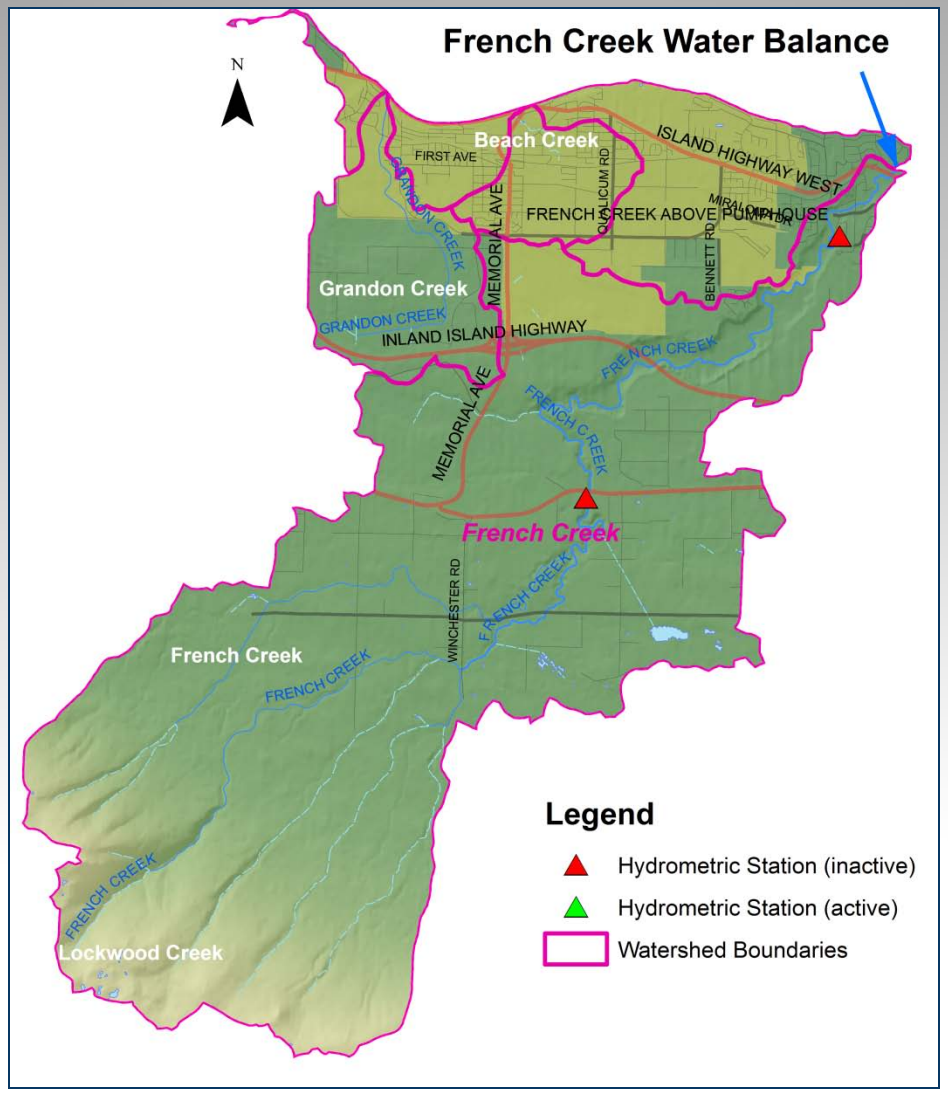
French Creek Watershed



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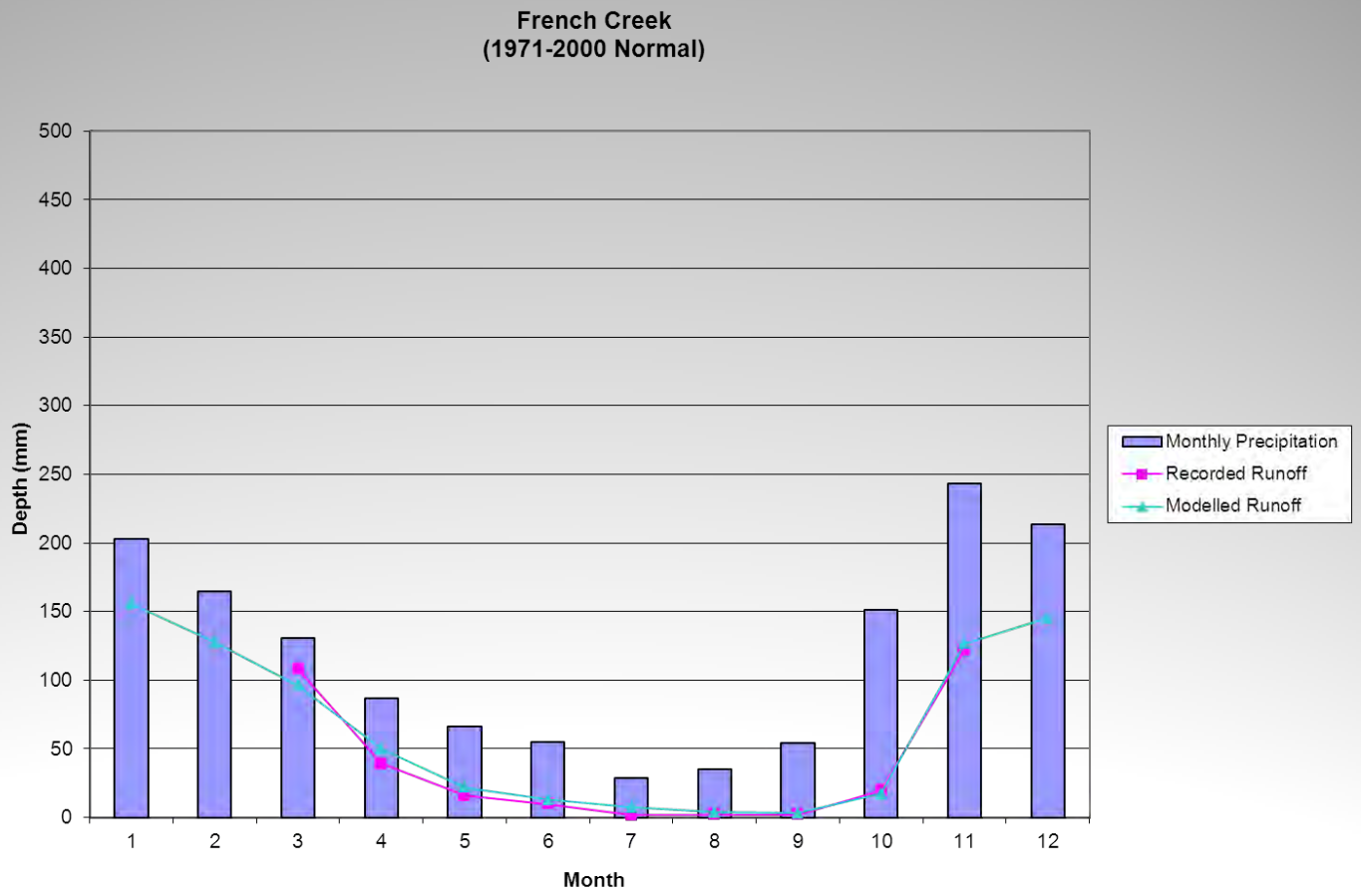
Preliminary Water Budget – Model Output



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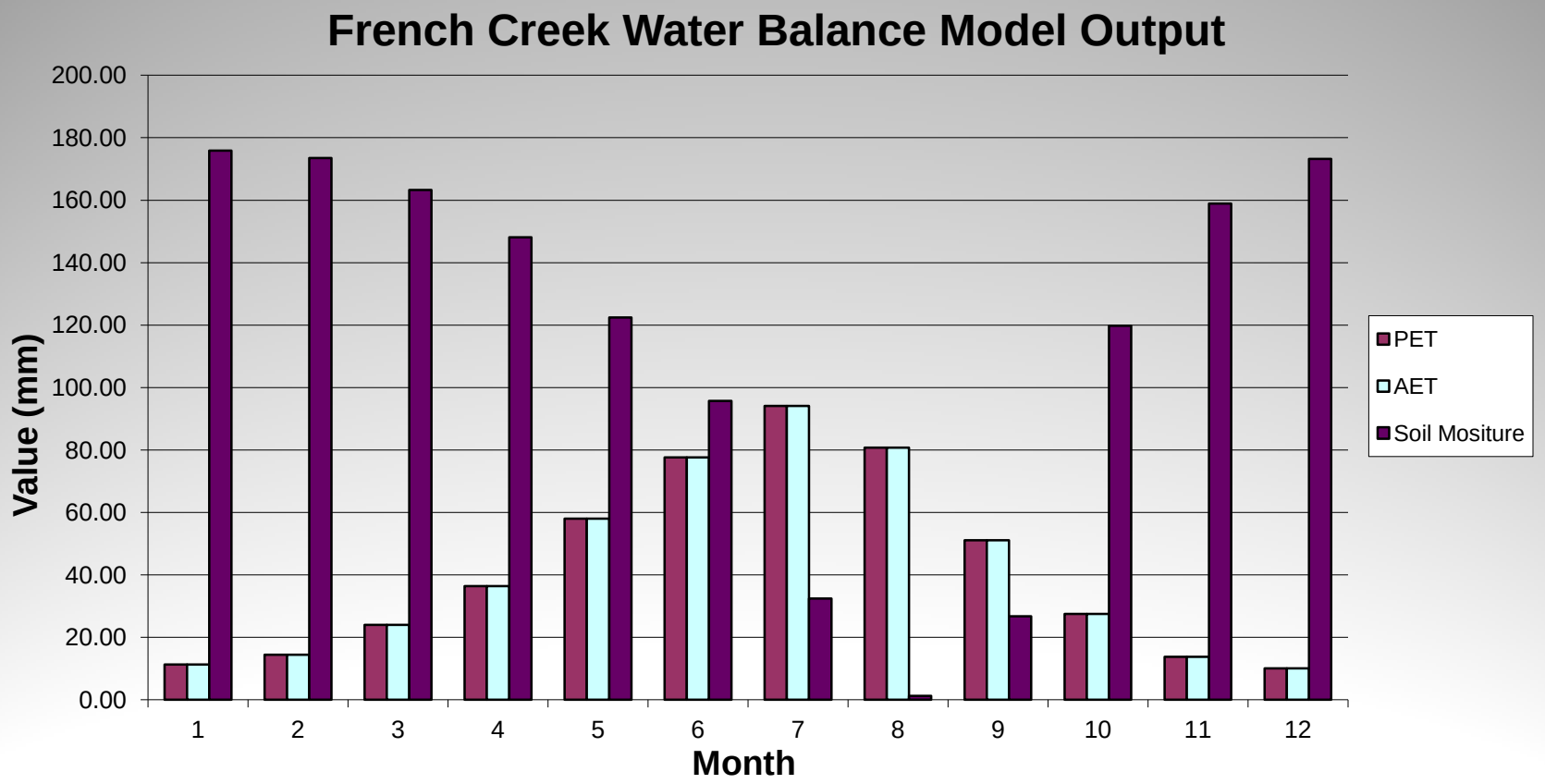
Preliminary Water Budget – Model Output



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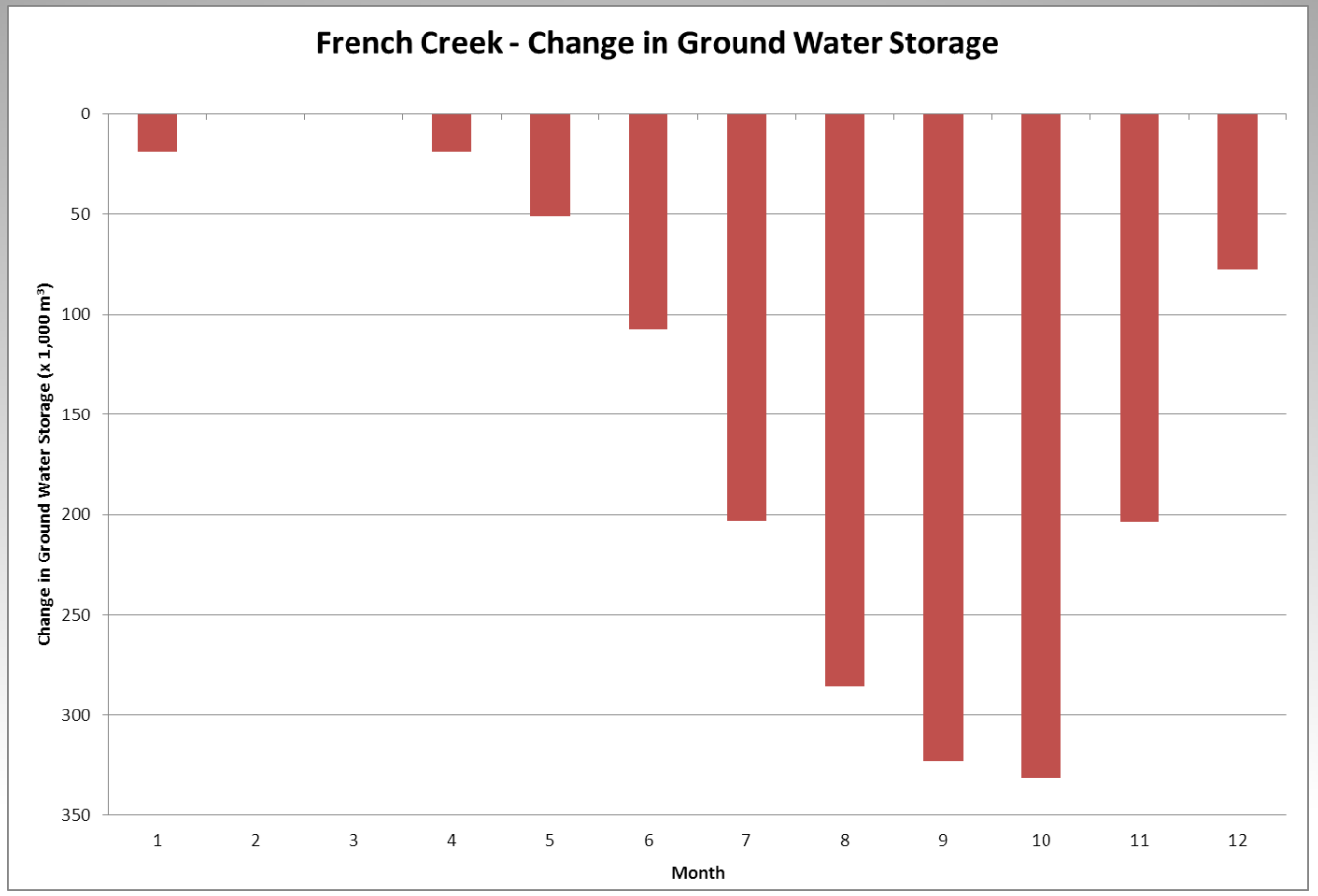
French Creek Groundwater Supply



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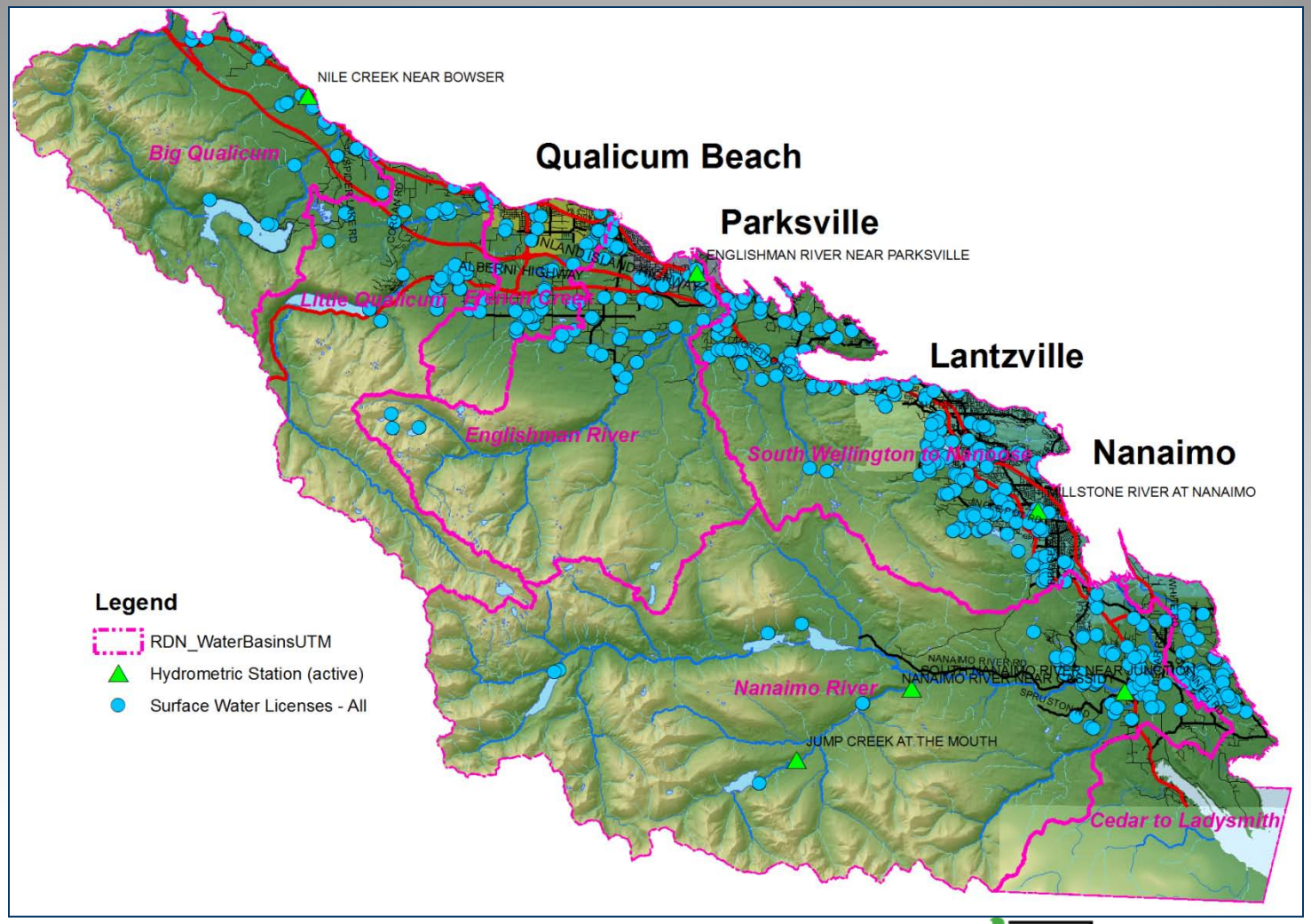
Surface Water Extraction -RDN



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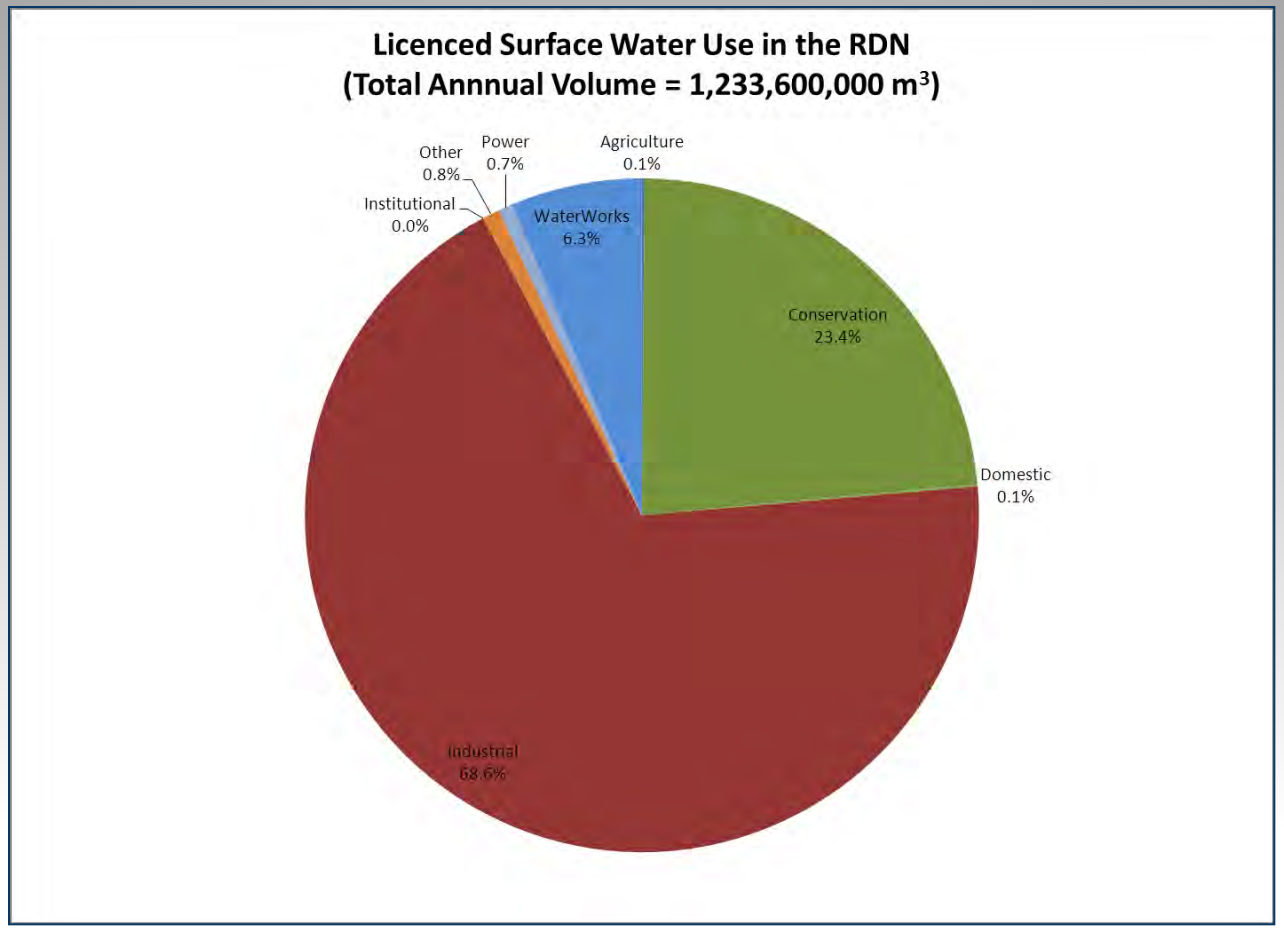
Surface Water Use



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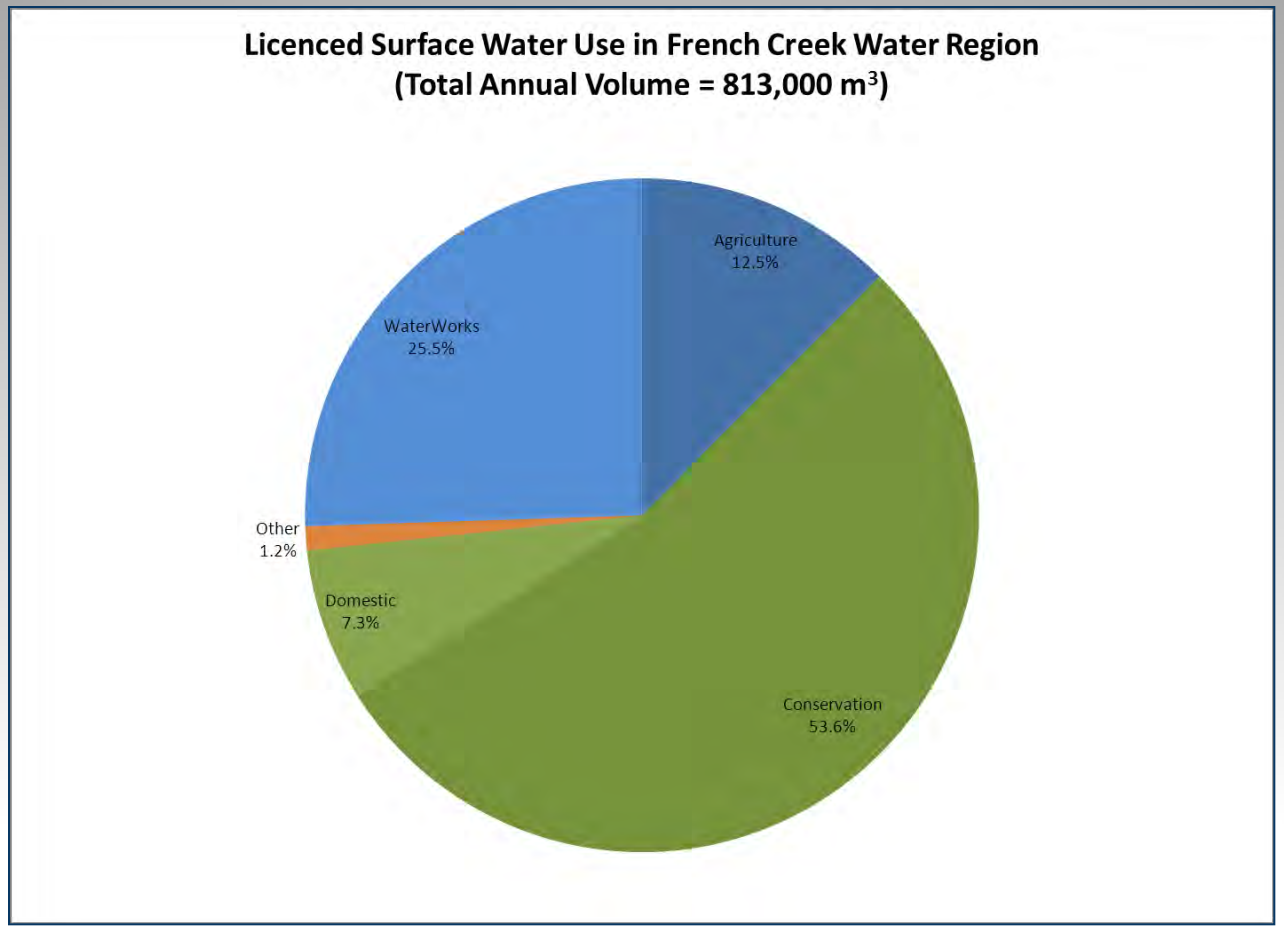
Surface Water Use



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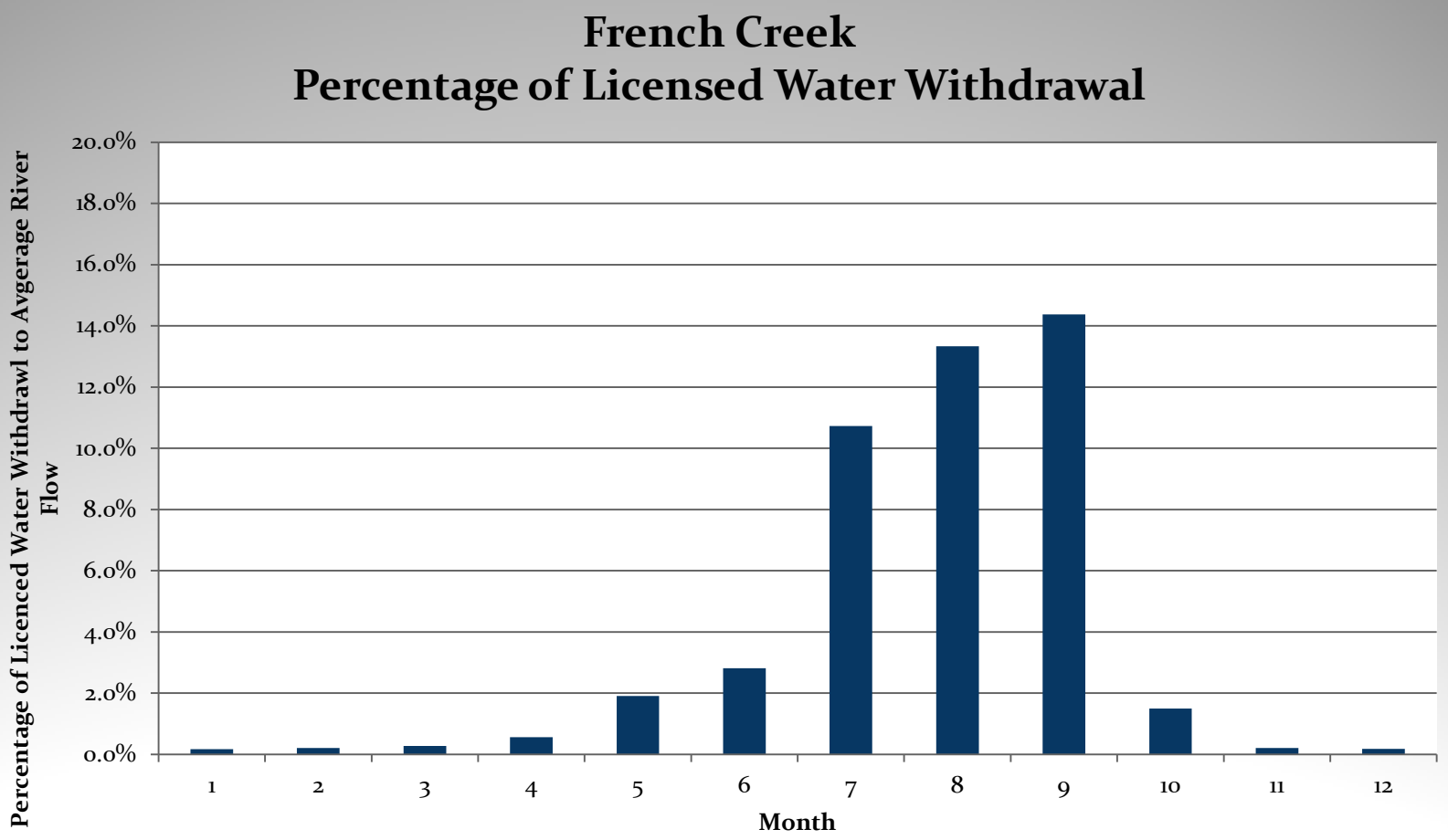
Surface Water Use



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Next Steps

- Water Budget and Stress Analysis:
  - ✓ Geodatabase constructed but some work remains to complete all conceptual hydrogeological models;
  - ✓ Complete monthly and annual water balance for all watersheds;
  - ✓ Groundwater input/output based on subsurface conceptual model;
  - ✓ Some aquifers may be need to be assessed separately;
  - ✓ Assess aquifers extending beyond watershed boundaries; and
  - ✓ Focus on critical areas identified in RDN's Drinking Water and Watershed Protection Action Plan.

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Data/Knowledge Gaps

- Not mandatory to submit water well logs to BC MOE database.
  - ✓ Major issue for hydrogeologists who need the data to understand geology and groundwater flow.
- More data may exists in MOT files?

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Data/Knowledge Gaps

- LIDAR versus TRIM Data;
  - ✓ LIDAR would improve GSC surficial geology map;
  - ✓ Could be 10-20 m discrepancy in topo in some areas;
  - ✓ OK for regional scale assessment but need accurate survey datum in coastal areas to assess salt water intrusion.
- Need water level data in community & private wells.
  - ✓ RDN to install loggers in critical groundwater use areas.
  - ✓ Encourage private well owners to measure water levels and submit to VIU Website (provide acoustic meter?).
- Lacking surface water flow data….
  - Reactivate discontinued Water Survey of Canada gauges;
  - Rating curve already established so it most cost effective.

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Future Considerations

- Community water database needed (levels, flows, quality):
  - ✓ Good data collected by various community groups but is not easily accessible to everyone;
  - ✓ Data in various formats & takes time to consolidate.
- Considerations for a community water database
  - ✓ Waterline Geodatabase provides the framework, can VIU DB provide the interface?;
  - ✓ Easily accessible online user interface which is platform independent;
  - ✓ Secure user based system which allows access for editing, adding or just viewing data;
  - ✓ Consistent data entry & quality (data collection standards…etc);
  - ✓ Allows for integration of other data sources (WSC real-time data, etc.);
  - ✓ Privacy Issues.

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Questions?

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